

Sustainable Hybrid Bio-Solar Energy development for Developing countries

.Mr Avishkar Vijay Wanjari
Assistant Professor, Electrical Engineering Department,
Govindrao Wanjari College of Engineering & Technology, Nagpur, India

Abstract : In the 21st Century, the usage of electricity has increased rapidly and this demand is increasing day by day. In order to fulfill the required demand of electricity, the use of carbon based fuels is being done. The demand at certain extent is yet fulfilled but it has done an adverse effect on global environment. In order to cut out the use of carbon based fuels, some countries in South Asian continents have started to shift from non-renewable to renewable sources but, still there is a need for implementing new methods and it has become the need of an hour. In country like India, number of villages is yet not fully connected to the grid resulting into load shedding in rural areas. The primary focus of this research paper is to develop a method in which hybrid form of Bio energy and Solar Energy can be used as an alternate source for producing electricity in order to reduce such load shedding methods in rural part of India.

IndexTerms - Solar, Biomass, Hybrid energy, solar radiation, organic material

1. INTRODUCTION

Electrical Energy is the most important factor in today's society. Our complete daily routine work is dependent on it, starting from the use of home appliances, transportation, lighting, heating, cooling to industrial processes. As per the records, a total of 92% energy coming from non-renewable sources is being used out of total 500 Quadrillion Btu [1]. As the usage of electricity has increased the use of more non-renewable products has been increased resulting into the price hike of non-renewable products. This has resulted into the adverse effect on overall environment.

On the other hand, in case of renewable a total of only 8% of total energy contribution comes from it. Solar, Wind, Hydropower, Biomass equally is adding their share to fulfill the remaining required energy quota. With such a small percentage of sharing indicates a lot of work has to be done in this part of share. Thus there is huge demand of research and development plans under this sector.

As defined by Michael D. Brenes [3], the Bio energy is the form of energy which is derived from the bio mass, which includes products such as woody biomass, non woody biomass and animal residues. According to the survey of U.S Energy Information Administration, the O.E.C.D (ORGANIZATION FOR ECONOMIC CORPORATION AND DEVELOPMENT) will be requiring less amount of energy consumption when compared with the non O.E.C.D nations, because of their efficient economic growth and industrialization. [5]

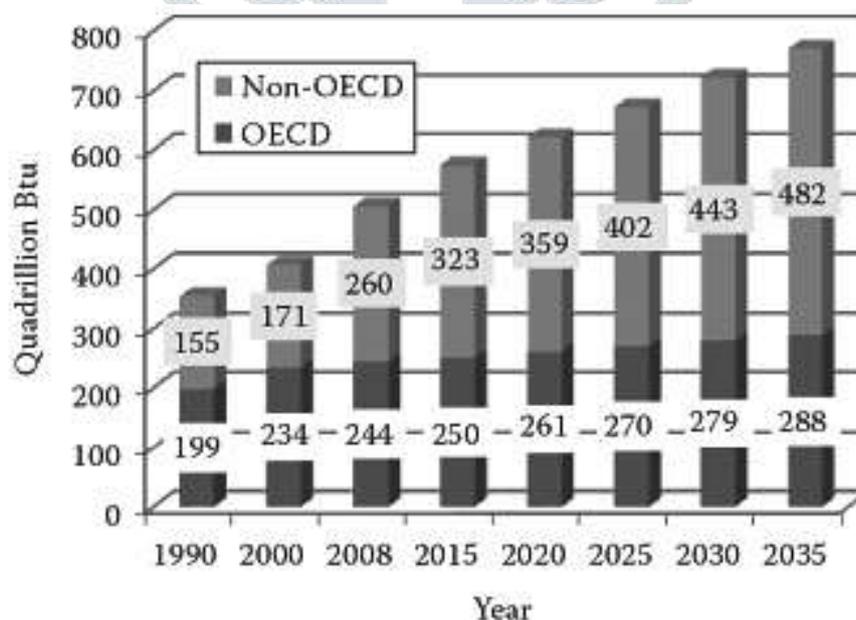


Figure 1.1: Energy consumption from 1990 to 2035, EIA [5]

The energy produced from the renewable sources is environmentally good as no waste by-products are produced. The development of Bio based fuels will result into several advantages such as, better security of energy, improved local and national economy and improved environmental conditions.

