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Performance analysis of a solar-storage hybrid system in a remote oil extraction sme in Senegal

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Abstract

This study evaluates the technical performance of a solar-grid hybrid energy system installed at a remote small and medium-sized peanut oil extraction enterprise (SME) in Passy, central Senegal. Within the framework of the BioStar project, which developed innovative bioenergy solutions to strengthen agri-food industries in West Africa, the SME Yaye Aïssatou was equipped with a 19.8 kWp photovoltaic (PV) system and 17.8 kWh of lithium-ion battery storage. The installation aimed to reduce operating costs and lessen dependence on unreliable grid electricity with frequent outages that had previously caused significant production shortfalls. Using operational data (total PV power, battery state of charge, and energy yield) over a period of one year at a 15 - minutes resolution, we quantify the contribution of PV and storage to the site's total energy demand and the resulting cost savings. The observed performance is compared with initial design simulations to identify key discrepancies, and control strategies. The PV system delivered an average power of 0.96 kW and reached a maximum instantaneous output of 14 kW during the production season at the SME. The recorded state of charge (SoC) of the batteries was on average 84.2 % and dropped during the night hours to recover the next day, suggesting the PV generation capacity matched well the connected load under typical conditions. The corresponding daily energy yield averaged 8.8 kWh, with a maximum recorded value of 55.1 kWh in February. These results show that the hybrid system can reliably supply up to 90 % of the SME's total daily energy demand of 60 kWh, as initially specified during the design phase. Overall, the results confirm that properly sized and operated solar-storage hybrid systems offer a technically viable and economically attractive option for enhancing energy security and productivity in similar SMEs across sub-Saharan Africa.

Keywords: Agro industry, off-grid energy, peanut oil extraction, photovoltaic, renewable energy, rural electrification