Computational Simulation and Optimization of Poly-Generation System Using Homer Pro

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Abstract

Apart from access to electricity, clean drinking water and clean energy are genuine needs of inhabitants in rural areas. This could be achieved either by individual or integrated approach. This paper shows a poly-generation system for providing access to electricity, cooking demand and safe drinking water to a remote village of India. HOMER PRO is a design tool for simulation which analyses the sizing and price of various components of hybrid system. Techno economic analysis of system is also performed in HOMER for obtaining the Levelized cost of electricity (LCOE), energy balance, cooking gas as well as nominal cash flow. The simulation results optimum sizing of components as Biogas generator (5kW) – solar PV (5kW) – with battery storage and Levelized cost of electricity is about 0.193 $/kWh.

Keywords- HOMER PRO, Poly-Generation, Biogas, solar, Off-grid

Introduction

India ranks seconds in population, with increase in population demand for power, clean drinking water, cooking energy also increases at tremendous scale resulting in power crisis. India has still more than 5% population with no access to electricity. India Power sector is much dependent on fossil fuels for generation of electricity with traditional technologies. Total installed capacity of country is 322.88 GW with 62% contribution only from coal. Country has huge potential of renewable source which need to be explored to get clean energy.

More that two-third of inhabitants in rural areas still use biomass as cooking fuel which results in huge smoke and other harmful flue gases. [National Sample Survey Office (NSSO), 68th Round]. Poly-generation system is current demand of time which serves multiple activities such as cooking, water and electricity demand, it includes decentralized off-grid hybrid system from renewable resources

Objective

The poly-generation system is proposed for satisfying cooking, clean water and electricity demand of a small tribal village “dheeya” of Rajasthan, India. The current status of village is completely un-electrifiedand inhabitants have no access to clean energy and water. The village could be located on map with Latitude 24.110372 and Longitude 73.194740 coordinates.

Load Profile Of Site

Based on questionnaire the load demand is calculated for village. The electricity for household demand includes lightning lamps, fans, Television sets etc. The major consumption of electricity is for water purification system. Monthly load profile for average load demand of 44.3 kWh/day is obtained by HOMER as shown in figure 1.

