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Optimization of Grid connected Hybrid Energy (solar and biomass) System Using HOMER Pro Software

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***Abstract*—India lives in villages as said by father of the nation M.K Gandhi, the country will only develop with its rural areas. The work is an approach towards the betterment of rural areas providing a cleaner ecofriendly environment by using renewable energy resources to meet the load requirements. The purpose of this project is simulation and optimization of the hybrid energy systems.In this case the hybrid energy system with the flat solar PV module, generator set with biomass as its source, connected to overhead grid system available to fulfill the load requirement of Bandhuguda village, Rayagada, Odisha, India. The simulation and optimization of the system is executed with HOMER Pro Micro grid Analysis Tool 3.8.5 (Evaluation Edition).The analysis of the hybrid system for a load demand of 623 KWh/d with peak load at 108.29 KW gives simulation result of optimized components solar, biomass gasifier, cost of energy and emissions.**

Keywords— Biomass, , HOMER Pro, Hybrid, grid, Solar.

I. INTRODUCTION

Every year the demand of electrical energy is growing rapidly throughout the world.. Generally the production of electrical energy depends on fossil fuels. As a result it increases CO2 emissions, which are not healthy for environment concern. To reduce the emissions of CO_2 and greenhouse gas effects & improvement of quality of life renewable energy is very much useful for environment as well as to develop the economy of a country .While many of the renewable energy projects are of large scale, renewable technologies are also suited to rural and remote areas, where there is often crucial in human development is going on[5]. Energy plays a crucial factor in technological and economic development of present society. It has always been the key to man's greatest dream of a better world. India with its 70% population lives in rural areas where it is uneconomical for them to pay the conventional cost of energy, we need to find alternatives to reduce the cost of electricity. For this only now new implementation is going on hybrid systems consisting of renewable energy sources .We are considering the case study of a small village named Bandhuguda in Rayagada district Odisha,India. These hybrid systems involve combination of different energy sources with wind, PV, mini hydro, Biomass, fuel cells etc. There are many renewable energy can be implemented in hybrid systems like solar, wind, hydro, geothermal, biomass etc[5]. But especially for this area it is economical to use hybrid systems consisting of solar and biomass. Grid connected systems are intended to operate independent of electric utility. It is being connected to main grid. The main useful of this system are it requires lesser operating cost and as well as it is healthy as for environmental consideration. Generally such type of systems supports to the distributed generation and connected to micro grids. In near future the system is favouring to.

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II. OBJECTIVES

A. To implement energy production using renewable energy resources.
B. To reduce the cost of electricity.
C. To reduce the emission of greenhouse gases.
D. Power saving and improving overall power efficiency.
E. Technological advancement of rural India

A.To implement energy production using renewable energy resources.:

Recent development in technologies allow us to harness the renewable energy resources like solar, wind, biomass, tidal energy etc. from different sources. Here we are going to design a grid connected hybrid energy system using solar and biomass as the renewable resources to provide an ecofriendly energysupply[4].

B.To reduce the cost of electricity.

The Hybrid system connected with grid reduces the cost of electricity by reducing the operating cost of the overhead grid supply .Thus economically support the rural citizens of India for getting an uninterrupted power supply in low cost.

C.To reduce the emission of greenhouse gases.

It reduces the emission of greenhouse gases like carbon dioxide, Sulphur dioxide and Nitrogen dioxide thus provide an environment friendly resource to the people.

D.Power saving and improving overall power efficiency.

It saves the wastage of excess electricity by selling the unused electricity to the grid and improves the overall efficiency of the system by having a renewable energy fraction of 53%.

E.Technological advancement of rural India:

Rural India is devoid of technological advancements going on around the world ,by implementing this we can improve the perception of the people towards the benefits of technology and hence encourage them to have new ideas.

III. SCOPES

The project aims at designing a prototype for implementing energy production in rural areas from the day to day available renewable energy resources like biomass and solar energy. This system aims at designing the model of an advanced grid system to reduce the cost of electricity and emission of greenhouse gases. The system integrated with different features can be applied in the neighboring villages to supply them uninterrupted power supply during power crisis[3].

IV.SOFTWARE USED

HOMER Pro Micro grid Analysis Tool 3.8.5 (Evaluation Edition).

