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Efficient Implementation of Hybrid System Using Solar PV and Biomass

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Abstract – One of the primary requirements of our modern civilization in any aspect is the procurement of reliable electricity supply systems. Vast part of world's population resides in rural areas. This paper discusses the renewable hybrid power generation system which is suitable for Baheya village situated in Jharkhand. All the load details of the village are collected and accordingly the amount of power to be generated is calculated. The technical, economic and C02 mitigation potential of solar PV-bio hybrid system is evaluated. Off grid hybrid power system is an attractive method to supply electricity to rural areas, especially for communities living far away from the main grid, where the grid extension is not possible. In this paper, a PV-biogas hybrid system has been modeled for the people of Baheya Village, which is located in the north eastern area of the Suwarnrekha River Ranchi. This village is under developed and lacks the electricity supply from the main grid due to its remote location. The PV-biogas hybrid system makes use of biogas and solar power to generate a major portion of the electricity as both solar irradiation and biomass is abundant in the village and it provides a green solution to the electricity shortage. The diesel generator is used to meet the energy demand at night which cannot be met by the renewable energy alone. In order to get a practical idea about technical and economical feasibility of setting up a hybrid renewable based power system in Baheya Village, some of the renewable based power plants located in different parts of the country were visited. Furthermore, a field survey is done in order to collect information about the population, load demand and to understand the socioeconomic condition of the village. The proposed PV- biogas hybrid system is able to provide cost effective, reliable and clean energy to the residents of the village.

Key words: Biomass, Solar PV, Economic Considerations, Hybrid System

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I. INTRODUCTION

Method of Hybrid power generating system enables us to improve the power system efficiency and encourage us to implement this system with renewable energy sources. To fulfil the load demand with change in load scenarios requires no's of non-conventional energy sources as Sunlight, bio-gas/bio-mass, Wind, Energy from waste of municipal, Geothermal, Ocean energy, Fuel cell, Hydro power plants etc., are needed to be combined together. After, various analysis of different renewable energy sources we found that Bio-gas is the most reliable for generating energy either in form direct heat or through generation of electric energy. The use bio-gas is associated with various advantages like it can be generated locally, reduces the emission of greenhouse gases means can contribute a large to minimise global warming effect. The rate of development of any country is directly associated with per capita Income and consumption of Energy. Energy consumption per capita is the development gradient for any nation therefore we are making an effort to increase the per capita energy consumption by utilising non-conventional energy sources. Generally, Hybrid electrical network are the integration of Solar PV array with Hydro turbines, wind turbines and/or generators running on diesel or bio-fuels/biogas. Electrical power by PV array only produced during day hours that can be stored in battery bank of suitable capacity through a special device which manages the distribution of available energy called energy manager. It also controls the whole system. The quick responsive generating units like Diesel generators are expensive to run whole the time therefore they are only employed to fulfil the frequent load demand to support the system during pick demand hours. A suitable combination of solar and other renewable energy generating technologies, coupled with a diesel generator or grid, can offer a techno-commercially efficient solution that will prove the backbone of rural connectivity. This system will offer a reliable and optimal solution at a reasonably lower cost. It can be employed economically for electrification of Indian villages. Evolution of this

technology to combine more than two power sources efficiently is based on latest research. Future scope of Hybrid power network with solar system and bio-gas is very useful. The concept used for hybrid system by using biogas and solar panel is depicted in fig (1). The energy generated by both systems is controlled by the DC control unit where we are interested to integrate both powers at same frequency level and depending upon requirements, it may be converted into AC by using an inverter for operation of various loads This study deals with assessing the technical and economic feasibility of solar- biomass hybrid system for Baheya village, Jharkhand, India.

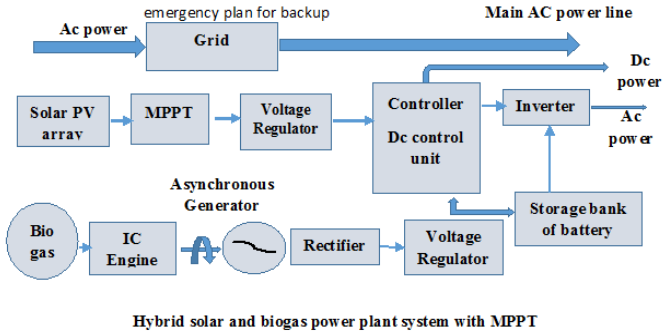

Fig. 1 Functional Block Diagram of Hybrid System

(a) Specific objectives:

(i) Analysis of availability of sun light and biomass round the year in rural areas of India.