Bio Energy is such a source which can be available in local surrounding very easily, making it versatile from other forms of renewable energy sources as it is available in different forms. Use of such type of energy source may lead to development in agriculture, forest and can enhance the development of rural areas more effectively with increase additional jobs. In recent year the, the development in Bio Energy sector has been increased and most of the countries globally are tending to move towards such type advantageous energy source.

As Bio Energy finds its way to be an efficient form of renewable energy, combining it with other form of renewable energy will be of great advantage. Solar energy can be used as an add-on form to increase the level of generation.

Without any doubt in can be said that with the heavy use of fossil fuels, they are going to deplete in coming years. In that case, Hybrid form of Solar and Bio Energy is a good alternate solution for the future.

2. LITERATURE REVIEW

Bonanno. F, Consoli.A , Lombardo. S, Raciti. A [7] as showed in there published paper that an renewable form of energy can be combined together with some non-renewable form of energy sources in order to get better generation capability. They focus on these type of idea to be implemented more in rural areas so that the small hybrid form of generating stations fulfil the need of the consumers in that respective area. In their paper they have used Diesel Generator sets, Wind Turbines and Solar form of energy to form a Hybrid Generating system.

Also, as stated by Choi S.S, Larkin R [8] that in Western Australia the combination of hybrid generating system (Wind and Diesel Generator) are found to be efficient to fulfil the required demand.

As mentioned by Gavanidou E.S and Bakirtzis. A.G. [9] that the non-renewable sources are in depletion stage and thus the interest in renewable form of energy has been increased. They suggest to form an autonomous plant with an hybrid combination of solar and wind which could be beneficial.

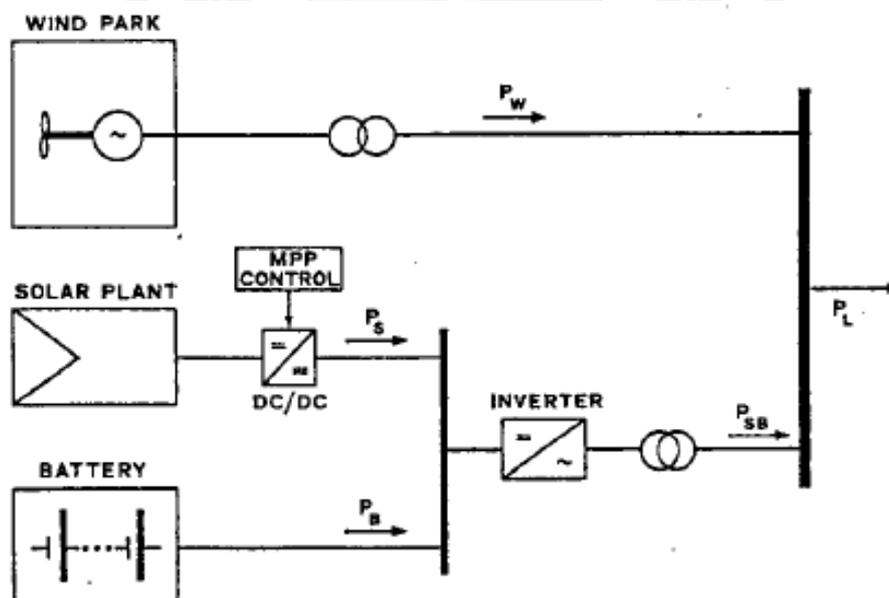


Figure 2.1: - Hybrid system model by Gavanidou E.S and Bakirtzis. A.G. [9]

From above paragraphs, it is evident that a large number of hybrid type of generating stations are being researched on, though still a lot of work has to be done. The combination of Hybrid Solar and Biomass can be seen to be increasing its importance. The photograph below shows unique 22.5 MW biomass-solar hybrid power plant which is placed in Spain [10]



Figure 2.2: - Hybrid Plant in Spain [10]

As said for such type of plant, this biomass-solar hybrid system can capture the sunlight during day time with the help of parabolic type of collectors and at night with the operation of the biomass. It is mentioned that such a installation will provide an energy of 98000 MWh [10].

