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Solar–wind hybrid renewable energy system: A review

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ABSTRACT

The demand for electricity is increasing day by day, which cannot be fulfilled by non-renewable energy sources alone. Renewable energy sources such as solar and wind are omnipresent and environmental friendly. The renewable emulnergy sources are emerging options to fulfill the energy demand, but unreliable due to the stochastic nature of their occurrence. Hybrid renewable energy system (HRES) combines two or more renewable energy sources like wind turbine and solar system. The objective of this paper is to present a comprehensive review of various aspects of HRES. This paper discusses pre-feasibility analysis, optimum sizing, modeling, control aspects and reliability issues. The application of evolutionary technique and game theory in hybrid renewable energy is also presented in this paper.

Contents

1. Introduction

Electricity is the important factor for industrialization, urbanization, financial growth of any country [1]. There are different types of conventional and non-conventional energy sources used to generate electricity. Solar and wind energy system is one of the most prominent sources of energy. The utilization of solar and wind energy system has become increasingly popular due to modular and environment friendly nature [2]. The field of solar–wind has experienced a remarkable growth for past two decades in its widespread use of standalone to utility interactive solar–wind systems [3].

Solar and wind energy system works normally in standalone or grid connected mode, but the efficiency of these sources is less due to the stochastic nature of solar and wind resources. The hybrid renewable energy sources with grid integration overcome this drawback of being unpredictable in nature. Hybrid renewable energy system (HRES) is a combination of renewable and conventional energy source, it may also combine two or more renewable energy sources that work in standalone or grid connected mode. The HRES that combines solar and wind energy key resources, operates in two modes: simultaneous and sequential. In simultaneous mode, the solar and wind energy system produces

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energy concurrently while in sequential mode they produce electricity alternatively [4,5].

The significant characteristics of HRES are to combine two or more renewable power generation technologies to make proper use of their operating characteristics and to obtain efficiencies higher than that could be obtained from a single power source. This paper presents a review of solar–wind hybrid renewable energy system covering issue such as pre-feasibility study, modeling, controlling, optimization technique, reliability and power quality of the system [6]. Fig. 1 presents a basic component of solar–wind hybrid renewable energy system.

2. Pre-feasibility assessment of HRES

Prior to installation and operation, the prefeasibility study of hybrid energy system is customarily carried out. The prefeasibility analysis includes the study of climatic condition of the proposed site, availability of renewable energy sources and assessment of its potential load and load demand of application site. The prefeasibility study assists in finding out the best location to develop a solar wind hybrid renewable energy system. Few significant contributions of various researchers are discussed here.

Rahman et al. [7] gave the feasibility study of Photovoltaic (PV)-Fuel cell hybrid energy system considering difficulty in the use of PV and provide new avenues for the fuel cell technology. A photovoltaic system uses photovoltaic cells to directly convert sunlight into electricity and the fuel cell converts the chemical energy into electricity through a chemical reaction with oxygen or other oxidizing agent. Khan et al. [8] gave meticulous description about pre-feasibility study of stand-alone solar–wind hybrid energy system for application in Newfoundland. Hydrogen is used as an energy transporter for application in Newfoundland, Canada. Sizing, performance and various cost indexes were also analyzed. The capital cost, net present cost and cost of energy for energy consumption of 25 kW h/d with a 4.73 KW peak power demand is $36738, $47910 and $0.492 respectively. Graditi et al. [9] developed scientific and ecological aspects of hybrid system as well as non conventional energy source. Nayar et al. [10] discussed a case study of a Photo-voltaic/Wind/Diesel hybrid energy system installed in three remote islands in the republic of Maldives.

