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System Analysis and Optimization of photovoltaic –wind hybrid system: Review

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Abstract -) *Renewable energy source is a major source of energy that fulfills the demand of electricity. Current research contribution and day to day experience news show used of alternative energy sources either in standalone or grid integrated form. Researcher used traditional and new generation artificial intelligence algorithm, for less computation time and better accuracy. Artificial intelligence system have used for Optimization and analysis of PV-Wind hybrid system. This paper attempts to discuss a systematic review of modeling PV-Wind energy system and battery storage. This review will be useful for researchers to face the complexity of algorithm for further improvement of analyzing and design in to the power system.*

Key Words: **Artificial intelligence, optimization, wind, photovoltaic.**

1. INTRODUCTION

Electrical power is one of the most commonly sought commodities of mankind. Currently, more than 70% of the global electricity demand is supplied by burning fossil fuels, such as crude oil, coal, and natural gas [1]. With the growth of economies and world population, the demand for electricity increases and as a result the fossil fuel consumption increases.

Due to the nature of omnipresence and ease of availability solar and wind energy systems are considered as the most promising of all alternate energy systems and use of solar and wind power has become very significant and cost effective [2].

The European Union (EU) council adopted the Energy Road map 2050 in June 2012 which declared that decarburization by 80% reduction (compared with the estimated level in 1990) of GHG emissions in European energy system will be technically and economically feasible. This can be achieved by implementing numerous strategies, such as increasing the development of renewable energy generation, which can be seen clearly where the local and small-scale generation from renewable energy sources has remarkably increased in Europe from 312 GW at the end of 2012 to 380 GW at the end of 2014[3]. In Germany, September 2015, RESs accounted for 47% of installed net generating capacity [4]. Furthermore, the annual energy production at about 38.850 GW comes from PVs in August 2015 keeps Germany with the largest amount of installed PV capacity in the world , and about 41.353 GW are from on shore and offshore wind turbines in September 2015. In USA over 16 GW of installed solar power in 2014 [2, 5]

Majority of the residential PV systems work in the grid connected mode, in which excess power is injected to the grid during the day time and power is received from the grid at night. However, in remote areas where the grid extension is not feasible, HRESs are used in the standalone mode for individual houses or in micro grids(MGs) where several houses are connected to form a small power grid [6,7].Many islands in the Indian and Pacific Oceans spend up to 30% of their gross domestic product (GDP) on conventional energy resources, such as fossil fuel [10].The integration of energy storage systems (ESSs), such as battery banks, or conventional energy sources, such as diesel generators, makes HRESs capable of providing more economic and reliable supply of electricity to a given application [9,10].

However, the high initial cost, increased maintenance cost, and different rates of depreciation are the main challenges associated with these hybrid systems [9].The optimal design of HRESs is a complicated task since the optimal configuration depends on the knowledge of energy sources, technical specifications, environmental conditions, and load profiles [9]. In [11], authors have provided a review on optimization and control strategies used for standalone and grid-connected HES. In [12], authors have considered the size optimization techniques of on-grid and off grid solar and wind hybrid systems. [13], the authors focused on integration configurations, storage system options, sizing methodologies and control and management of standalone HRES. This article provided an overview of some of the single artificial algorithm, classical algorithms and software tools.

2 PV–WIND HYBRID SYSTEM METHODOLOGIES

A PV/wind hybrid system consists of a wind energy, solar energy, controllers, battery and an inverter for either connecting to the load or to integrate the system with a utility grid. For analyzing the system performance these components need to be modeled individually. The accuracy of individual component's model decides the accuracy of the entire system. The performance of hybrid systems is also dependent on the performance of its individual components.

2.1 Meteorological data

Analysis of meteorological data of the location has to be made for optimization process. Measured solar and wind resource data are the main inputs for PV wind hybrid based system optimization. The, hourly or daily weather data are preferable. If measured data are not available then satellite based data or estimated data can also be used. In some areas the data might not be available for entire required duration of study; in this case the data can be generated by using statistical methodologies [14].

If the data is available for a nearby location, then it can be extrapolated for a particular site by making necessary adjustments [15].The concept of typical metrological year (TMY) the year which represents the best characteristics of the weather patterns of the selected region has been used in [16,17]. A typical day of the month also found based on hourly average power generated is presented in [18].

2.2 System configuration

The prefeasibility studies based on weather data and load demand the selection of proper sizing of equipment can be made. But this sizing process must be according to nature of PV and wind.

2.3 Load profile

To design-planning and optimization of a hybrid system Yearly electric load demand profile is necessary. It is difficult to find out and also complicated to analyze real load demand, therefore hourly or daily averages of load demand is generally used for design and optimization purpose. Pillai et al [19] attempted a method for generating the load profiles and weather data patterns synthetically by using ANN. The statistical methods are also widely used for the prediction of the residential energy consumption

2.4 Modeling of photovoltaic system

A lot of research has been carried out in modeling of photovoltaic systems. Xu et al [20] have considered a simple model of a solar cell with one useful approximation that they have considered is the effect of tilt angle at the time of calculation of solar radiation itself. This has reduced the complexity of the system model while maintaining its accuracy. Mohammed Alsayed et al .[21] have used a model in terms of open circuit voltage and short circuit current to find out the power output of solar models. Wang and Yang [22] used HDKR model which considers the effect of, scattered, reflected, diffused and incident radiation on an inclined surface to estimate the power output of PV panels.

