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DESIGN AND COST ASSESSMENT OF HYBRID POWER GENERATION SYSTEM

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***Abstract*-The profuse energy convenient in nature can be harnessed and converted to electricity in a sustainable way to give the indispensable power demand and thus to elevate the live standards of the community with or without accessibility to the electricity grid. So as to productively and financially use the sustainable power source assets, one optimum match design sizing method is necessary. This paper deals with the designing and estimation of cost of the proposed model of hybrid system using software system HOMER. The 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 investment and power dependability demand of the hybrid system can be optimized and can be effectively implemented for rural electrification.**

Keywords- solar, biomass, hybrid system, HOMER.

I. INTRODUCTION

A Software system "Hybrid Optimization Model for Electric Renewable" developed by the National Renewable Energy Laboratory within the United States. Off-grid and on-grid power systems design for remote, stand-alone and distributed generation applications to obtain technical and economic options effectively, HOMER software system is employed. An outsized range of technology choices are permitted to account for energy resource availableness. The optimization model simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. Before designing a system, many decisions about the configuration of the system were made such as type of the components to include in the system design, size and utility of that component according to the availability of recourses. Even though the large number of technology options and the variation in technology costs and availability of energy resources make these decisions difficult. Optimization and sensitivity analysis algorithms in the software make it easier to assess the many possible system configurations [3] [10].

HOMER simulates the operation of a system by creating energy balance calculations for every of the 8,760 hours during a year. For each hour, HOMER compares the electrical and thermal demand within the hour to the energy that the system will provide in this hour, and calculates the flows of energy to and from every element of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries. This software performs these energy balance calculations for every system configuration that needs to contemplate [3] [12]. It then determines whether or not a configuration is possible, i.e., whether it can meet the electric demand under the conditions that you specify, and estimates the cost of installing and operating the system over the period of the project. The system economic calculations account for prices like capital, replacement, operation and maintenance, fuel, and interest.

Optimization: HOMER displays a list of simulating all of the attainable system configurations, sorted by net present cost (sometimes called lifecycle cost), that can be used to compare system design options.
Sensitivity Analysis: Once sensitivity variables as inputs outlined, HOMER repeats the optimization process for each sensitivity variable that will be specified.
For example, if outlined wind speed as a sensitivity variable, HOMER can simulate system configurations for the variation of wind speeds that was just specified [1] [7].

Hybrid power systems combine two or more energy conversion devices, or two or more fuels that when integrated, overcome limitations inherent in either [8]. The table 1.1 shown below compares the different issues related to renewable energies technologies for the consistent supply. Because of this intermittent nature (solar, wind, hydro, biomass), different technologies are integrated to create a hybrid system to overcome the limitations. There are number of benefits of hybrid system which can be outlined as [9]:

- Improved reliability and energy services
- Reduced emissions and noise pollution
- Continuous power can be supplied by incorporating batteries and backup system.
- Increased operational life and reduced cost of maintenance and transportation.
- Efficient use of energy

Recent researches and development of non-conventional energy sources have shown valuable potential as a form of contribution to conventional power production systems. There is a vast possibility for utilizing renewable energy sources, for example solar power, wind power or micro-hydropower to supply a quality power supply to distant areas.

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Table 1: comparison between renewable technologies [6]

	Land condition for power generation	Power generation stability	Issue
Solar power	Wide open land to secure a large amount of sunlight	Dependent on the amount of sunlight	Power cannot be generated at night
Wind power	Place where strong winds blow constantly	Dependent on the volume of air flow	Low-frequency noise caused by windmills
Hydro power	Place where a dam can be constructed	Influence by the amount of rainfall	Risk of waterside environmental destruction
Geo-thermal power	Hot springs where vapor can be obtained	Dependent on magma activities and springhead	Locations are limited
Wave power	Coasts where sea routes and fishery industry are not compromised	Dependent on wind and tides	Low diffusion rate- high cost
Tidal power	Coasts where sea routes and fishery industry are not compromised	Relatively stable	Low diffusion rates- high cost
Biomass	Thermal power plant and plantation are needed	Equivalent to thermal power generation	Competition with food, depending on cultivation method