V. HYBRID SYSTEMS

Hybrid systems used to produce energy from different sources of energy in order to improve the efficiency of power production. PV – Biomass power system, which is a combination of a photovoltaic array integrated with a biomass generator, is a better option for a remote areas where an abundance of livestock manure and solar energy is available. This system consists of a PV array, a biomass generator and a DC/AC converter which is connected to the grid system of the local area. In the design and sizing of the system, the system should be considered as a grid connected system. Such a constraint leads to an improved power grid system to reduce cost of electricity and emission of greenhouse gases[1].

A. Biomass System

Biogas is gaseous mixture of methane, carbon dioxide, hydrogen sulphides and several other gases, produced by anaerobic fermentation of organic material such as animal and human manure, leaves, twigs grasses, industrial waste etc. This energy release and allows biogas to be used as a fuel. It used in a gas engine to convert the energy in the gas into electricity and heat. The biogas is produced by microorganisms in the absence of oxygen. This process is called anaerobic process. The main factor of choosing this type of hybrid system consist of biomass is that in remote area villages it is very easy and economically available in the form of dung of cow, buffalo, goats, pigs etc. During the cloudy day, the total electricity production can depend on the biomass. The most perspective was the building of biogas plant in Bandhuguda care has to be taken that, as there is an availability of livestock like cows ,pigs etc. . It is recommended to include in feedstock, a part of manure, the different local biomass, e.g. maize, perennial grasses, waste biomass

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from food industry, biodegradable part of municipal wastes, aiming to increase economic viability for potential biogas projects and to provide stable and reliable biogas cogeneration plants[2]

B. PV-System

Photovoltaic is the direct conversion of light energy into electrical energy. As Solar radiation fall on the solar cell, the free electrons of solar cell capture that radiations and produce electricity. Photovoltaics were initially used as a source of electricity for small and medium-sized applications. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun . Here in this system we are using PV system just to provide lighting to all the houses in the village keeping the biomass generator as the major source of energy[3].

VI. SYSTEM DESIGN

The system was designed by calculating monthly demand of electrical energy required by a small village Bandhuguda in the rayagada district of Odisha, India as well as power output of the bio-solar combinations.

A.Optimization Analysis of the Hybrid System

HOMER performs the optimization process in order to determine the best configuration of hybrid renewable energy System based on several combinations of equipment. Hence, multiple possible combinations of equipment could be obtained for the hybrid renewable energy system due to different size of PV array and biomass system, size of DC-AC converter and operating cost of grid system . Each and every combination of the system configuration can be optimized by simulating it in the search space. The feasible one will be displayed at optimization result sorted based on the Total Net Present Cost (TNPC). The main feature of optimization is to know the optimized value and to meet the load by the energy supplied by the PV-biomass system for the entire year with coordination ongrid.

B.Modelling of PV and Biomass

- **PV System**: In order to efficiently and economically utilize the renewable energy resources, one optimum match design sizing method is necessary[2]. The sizing optimization method can help to guarantee the lowest investment with adequate and full use of the solar system, biomass system and battery bank, so that the hybrid system can work at optimum conditions in terms of investment and system power reliability requirement. Various optimization techniques such as the probabilistic approach, graphical construction method and iterative technique have been recommended by researchers**.**

- **Power output from PV array:** For design of a PV system, we should know how much solar energy is received at the concern place. It is effected by sun position, could covering atmospheric affect, and the angle at which the collector is placed, called tilt angle 'β'. Normally this angle is equal to the latitude of the concern place. The related equation for estimation of the radiation is listed below :

1. Isolation $i = Io \{ \cos \phi \cos \delta \cos \omega + \sin \phi \sin \delta \}$ kW/m2

2. $Io = Isc [1 + 0.033 \cos (360N/365)]$ where Isc solar constant. =1.37 kW/m2 3.HoA = energy falling on t

3. $H o = \int i dt \omega_{sr}$ = hour angle when sun rising ω_{ss} = hour angle when sun setting

$= (24/\pi) I sc [1+ 0.033 \cos (360N/365)] \{\cos \phi \cos \delta \cos \omega + \sin \phi \sin \delta\}$ kWh/m 2 /day he concern place considering atmospheric effect = KT Ho kWh/m2/day where KT dearness index

4. H oA = energy falling on the concern place considering atmospheric effect = K T Ho kWh/m 2 /day where K T dearness index

5. $K T = A1 + A 2 \sin (t) + A 3 \sin (2t) + A 4 \sin (3t) + A 5 \cos (t) + A 6 \cos (2t) + A 7 \cos (3t)$ $t = (2\pi/365) (N-80)$ N= 1 for Jan 1 stWpeak = {1/ hpeak } [(Wh((load)

* No. of no sun days / (ηb * no of discharging. Days)) + Whload(day) + Whload(night)/ ηb)]

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Where: ηb = battery efficiency hpeak = no of hours for which peak insolation falls on the PV cell[1].