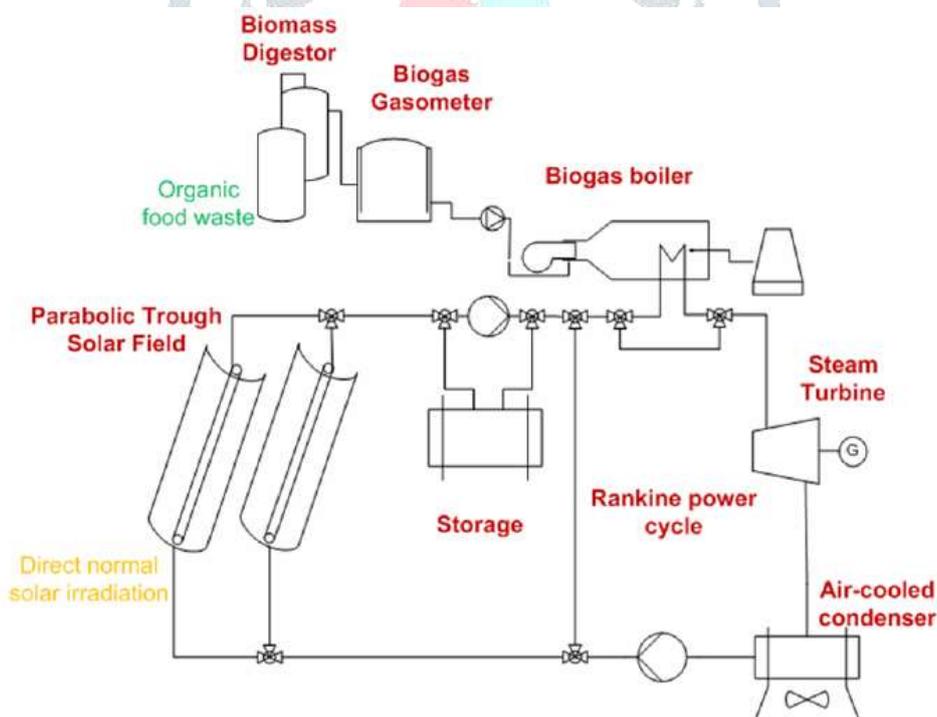


Figure2.3: - Prototype system by REELCOOP [11]

According to Oliveira A.C, Coelho. B [11] the hybridization of solar and Bio energy will add several advantages to CSP plant as well, such as it will increase the efficiency, maximize the operating time and production cost will be reduced. In this method, generation of steam from solar energy led to decrease the investment cost and resulted into good efficiency. With an addition of Bio Energy to it large devices required for storage has reduced with extended power plant operation in night time also.

It can be also seen a large area of rural place is not yet electrified in developing countries as the distance from the grid is more, also this lead to heavy transmission losses and cost of transmission itself increases. Thus from above it is very evident that the hybrid combination of generating plants in rural areas will be very much beneficial for the developing countries.

3. PROPOSED COMBINATION OF BIO ENERGY & SOLAR ENERGY

The following block diagram shows the proposed system for generating electricity with the combination of Solar and Biomass.

