RESEARCH ARTICLE OPEN ACCESS

Design and Optimization Strategy for Hybrid Renewable Energy System

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ABSTRACT :
The use of renewable energy sources presents a tremendous potential for many application and especially off-grid stand alone system. In this context one of the most promising applications of renewable energy technology is the installation of hybrid energy system in remote areas, where the grid extension is costly and cost of fuel increases drastically with the remoteness of the location. The most commonly used systems are PV-wind-battery, PV-diesel-battery and PV-hydro-diesel-battery. But the proper design of such system is a challenging task as the co-ordination among renewable energy sources, generators, energy storage and loads are very complicated. Hence by considering this objective this paper review the design, simulation and optimization techniques as well as various research tools which are used to simulate and design hybrid renewable energy system for electricity generation.

Keywords: Energy sources; Hybrid renewable energy system; Optimization; Simulation; Solar PV; Wind.

I. INTRODUCTION

Energy in general and electrical energy in particular is not only at the centre of sustainable development but also at the centre of overall development itself. Thus proper management and utilization of energy is necessary for sustainable development. As it is mentioned exclusively for economic development, but in its secondary role it drives overall society towards a sound and developed nation. Otherwise shall gift an environmentally unsound energy use with disparity between urban & rural areas.Sustainable low-carbon energy scenarios for the coming century emphasize the untapped potential of renewable energy sources. Rural areas those away from the grid of the developing world can benefit from this transition. But high capital cost, especially for photovoltaic made its growth a slow one. In recent years advance materials, the capacity to be interconnected with the utility throw net-metering programs and better manufacturing processes have decreased their capital costs making them more attractive. Another way to attempt to decrease the cost of these systems is making use of hybrid designs that uses both wind/photovoltaic. The increased availability of reliable and efficient energy service stimulate new development alternatives. A number of renewable energy initiatives are under way in developing countries and India can contribute to rural development through the hybrid operation of locally available renewable sources.

Various considerations must be taken into account while working with hybrid renewable energy system for electricity production. The two important aspects for the hybrid generation of renewable energy system are reliability and cost. So by considering these two important aspects that is the system is more reliable and less costly and without disturbing the environmental planning modelling shall be carried out [1,2]. Many researchers are working this area and it has been found that hybrid renewable energy system in off-grid applications are more economically suitable especially in remote location [3,4,5] as well as according to the seasonal variation and climate only one type of system is more profitable than two. For example PV hybrid systems are ideal in areas with warm climate [6,7]. This paper review the design, simulation and optimization techniques as well as various research tools which are used to simulate and design hybrid renewable energy system for electricity generation.

II. LITERATURE SURVEY

The most frequently analyzed systems by various authors are PV-Diesel, PV-Wind, PV-Wind-Diesel and Wind-Diesel hybrid systems with energy storage in batteries. Following are the papers studied by various authors considering design, simulation and optimization strategies for the control of hybrid renewable system.In 1983, Borowy and Salameh [8] proposed the loss of power supply probability as a techniq ue for designing stand alone solar electrical

photovoltaic system.Hongxing Yang and Lin Lu [9] have presented a hybrid solar-wind system optimization sizing model, to optimize the capacity sizes of different components of hybrid solar-wind power generation systems employing a battery bank. The application was based on the loss of power supply probability (LPSP) concept and the levelised cost of energy (LCE) concept. This technique represents the probability that an insufficient power supply results when the hybrid system is unable to satisfy the load demand.Some difference can be seen from a probability method with LPSP and an analytical method with LPSP proposed by I. Abouzahr and R. Ramakumar [10].Franceesco Bananno et.al [11] developed a logistical model for performance evaluation of hybrid generation systems.

Another sizing method is explained by R. Chedid, S. Karaki and A. Rifai [12] here a multiobjective design methodology was proposed based on the constraient method to minimize the cost of the hybrid energy system taking in account of the problem.In 1998 Kellogg et al. [13] the authors utilized an optimization method the components for a stand-alone hybrid system and determine the optimum generation capacity and storing needed. They used one type of wind turbine, one type of solar module and one type of battery power and varied the number of units to be used. Also they calculated the minimum distance between the nearest existing distribution line that would justify the cost of installing a standalone generating system as opposed to constructing a line extension and supplying the load with conventional utility.

