Solar-Biogas-Biomass Hybrid Electrical Power Generation for a Village (a case study)

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***Abstract* – Increasing electricity demands, environmental concerns, and hike in fuel prices are the main factors which motivate the use of renewable energy in India. This paper includes the study of combined biomass, biogas and solar hybrid system for generation of electric power. This system will help to conquer from global warming effect and the statistical impact on prosperity and dependency. In the hybrid system energy has a more consistency, can be cost effective and also improves the quality of life in rural areas. The aim of hybrid power system is to increase the system efficiency and the use of renewable energy based hybrid power system. In sort to meet the sustained load demands, different renewable energy sources require to be integrated. In this work we will integrate biomass, biogas and solar energy for generation of electricity, the composite produced will be less and cost per unit of electricity generated will be less comparatively. Solar energy is free of cost, installation cost of solar power plant is high but its operating cost is almost negligible. This paper discusses the renewable biomass, biogas and solar PV combined power generation system in village to overcome those problems which occurred when they operate standalone.**

***Keywords* - Biomass Power, Biogas Power, Hybrid Plants, Renewable energy, Rural area electrification, Solar PV Power**

I. INTRODUCTION

Energy play very important role for the progress of a nation and it has to be conserved in a most efficient manner. Energy should be produced in a most environment-friendly way from all varieties of fuels as well as should be conserved efficiently [5]. The use of Renewable Energy technology has been steadily increasing so as to meet demand. However, there are some drawbacks associated with renewable energy systems such as poor reliability and lean nature. Over 200 million people, live in rural areas far away from the grid [10]. The installation and distribution costs are considerably higher for remote areas [11]. Due to increase in demand of electric power we have need for the growth of non-conventional methods for generation of electric power.

A. Availability of Resources

As materials used for these methods are easy available, cost of electricity will be lesser. Several different sources of energy are being thought of, including the nuclear, geothermal, wind, tidal, solar, biomass and the biogas based [6],[9]. Presently, standalone solar PV systems, biomass and biogas systems have been promoted around the globe on a relatively larger scale. But they are facing a lot of problems during their operation. Like, in solar plants, solar panels are too costly, energy only produced during daytime and in sunny weather. Similarly, biomass plants may save on carbon dioxide emissions, but it increases methane gases, High ash content, and heat release into environment and in biogas plants some pollutants are produced. So to get optimal generation conditions, we could use the combined operation of the biogas, biomass and solar power plant.

B. Hybrid Power Plant:

A combination of different cooperating energy systems (which are complementary in nature) based on renewable energies, working with some back up sources, is known as a Combined (Hybrid) power system[12]. Solar energy can be considered as uncontrolled source. The sources are uncontrolled because their availability is totally dependent on the climate condition. Controlled sources are the sources, whose power production can be controlled. Biomass, biogas etc can be considered as controlled source of energy [2]. It is perfect for electrification of remote villages in India. The new form of power generation is usually a type which is able to modulate power out function of demand. India is prepared to offer reliable off-grid and hybrid solutions energy needs for small area especially rural areas where powering critical loads are often a analysis. However if more than one form of energy is to be used which can be solar/biogas/biomass, the photovoltaic power generation serves to decrease the consumption of non-renewable fuel [7-8].

II. COMBINED BIOMASS BIOGAS AND SOLAR PV SYSTEM

In the first step we will collect the data regarding location of area, the total land area, area under crops, crop production, energy consumption, agri-residue output, raw material available, average radiation per square meter, sunshine hours per year etc and second step calculate load of the selected village. The next step will be proper selection of equipments (Engines, generators, turbines, boilers, types of engines, effect of temperature, digester design, height of digester, batteries, inverter, PV collectors, cables etc.) [3]. Next step Cost estimations (Subsidies by government and private bodies, generation cost etc). At last step we will

calculate of payback period. Finally the whole area will be supplied power with the help of Micro Hybrid biomass, biogas and solar combined power plant [1].

Different parts of the Combined Biomass and Solar power system are:

- Solar PV Plant
- Biomass power plant
- Biogas power plant
- Inverter
- Controller

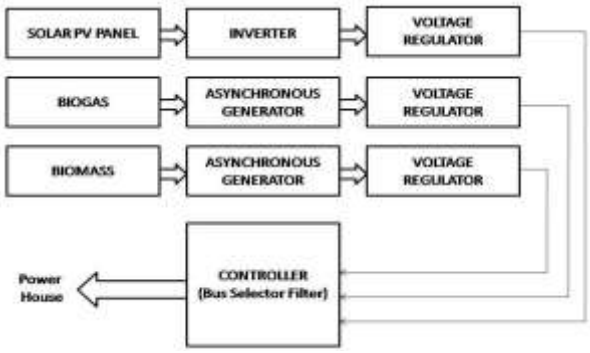

Figure 1 Block diagram of Hybrid Power Plant

Benefits of biomass, biogas and solar hybrid plant:

- Suitable for distributed power generation in any location.
- Reduces the usage of biogas and biomass.
- Rural energy electrification.
- Employment to local people
- Better utilization of available renewable resources
- Cost effectiveness
- Plant can provide peaking power using a combination of the two, regardless of the time or weather.