(ii) Study of loads demand for rural areas of India

(iii) Designing hybrid power system for remote village of India.

(iv) Selection of renewable as well as reliable power generating technologies.

A survey was done to find information on energy consumption, data were collected from all 200 houses in Baheya the total animal dung collectable was also calculated.

Village Profile: Baheya Village Ranchi

Particulars	Total	Male	Female
Total No of Houses	200		
Population	974	500	474
Child	170	95	75
Literacy	71.14%	82.47%	59.65%
Total Workers	643	320	323
Main worker	286	0	0
Marginal Worker	357	89	268

Baheya is endowed with more land (0.28 ha/capita). The animal density is 0.7/capita as far as cooking fuel is concerned small quantity of kerosene is used with biomass.

II. SOLAR PV

In our world, energy from Sun in form of electromagnetic radiation is only the source, which is redial and most freely available source of energy. It is renewable, non-exhaustible and echo-friendly. The geographical condition of India is such that solar energy is available in abundant round the year. The average power from sun is about 490W/m^2/day. Batteries charged from electricity produced by solar PV systems provide power supply for 24hours. Solar Cells are photo voltaic cell which converts the energy contained in sunlight directly into D.C electricity. The special semiconductor materials like silicon, germanium and some alloys are used to manufacture solar cell of PV module. The electrical power produced from PV cell can be used to drive loads or can be stored in a battery. Generally, PV systems are robust, cheaper and most maintenance free and can be easily installed in rural areas.

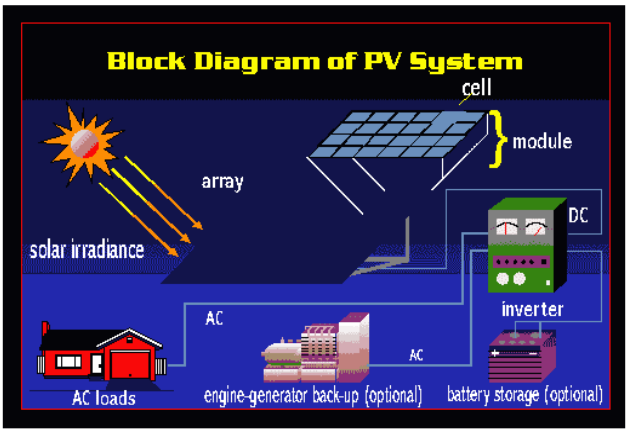

Fig. 2 Solar PV plant

The major components are PV modules, DC to DC converter, battery and inverter. The capacity of these components can be determined by estimating the load demand. The estimation of size of battery bank depends on energy to be stored, capacity of each battery, the rate at which batteries discharges and the operating temperature at which batteries are used. Usually, Lead-acid batteries are in use with Photovoltaic system.

PV cells are individual and independent units of solar PV module. Each PV cells have definite rating of voltage and current are made up of special semiconductor materials like mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium Telluride, and copper indium gallium sulfide. These materials have the property to produce electric current when exposed to light of definite energy. Each

PV cell produces small specific amount of power with particular voltage. By combining these cells in series and parallel manner a large power rating solar PV module is constructed. In our present day with advancement of technology and manufacturing technique the efficiency of PV cells are considerably improved. Now, it is about 20-25% for polycrystalline PV cells and 40-45 for Concentrated PV cells. When light incidents on a PV cell, some part of it reflected back, absorbed or pass right through. But only the light which is being absorbed by PV cells is capable to produce electricity. The energy of the absorbed photons are transferred to electrons of atoms of semiconductor material of the PV cell. Acquiring energy from incident photons, the electrons of atoms goes to valance band to conduction band and may participate in conduction of electric current when connected to external path with some lode as bulb.

