

ABSTRAK

MACHMOED SANTOSO. Simulasi Produksi Energi Listrik Untuk Evaluasi Portofolio Pengembangan Kapasitas Subsistem Bali Berbasis Unit Commitment dan Economic Dispatch. Dibimbing oleh Prof. Dr. Ir. IWA GARNIWA M. K., M.T.

Subsistem kelistrikan Bali menghadapi tantangan peningkatan permintaan beban, dominasi pembangkit berbahan bakar fosil, serta tuntutan peningkatan bauran Energi Baru Terbarukan dalam kerangka transisi energi. Kondisi tersebut menuntut evaluasi pengembangan kapasitas yang tidak hanya berfokus pada pemenuhan kebutuhan energi, tetapi juga mempertimbangkan efisiensi biaya sistem, kebutuhan investasi, keandalan, dan ketahanan terhadap perubahan kondisi operasi. Penelitian ini bertujuan untuk mengevaluasi portofolio pengembangan kapasitas Subsistem Bali pada periode 2025–2034 melalui simulasi produksi energi listrik. Metode penelitian dilakukan dengan simulasi operasi sistem berbasis *unit commitment* dan *economic dispatch* untuk merepresentasikan perilaku pembangkit dalam memenuhi permintaan beban. Evaluasi dilakukan menggunakan indikator keandalan, biaya total sistem, kebutuhan investasi, emisi, dan bauran energi terbarukan, serta dilengkapi dengan analisis sensitivitas kenaikan permintaan beban sebesar lima persen. Hasil penelitian menunjukkan bahwa seluruh portofolio mampu memenuhi keandalan sistem pada kondisi beban dasar dengan nilai *unserved energy* sebesar 0 MWh. Secara ekonomi, portofolio R2 menghasilkan biaya total sistem terendah sebesar 5.712,31 MUSD, lebih rendah dibandingkan portofolio acuan RUPTL sebesar 5.744,97 MUSD. Analisis multiobjektif menunjukkan adanya hubungan antara biaya sistem dan kebutuhan investasi, di mana portofolio dengan biaya sistem lebih rendah memerlukan investasi yang lebih tinggi. Pendekatan base case optimal dan robust optimal memberikan kerangka pengambilan keputusan yang lebih operasional dalam pemilihan portofolio pengembangan kapasitas Subsistem Bali.

Kata kunci: pengembangan kapasitas, portofolio, simulasi sistem tenaga, keandalan sistem, biaya sistem

ABSTRACT

MACHMOED SANTOSO. Electricity Energy Production Simulation for Evaluating the Capacity Expansion Portfolio of the Bali Subsystem. Supervised by Prof. Dr. Ir. IWA GARNIWA M. K., M.T.

The Bali power subsystem faces challenges related to increasing electricity demand, continued reliance on fossil-fuel-based generation, and the need to increase the share of renewable energy within the energy transition framework. These conditions require a capacity expansion evaluation that not only focuses on supply adequacy, but also considers system cost efficiency, investment requirements, reliability, and robustness to changes in operating conditions. This study aims to evaluate capacity expansion portfolios for the Bali power subsystem over the 2025–2034 planning horizon using electricity production simulation. The methodology is based on power system operation simulation using unit commitment and economic dispatch to represent generator behavior in meeting system demand. Portfolio performance is evaluated using indicators of reliability, total system cost, investment requirements, emissions, and renewable energy share, complemented by a sensitivity analysis with a five percent increase in demand. The results show that all portfolios meet system reliability under base load conditions, with unserved energy equal to 0 MWh. From an economic perspective, portfolio R2 achieves the lowest total system cost at 5,712.31 MUSD, lower than the reference RUPTL portfolio at 5,744.97 MUSD. Multi-objective analysis indicates a relationship between long-term system cost and capital investment requirements, where lower system costs are associated with higher investment levels. The base case optimal and robust optimal perspectives provide an operational decision-making framework for selecting capacity expansion portfolios aligned with policy priorities, investment constraints, and system resilience.

Keywords: capacity expansion, portfolio, power system simulation, system reliability, system cost