A SOLAR-BIOMASS HYBRID POWER PLANT IN INDIA

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Abstract— **Sun is the source of all energy. India is struggling to reach 100GW by renewable resources. More than two third of the power generated in India is through power stations which use coal as the fuel. This has also started hurting the environment due to pollutants like Co_2, So2 which are leading to climate changes that have serious implication on life itself. In this paper, we upgrade existing and proposed biomass power plant into integrated solar & biomass hybrid power plant to add green power to the national grid based on American experience at Colorado. Recants reports from media highlighted critical shortage of biomass fuel to the plant leading to imports which hurts self-reliance. This paper provides a practical introduction to the production of electricity from conventional biomass power plants and concentrated solar power, which is used as the basis to evaluate the technical and economic benefits associated with hybrid CSP-biomass energy systems. The paper initially analysis alternative configuration for a 10MW hybrid CSP-biomass combustion power plant.**

Keywords— Concentrated solar power (CSP), thermal power plant, biomass power plan, heat transfer fluid (HTF)

I. INTRODUCTION

The potential for biomass in India is huge with over 500 million metric tons of biomass being produced every year. Biomass obtained from direct harvesting, agricultural wastes, and as a by-product from industries such as sugar mills rice mills, and saw mills. But, due to problems of seasonal variability of biomass and infrastructure in India, till now the consumers are struggling to obtain a consistent fuel supply. Even, biomass is still competitive, prices have increased greatly in recent years [1]. The solar energy is an intermittent nature of source. Integration of single source plants like combined cycle power plants increase the overall energy conversion efficiency but it would not address the lack of fuel especially for seasonal available fuels [2,3]. In like manner the maximum limit for performance of solar thermal power plant also limited to some extent [4]. Hybridization of biomass combustion with solar thermal complements each other, both seasonally and every day, to overcome their individual drawbacks and results continuous and uniform supply [5]. The solar irradiance can be harnessed by solar collectors and biomass feedstock can be burnt as a fuel to obtain constant base load operation. Hybrid power plant has a great future due to its more flexibility in operation. Hybrid plants will become a growing attractive option as the cost of solar thermal falls and feedstock, fossil fuel and the price of land continue to rise. Reichling and Kulacki [8] solved the economic factors for wind–solar hybrid plant and showed the cost effectiveness of the total plant. Perez-Navarro et al. [9] proposed a hybrid system, combining a biomass boiler and a wind generation plants to compensate the deviations in the wind generation to 24 hrs. Studied about the supplementary hybrid biomass–solar thermal system for heating and domestic hot water preparation for small residential applications. The main objective of current work is the study of performance levels of biomass– solar hybrid plant under variable solar radiation and plant conditions. The Hybridization of the solar field into the conventional coalfired unit has huge potential for the energy saving and mitigation of the harmful/greenhouse gas emissions

II. BIOMASS PLANT

Biomass has always been a very important energy source for the country .it offers many advantages. It is renewable energy, widely available, carbon-neutral and has the potential to give significant employment in the rural areas. Biomass is also having the ability of providing firm energy. About 32% ofthe total prime energy use in the country is still comes from biomass and more than 70% population of the country depends upon it for its energy needs. Ministry of New and Renewable Energy has realized the potential and role of biomass energy in the Indian context and therefore has initiated a number of programmes for encouragement of efficient technologies for its use in various sectors of the economy to ensure derivation of maximum benefits generation from Biomass in India is an industry that attracts investments of over Rs.600 crores yearly, generating more than 5000 million units of electricity. For effectively utilization of biomass, bagasse based cogeneration in sugar mills and biomass power generation have been taken up under biomass power and cogeneration programme. Biomass power and cogeneration programme is implemented with the key objective of promoting technologies for optimum use of country's biomass resources for grid power generation. Biomass materials used for power generation include bagasse, soya husk rice husk, straw, cotton stalk, coconut shells, de-oiled cakes, coffee waste, jute wastes, and groundnut shells, saw dust etc. The availability of biomass at current scenario in India is estimated at about 500 million metric tons per year. Studies by the MNRE has estimated additional biomass availability at about 120–150 million metric tons per annum covering forestry and agricultural residues corresponding to a potential of about 18,000 MW. Apart from This, about 5000 MW additional power could be generated through bagasse based cogeneration in the country from 550 Sugar mills, if those sugar mills were to adopt economically and technically optimal levels of cogeneration for extracting power from the bagasse produced by them[10] The MNRE has been implementing biomass energy and cogeneration programme since mid-90s A total of 288 biomass and cogeneration projects aggregating up to 2665 MW power capacity have been installed in the country for feeding power to the grid consisting of 130 biomass power projects up to 999 MW and 158 bagasse cogeneration projects in sugar's mills with additional capacity aggregating to 1666 MW. In addition, around 30 biomass power projects aggregating to about 350 MW are under different stages of implementation. Around 70 Cogeneration projects are under implementation with additional capacity aggregating to 800 MW. States which have taken leadership position in implementation of bagasse cogeneration projects are Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, and Uttar Pradesh. The leading States for biomass power projects are Andhra Pradesh, Chhattisgarh, Maharashtra, Madhya Pradesh, Gujarat and Tamil Nadu.