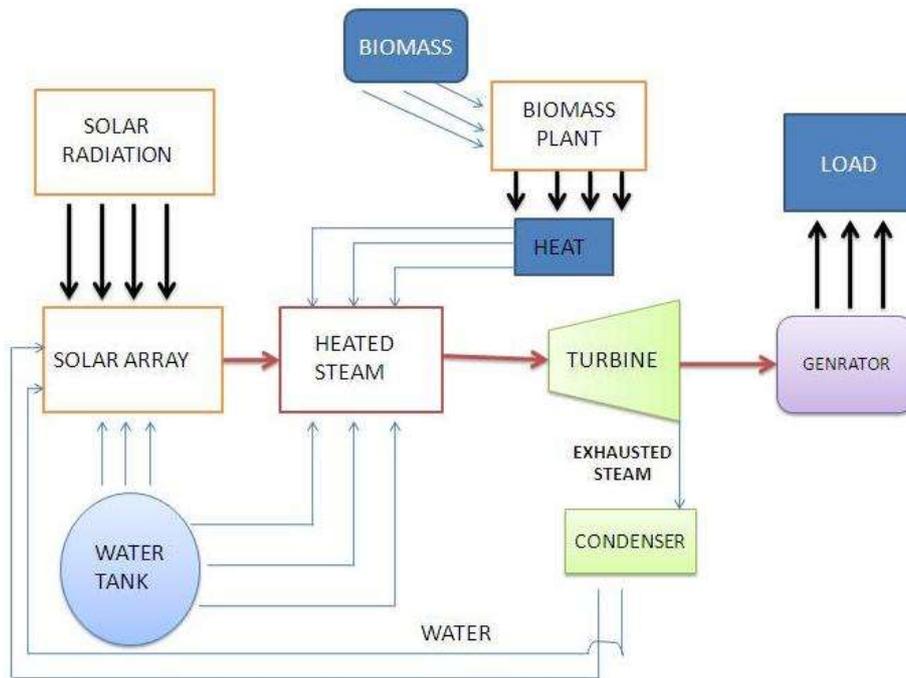


Figure 3.1: - Proposed Hybrid system model

1] **SOLAR RADIATION** : - The solar radiation reaching the earth surface can be of direct form or in diffused form. Maximum temperature can be achieved when direct radiations are captured i.e., higher efficiency can be achieved. In order to track the direct radiations for the complete day it would be beneficial to have a rotating type of solar array.

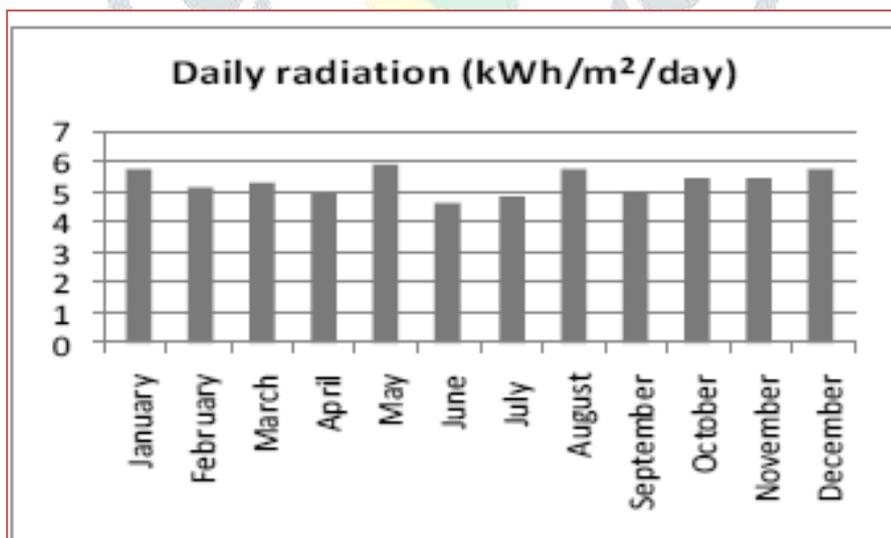


Figure 3.2: - Typical Solar radiation data [14]

2] **SOLAR ARRAY**: - A PV module exposed to sunlight can generate electricity as well as heat. The heat that the solar array captures can be utilized for heating the water. It is seen that about 10 to 15% of the incident sunlight which falls on array is used to generate electricity, and the remaining radiation is converted into heat [12].

3] **BIOMASS**: - The fuel which is prepared from organic material is called as BIOMASS. The Biomass is a very good source of energy which can be used for generating electricity. Some of the good examples from which biomass fuel can be prepared are – scrap lumber, forest debris, certain crops, manure, and some type of waste residues. [13]

4] **BIOMASS PLANT**: - The Biomass plant collects the organic material from various sources and here it is burnt in order to achieve high amount of heat energy. Before collecting the organic material it is filtered, foreign elements which are not required are eliminated before burning the organic material.

