INTISARI

Pesatnya pertumbuhan adopsi sepeda motor listrik di Indonesia, khususnya di DKI Jakarta, telah menciptakan kesenjangan infrastruktur yang kritis pada jaringan Stasiun Penukaran Baterai. Per tahun 2025, sebanyak 291 unit BSS yang ada di lima kota administratif hanya menghasilkan rasio *coverage* sebesar 11% hingga 31% terhadap perkiraan permintaan. Studi ini bertujuan mengoptimalkan penempatan *Battery Swapping Station* (BSS) di DKI Jakart**a** menggunakan model *Capacitated Facility Location Problem* (CFLP) di 261 kelurahan di DKI Jakarta, dengan merumuskan dua tujuan yang saling bertentangan yaitu minimalisasi total biaya dan maksimalisasi kepuasan pelanggan yang dimodelkan melalui fungsi penurunan eksponensial terhadap jarak (*exponential distance decay function*). Metode *ε-constraint* menghasilkan kumpulan solusi optimal Pareto yang merepresentasikan *trade-off* antara kedua tujuan tersebut. Sebanyak 694 lokasi kandidat dari Alfamart, Alfamidi, Dan+Dan, Circle K, FamilyMart, KFC, dan SPBU BP dievaluasi terhadap 103.157 pengguna sepeda motor listrik sebagai basis permintaan, model ini diimplementasikan menggunakan *Python* dan diselesaikan dengan Gurobi. Solusi optimal merekomendasikan 391 lokasi BSS dengan total biaya sebesar Rp43,796,200,000 dan tingkat kepuasan pelanggan sebesar 85.14%. Analisis sensitivitas untuk periode 2026–2030, yang memperhitungkan pertumbuhan penetrasi kendaraan listrik dari 39% menjadi 69%, inflasi tahunan sebesar 3,08%, dan peningkatan jumlah mesin sebesar 10% per tahun, menunjukkan bahwa perubahan parameter tersebut memengaruhi konfigurasi jaringan BSS yang optimal, kebutuhan investasi, dan tingkat kepuasan pengguna. Oleh karena itu, pengembangan infrastruktur BSS perlu direncanakan secara adaptif sesuai dengan pertumbuhan pasar kendaraan listrik.

Kata kunci: Stasiun Penukaran Baterai, *Capacitated Facility Location Problem*, Optimisasi Multi-Objektif, *Metode ε-constraint*, *Pareto Front*, DKI Jakarta

ABSTRACT

The rapid growth of electric motorcycle adoption in Indonesia, particularly in the Special Capital Region of Jakarta (DKI Jakarta), has created a critical gap in the Battery Swapping Station (BSS) infrastructure network. As of 2025, the existing 291 BSS units distributed across the five administrative cities provide a service coverage ratio of only 11% to 31% of the estimated demand. This study aims to optimize the placement of Battery Swapping Stations (BSSs) in DKI Jakarta using a Multi-objective Capacitated Facility Location Problem (CFLP) model across 261 urban villages. The model incorporates two conflicting objectives: minimizing total investment cost and maximizing customer satisfaction, where customer satisfaction is represented using an exponential distance decay function. The ε-constraint method is employed to generate a set of Pareto-optimal solutions that represent the trade-off between these objectives. A total of 694 candidate locations, including Alfamart, Alfamidi, Dan+Dan, Circle K, FamilyMart, KFC, and BP gas stations, are evaluated against a demand of 103,157 electric motorcycle users. The model is implemented in Python and solved using the Gurobi Optimizer. The selected optimal solution recommends establishing 391 BSS locations with a total investment cost of IDR 43,796,200,000 and a customer satisfaction level of 85.14%. A sensitivity analysis for the 2026–2030 period, considering the growth of electric vehicle penetration from 39% to 69%, an annual inflation rate of 3.08%, and a 10% annual increase in the number of battery swapping machines, indicates that these parameter changes significantly affect the optimal BSS network configuration, investment requirements, and customer satisfaction levels. Therefore, the development of BSS infrastructure should be planned adaptively to accommodate the future growth of the electric vehicle market.

Keywords: *battery swapping station, capacitated facility location problem*, *multi-objective optimization, ε-constraint method, Pareto front*, DKI Jakarta