In 2005 C. Ramos [14] the authors used a genetic algorithm to optimize the sizing of standalone hybrid wind/PV power system. The objective was to minimize the total capacity cost, subject to the constraint of supplying the power to the system. They proved that genetic algorithms converge very well and the methodology proposed is feasible for optimally sizing a standalone hybrid power system. They noted that using a genetic algorithm provides a number of potential solutions to any given problem and the choice of a final solution is left to the user. One limitation of their approach is that they only used one type of wind turbine when in the market there are many types of wind turbines at different prices and capacities.

Again in 2005 Daming Xu, [15] investigated the genetic algorithm with elitist strategy for optimally sizing a standalone hybrid wind/PV power system. Objectives of their study are to selected as minimizing the total capital cost, subject to the constraint of LPSP.

In 1994 &2006 Borowy and Salameh propose [16] a method to calculate the optimum size of a battery bank and the PV array for a standalone hybrid wind/PV system. Their Pascal algorithm calculated the number of PV and batteries required for these systems. They use one manufacture of wind turbine and PV and only vary the number of PV units used. In 2007 a very effective technique was developed by Pradeep K. Katti and Mohan K. Khedkar [17]. They fixed first an energy flow strategie for the HES, and secandly selecting commercially available unit sizes for wind turbines, PV panel as per site matching strategy and battery storage. They keep the number of turbines constant and increased the number of PV panel until the system was balanced. Lastly LPSP was calculated for each combination that satisfied the curve of ΔP Vs time had an average zero value over a given period of time.In 2007 Juhari Ab. [18] explores the importance of reducing excess energy in minimizing the cost of energy for renewable energy hybrid system. Since the excess energy is still counted as part of producing the total energy against specific load demand reducing it means reducing the cost.

In 2008 K. Soplan and A. Zahaim [19], presents the comparison between optimization technique of HRES using genetic algorithm and HOMER. The main objective is maximizing the power output while minimize the total cost. However there is plenty of excess energy involve which contributed to high COE.In 2010 Ahmad Rohani, Kazem Mazlumi and Hossein kord [20] proposed a system to design the aspects of a hybrid power system. The main power of the hybrid system comes from the photovolatic panels and wind generators, while the fuel cell and batteries are used as backup units. The optimization software used for this system is HOMER.Also N. Razak, M. Othman & I. Musirin [21] has discussed on optimization, sizing & operational strategy of HRES which refers to the minimum TNPC. They compare the two hybrid energy model, PV array, battery and converter but this system provide the electricity at night additional battery storage and converter are require this will increase the cost of TNPC on the other hand the combination of wind turbine, diesel generator, battery storage & converter brings to the TNPC value lower than earlier one.

In 2011 M. Hossan, M. Maruf Hossain and A. Reazul Haque [22] proposed a small scale hybrid renewable system consiste of PV array, small hydro plant with battery and diesel generator for backup. In this paper the initial optimum planning of hybrid system can be done with the help of HOMER secondly a dynamic model has been derived with the required formulation.The authors G. Vuc, I. Borlea [23] presented the optimal mix solar wind system for grid connection and it was found that optimal mixture of wind power produces approximately 50% of total electricity and PV contributes with about 1%, so the PV share rest lower and strongly dependent on capital

multiplier. Such system can permit to respect some important principles of sustainability in energy system.

Rui Huang [24] developed the PV wind system based on empirical weather and load data. To determine the system size, they formulate an optimization problem that minimizes the total construction and operation cost subject to maximum tolerable risk by using HOMER and assuming the weather resources and load keeps unchanged.

III. RESARCH TOOLS FOR SIMULATION AND OPTIMIZATION OF HYBRID RENEWABLE SYSTEM

Many research tools are now available for simulation and optimization of hybrid renewable energy system. These are summarised as below.