III. PRESENT WORK

The site proposed for hybrid power generation is village situated in Punjab. The total population of the village is 3900. In the village, raw material for biomass power plant can be made available. The total number of cattle in the village is 2340. In the village has abundant quantity of human waste and animal dung, which can be used to generate electricity by installing biogas power plant. Average solar radiation at the village is 4.73kWh/m^2/day, therefore the site has also a great potential to generate electricity through solar power plant. Three project models, one is of biomass power plant of 1000kW, second is of biogas power plant of 350kW capacity and the last is of solar power plant of 400 kW capacity are hence proposed.

IV. RESULTS AND DISCUSSION

Annual energy generated by 1000 kW biomass plant is 4993200 kWh and it's per unit cost is Rs. 3.49 per unit. Annual energy generated by 350 kW biogas plant is 1412915 kWh and it's per unit cost is Rs. 4.18 per unit. Annual energy generated by 400 kW solar plant is 854975.45 kWh and it's per unit cost Rs. 22.22.

Table 1 Biomass power plant details

1	Proposed plant capacity	1000 kW_p
2	Capital cost of the plant(after subsidy)	Rs. 5,00,00,000
3	Annual fuel cost	Rs. 7253280
4	Annual fixed cost	Rs. 10193848
5	Annual plant cost	Rs.17447128
6	Annual energy generated	5256000 kWh
7	Total no of units left after auxiliary consumption	4993200 kWh
8	Per unit cost	Rs. 3.49
9	Operating years	20
10	Payback period of biomass plant	3.8 years

Table 2 Biogas power plant details

1	Dung available	30730 kg/day
2	Biogas produced	1488.9985 m^3/day
3	No. of digesters	2
4	Proposed plant capacity	350 kW
5	Capital cost of the plant	19880100 Rs.
6	Subsidy @ 33%	6626700 Rs.

7	Net capital cost	13253400 Rs.
8	Annual operating cost	3927913.92 Rs.
9	Annual plant cost	5915923.92 Rs.
10	Annual energy generated	1412915 Rs.
11	Generation cost(Rs)	4.18/ kWh
12	Operating years	20
13	Payback period of biogas plant	3.24 years

Table 3 Solar Power Plant details

1	Proposed plant capacity	400kW
2	Average solar radiation	4.73kWh/m^2/day
3	Solar panel	333W
4	No. of solar panel	1202
5	Annual energy gain	854975.45kWh
6	Net capital cost	47397450.24 Rs.
7	Annual operating cost	677106.432 Rs.
8	Per unit capital cost	22.22 Rs.
9	Operating years	20
10	Payback period of solar power plant	9.5 years

Cost of per unit power of Hybrid System:

Operating years of Biomass power plant = 20 years
Operating years of Biogas power plant = 20 years
Operating years of Solar power plant = 20 years
Per unit cost of the Biomass power plant = Rs. 3.49
Per unit cost of the Biogas power plant = Rs.4.18
Per unit cost of Solar power plant = Rs. 22.22
No. of unit generated/day of Biomass power plant = 14400
No. of unit generated/day of Biogas power plan = 3871
No. of unit generated/ day of Solar power plant = 2603
Per unit cost from Hybrid system = [(20×14400×3.49) + (20×3871×4.18) + (20×2603×22.22)] / [(20×14400) + (20×3871) + (20×2603)] **= Rs 5.95**

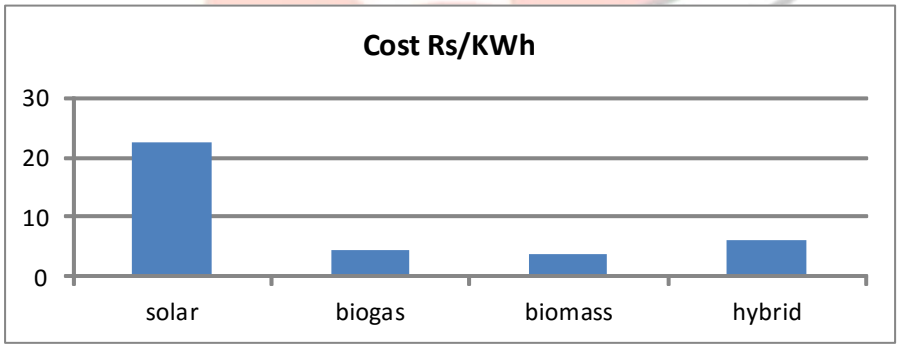

Figure2. Per unit costs for different plants

V. CONCLUSION

This work provides a newly approach to renewable technologies and their potential in developing countries like India. The Hybrid power plant based power generation using solar energy, biogas and biomass as source aims at increasing the system efficiency and therefore encourages the use of Non- conventional energy resources. This work includes power generation from Biomass, Biogas and Solar PV power plants. By use of this study, 1750 kW_p power plant could be set up in village which includes 1000 kW Biomass power plant, 350 Biogas and 400 kW Solar PV power plant. Hybrid power plant per unit cost generation is Rs. 5.67/ kWh. It utilizes solar energy, biogas and biomass as fuels in a combined cycle power plant to provide clean energy. It can be concluded that solar, biogas and biomass hybrid system is a viable green technology source for rural electrification. In this paper presents a biased solution for small to medium scale power generation using renewable biogas, solar and biomass energy in developing nations.

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