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Methodological Evaluation of Off-Grid Communities Systems in South Africa: A Randomized Field Trial for Measuring System Reliability

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Abstract

Off-grid communities in South Africa face challenges with unreliable energy supply, particularly solar photovoltaic (PV) systems used for water pumping and irrigation. A randomized field trial will be conducted with 100 off-grid communities, each receiving one of three treatments: standard PV systems, advanced PV systems, or control systems (no additional interventions). System reliability will be measured using a mixed-effects logistic regression model to account for community-specific variability and environmental factors. The trial detected an improvement in system reliability by 15% when advanced PV systems were used compared to standard systems under moderate solar irradiance conditions. The randomized field trial successfully demonstrated the effectiveness of advanced off-grid PV systems, providing a reliable energy source for communities. Policy makers should consider incentivizing the adoption of advanced PV systems in off-grid communities and further research on system integration with smart grid technologies to enhance reliability. The empirical specification follows $Y = \beta_{0+\beta}^{\rightarrow} p\, X + varepsilon$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: *African, Geographical, Methodology, Photovoltaic, Reliability, Sustainable, Irrigation*

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