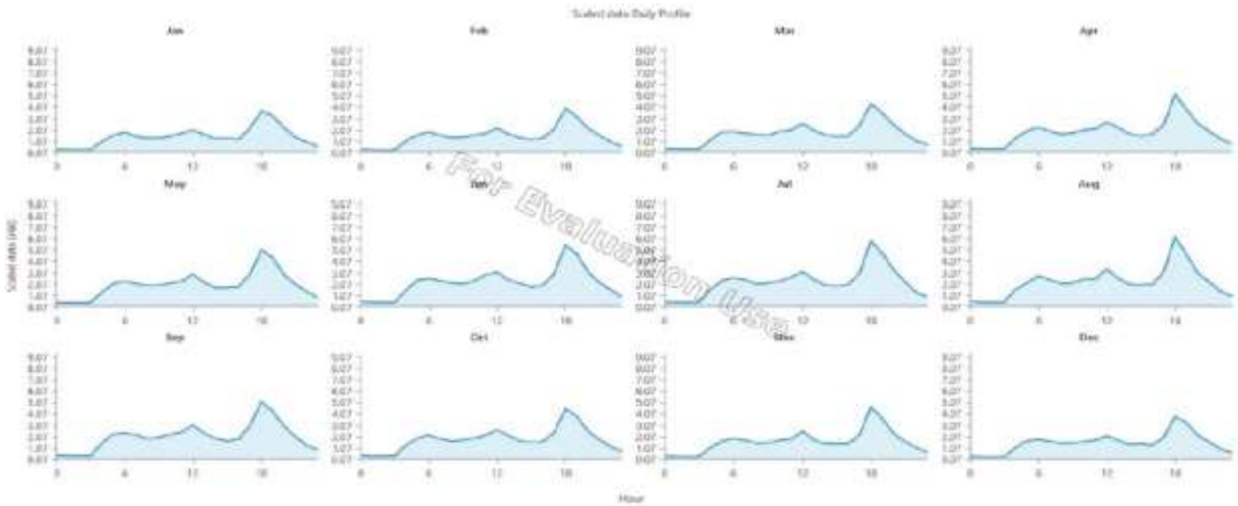

Figure 1:Monthly load profile for a village

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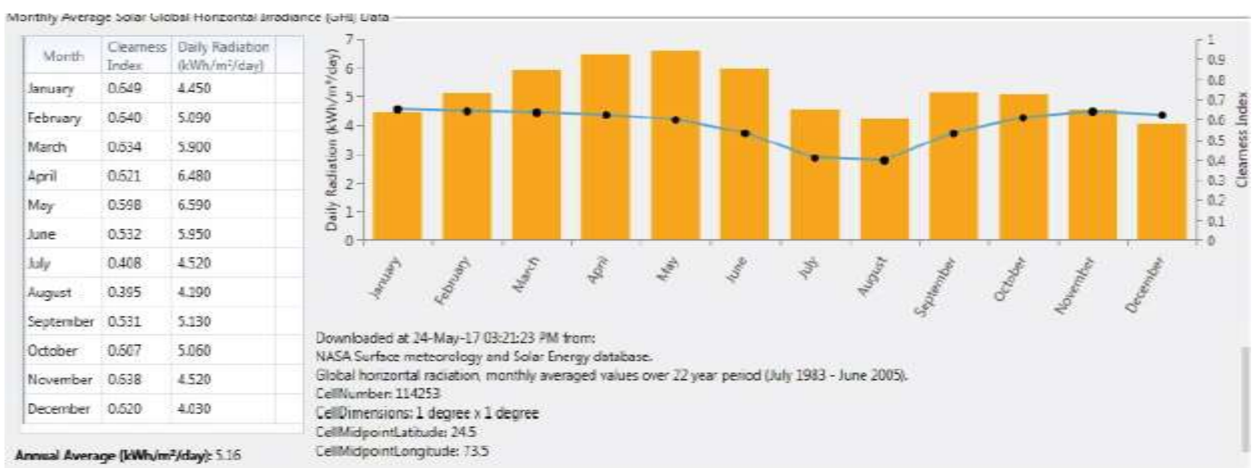

Figure 2: Monthly solar global horizontal irradiance data

Resources data available for village is obtained from NASA surface Meteorology and other energy related government sites. Monthly average solar global horizontal irradiance (GHI) data, Monthly average wind speed data and Monthly average temperature is shown in figure 2, figure 3 and figure 4 respectively.

Figure 3: Monthly wind speed data

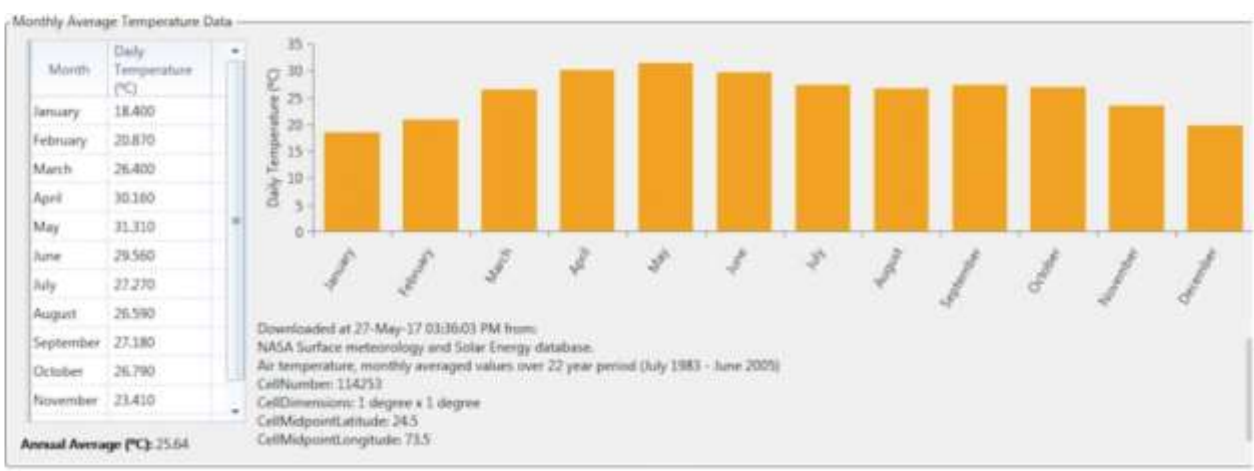

Figure 4: Monthly average temperature data

Homer Pro Simulation Model

HOMER PRO performs the simulation and chooses the most winning size configuration for different components of hybrid system. It also analyses the energy flow, Levelized cost of electricity (LCOE), Net present cost (NPC) for the most optimum configuration of hybrid system. The system cost accounts for costs such as capital, operation and maintenance, replacement, fuel and interest. The simulated model designed for village is consists of Biogas generator, solar PV modules, converter and battery storage. The design model of hybrid system is shown in Figure 5.