III. SOLAR COLLECTOR

In concentrating solar power plants , electricity generated by fluid (synthetic oil to high temperature(typically 370$_0$C) using solar radiation that has been concentrated using lenses or mirror, the hot fluid is used to produce superheated steam (370- 375$_0$C,90-100 bar) depending of the Rankine cycle that drive the Rankine cycle steam turbine connected to an electricity generator. Different technologies have been developed to concentrate the solar radiation, depending on the required fluid temperature, capacity and plant size. The most widely used are parabolic trough collector (PTC) and power towers. Solar field collectors are special type of heat exchangers that transform solar radiation to internal energy of the transport medium. The main component of solar thermal system is the solar collector that is used to absorb the incoming solar radiation, converts it into heat, and transfers this heat to a fluid flowing through the collector. The solar energy thereby collected is taken from the circulating fluid either directly to the hot water or space conditioning equipment, or to a thermal energy storage in tank from which can be drawn for use in cloudy days and/or night. There are basically two types of solar collectors: non concentrating or stationary and concentrating. A non-concentrating collector has the same area for preventing and for absorbing solar radiation, whereas a sun-tracking concentrating solar collector usually has concave reflecting surfaces to intercept and focus the sun's beam radiation to a smaller receiving area, thus increasing the radiation flux. A large number of solar collectors are available in the market. A comprehensive list is shown in table 1.In this section a review of the various types of collectors currently available will be presented. This includes flat plate collector (FPC), Evacuated tube collector (ETC), and concentrating collectors.

TABLE I. SOLAR ENERGY COLLECTORS

Motion	Collector type	Absorber type	Concentration ratio	Temperature range(0C)
Stationary	Flat plate collector(FPC)	Flat	1	30-80
	Evacuated Tube collector(ETC)	Flat	1	50-240
	Compound parabolic collector	Tabular	1-5	60-240
Single axis tracking	Linear Fresnel reflector(LFR)	Tabular	10-40	60-250
	Parabolic trough collector	Tabular	15-45	60-300
	Cylindrical trough collector	Tabular	10-50	60-300
Two-axis tracking	Parabolic dish reflector (PDR)	point	100-1000	100-500
	Heliostat field collector (HFC)	point	100-1500	150-2000

Renewable Energy Association (REA), studied the parabolic trough collector power plants dominate the CSP installations at a very large scale by up to 96% compared to other CSP types of power plants [8]. However, the main drawback of parabolic trough mirror is very costly. Concave mirrors used in parabolic trough are costlier than flat mirrors of linear Fresnel. This conception can reduce mechanical constraints caused by the wind movement. Also, a lower land is required in a location close to the ground. In addition, risk of HTF leakage and resulting maintenance labor are reduced by the fixed receiver assembly [11]. This indicates that the Fresnel system is very promising. Based on Fresnel lens collector, most developed systems are using steam as HTF in order to avoid heat exchangers. Water is the cheapest Heat transfer fluid(HTF) that can be used in solar power plant. Some prototypes using Fresnel technology with direct steam generation have been built in Spain, Australia, and California. hence, employing water as HTF required high pressure to maintain it on liquid phase and thereby the two phases flows (liquid and steam) in the same tube absorber. Furthermore, high purity water for steam generation is primary criterion to be used in solar thermal power plant which would cause the price level to rise. Other fluids studies are in progress in order to be used in a linear Fresnel reflector power plant such as: molten salts. Molten salts (mixture of NaNO/$KN0_3$ (60/40%) can reach a high temperature of about 550°C. but, their high freezing temperature adds complexity to the solar thermal power plant. Using air as HTF in Fresnel reflectors is not a good option because, its volumetric density is significantly low. As a result, the pipes size should be extended. Otherwise, thermal oil offers low freezing point less than 25°C, high exchange coefficient with a maximum temperature range from 380 to 400 °C and, chemical neutrality in contact with stainless steel absorbers. The most commonly used thermal oils in solar power plants are: synthetic oils and mineral. Mineral oil is highly flammable and easily oxidizable. It reaches a temperature of about 310 °C while synthetic oil achieved 400 °C. Indeed, Synthetic oil presents the currently generation of commercial fluids [12].

