

ABSTRACT

Electric forklifts are widely adopted in industrial material handling for their energy efficiency and zero direct emissions. However, the quantitative relationship between load variation, productivity, and energy consumption under real operating conditions remains insufficiently characterized. This study aims to determine the effect of load variation on the productivity and energy consumption of the CPD30EJL electric forklift, and to identify the optimal working-load range (sweet spot) based on the Energy Effectiveness Ratio (REE) and specific energy (E_s) at PT AWGM.

A quantitative experimental method was applied through direct field measurements at the Parts Distribution Center of PT AWGM, Cakung, North Jakarta (September–December 2025). Forty-four loaded cycles were recorded across three load categories: light ($<1,500$ kg, $n=14$), medium ($1,500$ – $2,500$ kg, $n=15$), and heavy ($2,500$ – $3,000$ kg, $n=15$). Data were analyzed using simple linear regression, Pearson correlation, REE, specific energy, force-moment, and techno-economic analyses in IBM SPSS Statistics.

Load increase significantly and negatively affected productivity ($Y_1 = 104.3764 - 0.006481X$; $R^2 = 0.9948$; $p < 0.001$), and significantly and positively affected energy consumption ($Y_2 = -0.0038 + 0.000029X$; $R^2 = 0.9724$; $p < 0.001$), with a strong trade-off between the two ($r = -0.985$; $p < 0.001$). The energy-optimal load range was $1,050$ – $1,390$ kg, with peak REE of $45,652.17$ kg/kWh and minimum E_s of 0.0000219 kWh/kg, while the medium load category was the most cost-effective (Rp 28.24/ton). These findings jointly answer the three research objectives, providing a quantitative basis for load planning in industrial material handling.

Keywords: *electric forklift, load variation, productivity, energy consumption, energy effectiveness ratio*

INTISARI

Forklift elektrik banyak diadopsi dalam aktivitas material handling industri karena efisiensi energi dan nihil emisi langsung. Namun, hubungan kuantitatif antara variasi beban, produktivitas, dan konsumsi energi pada kondisi operasional nyata masih belum banyak dikaji secara mendalam. Penelitian ini bertujuan untuk mengetahui pengaruh variasi beban terhadap produktivitas dan konsumsi energi *forklift* elektrik tipe CPD30EJL, serta menentukan rentang beban kerja optimal (sweet spot) berdasarkan Rasio Efektivitas Energi (REE) dan energi spesifik (E_s) di PT AWGM.

Penelitian ini menggunakan metode eksperimental kuantitatif dengan pengukuran langsung di lapangan pada Parts Distribution Center PT AWGM, Cakung, Jakarta Utara (September–Desember 2025). Sebanyak 44 siklus operasional berbeban direkam pada tiga kategori beban: ringan (<1.500 kg, $n=14$), sedang (1.500 – 2.500 kg, $n=15$), dan berat (2.500 – 3.000 kg, $n=15$). Data dianalisis menggunakan regresi linear sederhana, korelasi Pearson, REE, energi spesifik, momen gaya, dan analisis tekno-ekonomi melalui IBM SPSS Statistics.

Peningkatan beban terbukti berpengaruh negatif dan signifikan terhadap produktivitas ($Y_1 = 104,3764 - 0,006481X$; $R^2 = 0,9948$; $p < 0,001$), serta berpengaruh positif dan signifikan terhadap konsumsi energi ($Y_2 = -0,0038 + 0,000029X$; $R^2 = 0,9724$; $p < 0,001$), dengan trade-off yang kuat di antara keduanya ($r = -0,985$; $p < 0,001$). Rentang beban kerja paling optimal secara energi berada pada 1.050 – 1.390 kg, dengan REE puncak $45.652,17$ kg/kWh dan E_s minimum $0,0000219$ kWh/kg, sementara kategori beban sedang paling ekonomis (Rp 28,24/ton). Temuan ini menjawab ketiga tujuan penelitian dan memberikan landasan kuantitatif untuk perencanaan pembebanan pada aktivitas material handling industri.

Kata kunci: *forklift* elektrik, variasi beban, produktivitas, konsumsi energi, rasio efektivitas energi.