Simulation and optimization of renewable energy hybrid power system for Semonkong, Lesotho

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Abstract

The vast majority of Lesotho's landscape is characterized by rugged hills and mountain ranges with sparsely populated rural villages, making it prohibitively expensive and financially unviable to connect these remote villages to the national electricity grid. This lack of access to electricity has hampered many social and economic developments due to insufficient provision of much-needed power to homes, schools, police stations, clinics and local businesses. This paper proposes a renewable energy hybrid power generation system for one such remote town of Semonkong, in Maseru district, Lesotho. The study is based on modelling, simulation and optimization of the hybrid power system using the load profile of Semonkong town and the available renewable resources data of solar radiation, wind speeds and water flow rates from the nearby 'Maletsunyane River. The HOMER software is used to provide an optimal system configuration in terms of the minimum levelized cost of electricity (LCOE) and the maximum renewable energy fraction, based on various renewable/alternative energy sources of solar photovoltaic, wind turbine, mini-hydro turbine, diesel generator and battery storage. Sensitivity analysis on solar radiation, wind speed, stream flow and diesel price is undertaken to evaluate the feasibility of a completely renewable power system suitable for this remote area application. Simulation results for the isolated optimized hydro/wind/PV/diesel/battery hybrid system configuration achieves LCOE of US$0.234/kW at a renewable energy fraction of 0.95. Thus, the diesel generator will always be required to augment power supply for Semonkong especially during the dry and cold winter months of May to September when the energy demand is at its peak but the solar radiation and stream flow are at their lowest.

Keywords: Renewable energy; Solar photovoltaic; Wind energy; Mini-hydropower; Optimal hybrid system.

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