- ***Biomass:*** Manure output from livestock in a year will be calculated as follows:

$$M = \sum_{n=1}^{i} N_i m_i$$

Where,
M- Livestock (animals and crops residues) manure produced in remote area, t. n- average number of livestock present year-round within ith group of livestock ,Ni- Number of specified groups of livestock population in remote area, Mi- manure produced per one head in a year in the ith group of livestock, t, Biogas production from manure potential was calculated as the sum of biogas volumes obtainable from manure produced by animals and crop residues in that area:

$$V_B = \sum_{n=1}^{i} N_i m_i K_{DMi} K_{OMi} V_{Bi} e_{bi}$$

Where, VB- biogas volume, potentially obtainable from manure biomass in parish (municipality, region) in a year, m3, KDMi- dry matter content in manure produced by ith group of animals , KOmi- organic matter content in dry matter of manure produced by ith group of animals VOmi- specific biogas output from manure organic matter for ith group of animals Energy of biogas obtainable from manure biomass in municipality (region) was calculated as follows:

$$E_B = \sum_{n=1}^{i} N_i m_i K_{DMi} K_{OMi} V_{Bi} e_{bi}$$

Where, EB- energy potential obtainable from biogas produced from manure, kWhebi- specific heat energy content of biogas obtained from manure produced by ith group of animals, kwh/m^3[1].

VII. OPTIMIZATION SIMULATION AND ANALYSIS

The optimization simulation of hybrid system is done by using HOMER software. This software is helps to find the best electricity generation system configuration which shows the appropriate technology, size and no. of equipment required[6]. It also compares the cost and environmental impact. This model is helpful for both conventional and renewable energy system. Homer is able to evaluate economics and technical feasibility of the system. First, Homer simulates the working power system by calculating the hourly energy balance for a year. Hour by hour, Homer determines the electric demand of the site and the local electricity supplied by the system. Comparing these energy flows, Homer is able to estimate if the configuration is feasible that is to say if the system can satisfy the electricity requirements. Then, Homer optimizes the results. Among the possible configurations defined by the simulation, Homer retains the most cost-effective in a table ranked by Net Present Costs (NPC). Homer can realize a sensitivity analysis by modifying some inputs in a range defined by the user in order to compare different possible scenarios.

A. Arrangement of source and load

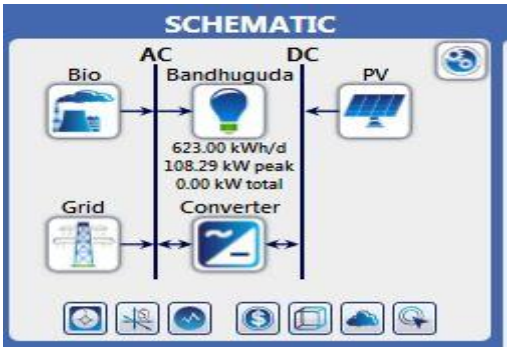

Fig. 1: Basic design of load and sources in homer

The main feature of simulation in Homer is selecting the suitable sizes of the sources to meet the daily load curve pattern of the system. As shown in "Fig. 1" the load is having an average load of 690.00kwh/day and the peak load is 108.29kw. Hence the size of the PV, biomass generator, battery and converter are matched with the load patterns.

