

## SHORT REPORT

# Randomised Field Trial on the Cost-Effectiveness of Power-Distribution Equipment Diagnostics in Uganda

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## ABSTRACT

Diagnostic technologies for power-distribution equipment are promoted to enhance grid reliability, but rigorous field evidence on their cost-effectiveness in low-resource settings is scarce. This study aimed to conduct a randomised field trial to evaluate the cost-effectiveness of implementing a diagnostic system for transformers and switchgear within a national utility. A randomised controlled trial was designed, allocating 200 primary substations to either a diagnostic intervention group or a standard practice control group. Cost data and failure events were recorded over an operational period. Cost-effectiveness was evaluated using a Bayesian hierarchical model:  $\lambda\{ij\} = \exp(\beta_0 + \beta_1 Ti + u_j)$ , where  $\lambda\{ij\}$  is the failure rate for substation  $i$  in region  $j$ ,  $Ti$  is the treatment indicator, and  $u_j$  are regional random effects. Robust standard errors were calculated. The diagnostic system reduced unplanned outages by an estimated 18% (95% credible interval: 12% to 24%). However, the net present cost per major failure averted exceeded the local benchmark for capital projects, indicating poor cost-effectiveness under current tariff structures. While technically effective in improving reliability, the diagnostic intervention was not cost-effective for the utility under prevailing economic conditions. Deployment should be contingent on tariff reforms or targeted at critical network segments. Utilities should prioritise cost-benefit analyses before large-scale adoption of such technologies. power distribution, diagnostic systems, randomised trial, cost-benefit analysis, grid reliability, Bayesian modelling This paper provides the first experimental evidence from a randomised field trial on the economic efficacy of distribution equipment diagnostics in a sub-Saharan African context.

**Keywords:** *cost-effectiveness analysis, randomised controlled trial, power-distribution diagnostics, sub-Saharan Africa, grid reliability, condition-based maintenance, low-resource settings*

### Article Highlights

- Randomised trial of diagnostic systems across 200 substations in Uganda.
- 18% reduction in unplanned outages with credible interval of 12–24%.
- Cost per failure averted exceeded local capital project benchmarks.
- Deployment recommended only with tariff reforms or for critical network segments.

### Methodological Note

Evaluation used a Bayesian hierarchical model to estimate failure rates, accounting for regional random effects and calculating robust standard errors.

*This study provides the first experimental evidence on diagnostic economics in sub-Saharan Africa.*

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