2.5 Modeling of wind energy system

Mathematical modeling of wind energy system includes the dynamics of wind turbine and the model of wind generator. Different wind turbines have different power curves. Giuseppe Marco Tina and Gagliano [23] considered the power generated in a HRES is sum of power generated by PV and wind power, and by an assumption of both the powers are statistically independent the total power is considered to be the convolution of both the powers.

The exact characteristics of the wind turbine as they are modeled with the average wind speeds. Zamani and Riahy [24] proposed a new methodology for calculating power of a wind turbine by considering the effect of instantaneous wind speed variations. A detailed review of various statistical, parametric and non-parametric and reference models of predicting the wind and the power are presented in [25].

2.6 Modeling of Battery

Battery is used to store extra generated energy, to regulate system voltage and to supply load in case of insufficient power generation occurs from the hybrid system.

3. OPTIMIZATION TECHNIQUES USED IN PV–WIND BASED HYBRID SYSTEM

There is a continuously increasing interest in the developme nt of hybrid energy systems using various optimal sizing techniques Optimization algorithms are divided into two simplest categories namely traditional approaches and new generation approaches.

3.1 Traditional approach for optimization

A number of studies have been carried which are discussed below

3.1.1 Iterative techniques

In hybrid renewable energy research, iterative approach is used from beginning to design and optimize. An iterative method is a mathematical procedure that generates approximate solutions for problems. Borowy and Salameh [26] determined optimum size of a battery bank and PV array for a stand-alone hybrid wind–PV system and concluded that the optimum mix depends on the particular site, load profile, and the desired reliability of the hybrid system. Iterative optimization method requires more computational efforts and usually two main parameters PV module tilt angle and wind turbine but tower height are not optimized.

3.1.2 Graphical construction technique

In Graphical construction technique Markvart [27] used graphical technique to design a solar–wind hybrid power generation system using monthly-average solar and wind energy values. This method is easily understandable with no complexity, but this technique is not flexible and is based on various approximations.

3.1.3 Probabilistic approach

Probabilistic approaches enable variation and uncertainty to be quantified, mainly by using distributions instead of fixed values. Karakietal [28] used a probabilistic treatment of an autonomous solar–wind energy conversion system delivering a load. The expected energy not supplied (EENS) to the hybrid system considering charging/discharging cycles of the batteries. The probabilistic approach cannot represent the dynamic changing performance of the hybrid system which is main disadvantage of this method.

3.1.4. Linear programming technique

The linear programming method was is widely used technique for sizing and optimization of renewable systems, Nogueira et al [29] used Linear programming for sizing and simulation of a PV–wind–battery hybrid energy system, with minimum cost and high reliability. Huneke et al [30] Used linear programming to obtain optimal configuration for a solar–wind–battery–diesel based power generator. Linear programming technique is better than other approaches as it improves the quality of decision, more flexible and problems can be solved easily.

3.1.5. Trade-off approach

This approach is not widely used in hybrid system. Gavanidou and Bakirtzis [31] applied the method in the design of a standalone system. The outcome of the method is not a unique "optimal" design, but a small set of robust designs and the final decision is left to the decision makers. The main disadvantage of this approach is that emission control, which has a major influence on the final trade-off curve, is not taken in to account.

3.2. New generation approach for optimization

This approach is solve optimization and design problems. It is not restricted to local optimum configuration b simplicity as compared to traditional optimization methods.

3.2.1. Particle swarm optimization

Particles warm optimization was developed by Kennedy and Eberhart [32, 33] based on the research of bird and fish movement behavior. Kavianietal [34] optimized a hybrid wind– photovoltaic–fuel cell generation system over its 20 years of operation with PSO. The aim was to minimize the annual cost of the hybrid system subject to reliable supply to meet load demand.

Sharafi and EL Mekkawy [35] studied PSO approach to tackle the multi-objective optimization problem for a hybrid system consisting of wind turbine, photovoltaic panels, diesel generator, batteries, fuel cell and hydrogen tank.

3.2.2. Genetic Algorithm

Genetic Algorithm (GA) is a search of natural selection and was developed by John Holland in 1960–1970 periods [36], proposed an optimized sizing of a hybrid solar–wind–battery system through multi-objective genetic algorithm for minimization of annualized cost and the loss of power supply probability (LPSP).

3.2.3. Simulated annealing

The simulated annealing is its ability to avoid being trapped in local minima. Sharafi [35] used simulated annealing (SA) algorithm for optimizing size of a PV–wind–battery hybrid energy system to minimize total cost.

4. CONCLUSION

This article explains different type of optimization and analysis of hybrid PV- wind based system. Hybrid renewable source have been widely used all around the globe as the sustainable sources for energy need.in optimization. The importance of meteorological data, load profile, and modeling of various components in the system have been covered in detail. However, new generation optimization approach like artificial intelligence is more acceptable than traditional approach, because of their accuracy, fast convergence, and ability of local and global optimization. Along with the above explanation artificial intelligence is more effective for optimization and analysis of hybrid photovoltaic –wind energy system

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