4. WORKING OF PROPOSED PLANT

Consider the figure no. 3.1, the solar radiation falling on solar array is captured and transferred to the tubes present inside the solar array. A tubular flat plate of collector is used which captures both direct and diffuse radiation for capturing the solar radiations. The water is taken from a common water tank placed nearby. The water coming from tank gets heated up because of solar radiations falling on it and thus at this stage the result is a heated steam. This heated steam then can be injected on the turbine which is coupled with the generator which in turn will generate electricity.

At the same time the Biomass plant can be used to create heat energy by organic material. The heat obtained from the biomass plant is then transferred or utilized for converting into the steam from water tank as shown in above figure to convert into steam. The other way possible would be to heat up a secondary fuel like thermal oil which is heated to get the steam. In same fashion the heated steam is injected on the turbine and further electricity is produced by conventional method. Here instead of utilizing two different chambers for steam only one is being used two distinct steam containers may result into the pressure difference.

The steam that is injected on turbine was used to rotate the blades of turbine; after it has done its work it becomes exhausted. This exhausted steam is then condensed in a condenser where we get water having certain temperature. This water can be again used in solar array or in biomass plant as it may lead to increase in efficiency.

The two different sources can effectively work in summer, winter and in rainy season. One source behaves as a backup of other source in typical seasons like rainy and winter and also in night durations where the possibility of availability of only one source is into existence.

The location of solar array shall be on top of the building; whereas the other equipments can be easily placed on ground level. As the solar array is placed on top, a pressurised water system will be required, which will pump the water upto its location.

5. ECONOMIC ASSESSMENT

This economic assessment is done by considering the reference values given in the *Spanish Plan de Energías Renovables (Renewable Energy Plan 2005-2010) (MITYC, 2005)*[16]. The venture costs planned below is for a 10 MW power plant based on Concentrated Solar Plant, biomass plant and hybrid of solar and biomass plant.

CSP Plants			Biomass combustion plants			Hybrid biomass-CSP plants		
			Biomass treatment plant	400	€/MW	Biomass treatment plant	400	€/MW
			Biomass boiler	800	€/MW	Biomass boiler	800	€/MW
Solar Field	2300	€/kW				Solar Field	2300	€/kW
Heat recovery boiler	200	€/kW				Heat recovery boiler	200	€/kW
Heat transfer system	200	€/kW				Heat transfer system	200	€/kW
Turbogenerator set	750	€/kW	Turbogenerator set	750	€/kW	Turbogenerator set	750	€/kW
Heat storage	300	€/kW				Heat storage	300	€/kW
BOP	450	€/kW	BOP	450	€/kW	BOP	450	€/kW
Evacuation line	50	€/kW	Evacuation line	50	€/kW	Evacuation line	50	€/kW
Civil Works	400	€/kW	Civil Works	400	€/kW	Civil Works	400	€/kW
Assemb.+Commiss.	350	€/kW	Assemb.+Commiss.	350	€/kW	Assemb.+Commiss.	350	€/kW
TOTAL	5.000	€/kW	TOTAL	3200	€/kW	TOTAL	6200	€/kW

Table 1: Cost for 10 MW plant [16]

The result in above table shows that the cost for hybrid power plant is more as compared to the concentrated solar power plant and biomass plant. The is quite obvious because the cost of concentrated solar power plant and Biomass plant together are getting added up for a single power plant. It is very remarkable to note that with the combination of two plants with common interest; around 20% money is being saved when considered with long life or time.

