



# Methodological Evaluation of Off-Grid Communities Systems in Ethiopia Using Panel Data for Efficiency Measurement

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## Abstract

Off-grid communities in Ethiopia rely on solar-powered systems for electricity generation. The efficiency of these systems is a critical factor affecting their sustainability and effectiveness. Panel data from 20 off-grid communities across Ethiopia were analysed over three years. A stochastic frontier production function model was employed to estimate technical efficiency scores. Technical efficiency varied significantly among the communities (ranging from 45% to 85%), indicating areas for improvement in system design and maintenance. The study highlights the need for targeted interventions to enhance system performance, particularly in less efficient regions where solar panels are installed at a lower density than recommended. Investment should be directed towards upgrading systems in underperforming communities and training local technicians on best practices for maintenance and repair. Off-grid communities, Solar power, Panel data analysis, Efficiency measurement Model estimation used  $\hat{\theta} = \operatorname{argmin}\{\theta\} \operatorname{sumiell}(y_i, f\theta(\xi)) + \lambda \sqrt{\theta} \sqrt{2^2}$ , with performance evaluated using out-of-sample error.

**Keywords:** Ethiopia, Panel Data, Efficiency Measurement, Renewable Energy, Methodology, Sustainability, Econometrics, GIS

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