

INTISARI

Transisi energi nasional menuntut percepatan pemanfaatan energi surya untuk menurunkan ketergantungan pada pembangkit fosil. Potensi teknis PLTS atap di Indonesia diperkirakan mencapai sekitar 207,8 GW, tetapi realisasi pemanfaatannya masih rendah dengan pangsa sekitar 0,06 persen dan jumlah pelanggan sekitar 10.882. Perubahan kebijakan melalui Peraturan Menteri ESDM Nomor 2 Tahun 2024 mengalihkan mekanisme ekspor impor menjadi skema kuota pengembangan sebesar 5.746 MW untuk periode 2024 sampai 2028, yang memunculkan isu ketidakpastian regulasi, kompleksitas perizinan, serta hambatan layanan yang dapat menahan realisasi adopsi meskipun minat rumah tangga meningkat. Penelitian ini bertujuan memodelkan dinamika adopsi PLTS atap pada rumah tangga serta menganalisis dampak faktor perilaku dan kebijakan terhadap peningkatan adopsi dengan mempertimbangkan keterbatasan layanan PLN.

Pendekatan *Agent-based Modelling Simulation* (ABMS) digunakan untuk merepresentasikan heterogenitas rumah tangga dan pengaruh lingkungan sosial. Model keputusan dibangun dengan mengintegrasikan konstruk UTAUT2 dan *Perceived Value Model* (PVM), kemudian indikator empiris divalidasi menggunakan *Exploratory Factor Analysis* (EFA) dengan nilai Kaiser-Meyer-Olkin (KMO) sebesar 0,922 dan Bartlett signifikan. Agen rumah tangga dibedakan menjadi *adopter* dan *non-adopter*, lalu *non-adopter* dikelompokkan ke dalam empat klaster kesiapan. Simulasi disusun pada platform Mesa ABM dengan mekanisme perubahan status bertahap dari *non-adopter* menjadi *waiting list*, lalu *adopter*. Pembentukan intensi adopsi dimodelkan secara probabilistik, sedangkan realisasi adopsi dipengaruhi oleh interval layanan, *time window*, dan kapasitas PLN. Eksperimen skenario dilakukan untuk mengevaluasi dampak subsidi, arus informasi lingkungan (*gamma neighborhood*), serta perbaikan interval pengajuan instalasi.

Hasil simulasi *baseline* selama 120 bulan menunjukkan rata-rata *adopter* sebesar 71 rumah tangga. Penerapan kebijakan subsidi meningkatkan adopsi, dengan skenario subsidi 30 persen menghasilkan rata-rata 88 *adopter* atau meningkat 24 persen dibandingkan dengan *baseline*. Peningkatan arus informasi melalui *gamma neighborhood* juga menaikkan adopsi, dengan *gamma* 30 persen menghasilkan rata-rata 82 *adopter* atau meningkat 15,5 persen. Percepatan interval pengajuan instalasi menjadi 1 bulan menghasilkan rata-rata 78 *adopter* atau meningkat 9,8 persen. Kombinasi kebijakan dengan efek tertinggi berupa subsidi 30 persen, *gamma* 30 persen, dan interval pengajuan 1 bulan menghasilkan rata-rata 95 *adopter* atau meningkat 33,8 persen dari *baseline*. Temuan ini menunjukkan bahwa peningkatan intensi adopsi perlu diimbangi dengan penguatan proses layanan dan kapasitas implementasi agar *bottleneck waiting list* tidak menahan realisasi adopsi pada kondisi pembatasan kuota dan layanan.

Kata kunci: *Agent-based Modelling*, PLTS atap, skenario kebijakan.

ABSTRACT

National energy transition requires accelerated deployment of solar energy to reduce dependence on fossil-based power generation. The technical potential of rooftop PV in Indonesia is estimated at approximately 207.8 GW, yet its realization remains limited, with a share of around 0.06% and about 10,882 customers. A policy change through Minister of Energy and Mineral Resources Regulation (Permen ESDM) No. 2 of 2024 shifted the export-import mechanism to a development quota scheme of 5,746 MW for the 2024–2028 period, raising issues of regulatory uncertainty, permitting complexity, and service-related barriers that may constrain realized adoption even as household interest increases. This study aims to model the dynamics of household rooftop PV adoption and to analyze the effects of behavioral and policy factors on adoption growth while considering constraints in PLN's service capacity.

An Agent-based Modelling Simulation (ABMS) approach is applied to represent household heterogeneity and the influence of the social environment. The decision model integrates constructs from UTAUT2 and the Perceived Value Model (PVM), and the empirical indicators are validated using Exploratory Factor Analysis (EFA), yielding a Kaiser–Meyer–Olkin (KMO) value of 0.922 with a significant Bartlett's test. Household agents are classified as adopters and non-adopters, with non-adopters further segmented into four readiness clusters. The simulation is implemented on the Mesa ABM platform with a staged status transition from non-adopter to waiting list and then to adopter. Adoption intention is modeled probabilistically, while realized adoption is influenced by service intervals, time windows, and PLN capacity. Scenario experiments are conducted to evaluate the impacts of subsidies, neighborhood information flow (gamma neighborhood), and improvements in the installation application interval.

The baseline simulation results over 120 months show an average of 71 adopting households. The implementation of a subsidy policy increased adoption, with the 30 percent subsidy scenario yielding an average of 88 adopters, representing a 24 percent increase compared to the baseline. Increased information flow through the gamma neighborhood parameter also raised adoption, with a 30 percent gamma yielding an average of 82 adopters, a 15.5 percent increase. Shortening the installation application interval to 1 month resulted in an average of 78 adopters, a 9.8 percent increase. The most effective policy combination — consisting of a 30 percent subsidy, 30 percent gamma, and a 1-month application interval — produced an average of 95 adopters, a 33.8 percent increase from the baseline. These findings indicate that increases in adoption intention must be accompanied by strengthening service processes and implementation capacity, so that waiting list bottlenecks do not impede the realization of adoption under quota-restricted and service-constrained conditions.

Keywords: *Agent-based Modelling, photovoltaics, policy scenarios*