II. HYBRID SYSTEM MODEL

Designing of hybrid system is completed by optimization model for electrical renewable software (HOMER). The proposed system contains solar power, biomass power with battery storage system for storage of excess generated electricity. Converter system connected between AC and DC link.The system was designed majorly with PV modules and remaining with biomass, battery ,diesel or other conventional as well as non conventional resources but the primary target was to achieve 100 percent electricity supply through renewable energy. The system manly consists of 5 kilo watts (kW) PV, 6 kW converter, 8 batteries, and five single 1 kW biomass generator [12].

The main feature of simulation in Homer is choosing the acceptable sizes of the sources to fulfill the daily load curve pattern of the system. As shown in fig.1 the load is having an average load of 70kwh/day and the peak load is 9.7kw. Hence the size of the PV, biomass generator, battery and converter are matched with the load patterns. The fig 2 shows the daily load curve of the consumer. Once the load profile has uploaded in to the Homer software, the software simulates according the availability of the solar power. However, it will depend on the location of given area. The main feature of the Homer software is it will gives the availability of solar insolation once the area latitude and longitude has given as shown in the fig2a. Once the solar is accessible for load pattern; then schedule of the solar energy is obtainable and in addition to it at what time periods the solar PV will works also available. The remaining time periods the biomass generator or diesel generator according to the availability has to be operated.

