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**Unit Commitment Sistem Bangka Mempertimbangkan Pola Operasi Small Modular Reactor dan Penetrasi VRE**
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**Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/**

# INTISARI

Sistem Kelistrikan Bangka merupakan sistem tenaga listrik yang membutuhkan kecukupan pasokan, fleksibilitas operasi, dan keandalan frekuensi ketika sumber pembangkit baru diintegrasikan. Penelitian ini memodelkan operasi pembangkitan harian Sistem Kelistrikan Bangka tahun 2032 dengan mempertimbangkan integrasi pembangkit listrik tenaga nuklir berbasis *Small Modular Reactor* (SMR), *variable renewable energy*, pembangkit eksisting, dan interkoneksi. Optimisasi dilakukan menggunakan formulasi *unit commitment* berbasis *Mixed Integer Linear Programming* (MILP) dengan Python, CVXPY, dan solver HiGHS. Model mempertimbangkan keseimbangan daya, batas keluaran pembangkit, *ramp rate*, *minimum up time*, *minimum down time*, biaya energi, biaya *startup*, biaya *variable O&M*, cadangan putar N-1, serta *inertia constraint* berbasis *Rate of Change of Frequency* (RoCoF). Lima skenario disimulasikan, yaitu skenario tanpa SMR, skenario dengan SMR tanpa *inertia constraint*, skenario dengan SMR dan *inertia constraint*, skenario SMR *must run full load* 250 MW, dan skenario SMR *must run full load* 125 MW. Hasil optimisasi menunjukkan bahwa seluruh skenario mampu memenuhi kebutuhan energi harian sebesar 6.953,92 MWh. Skenario tanpa SMR menghasilkan biaya operasi tertinggi sebesar 1.010.387,18 dolar dengan BPP pembangkitan operasional sebesar 2.470,06 Rp/kWh, sedangkan skenario SMR tanpa *inertia constraint* menghasilkan biaya terendah sebesar 354.986,14 dolar dengan BPP pembangkitan operasional sebesar 867,82 Rp/kWh, tetapi belum mempertimbangkan kecukupan inersia sistem. Skenario SMR *must run full load* digunakan sebagai pembanding pola operasi beban dasar; konfigurasi 250 MW menghasilkan kelebihan energi dan kekurangan inersia RoCoF, sedangkan konfigurasi 125 MW layak secara teknis tetapi memiliki biaya lebih tinggi dibandingkan operasi SMR fleksibel dengan batas inersia. Berdasarkan indikator teknis dan ekonomi, skenario SMR dengan *inertia constraint* menjadi skenario terbaik karena mampu memenuhi kebutuhan energi tanpa defisit daya, kelebihan daya, *curtailment* PLTS, maupun kekurangan inersia RoCoF, dengan biaya operasi sebesar 440.946,39 dolar dan BPP pembangkitan operasional sebesar 1.077,97 Rp/kWh.

**Kata kunci** : *Unit commitment*, SMR, RoCoF, inersia sistem, MILP

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# ABSTRACT

*The Bangka power system requires supply adequacy, operational flexibility, and frequency reliability when new generation resources are integrated. This study models the daily generation operation of the Bangka power system in 2032 by considering the integration of a Small Modular Reactor (SMR), variable renewable energy, conventional generators, and interconnection supply. The optimization is carried out using a Mixed Integer Linear Programming (MILP)-based unit commitment formulation with Python, CVXPY, and the HiGHS solver. The model considers power balance, generation limits, ramp rate, minimum up time, minimum down time, energy cost, startup cost, variable O&M cost, N-1 spinning reserve, and an inertia constraint based on the Rate of Change of Frequency (RoCoF). Five scenarios are evaluated: without SMR, with SMR without an inertia constraint, with SMR and an inertia constraint, SMR must-run full-load at 250 MW, and SMR must-run full-load at 125 MW. The optimization results show that all scenarios can meet the daily energy demand of 6,953.92 MWh. The case without SMR gives the highest operating cost of $1,010,387.18 with an operational generation BPP of 2,470.06 Rp/kWh, whereas the SMR case without an inertia constraint gives the lowest operating cost of $354,986.14 with an operational generation BPP of 867.82 Rp/kWh, but inertia adequacy is not considered. The SMR must-run full-load cases are used as baseload operating comparisons; the 250 MW configuration produces surplus energy and RoCoF inertia shortage, while the 125 MW configuration is technically feasible but costlier than flexible SMR operation with an inertia limit. Based on the technical and economic indicators, the scenario with SMR and an inertia constraint is the best scenario because it meets the energy demand without power deficit, surplus generation, solar PV curtailment, or RoCoF inertia shortage, with an operating cost of $440,946.39 and an operational generation BPP of 1,077.97 Rp/kWh.*

***Keywords*** : *Unit commitment*, *SMR*, *RoCoF*, *system inertia*, *MILP*