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Design of an optimized photovoltaic and microturbine hybrid power system for a remote small community: Case study of Palestine

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ABSTRACT

Hybrid systems are defined as systems that utilize more than one energy source to supply a certain load. The implementation of a hybrid system that is based upon Photovoltaic (PV) to supply power to remote and isolated locations is considered a viable option. This is especially true for areas that receive sufficient amounts of annual solar radiation. While analysis of hybrid systems that depend on diesel generators as backup sources can be found in many previous research works, detailed techno economic analysis of hybrid systems that depend on microturbines as backup sources are less addressed. A techno-economic analysis and the design of a complete hybrid system that comprises of Photovoltaic (PV) panels, a battery system, and a microturbine as a backup power source for a remote community is presented in this paper. The investigation of the feasibility of using the microturbines as backup sources in the hybrid systems is one of the purposes of this study. A scenario depending on PV standalone system and other scenario depending on microturbine only were also studied in this paper. The comparison between different scenarios with regards to the cost of energy and pollutant emissions was also conducted. A simulation program was developed to optimize both the sizes of the PV system and the battery bank, and consequently determine the detailed specifications of the different components that make up the hybrid system. The optimization of the PV tilt angle that maximizes the annual energy production was also carried out. The effect of the variation of some parameters on the cost of energy was duly evaluated. Powering a rural community using microturbine alone indicates lower values of cost of energy (COE) production compared to the hybrid system in which a combination of PV panels, battery bank and microturbine has been used. The difference is very small and taking into account the environmental effect of the microturbine surely will make the hybrid system with limited running hours of the microturbine more attractive. Furthermore, as it is obvious from the sensitivity analysis, any reduction in the price of the PV panels or any increase in the natural gas price will make the hybrid system economically and environmentally more attractive.

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1. Introduction

Photovoltaic (PV) power sources are ubiquitous as power supply options, especially in remote areas [1–9]. The advantages of using PV panels to generate electricity is the fact that it does not emit pollutants during its operations, its low operating and maintenance costs, long lifetime, and silent operation [10–18].

Hybrid systems are defined as systems that utilize more than one energy source to supply the load. Hybrid systems that include PV panels are widely used to supply various types of loads, especially in remote areas. The low cost of energy production, and the ability to cover load demand under various climatic conditions are usually features that distinguishes hybrid systems from single source systems [19–27].

Palestine receives quite an amount of solar radiation, with high exposure to sunshine hours annually. In the Palestinian territories, the yearly average daily solar radiation on horizontal surface ranges from about 5.5 kW h/m^2 to about 6 kW h/m^2, while the total annual sunshine hours exceeds 3000 h [13]. These values are relatively high, and encourage the use of solar energy for solar water heating or other Photovoltaic (PV) applications. The highest solar radiation is recorded to be in June to August, while the lowest is in December to February.

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