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Enhancing Rural Electrification: An In-depth Analysis and Optimization of PV/Hydrogen Fuel Cell/Battery-Powered Microgrids

The global shift towards sustainable energy highlights the importance of supplying electricity to rural regions through renewable energy microgrids. Community development centres, such as the Masia Development Centre in Limpopo, South Africa, play a crucial role in community development and local economic growth. However, they often face challenges related to unreliable or insufficient power supply. This study comprehensively evaluates and enhances a hybrid microgrid powered by PV, hydrogen fuel cells, and batteries to improve energy availability in rural areas. Demand on energy consumption was analyzed to identify daily fluctuations in demand and determine peak usage times. The study examined critical energy requirements, such as lighting, appliance operation, and water pumping. Multiple hybrid configurations and dispatch methods were modelled using the Hybrid Optimization Model for Electric Renewables (HOMER) to identify the most viable technical and economical solution. Instead of analyzing existing systems, this study looks into the possibilities for optimized system design and demand-side management that cater to rural energy requirements. The results provide vital benchmarks for creating resilient and sustainable microgrids, furthering efforts to enhance energy access in off-grid rural communities.

Keywords: Rural Electrification,Hybrid Microgrid, Hydrogen Fuel Cell, PV/Battery Optimization

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