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A Review Study on HOMER based Economic Analysis of Solar –Biomass Hybrid Generation

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***Abstract*—** Increasing electricity demand, limited reserves of fossil fuels and global environmental concerns are the main factors which motivates the use of renewable energy in India. Solar energy is available in abundance but the high initial investment and non-uniformity are the problems associated with the solar energy technologies. Biomass power plant demands a huge amount of feedstock which may not available all the time. Hence, the use of hybrid system consisting of solar and biomass in combination overcome the limitations associated with the conventional solar power plant and biomass power plant alone. Renewable energy technologies are suitable for serving the remote areas without having to extend expensive and complicated grid infrastructure. This review study focuses on the energy sustainability. It highlights the research on energy conversion technologies and HOMER software based economic analysis of hybrid renewable energy system.

***Keywords*—** solar, biomass, hybrid system, HOMER.

I. INTRODUCTION

Many villages in world are isolated from the main utility grid. It is really difficult to meet their requirements by the conventional resources because of high cost of transportation and the distribution of energy to the remote areas. At present, the electric provisioning of these sectors is done by the hybrid system for the production of electricity [1]. The hybrid system involves the combination of different energy sources with wind, photovoltaic, mini hydro, biomass, fuel cell and many more. Every year the demand of electrical energy is growing rapidly throughout the world. In India, it is very difficult and uneconomical to transmit power long distances throughout transmission lines for special remote villages. Generally, the production of electrical energy depends on the fossil fuels. Also, the world is experiencing many environmental issues related to usage of the fossil fuels. Green technologies play an important role in future power supply. The main reason for the deployment of the renewable energy system are their benefits, such as supply security, reduced carbon emission, and improved power quality, reliability and employment opportunity to the local people.

Since the hybrid combinations are employed because of the intermittent nature of the renewable energy resources. Hybrid power system has a great future due to its more flexibility in operation research. The development efforts in solar, wind, biomass and other renewable energy technologies are required for improving system performance.

II. BIOMASS ENERGY AND CONVERSION TECHNOLOGIES

Biomass is the amount of organic material, which has stored solar energy from sunlight in the form of chemicals in the plant through the process called photosynthesis [3]. Basically, biomass is like a natural battery for storing solar energy. In India, over 370 million tons of biomass from energy crops or agricultural wastes, grasses, crop residues, forest wood, by-products from industries such as rice mills, sugar mills, paper mills and saw mills. A pulp and paper industry expresses an interest in adopting various advanced biomass energy conversion technologies into mill operation [4]. Nisha Sriram, presents paper on various important biopower conversion technologies comprised of direct combustion, co-firing, gasification, pyrolysis, anaerobic digestion and fermentation [3][4] as well as advantages and disadvantages of using biomass as a source of energy.

Biomass gasification is a process that exposes a solid fuel to high temperature and limited oxygen to produce gaseous fuel [5]. This process is made possible in gasifier. Gasification has advantage that has had many impurities removed and therefore cause a fewer pollution problem when burnt.

Biomass contributes 5% of the European Unions energy supply and 65% of the total renewable energy production predominantly for heat and power applications [3] [4]. In India, more than 2000 gasifiers have been established with a capacity in excess of 22 MW and a number of villages have been electrified with biomass gasifier based generators. Thus, it has been seen that the emerging technologies of biomass as a renewable source of energy is highly advantageous to promote a ecofriendly planet and also cut down the need of fossil fuels which not only cause pollution in the atmosphere but also are fast depleting.

III. SOLAR ENERGY AND CONVERSION TECHNOLOGIES

Sun is the natural source of energy. Even the energy in the fossil fuels ultimately comes from the sun. The sun radiates 174 trillion KWh of energy to the earth per hour. We can also say that the earth receives $1.74*10^{17}$ watts of power from the sun. The surface temperature of sun is about 5800 K with internal temperature is approximately 15 million Kelvin [6]. Mainly, solar energy is converted into electricity by means of solar thermal energy and photovoltaic system.

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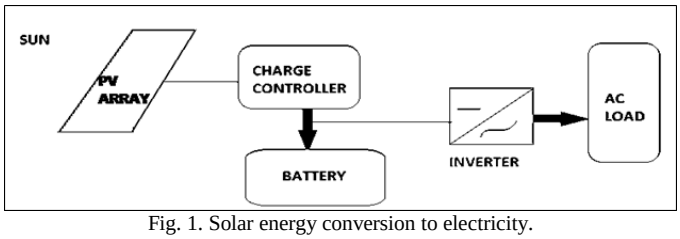


Fig. 1. Solar energy conversion to electricity.

By the application of different solar technologies solar radiations get converted into DC electricity either directly with the help of photovoltaics (PV) or indirectly using concentrated solar power (CSP) with the help of various equipments like rechargeable battery, charge controller and an inverter as shown in fig1.

Photovoltaic (PV) modules produce direct current power which fluctuates with the sunlight directly. Concentrated solar power (CSP) system uses lenses or mirrors and tracking system to focus a large area of sunlight into a small beam. A large number of CSP technologies are being used now days are: parabolic trough [2], linear Fresnel reflector and solar power tower. All these technologies are adapted as per the requirements in certain area of implementation.

