International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Simulation of PV – Bio – Hydro – Battery Connected Hybrid Power System for Rural Area

Jagtap R. S.[1], Waghmare P. M.[2], Kulkarni V. V.[3], Hake P. V.[4], Kundankar R. R.[5], Ramgirwar S. S.[6]

[1,2,3,4]B.E. Scholar, Dept. of Electrical Engineering, Balaghat Engineering College, Ruddha, Maharashtra, India
[5,6]Assistant Professor, Dept. of Electrical Engineering, Balaghat Engineering College, Ahmedpur, Maharashtra, India

---

Abstract – *Hybrid energy for electricity production is better option for rural areas. It reduces dependency of conventional energy sources and irregular production of electricity from single renewable energy source. The objective of this paper is to fulfill electricity demand in rural areas using hybrid power system. This study discusses the simulation of hybrid PV – Bio – Hydro and battery connected system for selected rural village using HOMER (Hybrid Optimization Model for Electric Renewable) software and determines the best combination of renewable energy source in order to reduce size of hybrid power system at maximum efficiency. For this Simulation design metrological data of solar radiation is taken for Panahalghar village from solar calculator designed by ISRO and MNRE of India. The simulation results shows proposed hybrid power system can fulfills electricity demand at reduced cost of energy*.

Key Words: Hybrid system, Solar PV, micro hydro, Biomass, HOMER.

1. INTRODUCTION

Electricity is the backbone and necessary condition for a country to be developed in terms of economy and quality of lifestyle for the citizens. In many developing countries several billion of people do not have mandatory and vital public services due to non availability of electricity. In most cases, the expansion of electricity is either impossible because of geographic location or financial requirements in the extension or not enough demand. Although the conventional fossil fuel energy sources such as petroleum, natural gas and coal which meet most of the world's energy demand today are being depleting rapidly. Also, their combustion products cause climate change effect on the globe [1].

There exists scope to utilize renewable energy sources to meet the demand in rural and remote villages. Including urban and metro as support to grid system, however the renewable energy sources pose the problem of intermittency. For example PV generation is mostly available in day time and other sources such as small hydro power generation are available only in rainy season. Wind also source of variable power generation. When wind is available wind farm generate power and when is not available it does not generate problem. Therefore hybrid power generation is more efficient to generate power in remote and rural villages.

Hybrid energy systems are combinations of renewable, traditional energy resources and energy storage devices to meet load demand. Hybrid systems provide energy security and reliability through the integrated operation and often will incorporate a storage system (battery, fuel cell) and backup system (Generator) to ensure consistent supply [1 – 3].

In this paper off grid hybrid PV – micro hydro – biomass energy is proposed for small village named Panahalghar in Raigad District and it is modeled in HOMER software. The aim of this study is to develop the hybrid power system solution from the best combination of renewable energy technology that will use for the rural and remote areas to fulfill the electricity demand in reliable, affordable and sustainable manner.

The organization of this paper is as follows: the structure of proposed system is presented and the proposed structure is simulated in HOMER. Finally simulation results are presented.

2. STRUCTRURE OF PROPOSED SYSTEM

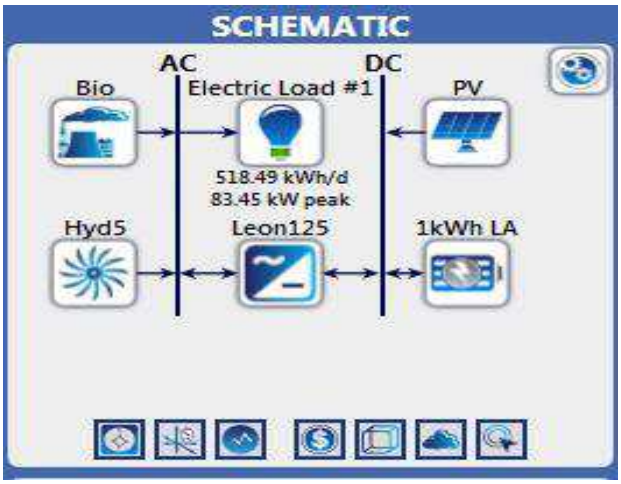

Fig -1: Structure of Proposed system

The structure of proposed system is shown in figure 1 Solar PV system, micro hydro and biomass are as a main source, battery is used to store energy for backup purpose and converter is used to convert electricity from DC to AC. In this system load is connected to AC line because it is more flexible, easily expandable and it offer flexibility for grid extension when necessary.

2.1Load Profile of Village

The major load in selected village is considered only domestic such as T.V., fan, small motor, lamps etc. the average demand of selected village is around to be 20 Kw and daily energy consumption 450 kwh per day. The figure 2 shows daily load profile of panahalghar village.

