Energy Conversion and Management 85 (2014) 120–130

Contents lists available at ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

Genetic algorithm based optimization on modeling and design of hybrid renewable energy systems

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ARTICLE INFO

Article history:
Received 18 March 2014
Accepted 7 May 2014

Keywords:
Cost benefit analysis
Diesel generator
Genetic algorithms
Global warming
Hybrid power systems
Microturbines
Photovoltaic systems

ABSTRACT

A sizing optimization of a hybrid system consisting of photovoltaic (PV) panels, a backup source (microturbine or diesel), and a battery system minimizes the cost of energy production (COE), and a complete design of this optimized system supplying a small community with power in the Palestinian Territories is presented in this paper. A scenario that depends on a standalone PV, and another one that depends on a backup source alone were analyzed in this study. The optimization was achieved via the usage of genetic algorithm. The objective function minimizes the COE while covering the load demand with a specified value for the loss of load probability (LLP). The global warming emissions costs have been taken into account in this optimization analysis. Solar radiation data is firstly analyzed, and the tilt angle of the PV panels is then optimized. It was discovered that powering a small rural community using this hybrid system is cost-effective and extremely beneficial when compared to extending the utility grid to supply these remote areas, or just using conventional sources for this purpose. This hybrid system decreases both operating costs and the emission of pollutants. The hybrid system that realized these optimization purposes is the one constructed from a combination of these sources.

1. Introduction

Hybrid energy systems that depend on renewable energies, especially solar photovoltaic (PV), are nowadays in widespread usage. Their effectiveness was proven when they are used in supplying power to various locations, especially for small isolated loads. Their use can mitigate the effects of greenhouse gases to meet the requirements of the Kyoto protocol, as they mainly reduce CO_2, NO, NO_2, and SO_2 emissions where other emissions are also subject to reduction. Their low maintenance costs and low pollutant emissions are regarded as its main advantages [1–8].

This paper addresses an approach based on genetic algorithm in designing a hybrid system with solar PV as a renewable source, and microturbine or a diesel generator as its backup source. The study has been carried out for a Mediterranean climate, particularly Palestine. Fig. 1 illustrates the block diagram of the proposed hybrid energy system. The DC bus and the AC bus are linked via the bidirectional inverter where the DC bus combines both the DC output of the PV panels through the solar charger converter and the battery bank, whereas the AC bus combines both the output of the microturbine and the load.

Using systems with more than one supply source; known as hybrid systems to supply power to a certain application can increase reliability and energy security compared to systems with only a single energy source [9–12].

The hybrid system types mainly depend on the renewable energy source and its availability. In Palestine, solar radiation has high potentials with high values for annual sunshine hours. Average values of between 5.5 kW h/m^2 and 6 kW h/m^2 on a horizontal surface have been recorded for the annual average daily solar radiations [13].

In the Palestinian Territories, there are many small communities in remote and isolated areas. These communities depend on diesel generators for their home electrical supply. Moreover, the Palestinian Territories depend on external power sources,

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http://dx.doi.org/10.1016/j.enconman.2014.05.064
0196-8904/