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Integration of grid-scale battery energy storage in solar microgrids for rural communities in Limpopo province

Abstract

The ongoing issue of community blackouts due to load reduction and shedding needs urgent solutions. These power interruptions disrupt daily life and affect supply and demand dynamics. The root of the problem is the high cost of electricity and annual tariff increases. As a result, some customers resort to illegal connections, theft, and meter tampering to reduce their expenses, further contributing to load reduction. This paper investigates the integration of grid-scale battery energy storage with solar photovoltaic plants to support rural communities in Limpopo. The Herman-beta method was used to estimate the electrical loads using 2022 census data from Statistics South Africa. Homer software was used to Analyse the technical and economic metrics of the communities of Ka-Dzingidzingi, Duthuni, and Mookgopong NU in terms of integrating them with solar-powered grid-scale battery energy storage systems. Solar panel capacities of 250W, 375W, and 500W were compared for their economic metrics, with a 48V, 14.4kWh lithium-ion battery selected for the grid-scale component. The results show that the 250W solar module has the lowest capital expenditure and the best Net Present Cost and Levelized Cost of Energy in Duthuni and Mookgopong NU, with Net Present Cost values of 79.7 million and 199 million and Levelized Cost of Energy of around 0.250 R/kWh and 0.5 R/kWh, respectively. In Ka-Dzingidzingi, however, the 375W module offers the most favourable Net Present Cost and Levelized Cost of Energy. The return on investment indicates that the system may not be beneficial for larger communities with more than 1,000 households. However, in suitable communities, electrical power delivery in the province can significantly improve.

Keywords: microgrids, battery energy storage, net present cost, levelized cost of energy, Herman beta method, Homer pro

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