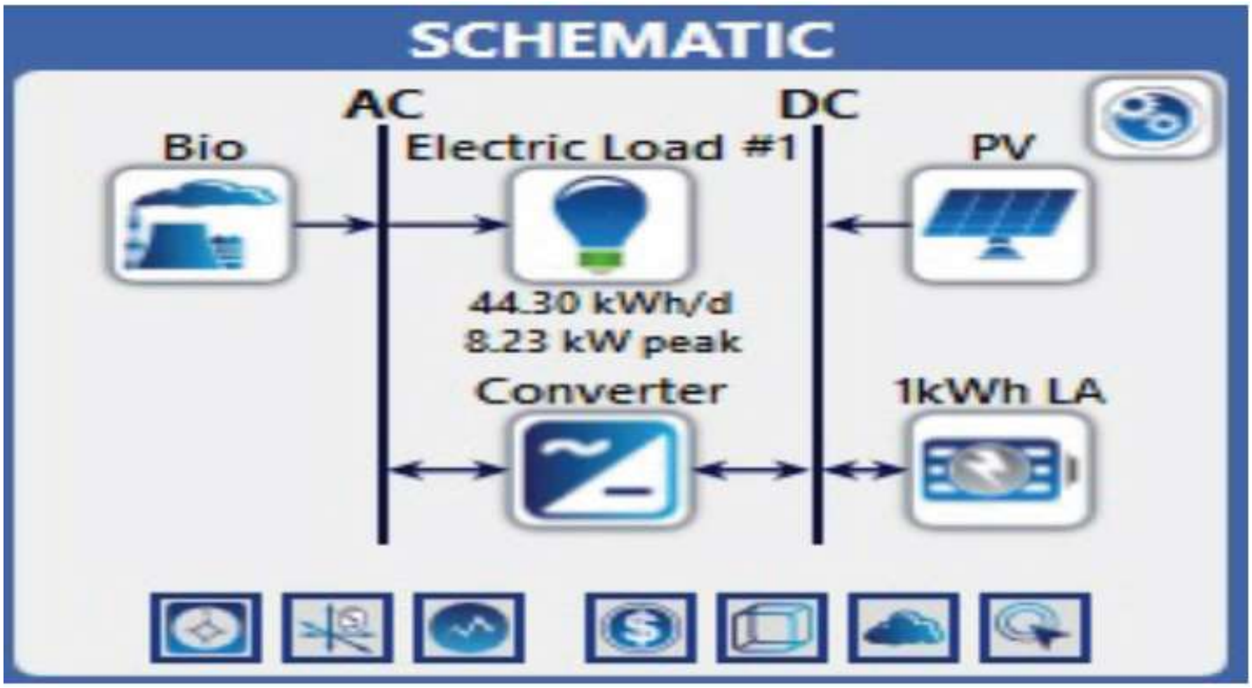

Figure 5: HOMER model for hybrid system

Cost Optimization

HOMER PRO simulates a different configurations of hybrid system in search space, and sorts out configuration having least cost within each category of system. The system cost includes the cost of it components i.e. solar PV system cost, Biogas generator cost, convertor cost and battery storage cost.

Various inputs to HOMER PRO includes electrical load profile for one year, renewable energy sources, capital cost, replacement cost, operation and maintenance cost of its components, technical aspects, constraints etc. More accurate we provide inputs better will be results.

Results

For the optimum results of hybrid system, capacity of its components is allowed to vary in range. Biogas gen set provided with capacity range of 5 to 10 kW. Similarly, capacity range for PV module is 0 to 10 kW. Optimized size of components of hybrid system obtained from HOMER is shown below in Table 1**.**

Table 1: System Architecture

PV	Generic flat plate PV	5	kW
Generator	Generic Biogas (size your own) genset	5	kW
Storage	Generic 1 kWh Lead Acid	16	Strings
Converter	System converter	4	kW

Table 2: Electricity Production From Hybrid System

Component	Production [kWh/year]	Percent (%)
PV	8191	42
Generator	11234	58
Total	19424	100

As shown in Table 2, total production of electricity by hybrid system is 19,424 kWh/year. whereas the AC primarily load of village is 16,165 kWh/year. So there is about 1,253 kWh/year excess production of electricity. Monthly production of electricity by PV and Biogas is shown in figure 6.