(a) **Storage battery**: Batteries or accumulators are the type of electrical storage. These are the devices which store electrical energy and may supply the stored energy whenever required. It consists of one or more electrochemical cells, and is a type of energy accumulator. It is known as a secondary cell because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of chemicals are commonly used, including: lead–acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li-ion), and lithium ion polymer (Li-ion polymer).

Rechargeable batteries have lower total cost of use and environmental impact than disposable batteries. Some rechargeable battery types are available in the same sizes as disposable types.

(b) **Charge Controller**: This is the devices which continuously monitor the flow of charges from battery to load and PV system to batteries. It is also called charge regulator and constitute the core of every solar system. It manages the flow of power from solar panel to the battery and running loads to ensure that the battery is neither overcharged nor deep-discharged to avoid any damage in battery.

A **solar inverter** is a electrical equipment employed to transform the DC output of a solar panel into AC of frequency same as utility grid supply frequency. Some investors are specially designed for Battery backup these inverters draw energy from a battery as well as balance the battery charge via an onboard charger the excess charge is exported to the utility grid.

III. BIOMASS AND BIO-GAS RESOURCES

Biogas is a mixture of different gases in different proportion. It's constituting elements are Methane, Carbon-dioxide, Nitrogen, Sulpher-dioxide and moisture. Largest proportion of biogas is occupied by methane v/v. Bio-gas is, produced during the natural decomposition of organic matter by the process of anaerobic and aerobic digestion of in an airtight container. Aerobic and anaerobic digestion of biodegradable materials such as biomass, manure, sewage, waste, green plant material, and crops is carried out by bacteria called fermentation. Typical composition of biogas is as below:

Material	Composition of the gas (percentage)		
	Methane	Carbon dioxide	Hydrogen Sulphide etc
Cattle dung	55-80%	40-45%	Negligible
Night soil	65%	34%	H_2S 0.6% other gases0.4%

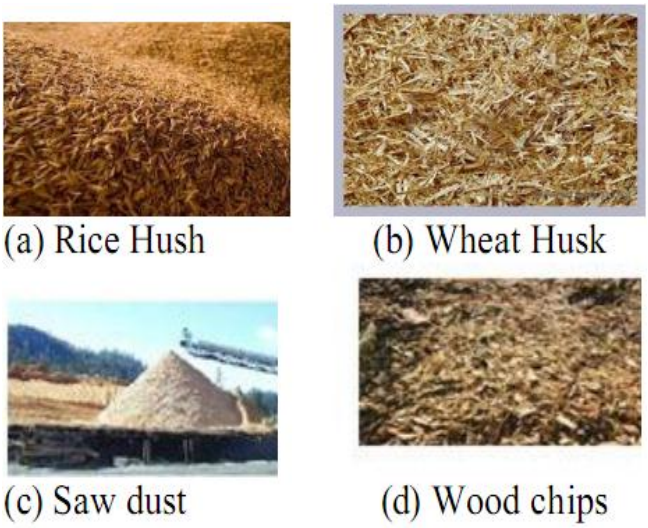

Fig. 3 Biomass Crops and wood chips

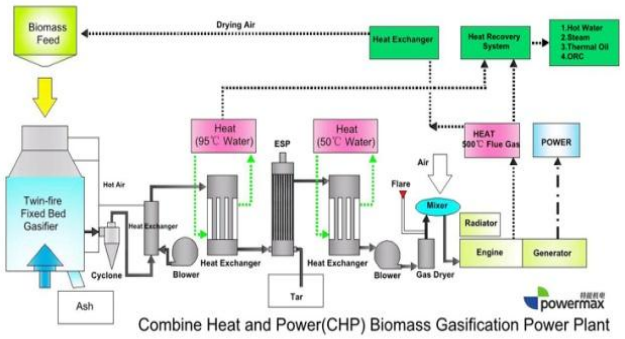

Fig. 4 Biomass Gasifier plant

Energy demand of future can be most probably answered by availability of Biomass. However, Bio-mass is available in plenty but not all biomass can be used for generation of rate electricity. Only small fraction of available biomass can be utilized to produce substantial amount of energy. Although, the energy efficiency of bio-mass electrification technology is limited and the operating and investment costs are high. Consequently financial returns are low. The range of Biomass power plants varies between 2-50 MW. The larger plant produces comparatively higher benefit because of greater energy efficiencies (usually up to 22-23 %) but have to face the bulk requirement of biomass. A suitable bio-mass can be characterized by following features as:

(i) It's increasing scarcity.

