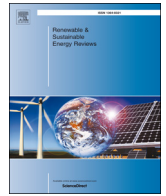




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Review of solar photovoltaic and wind hybrid energy systems for sizing strategies optimization techniques and cost analysis methodologies

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ABSTRACT

Electrical energy becomes necessary for human being. Generation of electrical energy mostly depends on fossils fuel, they are limited in nature and also responsible for environmental pollution. Renewable energy resources provides a better alternative for future, In comparison to conventional energy resources economical aspect is a major issue of renewable energy sources with the feasibility and efficiency. These limitations are tried to overcome by deployment hybrid renewable energy resources. There are certain criteria to analyze and implement the sized, optimized and cost efficient system. This paper focus on hybrid energy systems based on solar photovoltaic (PV) and wind resources. This paper shed lights on various parameters of economic feasibility, sizing strategies with logical advancements to enhance their utilization, future prospects, and their arrangement. Strategies to develop an effective storage system is also presented here. A brief review on developments in optimization techniques, reliability index and cost analyzing techniques for hybrid renewable energy systems are also presented.

1. Introduction

Growing consumption of fossil based energy resources necessitated an insistent seek out for substitute resources. Due to ecological reasons renewable energy resources have considered as better choices. Solar Photovoltaic and wind energy are recognized as most encouraging and feasible sources, it is widely known that solar and wind energy resources are never ending and their transformation into power are without contamination, and their accessibility is additionally at no cost [1]. One of major issue for humanity is increase in environmental pollution. [2] After the discoveries of alternative resources of electricity generation sources the deployment of solar photovoltaic and wind energy system has become increasingly more popular [3]. There are little symptoms that immediately required to change for global energy scenario, the era of fossil fuels is a long way to over, however their dominance still reduced but it is not affordable to wait for taking action againsts the movement volved in weather alternation [101]. Worldwide Governments have started to shift their regulations and policies to encourage the utilization of renewable energy resources by including the provision of improving the capability of renewable energy resources and energy preservation strategy [4,101]. It becomes difficult to providing reliable and persistent supply of energy as solar photovoltaic and wind energy resources are dependent on whether conditions. This issue can be fathomed by a reasonable arrangement of energy storage in addition to solar photovoltaic and wind energy resources [5]. Solar Photovoltaic and wind energy system individually utilized as stand

alone or grid connected with low efficiency while cumulative arrangement of solar PV and wind energy resources are considered as hybrid energy system [9]. Most significant feature of a hybrid renewable energy resource is utilization of many nonconventional energy sources to enhance the effectiveness of system and economic restrictions [6]. The solar Photovoltaic and wind energy resources operates in simultaneous and sequential manner, in first case, both generate energy at the same time while in second one electricity is generated alternatively [10]. Solar Photovoltaic and wind energy resources attracts various researchers to pursue several methodologies for unit sizing and optimization of hybrid energy system based on Photovoltaic and wind resources [11,128–130]. The variation in output of solar PV and wind energies in general not similar as load demand therefore reliability analysis is required for designing and function of hybrid energy systems for standalone application. [12]. In past few decades study of hybrid arrangement of energy resources renewable in nature have attracted noteworthy attention, Borowy et al. [12] have introduces loss of load probability (LLP) theory for determining Optimum level of sizing for solar photovoltaic and wind based hybrid system of energy generation. Shrestha et al. [13] discussed a technique based on energy generation simulated for optimum sizing and designing of hybrid system of energy based on solar photovoltaic and wind energy resources. An analysis for sizing and optimization of hybrid system of renewable energy had been performed by Kellogg et al. [14] determining probability of loss in power supply which is designated as LPSP (Loss of Power Supply Possibility) technique and levelised cost of energy (LCE) methodology.

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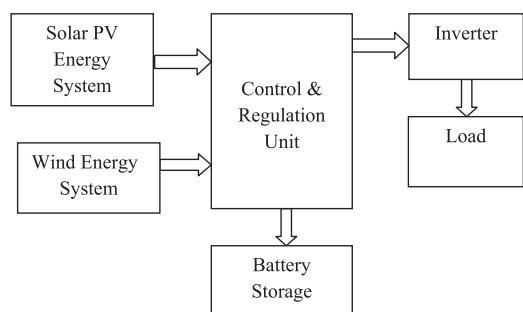


Fig. 1. Solar Photovoltaic and Wind based Hybrid Energy System.

Maleki A [16] gives an enlightening mathematical model for every framework segment and their performances are compared by different heuristic algorithms. This paper displays a broad review on different issues identified with solar PV/Wind hybrid system of energy at present time.(Fig. 1)

2. Renewable hybrid system of energy generation

The renewable power sources are being explored due to possibility of lack in availability of conventional resources in future. The major drawback of Renewable energy resources are dependency on geographical locations and environmental conditions however, the high initial cost, increased maintenance cost, and different rates of depreciation are the main challenges associated with these hybrid systems [18]. The irregular pattern of natural resources necessitates developing a hybrid system which can generate maximum conceivable energy for continuous and reliable operations [17]. The design of hybrid system is influenced by various factors such as condition of sites, energy availability, efficiency of energy sources as well as technical and social limitation In this specific situation, a combination of optimal sizing method is an indispensable factor to accomplish higher reliability quality with least expense [21,79,87,149]. The fundamental parts of the hybrid energy systems are renewable power source, nonrenewable generators, control unit, storage system, load or grid some times, sources and load may be AC/DC [102].