Chong et al. [11] presents prefeasibility analysis of a wind–solar HRES with rainwater collection features for urban high rise application. Economic analysis includes manufacturing and preservation costs of the system over the given life span. The system is analyzed for security, visual impact and noise pollution. Sinha et al. [12] presents pre-feasibility analysis of solar–wind hybrid systems for a complex hilly terrain. The study is carried out to assess the potential for a solar–wind hybrid system for Hamirpur town located in Northern Province of India. The prefeasibility study indicates the quality of potential for utilizing solar-micro wind hybrid system to supplement the energy needs in hilly regions. Aydin et al. [13] explore geological information system (GIS) based site allocation for solar–wind HRES at western turkey. In this paper Fuzzy logic and geographic information system tool are used to search best and alternative location of the target area that benefits financial and ecological criteria. Tao Ma et al. [14] presented a comprehensive feasibility study and techno-economic assessment of a remote solar–wind hybrid energy system with battery energy storage for a isolated island.

Climatic condition is the major input to carried out pre-feasibility analysis. Figs. 2 and 3 show global map solar energy and

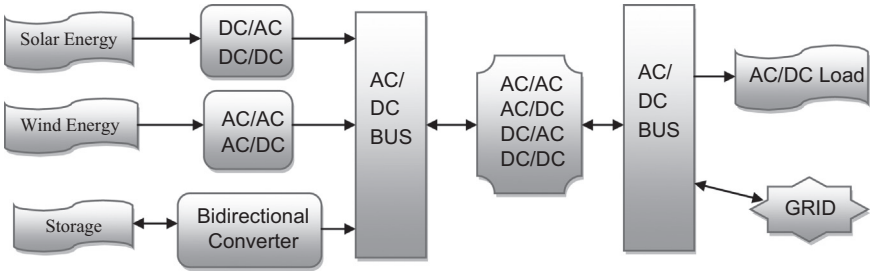

Fig. 1. Basic component of solar–wind hybrid renewable energy system.

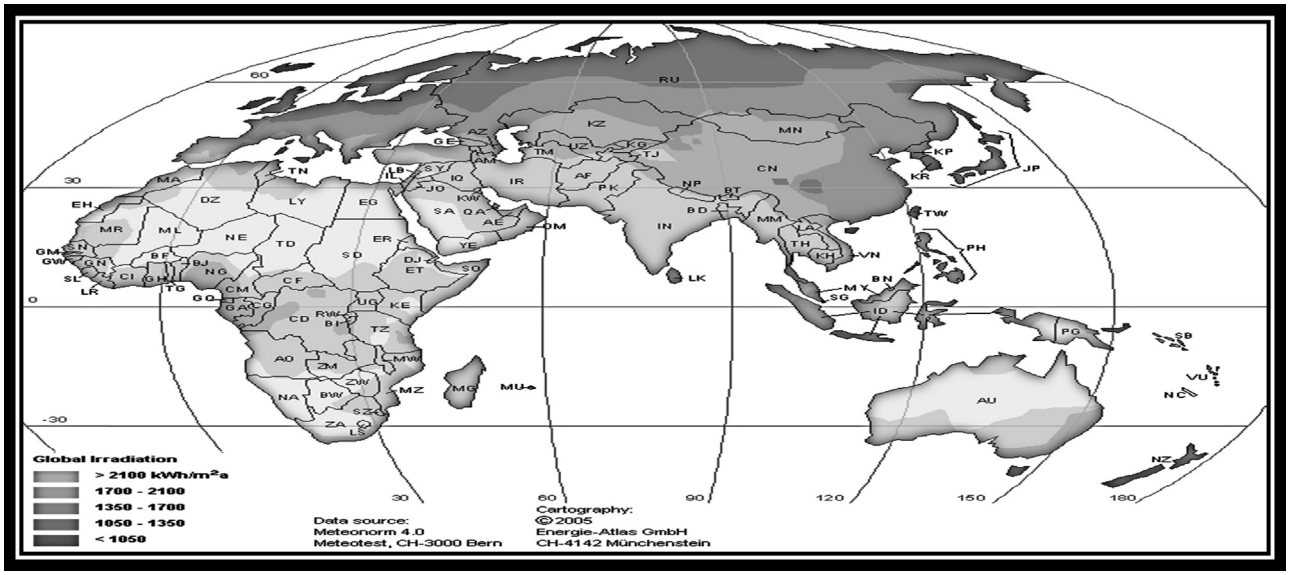

Fig. 2. Global solar radiation potential [15].