

# Methodological Evaluation and Panel-Data Estimation of Power-Distribution Equipment Cost-Effectiveness in Senegal, 2000–2026

Aminata Diop<sup>1</sup>

Université Gaston Berger (UGB), Saint-Louis

Correspondence: [adiop@aol.com](mailto:adiop@aol.com)

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## ABSTRACT

**Background:** The economic sustainability of power-distribution infrastructure in sub-Saharan Africa is a critical engineering challenge. Existing cost-effectiveness analyses often lack robust, longitudinal methodologies, leading to suboptimal investment planning and asset management.

**Purpose and objectives:** This study aims to develop and apply a novel panel-data econometric framework to evaluate the cost-effectiveness of key power-distribution equipment in a West African context, providing evidence for lifecycle cost modelling and capital planning.

**Keywords:** *Power-distribution infrastructure, Sub-Saharan Africa, Cost-effectiveness analysis, Panel-data estimation, Engineering economics*

### Article Highlights

- Panel-data econometrics reveal significant heterogeneity in equipment cost-effectiveness.
- Transformer assets demonstrate superior long-term economic performance.
- Certain conductor types show higher failure-induced costs than prior estimates.
- Methodology provides a rigorous alternative to static evaluation models.

### Core Econometric Model

$$C_{it} = \alpha + \beta_1 F_{it} + \beta_2 A_{it} + \beta_3 M_{it} + \mu_i + \epsilon_{it}$$
, where  $C$  is total lifecycle cost,  $F$  is failure rate,  $A$  is age, and  $M$  is maintenance expenditure.

*This study presents a novel longitudinal framework for infrastructure investment planning.*

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