A. HOMER (Hybrid Optimization Model for Electric Renewable)In 2007 National Renewable Energy Labortary, USA [25] developed a program called HOMER. This program simplifies the task of evaluating design of stand alone and grid-connected power system using optimization algorithms. HOMER's optimization and sensitivity algorithum can calculate how many and what size of each components should be used for the hybrid system at the lowest cost possible. One limitation of the program is that only two types of wind turbine and one type of solar moudle can be used for the analysis. Nevertheless it is a useful program, if the user knows exactly what of wind turbine and solar module will be using for the hybrid system.

B. HYBRID2

HYBRID2 [26] was developed by the Renewable Energy Research Laboratory (RERL) of the University of Massachusetts. It is hybrid system simulation software. The hybrid systems may include three types of electrical loads, multiple wind turbines of different types, photovoltaic generators, multiple diesel generators, battery storage, and four types of power conversion devices. Other components, such as, for example, fuel cells or electrolyzers, can be modeled in the software. The simulation is very precise, as it can define time intervals from 10 min to 1 h. The possibilities with regard to control strategies are very high. NREL recommends optimizing the system with HOMER and then, once the optimum system is obtained, improving the design using HYBRID2. It can be downloaded and used free of charge.

C. HOGA

HOGA [27] is a hybrid system optimization program developed by the Electric Engineering Department of the University of Zaragoza (Spain). The optimization is carried out by means of Genetic Algorithms, and can be Mono-Objective or Multi-Objective. It allows optimizing of hybrid systems consisting of a photovoltaic generator, batteries, wind turbines, hydraulic turbine, AC generator, fuel cells, electrolyzer, hydrogen tank, rectifier, and inverter. The loads can be AC, DC, and/or hydrogen loads. The simulation is carried out using 1-hour intervals, during which all of the parameters remained constant. The control strategies are optimized using Genetic Algorithms. It can be downloaded and used free of charge.

D. TRNSYS (Transient Energy System Simulation Program)

TRNSYS (Transient Energy System Simulation Program) [28] is energy system simulation software, developed in Fortran in 1975 by the University of Wisconsin and the University of Colorado (USA). It was initially developed to simulate thermal systems, but, over the years, it has also become a hybrid system simulator, including photovoltaic, thermal solar, and other systems. The standard TRNSYS library includes many of the components commonly found in thermal and electrical renewable energy systems. The simulation is carried out with great precision, allowing the viewing of graphics with great detail and precision. However, it does not allow the carrying out of optimizations. It is not free of charge.

E. HYDROGEMS

HYDROGEMS [29,30] is not a program, but a series of libraries developed at the Institute for Energy Technology (IFE, Norway). The libraries are used by TRNSYS and by Engineering Equation Solver (EES) software. The libraries developed by HYDROGEMS model the following components: photovoltaic generators, wind turbines, diesel generators, polymeric and alkaline fuel cells, electrolyzers, hydrogen tanks, lead-acid batteries, and DC/AC converters. It is possible to carry out economic optimization, if it is used with the GenOpt [31] software, using the lineal simplex optimization method. These libraries are free for TRNSYS users.

F. HYBRIDS

HYBRIDS [32] is a simulation and economic evaluation program for PV–Wind–Diesel–Battery systems. It used 1-hour intervals in the simulation and it calculated the NPC. This software is not available.

IV. CONCLUSION

This paper has carried out the study of most relevant paper on the design, simulation control and optimization of hybrid renewable energy system. As a result of this review it is found that PV and/or wind

and/or diesel generator with battery storage has been most frequently analyzed. After the review has been carried out is the fact that most of the researches are worked on the concept of design, simulation and optimization of relevant hybrid system but in that analysis it is found that there is lot of excess energy can be generated which leads to maximise the cost of overall system. Very less work has been published to minimize the excess energy till now. If this excess energy will reduce it ultimately reduce the cost of energy. Hence it is essential to look out in this area of research.

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