

Comparative Methodological Evaluation and Time-Series Forecasting for Cost-Effectiveness in Rwanda's Power-Distribution Infrastructure (2000–2026)

Alice Mukamana^{1,2}Jean de Dieu Uwimana^{3,4}

Marie Chantal Uwase⁵Jean Paul Nkurunziza⁶

¹ Department of Sustainable Systems, African Leadership University (ALU), Kigali

² Department of Civil Engineering, University of Rwanda

³ Department of Civil Engineering, Rwanda Environment Management Authority (REMA)

⁴ African Leadership University (ALU), Kigali

⁵ Department of Mechanical Engineering, Rwanda Environment Management Authority (REMA)

⁶ Department of Electrical Engineering, Rwanda Environment Management Authority (REMA)

Correspondence: amukamana@outlook.com

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ABSTRACT

Background: Power-distribution infrastructure in developing nations requires robust, cost-effective planning methodologies. Existing approaches often lack integrated, long-term forecasting models tailored to specific regional constraints and equipment lifecycles.

Purpose and objectives: This study conducts a comparative methodological evaluation of equipment systems and develops a bespoke time-series forecasting model to measure and project cost-effectiveness for national power-distribution infrastructure.

Methodology: A comparative analysis of transformer and switchgear systems was performed using historical operational and cost data. A seasonal autoregressive integrated moving average (SARIMA) model, specified as $\varphi(B)\varphi(B^s)\nabla^d\nabla^{Ds}yt = \theta(B)\theta(B^s)\varepsilon_t$, was developed for forecasting. Model diagnostics included analysis of robust standard errors to account for heteroskedasticity.

Findings: The forecasting model indicates a projected 22% reduction in total lifecycle costs per kilometre of network for the recommended equipment portfolio over a 25-year period. Comparative analysis identified specific switchgear technologies as having superior long-term cost-performance ratios under local operational conditions.

Recommendations: Infrastructure planners should adopt the developed forecasting model for capital investment appraisals. A phased transition towards the identified high-performance equipment portfolio is recommended to maximise future cost savings.

Key words: infrastructure planning, lifecycle costing, SARIMA modelling, power distribution, cost-effectiveness, forecasting

Contribution statement: This paper presents a novel integrated methodology combining comparative equipment evaluation with a bespoke time-series forecasting model, providing a new decision-support tool for engineering economists and infrastructure planners.

Keywords: Power-distribution infrastructure, Time-series forecasting, Cost-effectiveness analysis, Sub-Saharan Africa, Comparative methodology, Engineering economics

Article Highlights

• Comparative analysis identifies switchgear technologies with

Methodological Contribution

Presents an integrated comparative evaluation and bespoke

superior long-term cost-performance ratios.

- SARIMA model provides robust, seasonally-adjusted forecasts for infrastructure investment planning.
- Methodology tailored to regional constraints and equipment lifecycles in Sub-Saharan Africa.
- Novel framework combines equipment evaluation with time-series forecasting for decision support.

SARIMA forecasting model as a new decision-support tool for engineering economists.

This study offers a practical framework for long-term cost-optimisation of power-distribution infrastructure.

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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