CSP Plants		Biomass combustion plants		Hybrid biomass-CSP plants	
Investment costs	50000000 €	Investment costs	32000000 €	Investment costs	62000000 €
Operating costs	1102400 €	Operating costs	5329425 €	Operating costs	4641310 €
Equivalent hours	2600 ha	Equivalent hours	7500 h	Equivalent hours	7193.4 h
Production	26000 MWh	Production	75000 MWh	Production	71934 MWh
LCOE:	238.69 €/MWh	LCOE:	116.05 €/MWh	LCOE:	153.56 €/MWh

Table 2: Operating cost of plant [16]

IN above table it can been also seen that the biomass plant has more operating cost because for handling cost associated with the raw material and labour would be more.

Similarly, operating costs of Concentrated Solar Plant is almost less than one fifth that of biomass plant as the fuel available is free of cost and is readily available. But the usage of concentrated solar power plants and energy generated by such plants is significantly low.

From above analysis one can say that the biomass plant would be very promising in coming time. This choice depends on the sustainable supply of large amounts of a raw materials used in biomass whose value and availability is not forever sheltered. The cost of raw materials used in Biomass has been mounting in the last years, and it will continue in the future. [16]

6. Conclusion

Today the developing country like India is facing a big issue of supply demand. IN fiscal year 2015-16 about 1074 Billion Kwh of energy was generated, but there was a deficiency of 7.0 billion Kwh of energy. The energy demand will be increasing day by day in big population countries like India and China day by day, so the proposed concept would be very beneficial.

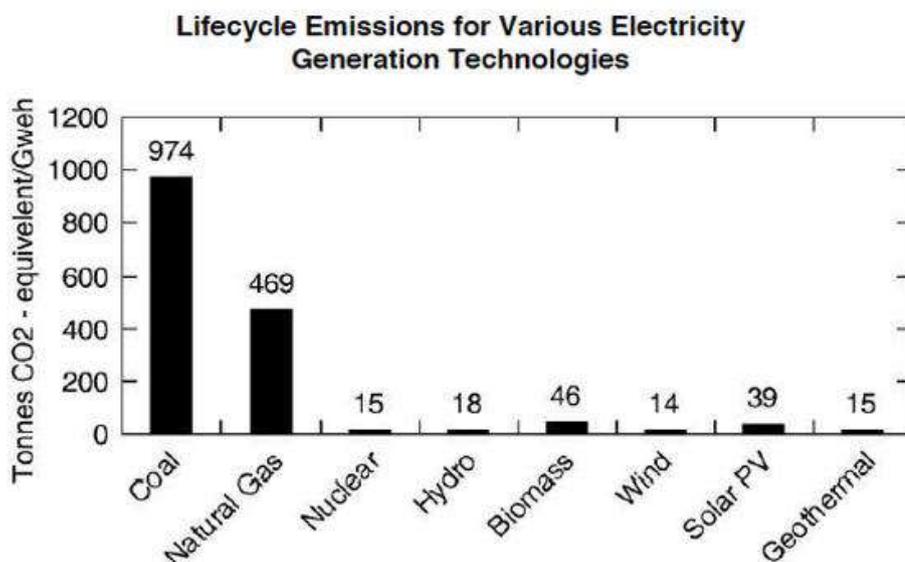


Figure 5.1: - CO2 emission data [15]

The proposed concept when implemented typically in rural areas will be more beneficial as the hours of load shedding are more in rural areas. The biomass fuel is available in large amount in rural areas and similar way the solar radiation availability is also high when speaking about India.

With implementation of such concept a huge reduction in CO2 emission can also be observed. Figure 5.1 shows the typical CO2 emissions, thus it can be clearly seen that the conventional method of electricity generation has more CO2 emission as compared to Solar and Biomass. When solar and Biomass together will be implemented this would result into more reduction in emission.

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ABOUT AUTHOR



Mr Avishkar Wanjari has completed his Graduation from Rashtrasanth Tukodoji Maharaj Nagpur University in the Year 2009. He later completed his Masters in Electrical Engineering from Staffordshire University, United Kingdom, in the year 2011. He has also completed MBA in Human Resource & Marketing from Rashtrasanth Tukodoji Maharaj Nagpur University in the Year 2018. He is now currently working at Govindrao Wanjari College of Engineering & Technology, Nagpur as an Assistant Professor. His area of interest in research is transient over voltages and non conventional energy sources.