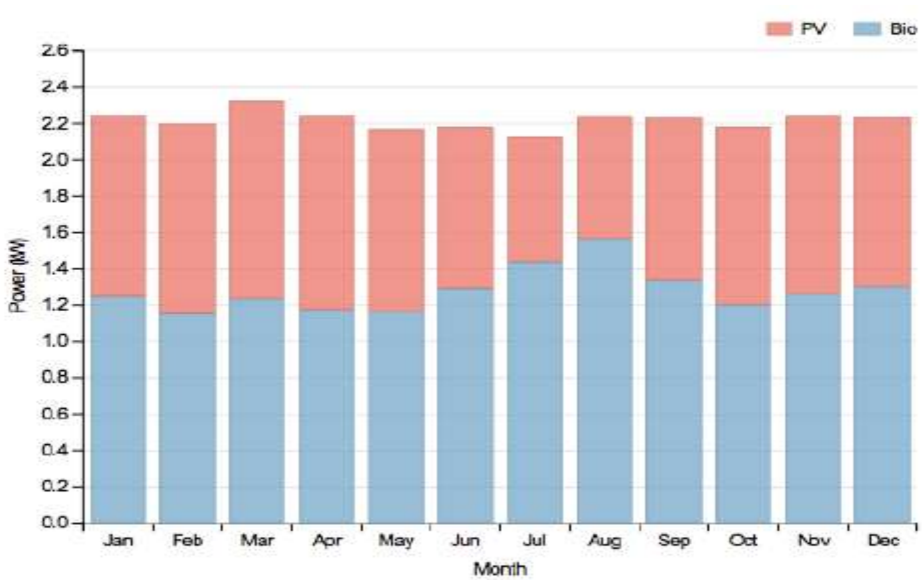

Figure 6: Monthly production of electricity from Hybrid system

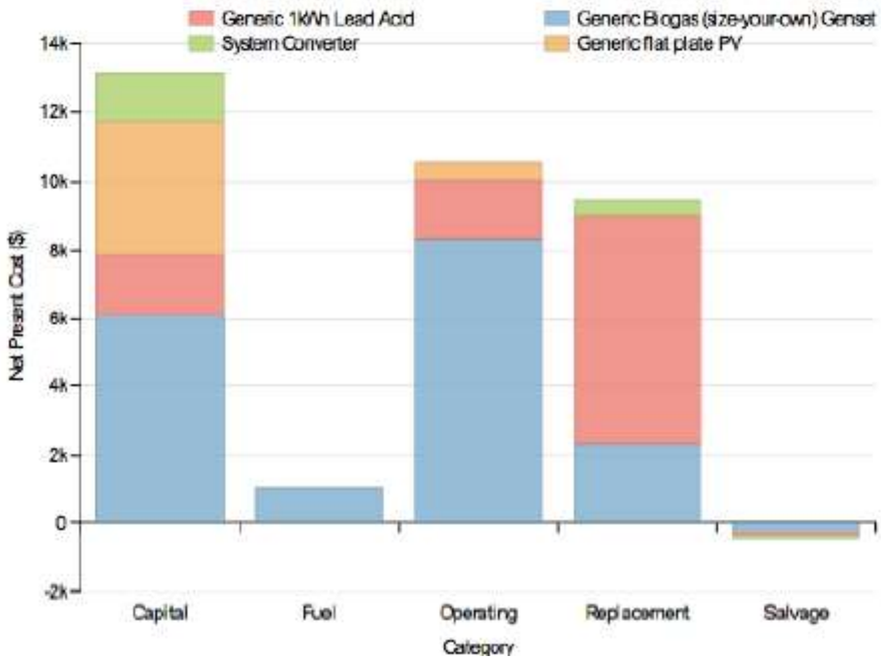

Figure 7: Net present cost of hybrid system

Total net present cost of hybrid system is 33,805 $. The Net present cost of system which includes capital cost, fuel cost, operating and maintenance cost, replacement cost and salvage of different components of hybrid system is show in figure 10. It could be noticed that the capital cost as well as operating cost Generic Biogas genset is high as compared to solar PV. The replacement cost is high for lead acid batteries as they have short life period. The Levelized cost of electricity of hybrid system is 0.193 $/kWh

Conclusion

This paper presents a simulated and optimized result of hybrid system having Biogas genset and solar modules with battery storage for satisfying energy needs of inhabitants. The Levelized cost of electricity of hybrid system is $ 0.193/kWh and Net present cost is 33,805 $. There is excess generation of electricity which could satisfy if the demand for energy enhances in future. The production of Biogas from digester plant is higher than daily fuel required for Biogas genset which is about 60 % of total fuel. Remaining 40 % could be used to supply as a cooking fuel for households. The result of HOMER clearly reflects that the optimum size of Biogas genset (5kW) and solar PV (5kW) with battery storage serves load demand of village completely without any interruption.

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Rupinderjit Singh was born on January 9, 1969. He received his B. Tech in Electrical engineering degree from Punjab University Chandigarh in 1990 and M. Tech in Power Engineering degree from Punjab Technical University, Jalandhar, Punjab, 2008.