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A Methodological Evaluation and Cost-Effectiveness Forecasting Model for South African Power-Distribution Equipment Systems (2000–2026)

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ABSTRACT

Background: The long-term financial sustainability of power-distribution infrastructure is a critical engineering challenge, particularly in contexts of constrained capital expenditure and ageing assets. Existing asset management models often lack integrated, forward-looking cost-effectiveness analyses tailored to specific national grid conditions.

Purpose and objectives: This case study develops and methodologically evaluates a novel time-series forecasting model to measure the cost-effectiveness of power-distribution equipment systems. The objective is to provide a robust, data-driven tool for long-term capital planning and asset replacement strategy.

Keywords: *Power-distribution systems, Cost-effectiveness forecasting, Time-series analysis, South African infrastructure, Ageing assets, Capital expenditure, Life-cycle costing*

Article Highlights

- A novel VAR model integrates technical performance and financial data for long-term forecasting.
- Transformer populations identified as the most critical cost-driver in distribution systems.
- Model provides a 95% prediction interval for cost-effectiveness metrics (16.2%–27.1%).
- Framework enables transition from time-based to condition-based asset management.

Methodological Contribution

This study develops an integrated vector autoregression (VAR) model that uniquely combines historical operational data with cost metrics, creating a robust forecasting tool for distribution asset management.

This technical analysis provides utilities with a data-driven framework for strategic capital planning.