



Sustainable Energy Storage Solutions for Grid Stability and Renewable Integration in Ethiopia: A Theoretical Framework

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Abstract

Energy storage solutions are critical for enhancing grid stability in Ethiopia, where a significant proportion of electricity generation relies on hydropower and solar photovoltaic (PV) systems. The country's energy sector faces challenges such as intermittency issues caused by variable renewable sources and the need to integrate these with existing power grids. The study employs a mixed-method approach combining literature review with conceptual modelling to analyse the techno-economic feasibility of various energy storage options. A probabilistic model is used to predict system performance under different scenarios. This theoretical framework offers a robust foundation for policymakers and stakeholders to evaluate sustainable energy storage options in Ethiopia, ensuring grid reliability and facilitating broader renewable integration efforts. Based on our findings, it is recommended that Ethiopia invests heavily in advanced battery technologies such as lithium-ion cells, alongside pumped hydro storage facilities. Additionally, the implementation of smart grid technologies should be expedited to optimise energy distribution and utilization. The empirical specification follows $Y = \beta_{0+\beta}^{-} p X + \text{varepsilon}$, and inference is reported with uncertainty-aware statistical criteria.

Keywords: Ethiopia, Geothermal, Renewable Integration, Energy Storage Systems, Grid Stability Models, Sustainability Metrics, Hybrid Power Systems

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