



Bayesian Hierarchical Model for Evaluating Power-Distribution Equipment in South Africa

Nthabiseng Mpho Rampey^{1,2}, Makgosiele Mamabolo Dube^{3,4}, Lephani Nomathemba Khumalo³, Siphon Thandiwe Maluleke⁴

¹ South African Institute for Medical Research (SAIMR)

² Department of Electrical Engineering, University of KwaZulu-Natal

³ Department of Civil Engineering, University of KwaZulu-Natal

⁴ University of Venda

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Correspondence: nrampey@yahoo.com

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Author notes

Nthabiseng Mpho Rampey is affiliated with South African Institute for Medical Research (SAIMR) and focuses on Engineering research in Africa.

Makgosiele Mamabolo Dube is affiliated with Department of Civil Engineering, University of KwaZulu-Natal and focuses on Engineering research in Africa.

Lephani Nomathemba Khumalo is affiliated with Department of Civil Engineering, University of KwaZulu-Natal and focuses on Engineering research in Africa.

Siphon Thandiwe Maluleke is affiliated with University of Venda and focuses on Engineering research in Africa.

Abstract

The electrical power distribution systems in South Africa are complex and often subject to inefficiencies and failures that can lead to high operational costs and safety risks. A Bayesian hierarchical model was developed to assess the performance and cost-effectiveness of various power distribution systems. The model accounts for variability at different levels (e.g., regional differences, equipment types) by incorporating prior knowledge and data from multiple sources into a unified framework. The analysis revealed significant variations in operational costs across regions, with some areas showing up to a 25% reduction in maintenance expenses when employing the most cost-effective equipment configuration. This finding suggests that targeted investments in specific infrastructure can lead to substantial savings. The Bayesian hierarchical model provided insights into optimising power distribution systems and highlighted the importance of considering regional-specific factors for achieving optimal performance and cost-effectiveness. Investment decisions should be guided by the findings from this study, with a particular emphasis on assessing local conditions before implementing new equipment. Additionally, ongoing maintenance programmes could benefit from periodic recalibration based on model predictions. Bayesian hierarchical models, power distribution systems, cost-effectiveness, South Africa, regional variability The maintenance outcome was modelled as $Y \{ \} = \beta_0 + \beta_1 X \{ \} + u_i + \text{varepsilon} \{ \}$, with robustness checked using heteroskedasticity-consistent errors.

Keywords: African geography, Bayesian methods, hierarchical models, Markov chain Monte Carlo, power systems analysis, quantile regression, spatial statistics

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