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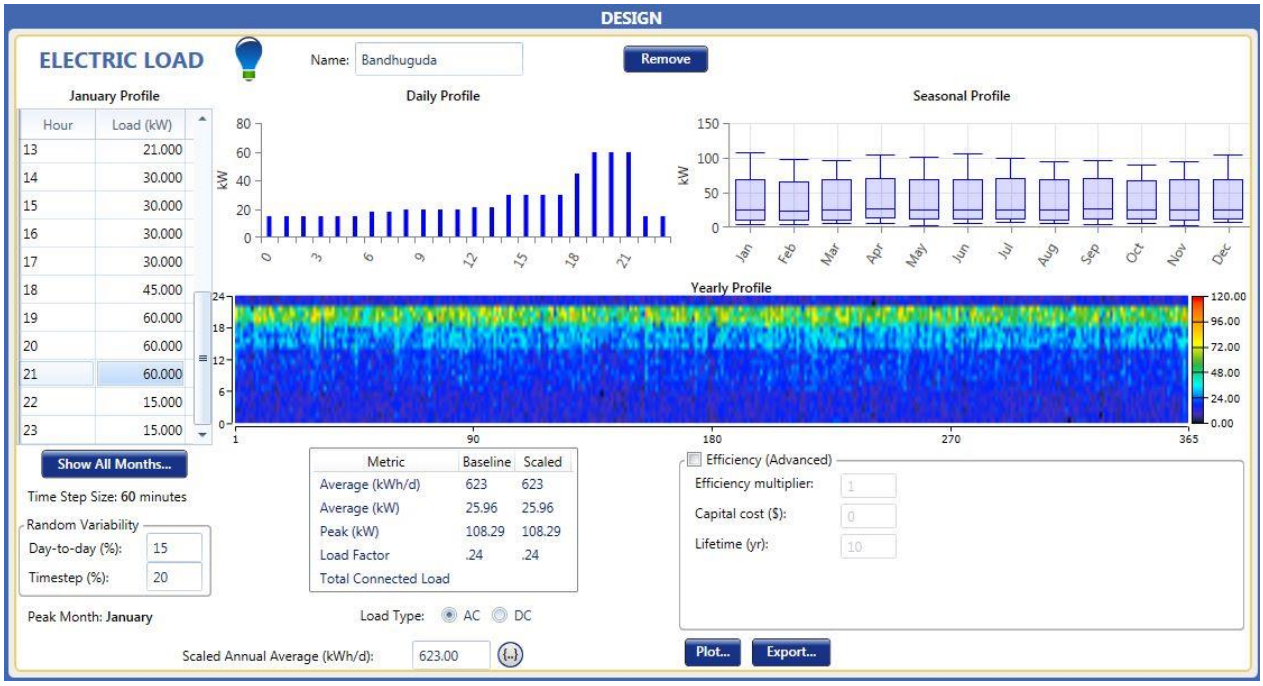

Fig. 2: Daily load profile

Fig. 3: Monthly average available biomass resource

The main feature of the Homer software is it will gives the availability of solar radiation once the area latitude and longitude has given. Once the solar power source is available for load pattern, then schedule of the solar power is available and at what time periods the solar PV will works also available.

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Fig.4: Monthly average solar resource

B.Analysis of Electrical energy production

Production	kWh/yr	%
Generic flat plate PV	30	0.01
Generic 500kW Biogas Genset	226,661	52.55
Grid Purchases	204,645	47.44
Total	431,336	100.00

Consumption	kWh/yr	%
AC Primary Load	227,395	52.72
DC Primary Load	0	0.00
Grid Sales	203,923	47.28
Total	431,318	100.00

Fig. 5: Production and consumption of power

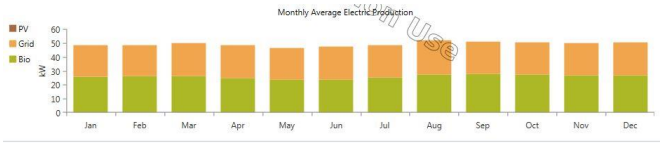

Fig. 6: Yearly share of PV-Biomass-grid system

This is the combined output power of bio-generator and solar-pv and grid system. In this system the major share of energy for meeting the load requirement is produced from biomass energy system i.e 52.55% .and grid purchase of 47.44%.Only 0.01% i.e for lighting at emergency period solar system is used.In consumption system 52.72% is consumed by AC primary load and the rest electricity i.e 47.28% is sold to the grid. Hence only a small fraction of grid electricity is purchased.

Quantity	kWh/yr	%
Excess Electricity	17.5	0.0
Unmet Electric Load	0.0	0.0
Capacity Shortage	0.0	0.0

Fig. 7: Excess electricity produced by the system.

Total 17.5kWh/yr energy is produced in excess is produced which is equvalent to 0.0%.

Quantity	Value
Renewable Fraction	52.6
Max. Renew. Penetration	105.3

Fig. 8: Renewable energy fraction of PV-Biomass-grid system

53% of the total power produced is from renewable energy sources.

