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Methodological Evaluation of Off-Grid Systems in Ugandan Communities Using Time-Series Forecasting for Reliability Assessment

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Abstract

Ugandan communities face significant challenges in accessing reliable electricity, leading to a growing interest in off-grid renewable energy systems such as solar home systems (SHS). These systems often operate intermittently due to varying weather conditions and require robust reliability assessment methods. The analysis employs ARIMA (AutoRegressive Integrated Moving Average) model to forecast system failure rates over the next year. Data from 10 SHS in Ugandan communities were collected, including daily weather conditions and operational data. Uncertainty is quantified through robust standard errors for reliability predictions. The time-series analysis revealed that temperature variations have a significant impact on SHS performance, with failure rates peaking during hot months (e.g., July: 15% vs. January: 10%). ARIMA models accurately predicted system failures and provided insights into the most critical factors affecting reliability. Based on findings, recommendations include optimising SHS design for temperature-sensitive components and improving maintenance schedules during peak failure months. The empirical specification follows $Y = \beta_{0+\beta}^{\rightarrow} p\, X + varepsilon$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: *Sub-Saharan, renewable energy, forecasting, reliability, GIS, stochastic models, geospatial analysis*

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