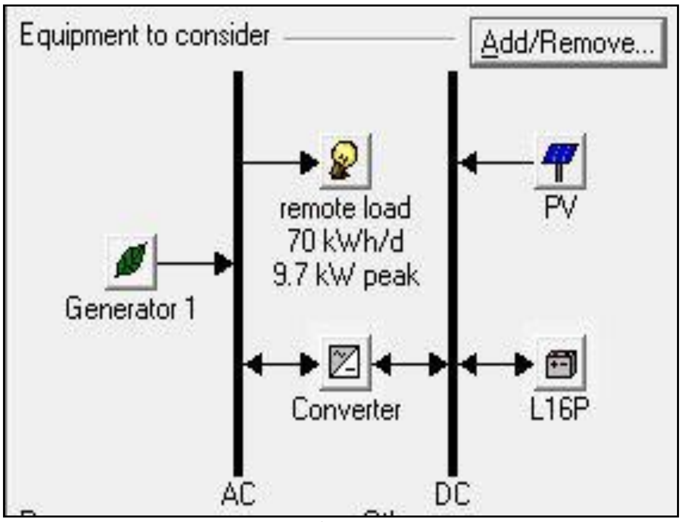

Figure 1: Basic setting of loads and sources in Homer

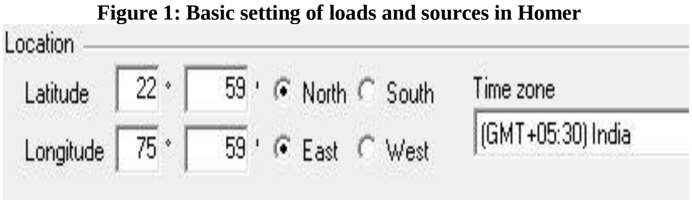

Figure 2a: Solar location data entry

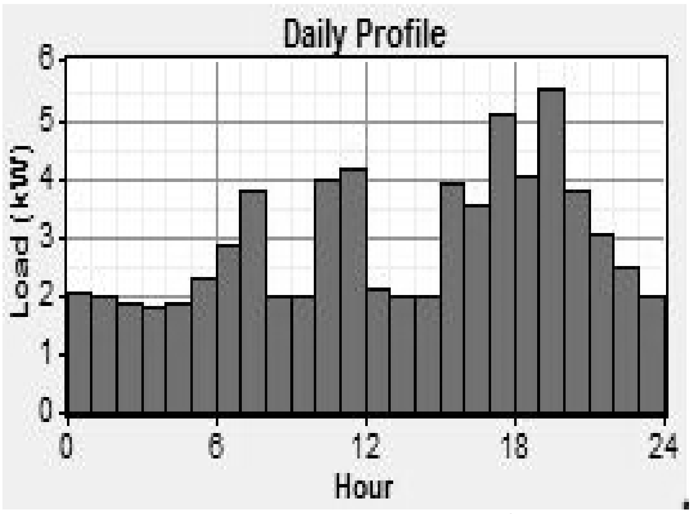

Figure 2b: Typical Load Profile

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Production	kWh/yr	%
PV array	12,127	39
Generator 1	18,579	61
Total	30,705	100

Figure 3: Percentage share of PV-Biomass

III. SYSTEM MODEL ASSESSIBILITY ANALYSIS

COE (Cost of Electricity) of Designed system: The obtained optimum COE from the designed system is $ 0.412 $/ kWh, and is as shown in the Fig. 6.

Monthly Average Electricity Production: The average monthly electricity production of the proposed system is as shown in the Fig.4 and fig.5. Among COE (Cost of Electricity) of Designed system the obtained optimum COE from the designed system is $ 0.412 $/ kWh, and is as shown in the Fig. 6.

Monthly Average Electricity Production: The average monthly electricity production of the proposed system is 3.4KW as shown in the Fig.6. Among the output from the modeled system 39% of the electricity was supplied through PV, whereas the remaining load was supplied through biomass generator.

Cash Flow Summary: The cash flow summary of the proposed system is as shown in the results. Initially, a capital investment of $ 39,112 for PV modules, $68,381 for biomass generator, $20,374 for batteries, and 6,328 for converter is necessary to establish the proposed system. By observing fig 3 the load met by PV array has 12,127kwh/yr and biomass is 18,579 kwh/yr. In other words the percentage shared by PV array is 39% and by biomass is 61%. But care should be taken that the dependence on PV array should be more and biomass will be less. The installation cost of PV array is high but, the operation and maintenance cost of PV array for the life span of 25 years will be almost nil except the change of batteries for every 5 years[2][7]. In case of biomass generator the initial cost of the generator is less, but every day procuring the 250 tons of biomass feed and the maintenance and operation of biomass for the 25 years will be more [3]. The initial cost of the PV and biomass is around 134,195$ and the total no. of units generated from the system is 10,136 kwh/year and the commercial rate of one unit is 7Rs [1] [11].

Successful stories had already been obtained with hybrid systems worldwide. Rural communities not connected to the public grid, lacking resources to compete with the fuel prices or with unused diesel infrastructures, found PV/diesel hybrid systems the most suitable, environmentally friendly and cost effective solution for power supply [4].

A PV/diesel hybrid system had been installed in Tanzania in 2006 Provides electricity to several households, community services (school, clinic, public lighting), small workshops, cabinetmaking, and technical equipment. In 2000, PV/diesel hybrid system had been installed in Algeria Provides electricity to 12 households and community services (school, health Centre).A PV/wind/diesel hybrid system in China Provides electricity to 3 villages composed of 500 households, community services (clinic, school, postal office, and TV transferring station) and a tourist facility in 2002.

Cotton mill Alpine Knits located in Palladam (Tamil Nadu) had been using diesel fuel generators to ensure a reliable power supply for their production site during power outages and experienced huge operation expenses resulting from the fuel consumption. Then the cotton mill operators had decided to install a PV panel on the rooftop of their factory workshop to reduce their bills which started producing inexpensive energy in June 2013. Hence, the PV diesel hybrid system operates reliably even when the grid fails.

