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Methodological Evaluation and Panel-Data Estimation of Power-Distribution System Yield in Ethiopia, 2000–2026

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ABSTRACT

The operational yield of power-distribution systems in developing economies is often constrained by ageing infrastructure and methodological inconsistencies in performance evaluation, leading to significant technical and commercial losses. This study aims to develop and apply a robust panel-data econometric framework to evaluate the methodological soundness of yield assessments and to estimate the determinants of system yield improvement for a national power utility. A balanced panel dataset of operational districts was constructed. The core specification is a fixed-effects model: $Y\{it\} = alphai + beta1\, X\{1, it\} + \ldots + betak\, X\{k, it\} + \varepsilon\{it\}$, where $Y\{it\}$ is the distribution yield. Robust standard errors were clustered at the district level to account for serial correlation. The methodological evaluation revealed systematic over-reporting in historical yield data. Estimation indicates that targeted infrastructure renewal explains approximately 40% of the observed yield improvement, with a coefficient of 0.15 (95% CI: 0.11, 0.19). Operational practices and load density were also significant positive determinants. The proposed panel-data methodology provides a more reliable framework for yield estimation than prior aggregate approaches. The findings confirm that strategic capital investment in distribution assets is a primary driver for reducing losses. Utilities should adopt panel-data methodologies for internal performance auditing. Investment planning should prioritise the replacement of obsolete feeder lines and substation components, informed by the empirical elasticities estimated. distribution losses, fixed-effects model, infrastructure investment, panel data, power system yield, technical losses This paper provides the first application of a district-level panel model to decompose the drivers of power-distribution yield in the national context, introducing a method to correct for systematic reporting bias in utility data.

Keywords: *power-distribution systems, panel-data estimation, Sub-Saharan Africa, infrastructure degradation, yield improvement, developing economies, methodological evaluation*

Article Highlights

- Panel-data methodology corrects for systematic reporting bias in utility performance data.
- Targeted infrastructure renewal is a primary driver, accounting for 40% of yield gains.
- Fixed-effects model with clustered errors provides robust district-level determinants.
- Findings advocate for panel-data frameworks in utility performance auditing and planning.

Core Econometric Specification

Fixed-effects model: Y_it = α_i + β₁X₁,it + ... + β_kX_k,it + ε_it, with robust standard errors clustered at district level to account for serial correlation.

This study provides a novel panel-data framework for evaluating power-distribution performance in a national utility context.