C. Analysis of Fuel

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Quantity	Value	Units
Total feedstock consumed	709	tons
Avg feedstock per day	1.94	tons/day
Avg feedstock per hour	0.0810	tons/hour

Fig. 9: Fuel share of PV-Biomass-grid system

Total 709 tons of feedstock is consumed by the biogas gasifier with a supply of 1.94 tons /day from different sources like cow dung, excreta from pigs, hens, crop residues and domestic wastes.

C.Comparing economies

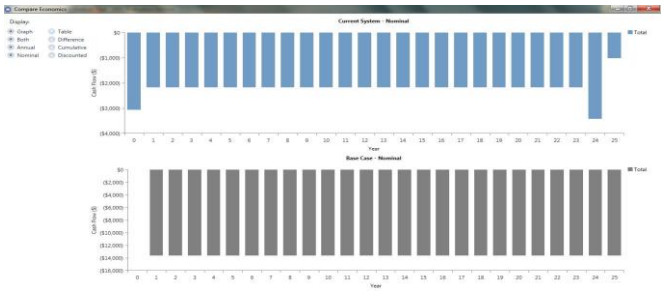

Fig. 10: Economic comparision of PV-Biomass-grid system and grid system.

The economies are compared with the Net Present Cost(NPC).If we are opting for only grid system the NPC is $176,379 but if we are employing this hybrid system the NPC reduces to $ 31,158. We can reduce the cost of electricity to $ 0.005 than $0.06 in grid system Thus the hybrid system is economical.

D.Analysis of emission

Quantity	Value	Units
Carbon Dioxide	143,713.62	kg/yr
Carbon Monoxide	0.00	kg/yr
Unburned Hydrocarbons	0.00	kg/yr
Particulate Matter	0.00	kg/yr
Sulfur Dioxide	623.06	kg/yr
Nitrogen Oxides	304.71	kg/yr

Fig. 11: Emission of grid system

Quantity	Value	Units
Carbon Dioxide	584.27	kg/yr
Carbon Monoxide	1.42	kg/yr
Unburned Hydrocarbons	0.00	kg/yr
Particulate Matter	0.00	kg/yr
Sulfur Dioxide	1.98	kg/yr
Nitrogen Oxides	1.85	kg/yr

Fig. 12: Emission of PV-Biomass-grid system

We can clearly see that with this hybrid system we are reducing the greenhouse gases to very low limit as compared to the grid system.

E.Analysis of Cost summary

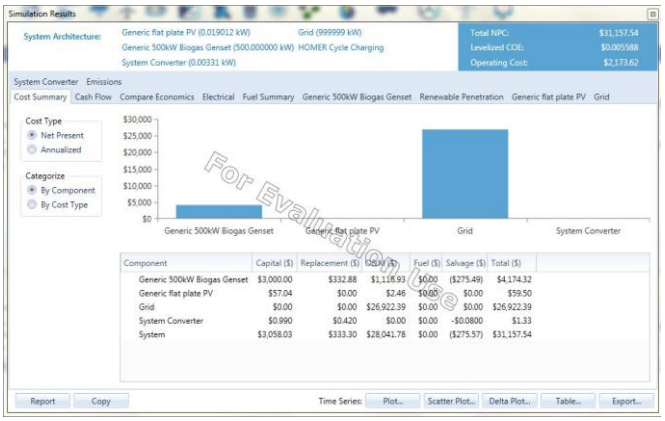

Fig. 13: Cost summary of PV-Biomass-grid system

We analyzed that the most amount of cost is spend on the grid system for operating and maintenance. Though in this system we are spending a capital cost of $3082 but we are reducing the cost of the maintenance and operation of the grid.

VIII. CONCLUSION

The results obtained by using Homer software can be very reliable and gives very efficient results for Hybrid systems[6]. The main feature of this software is, it will integrate the local climatic conditions and hence planning of energy model is simpler. In this paper the analysis has been given for systematic procedure towards to plan a Grid connected PV-Biomass based hybrid system and its Economic analysis including calculation of percentage savings, payback period analysis It is highly reliable and efficient for rural areas

like Bandhuguda which is connected with grid . The approach is very eco-friendly and economical.Initially these schemes need ample investments but the frequent usage of such schemes and wide acceptance of the technology can able to decrease the cost of such schemes.

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