(ii) High cost and seasonal availability.

(iii) Size of biomass particles ranges from 5 cm to few mm.

(iv) The biomass stocking yard should be airy and enough open to provide necessary heat to vaporize the water content from particles.

(c) Electric Load Design Analysis:

The storage capacity, S_c, of the battery can be obtained by (4 x Total energy to be stored per day)/ (Battery voltage x battery current).

Number of panels required, N_P = Rating of solar PV plant / Rating of solar pv panel The charging controller can be designed using the following formula:

Controller current, $I_{C,}$ Total power to be stored per day / V_B

The number of batteries required can be obtained by, N_B , Total power to be stored / (V_Bx I_B) where, V_B, I_B are the voltage and current rating of each battery.

IV. LOAD ESTIMATION

Table1

Domestic load of the village

S. No.	Gadget	No	Rating (W)	Total rating(W)	Duration (hrs)	Load (kWh)
1	CFL	200	15	3000	8	24
2	Fans	200	60	12000	8	96
3	Water Pumps	7	1500	10500	4	42

Due to domestic loads units consumed per day are 162 units.

S. No.	Gadget	No	Rating	Total Rating	Duration	Load (kWh)
1	T.V	1	300	300	8	2.4
2	Computer	1	600	600	4	2.4
3	TFL	4	55	220	8	1.76
4	C.D.Player	1	100	100	8	0.8
5	Fans	4	60	240	8	1.92

Table 2

Community load of the village

(a) Energy Consumption of Village:

For community hall design the load consumed per day is 9.28 for street lighting we are using 30 T.F.Ls and these are operating 8 hrs per day, so these consume 13.2kWh per day. So the total units consumed per day are 185 units. For economic designing of system the contribution of solar PV system and bio-gas generating system must be in proper ratio. Here, our design ratio is (2/3) which is equivalent to (40/60) which means that 40% of demand is satisfied by solar PV and 60% is managed by biomass electrification. Since, 40% of total demand (185kW) is 74kW, which can be generated by installing 15kW PV plant (with 70% efficiency of rated) rest 60% can be produced by installing 10kW biogas electrification.

V. DESIGN RESULTS

(a) Modeling of PV System

Suitable PV Power Plant Rating = 15KW

Duration of operation = 7hrs

Then, total Electrical Energy Produced (Watt-hours) = 15×7= 105KWhr

The operating period of the PV module exposed to the sun is usually 9:00AM to 4:00 PM

For this design 150W power rating panels are desired.

Therefore total number required PV panels = (15000/150) =100 nos.

(b) Charging Controllers

For modeling of 15KW solar PV system, Let P is the total power to supply. Therefore P =(I x V) Where I is the charging current and V is the voltage of the battery. If voltage rating of each battery is 12V. Normal, availability of sunshine in a day is about 7 hours. Solar PV array can generate maximum 15 X 7= 105 units. It is general observation that solar PV panels only 70% of their rated capacity. Hence, designed PV system will generate 73.5 units per day. In day time we can directly feed consumers from solar power plant. To make the charging process fast we can feed directly 32% available solar power. Therefore, about 24KWh can be directly distributed without storing it. Remaining 50KWh is stored in the battery banks. *Hence* I = P/V= 50000/12=4166*Amps.*

Since, the 5KA charging controller is needed to charge the battery banks.

(c) Battery capacity

Battery capacity plays a vital role in PV system. So the battery capacity should be maintained in PV system.

So our Watt-hour capacity of the battery should be 50 kWh

To make the battery life long, we should discharge electrical energy $(1/4)_{th}$ of total battery capacity. So, we have to choose the battery capacity four times of required electrical energy.

So, desired battery capacity will be = 50,000 X 4 = 2, 00 kWh

Now, the selection of battery depends on A-H capacity of battery. For example, if we choose a battery of 500Ah having 12V voltage rating. Hence, number of batteries needed to design battery bank 2, 00,000/ (12 X 500) =34 batteries.