IV. METHODOLOGY

Figure 1 illustrates the Solar-Biomass hybrid power plant. The major component in this system is the biomass boiler, which is, where biomass is burnt to generate superheated steam. Heat generated in the combustion process is used to heat the feed water(economizer), generate steam (evaporator) and superheat the steam to its final pressure and temperature for inlet of turbine. In CSP and biomass hybrid power plants, heat is produced as an intermediate source of energy that drive the turbine generator set for the generation of electricity. This compatibility can be used to design a turbine -generator power plant that uses CSP during the day and biomass during periods of reduced irradiation (cloudy periods night) Therefore, CSP Biomass combustion hybrid technology depend on the effective integration of a solar collector into the water/steam cycle of a biomass power plant. Both the biomass and solar field have the capacity to generate superheated steam. Both streams are connected together to increased power generation.

In order to maintain proper steam conditions, the volume of water outlet from high pressure heater fed through the biomass boiler is adjusted depending on the sun's radiation and the steam generated by the solar field. The biomass boiler works at different capacities, depending on the solar contribution, to produce a constant electrical output. The solar-coal hybrid power plant in western Colorado, America parabolic troughs are used to preheat water that will be send into the coal plant's boilers, where coal is burned to turn the water into steam for turning to turbine to generate electricity [13]. The first stage is made Solar for Pre-heating the water and the second stage of steam generation is done with coal. The net effect is that less amount of coal is used to generate a given amount of electricity, and the augmented system reduces CO_2 emissions.

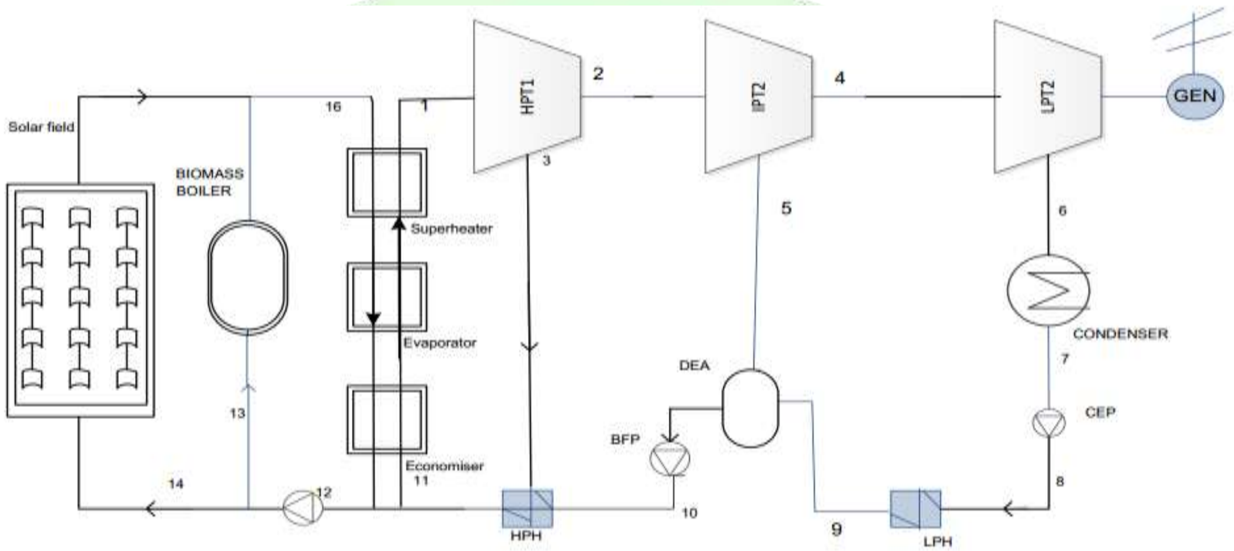

Fig. 1. Solar-Biomass hybrid power plant

V. CONCLUSION

The Hybridization of the solar energy into the conventional coal-fired unit has great potential for the energy saving and mitigation of the harmful/greenhouse gas emissions. In particular, with the pressure of CO2 emission reductions, the rising carbon tax and a biomass fuel price, the solar field integration will become good option for biomass power plants. Thereby the government should actively introduced reasonable and effective policies to guide the development of solar and biomass hybrid integration technologies.

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