IV. CONCLUSION

Hybrid systems capture the best features of each energy resource and can provide grid quality electricity with power range of 1 Kilowatt (KW) to several hundred [4]. Also they can be developed as new integrated designs within mini as well as micro grids. The optimization Homer software can be employed to obtain very promising results for Hybrid systems. The main feature of this software is that it will integrate the local climatic conditions and hence planning of energy model is simpler. In this project the analysis has been given for systematic procedure towards to plan a PV-Biomass based hybrid system and its Economic analysis including calculation of percentage savings, optimized design, and cost of electricity etc. the power problems of remote areas which are not accessible to the grid can be easily solved. Initially these schemes may not be economical however; the frequent usage of such schemes and wide acceptance of the technology can able to decrease the cost of such schemes.

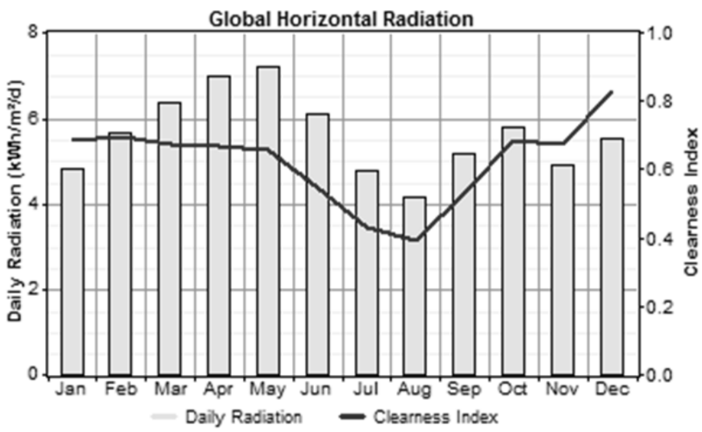

Figure 4: Daily solar radiation data

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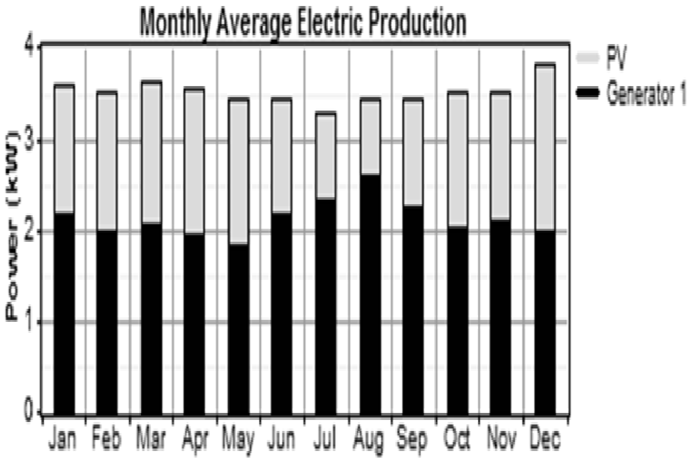

Figure 5: Monthly average electrical power production

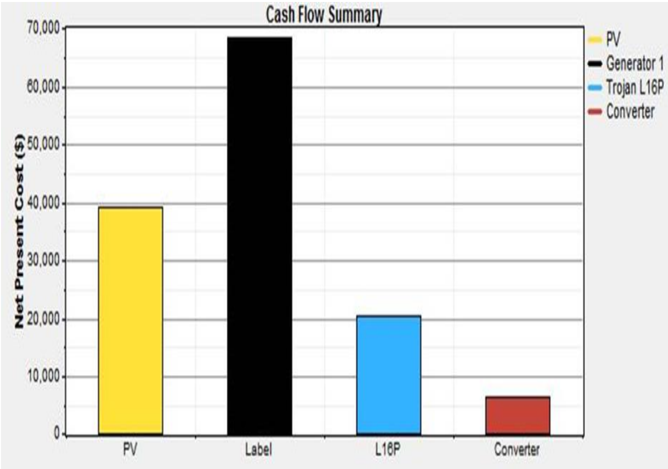

Figure 6: Cost summary of different components

Sensitivity Results | Optimization Results

Double click on a system below for simulation results.

	PV (kW)	Label (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Biomass (t)	Label (hrs)
	5	5	8	6	$ 50,215	6,569	$ 134,195	0.412	1.00	177	5,701

Figure 7: Optimum cost of electricity from designed system

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