(d) Inverter

As analyzed above, the maximum instantaneous load on Solar PV and battery system is 30kW. Hence, required rating of pure sine wave inverter will be 30kVA for long life, reliability and consistence performance

(e) Biomass power plant

(i) Biomass resource availability-In Baheya the biomass availability is 0.36 kg/cap/day Population of the village is 1196. The total biomass availability in the village is around 420 kg; from this we can generate the sufficient power, to satisfying the load requirement of Baheya village.

(ii) Plant rating- Here we are installing the power plant is 10 kW and we are connecting to the synchronous generator, so it will gives the rated voltage and frequency and Gasifier can give the gas 12 hrs/day from this we can generate 120 units minimum per day, biomass plant is working at peak loads and solar is working at day time and solar power we are storing through batteries and one controller also we are placed so that it will control the power flow to the consumer load.

VI. ECONOMIC CONSIDERATION

Table 3

Summary of biomass

Gasifier plant capacity	10 kW
Cost of installation	Rs. 5, 00,000
Maintenance cost	Rs.10, 000
No of consumers	200
Operation hours	12 hrs
Fuel efficiency	1.5 kg of crop residue/kWh
Cost of fuel	Rs. 0.30/kg
Operating period	20 years

Table 4

Operation cost per unit electricity

Description	With grid system	With gasifier system
Electricity	Rs.4.7/kWh	Rs.0.45/kWh
Labour cost	Rs.0.48/kWh	Rs.0.66/kWh
Maintenance cost	Rs.0.1/kWh	Rs.0.28/kWh
Total	Rs.5.28/kWh	Rs.1.39/kWh

Table 5

Summary of Solar PV power plant capacity 15 kW

Cost of installation	Rs. 26,25,000
Maintenance cost	Rs 26,250
No of consumers	196
Operation hours	7 hrs
Operating period	15 years

(a) Hybrid system cost:

(i) Biomass:

Total installation cost of biomass = Rs 5, 00,000

Maintenance expenses for biomass plant = 2 % of the installation cost

Cumulative cost (installation and maintenance) of the plant installation

= 5, 00,000 + (0.02 X 5, 00,000)

= Rs.5, 10,000

Operating years = 20 years

Per day we can generate = 120 units

So, per unit cost = 5, 10,000/ (20 X 120 X 365) = Rs 0.582.

Total cost per unit generation = Installation and maintenance costs + operation cost = 0.582 + 1.39 = Rs 1.972.

(ii) Solar:

Total installation cost = 175 X 15,000 = 26, 25000. (Per watt installation cost is Rs.175)

Maintenance expanses of the solar PV power plant = 1 % of the installation cost = 26, 25,000 + (0.01 X 26, 25,000) = Rs.26, 51,250

Operating years = 15 years.

Per day we can generate = 73.5 units.

Per unit cost = 26, 51,250/ (15 X 365 X 73.5) = Rs 6.588.

(iii) Hybrid

Per unit cost from hybrid system = (2400 X 1.972 + 1102.5 X 6.588)/(2400 + 1102.5)= Rs 3.425.

Through hybrid system, per unit generation and distribution charge is not beyond Rs 4. But through main grid connection per unit tariff is minimum Rs5.50.

So, through hybrid system of generation and distribution is cheaper than conventional energy.

(iv) Carbon Reduction Potential

Co_2 emission from biomass per unit generation = 6 g/kWh Co_2 emission from solar PV plant per unit generation = 68 g/kwh

Per day we can generate power from biomass = 120 X 365 = 43,800 kWh

Per year we can generate the power from solar PV plant = 73.5 X 365 = 26,827.5 kwh Carbon emission from solar pv plant per year = 26827.5 X 0.067 = 1824.25 kg= 1.825 tonnes/year

= 1.825 carbon credits Carbon emission from biomass plant/year = 43,800 X 0.006 = 262.8 kg

= 0.2628 tones/year

= 0.2628 carbon credits from total hybrid system, the carbon emitted per year = 1.825 + 0.2628 = 2.0878 tonnes/year If the same energy is generated through conventional (coal), then carbon emitted per year = 1.5*(43,800+26827.5) = 105.94 tonnes/year. So by installing renewable hybrid system, the carbon emission reduction = 105.94 – 2.0878 = 103.85 tonnes/year = 103.85 carbon credits. Total money earned through carbon credits = 103.85* 30 = Rs 1, 36,048 per year.

