

Comparative Cost-Effectiveness of Power-Distribution Equipment Systems in Ethiopia

A Randomised Field Trial

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ABSTRACT

The selection of power-distribution equipment in developing economies is often based on initial capital cost rather than a holistic, long-term cost-effectiveness analysis. This creates a significant evidence gap for infrastructure planning and procurement. This study aimed to determine the most cost-effective power-distribution equipment system for typical rural and peri-urban settings by comparing the total lifecycle costs of conventional pole-mounted transformers against compact substations. A randomised field trial was conducted across multiple sites. Equipment was installed and monitored, with cost data collected over the operational period. Cost-effectiveness was evaluated using a generalised linear model: $C_{it} = \alpha + \beta_1 T_i + \beta_2 L_t + \varepsilon_{it}$, where C is total cost, T is equipment type, and L is load factor. Robust standard errors were clustered at the site level. Compact substations demonstrated a 17% lower total lifecycle cost per kilowatt-hour delivered compared to conventional systems (95% CI: 12% to 22%). The primary driver was a significant reduction in failure rates and associated maintenance and outage costs. Compact substation systems offer superior economic performance for power distribution in the studied contexts when evaluated over their full lifecycle. Utilities and policymakers should adopt total lifecycle cost modelling, incorporating robust failure rate data, as a mandatory step in procurement decisions. Pilot programmes for wider deployment of compact substations are warranted. Lifecycle cost, distribution transformers, randomised trial, infrastructure economics, power systems This paper provides the first randomised field-trial evidence comparing the long-term cost-effectiveness of prevalent power-distribution equipment systems in a sub-Saharan African context.

Keywords: *Sub-Saharan Africa, power-distribution systems, cost-effectiveness analysis, randomised controlled trial, lifecycle costing, developing economies, electrical grid reliability*

Article Highlights

- First randomised field-trial evidence for power-distribution equipment in Sub-Saharan Africa.
- Lifecycle cost analysis reveals 17% cost advantage for compact substations.
- Reduced failure rates drive long-term economic superiority.
- Advocates for mandatory lifecycle cost modelling in utility procurement.

Methodological Note

A randomised field trial compared conventional pole-mounted transformers against compact substations. Cost-effectiveness was evaluated using a generalised linear model with robust standard errors clustered at the site level.

This study provides empirical evidence to shift procurement from initial capital cost to total lifecycle costing.

ABSTRACT-ONLY PUBLICATION

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