IV. HRBRID SYSTEM

A judicious mix of solar and other renewable technologies can offer a feasible solution that will power the backbone of rural connectivity. The resultant solution offers an optimal solution at optimum cost. It is ideal for rural electrification of remote villages in India. Hybridization of photovoltaic system with the biomass generator is the better option for the remote areas which is not connected to the grid where as extension of the national grid is not a cost-effective option. In case of insufficient solar irradiation and after day time, a large amount of budget will be needed for the set up of large storage system. Under these circumstances, a special arrangement can be made for the continuity of supply. The solar-biomass plant is the better option for generation of electrical energy continuously after sunset or in case of disappearance of solar radiation. [9]
Hybrid systems capture the best features of each energy resource and can provide grid quality electricity with power range of 1 kilowatt (KW) to several hundred. Also they can be developed as new integrated designs within mini- grids and can also be combined with diesel based power systems. These systems can provide a steady electricity service at community level, such as rural electrification which can be further upgraded through grid connection in the future

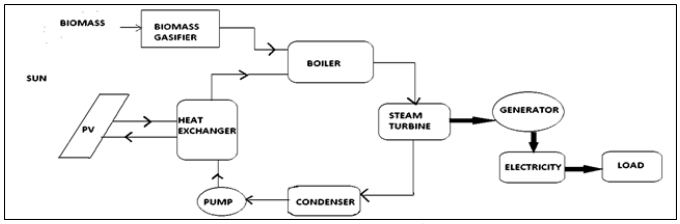


Fig. 2. Schematic representation of hybrid system.

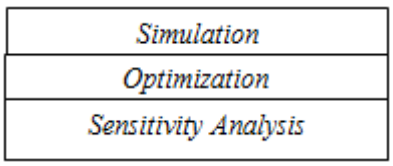
J.D Nixon [8] presented a paper about feasibility of hybrid power plant for various applications in India including tri-generation, electricity generation and process heat. The levelised costs are high compared to conventional energy sources but when compared to other renewable resources they can compete very well. A case study with the help of simulation models with peak thermal capacities ranging from 2-10MW for suitable solar multiple shows that due to long payback periods for hybrid ants cannot compete directly with biomass only systems but increase in 1.2-1.3 times increased feedstock price results in hybrid systems becoming cost competitive. Also hybrid system saves up to 29% Biomass and land.

T. Srinivas [2] proposed his studies on solar-biomass power plant without energy storage based on performance characteristics of hybrid power plant developed for turbine inlet conditions such as pressure and temperature resulting in cycle thermal efficiency, hybrid plant thermal efficiency, plant fuel efficiency and specific power. The case study shows that plant fuel energy efficiency increases from 16% to 29% with an increase of 10% to 50% in solar radiation at the boiler pressure of 20 bars.

Shaheen Hasan Chowdhary [10] in his analysis proposed an optimal operating mode of hybrid solar thermal power plant (STPP) with biomass for continuous electricity generation. This gives a review of running mode of STPP which ensures 100% electricity generation from renewable sources with optimized strategies. Also overall efficiency increases by saving of biomass fuel by storage system of STPP.

Economic analysis

Hybrid Optimization Model for Electric Renewable (HOMER) is a computerized model developed by the U.S. National Renewable Energy Laboratory (NREL) to assist the design of power system and facilitates the comparison of power generation technologies. HOMER is used to determine the life-cycle cost or total cost of installation and operating the system over its lifetime



In designing the power system many decisions about the configuration of the system are to be made: components to include in the system design, size of the component etc. The large number of technology options and variations in the technology costs and availability made these decisions difficult. But it is easier with the HOMER software to optimize and evaluate the many possible system configuration [6] [7]. The Hybrid Optimization Model for Electric Renewable (HOMER) is a computerized model developed by the U.S. National Renewable Energy Laboratory (NREL) to assist the design of power system and facilitates the comparison of power generation technologies. HOMER is used to determine the life-cycle cost or total cost of installation

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and operating the system over its lifetime. This software performs the optimization process in order to determine the best configuration of hybrid renewable energy system based on several combinations of equipments in the hybrid system. This software performs hundreds or thousands of hourly simulations over and over in order to determine the optimized system. The best configuration evaluated based on the total net present cost (TNPC).

The feasibility of solar-wind hybrid system based on load profile, solar radiation and wind speed which was collected from the Mandapam in Ramanathapuram district, Tamil Nadu in India[12] was analysed. HOMER is used to optimize the system based on TNPC. The data is analyzed for designing the system which has to meet the load requirement of 1.989KWh/d. The simulation results indicates that the cost of the generating energy from the PV/wind hybrid system comes out to be 0.235$/KWh. In order to estimate the system performance under different situation, simulations have been carried out using real weather data (solar radiation, wind speed). Two strategies have been applied while performing simulation: first without consideration of the sensitivity variables and other by considering the solar radiation and wind speed as sensitivity variables. It comes into notice that with the consideration of sensitivity variables the hybrid system becomes more commercial and more economical as compared to the optimization results without considering the sensitivity variables.

Rahul Mishra [11] proposed a solution for meeting the electricity demand for a village in Punjab. Based on a survey conducted in the kaidupur village situated in district in Patiala in Punjab, the renewable energy resources solar and biomass are available in abundance. The better optimized results for the set up of the plant are analyzed with the help of HOMER software. Before designing the model, certain data like solar irradiation, availability of biomass near by area and load profile of the village must be evaluated. The estimated peak load for the village is 78 KW. Various optimized results of size and cost must be evaluated with the help of computerized software and after simulation the results indicate that TNPC of the biomass only plant is lesser than the hybrid system.

V. Conclusion and Future Scope

This paper concludes that hybrid solar-biomass plants are feasible solution for tri-generation for small-mid scale applications in India. Also the plant fuel efficiency increases with increase in solar support, boiler pressure and temperature. The number of studies and simulations showed the comparative costs of renewable energy systems by using HOMER software which gives the best optimized solution for electricity generation.

Therefore, these systems will become an attractive option as fossil fuel prices are increasing and side by side new technologies and softwares are emerging for simulation, sensitivity analysis and cost optimization of hybrid plants. At the end of paper, the list of references helps researchers interested in Solar-Biomass hybrid power plant implementation.

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