A 15kw standalone solar photovoltaic system has been considered to evaluate the unit cost of energy generation. Assuming the sunshine hours of 6 hrs per day and 365 days of operation. Capital cost of solar PV is Rs 26, 51,250 and the total cost of bio energy system is 5, 10,000. Therefore, the total cost of installed capacity is Rs 31, 61,250 which is shown in

Table 3 and Table 5. The unit cost of the solar-biomass hybrid energy system is calculated above and it was found to be Rs 3.425.Here we are installing the power plant is 10 kW and we are connecting to the synchronous generator with the rated voltage and frequency. Gasifier can produce the gas 6-7 hrs/day, from this we can generate 120 units minimum per day. Biomass plant is working at peak loads. Similarly solar plant can generate power at day time for 7 hrs(from 9 a.m to 4 p.m)and at night time, batteries will discharge the stored electricity and one controller also we are placed so that it will control the power flow to the consumer load. So during clear sunny day the net power generated from solar plant is 73.5 kWh. Charge controller is placed in between solar panels and batteries to control the power flow.

CONCLUSION

Some of the remote villages are far away from the main grid so they are still unelectrified. Due to the distance problem, losses increase and transmission line installation cost also goes high. This paper discusses the renewable hybrid system with solar PV and biomass which helps in overcoming many of the problems. In this paper the load requirement of Baheya village is calculated and in order to satisfy this load the energy requirement is predicted. It can be concluded that solar and biomass hybrid system is a viable green technology source for rural electrification.

REFERENCES

B. Rangan (2006). Comparison of options for distributed generation in India Energy Policy, 34 (1), pp. 101–111.

C. Thipwimon, H. Gheewala Shabbir, P. Suthum (2004). Environmental assessment of electricity production from rice husk: a case study in Thailand Electricity Supply Industry in Transition: Issues and Prospect for Asia, 20, pp. 51–62.

Caputo A.C., Palumbo M., Pelagagge P.M., Scacchia F. (2005). Economics of biomass energy utilization in combustion and gasification plants: effects of logistic variables, *Biomass and Bioenergy*, **28**(1), pp. 35-51.

Cot A, Ametller A, Vall-llovera J, Aguiló J, Arque JM. Termosolar (2010). Borges: a thermosolar hybrid plant with biomass. In. Third international symposium on energy from biomass and waste, Venice, Italy.

D. Ayhan (1997). Calculation of higher heating values of biomass fuels Fuel, 76 (5), pp. 431–434.

Francois Giraud and Zyiad M. Salameh (2001). Steady-state performance of a grid-connected rooftop hybrid wind-photovoltaic power system with battery storage. IEEE Transactions of energy conversion. Vol. 16, pp. 1-6.

López-González L.M., Sala J.M., Mínguez-Tabarés J.L., López-Ochoa L.M. (2007). Contribution of Renewable energy sources to electricity production in the autonomous community of Navarre (Spain): A review, *Renewable and Sustainable Energy Reviews*, 11(8), pp. 1776-1793.

M.R. Nouni, S.C. Mullick, T.C. Kandpal (2008). Providing electricity access to remote areas in India: an approach towards identifying potential areas for decentralized electricity supply Renewable and Sustainable Energy Reviews, 12 (5), pp. 1187–1220.

Ministry of New and Renewable Energy Guidelines for generation based incentive, grid interactive solar thermal power generation projects (2008).

Mohanlal Kolhe, Sunita Kolhe and Joshi J.C. (2003). Economic viability of stand-alone solar photovoltaic system in comparison with diesel-powered system for India. Energy economics. Vol. 24, pp. 155-165.

N.H. Ravindranath, H.I. Somashekar, M.S. Nagaraja, P. Sudha, G. Sangeetha, S.C. Bhattacharya et. al. (2005). Assessment of sustainable non-plantation biomass resources potential for energy in India Biomass and Bioenergy, 29 (3), pp. 178–190.

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