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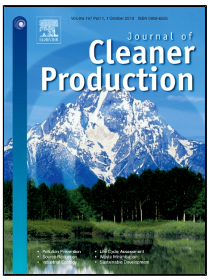

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A sizing approach for stand-alone hybrid photovoltaic-wind-battery systems: A Sicilian case study

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Abstract

Solar and wind energy are the two most available renewable energy resources in the world. In this paper, a high-resolution analysis that allows sizing a hybrid photovoltaic-wind turbine-battery banks has been carried out. The analysis aims to minimize the annualized cost of the systems satisfying two reliability constraints. The solution has been obtained numerically by means of an iterative technique. The decision variables are the photovoltaic area, wind turbine radius, and battery capacity. A high-resolution model, based on fuzzy logic inference system, has been developed to evaluate the number of active occupants and the domestic electricity consumption. In order to allow a more accurate sizing of the system, a new reliability parameter named seasonal loss of load probability ratio that takes into account the seasonality of data has been defined. Seasonal loss of load probability ratio has been used in the iterative process in addition to the most common loss of load probability. Compared with traditional processes, the obtained results demonstrate that the introduction of the new parameter to iterative process causes a meaningful improvement of the system's reliability and a slight increase of its cost on the other hand. The simulation, conducted in MATLAB® environment, has been carried out to supply power for a domestic dwelling located in three different locations of Sicily. Compared to reliability values arising from the traditional procedure, the obtained results show that a reliability improvement of 75% is reached by using the new sizing procedure. Therefore, the proposed methodology gives an important advancement on the current state of the art since it allows at designing renewable plants in a more efficient way.

Keywords: Hybrid PV-Wind energy system; Fuzzy Inference System; LLP; Economic optimization; Matlab.

1. Introduction

In 2014, the world's annual electricity consumption was around 19.8 TWh [1]. Today, this value has an excessive dependency on the fossil fuels, which creates an adverse impact on the environment. In fact, the energy sector still strongly depends on the low cost fossil fuels, which increase the greenhouse effect and global warming phenomena [2]. Hence, it is crucial to find out alternative energy sources to cover the continuous increasing demand of energy, while minimizing the negative environmental impacts. Nowadays, scientific research into the renewable energy sector is mainly concerned with decentralized energy production systems, in fact, the noble goal to reach is a self-sufficient and completely renewable supplied home [3-6]. In particular, in order to achieve an electricity target of net zero energy (Net Zero Energy Buildings), Cellura et al. [3] analyze several scenarios of a building redesign problem. Esen et al. [4-6] introduce performance experiments and economic analysis of several heat pump systems by proving the economic advantages over the traditional heating methods. Solar and wind energy systems are being considered as promising power generating sources thanks to their availability and topological advantages for local power generation. Today, good efficiency and cost effectiveness of these plants represent their strength. Bazilian et al. [7] aim at informing photovoltaic stakeholders of their real costs and