2.1. Solar photovoltaic /wind based hybrid energy system

An arrangement of the renewable power generation with appropriate storage and feasible amalgamation with conventional generation system is considered as hybrid energy system or some time referred as a micro grid [155]. This system may be any probable combination of Photovoltaic, wind, micro turbines, micro hydro, conventional diesel generation, battery storage, hydrogen storage and Fuel Cell in grid-connected or off grid arrangement,

An assembly of interconnected loads, conventional distributed energy resources like distributed generators (DG), renewable resources and energy storage systems in a specified boundary as a controllable single entity referred as micro grid. It may be eternally connected to grid, or isolated by grid. There are worldwide numerous remote communities those are not directly connected to grid, and fulfill electricity demand from distributed generators based on fossil fuel in isolated Microgrids [97,165]. In this paper a assimilated arrangement of solar PV and wind renewable energy resources is discussed which is slightly different from the concept of microgrid.

Solar Photovoltaic /Wind based Hybrid Energy System shows its adequacy to provide the essential electrical demand for off grid utilization. The at most imperative feature of a Solar Photovoltaic (PV) and Wind based Hybrid Energy System is that it uses at least two sustainable power sources which enhances reliability, efficiency and financial restrictions emerges from single energy resources of renewable nature [18,89,133]. Solar Photovoltaic and Wind based Hybrid Energy System

is considered as amalgamation of solar PV panel, Wind mills, charge controller, storage system, power conditioning units, diesel based generator set and load [19]. The assessment of performance of Hybrid system can be done by recreating their models at Simulink platform for the accessible insulation, speed of wind, electrical load and various components [20].

The essential objective for evaluation of Hybrid System are building up the suitable models for various components and their simulation in a sequential manner as firstly availability of speed wind, accessibility of sunlight and the demand of load models are simulated after that model of battery storage and diesel generator can be Simulated. Last strides in the entire procedure of assessment is deciding the coveted criteria and exploring the optimum structure of system. [21]. The optimal hybrid system arrangement should satisfy and compromise the objectives of power reliability and cost of system. The load demand frequently considered as limitation of the optimization issue and ought to be totally satisfied [22]. The solar PV/wind hybrid system is mostly reliant on execution of individual segments. To estimate the performance of solar PV/wind hybrid system, individual components are modeled initially after that entire system evaluated to meet the demand [23]. In general key aspects to analyze a hybrid system are hybrid system configuration with respect to the available resources, the optimization of the available renewable resources exploitation and the optimization of the output power quality [24].

Solar energy and wind energy are analogous to each other in nature and both are well appropriate to develop a hybrid system [26]. Availability of solar radiations are relatively greater in summer, winds are more accessible in the evening times of winters. This hybrid renewable energy systems give a more reliable output throughout the year can be planned to fulfill craved qualities on more decreased possible cost [27]. The constraints of Photo voltaic system, the assessed energy of wind energy system and the battery storage are the majorly considered parameters for evaluation of solar and wind based hybrid energy system. In addition, the precise angular attitude of Photo voltaic panels and the tower height of wind turbines are considered for achieving the minimum levelised cost of energy. Ribeiro [31] proposed multi-criteria based analytical decision scheme abbreviated as MCDA which consider several issues like economic, quality of life, technical and environmental issues of local populations.

Metrological data based on technological, economical, socio-political and environmental factors having major impact for estimation and selection of various components of Solar Photovoltaic and Wind based Hybrid Energy System [32]. Hourly climate information as sun oriented radiation, wind speed and temperature are raw information illustrates the inconstancy of the parameter input. Place to place data is hard to obtain for designing purpose at remote location [3,73]. Statistical metrological climatic information can be delivered by the average of month to month meteorological information. The information of climate can be anticipated from an adjacent site or synthetically can be produced [32]. Simulation for performance of Solar PV/Wind Hybrid Energy System required climate data including solar radiation, speed of wind and temperature which can be find from web sources and also from local meteorological station, it is best to find realistic solution preference should be given to the specified location based weather data [28]. To optimize solar photovoltaic and wind based hybrid energy system are hourly or day by day climate information of solar and wind energy are considered as required significant inputs [29]. Meteorological data determined the receptiveness and amount of sunlight based radiation and wind energy sources at a particular region. An investigation of characteristics of sun based emission and availability of wind at a specific location ought to be concluded before starting [28]. Bianchini A et al. gives stress on the metrological data in the form of solar irradiance and wind distribution and considered hybrid renewable energy system as a amalgamation of PV panel of rated power, horizontal axis wind turbine of rated power, a diesel generator of precise nominal power able to manage peak load and a battery bank of specific

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