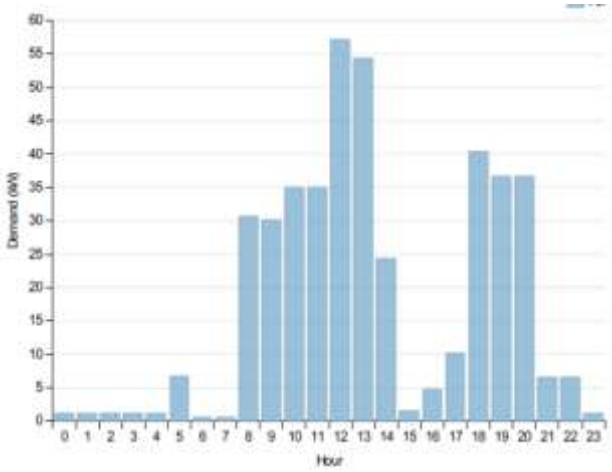

Fig -2: Daily Load Profile

3. RESOURCE ASSESSMENT:

3.1 Solar PV

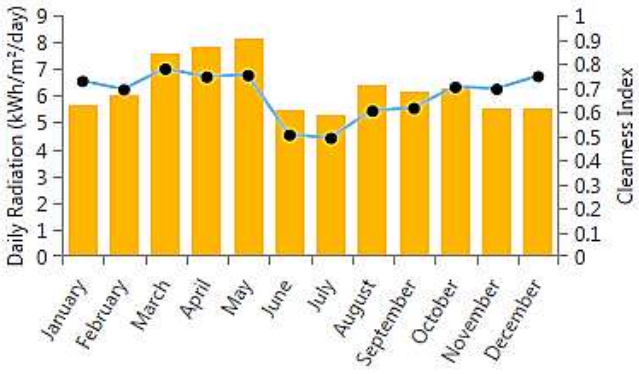

Fig -3: Monthly average of daily solar radiation.

Solar energy is non conventional source of energy. PV system converts photon from sunlight in to electrical energy. Output of PV system is dependent of solar irradiance and to perform simulation, HOMER requires daily solar radiation data. In this study, the solar resource information used for selected village at a location at 18° 10' 1" N latitude and 73° 21' 42" E longitudes was taken from solar calculator which is developed by Indian Space Research Organization (ISRO) and MNRE of India. The fig. 3 shows Monthly average of daily solar radiation.

3.2 Micro Hydro

A small dam is constructed near at Panhalghar named as Panhalghar dam. A small study is carried out on this dam. Catchment area of the dam is about 2.74 sq.km and gross head of the dam is 19m. Average rainfall of the last 20 year is about 3327mm. The discharge required for each month of the year for generation of power is calculated based on direct runoff generation using Average Rainfall Data. Fig.4 shows the monthly discharge of water.

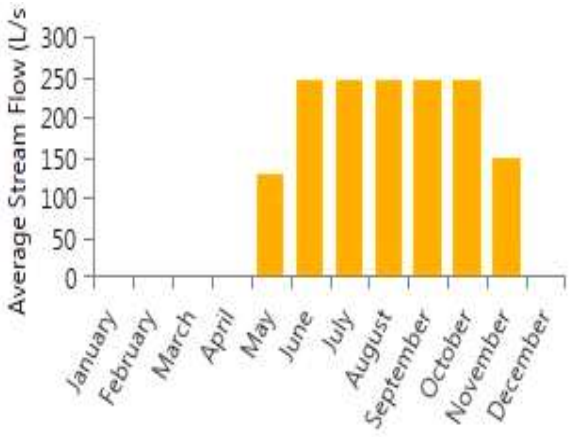

Fig -4: Monthly Discharge of water

3.3 Biomass Energy

Biomass is one the most important energy sources among renewable energies (REs). Different types of biomass are available in Panhalghar village like cattle dung, rice husk, rice straw and other wastages etc. About 65 hectors of land is available in Panahalghar village for agricultural purpose. Out of these 50 to 55 hectors of land rice is cultivated annually. The cultivation of rice results in two major types of residues straw and husk having attractive potential in terms of energy. Rice husk is used for power generation. The following table 1 shows monthly average of biomass available at the village.

Table -1: monthly average of biomass available

Month	Biomass (ton/day)	Month	Biomass (ton/day)
JAN	0.8	JULY	0.6
FEB	0.7	AUG	0.6
MAR	0.5	SEPT	0.6

APR	0.5	OCT	0.8
MAY	0.5	NOV	0.9
JUN	0.5	DEC	0.9

3.4 Component assessment

Table 2 shows the various technical and nontechnical parameters of component used in proposed system. Solar PV, biomass and hydro energy is considered as main source of energy and for backup storage battery is used.

Table -2: Technical and Nontechnical parameters

Solar PV system (per 1 kW)	
Capital cost	35000
Replacement cost	35000
O & m cost	3500
Lifetime	25 years
Micro hydro turbine (for 10 kW)	
Capital cost	40000
Replacement cost	20000
O & m cost	1200
Lifetime	25 years
Battery	
Range and capacity	48 V, 2080Ah
Efficiency	64%
Max. charge current	200 A
Max. discharge current	313 A
Capital cost	100000
O&M cost	10000
Convertor (per kW)	
Capital cost	600
Replacement cost	600
Lifetime	25
Efficiency	96

4. SIMULATION RESULTS

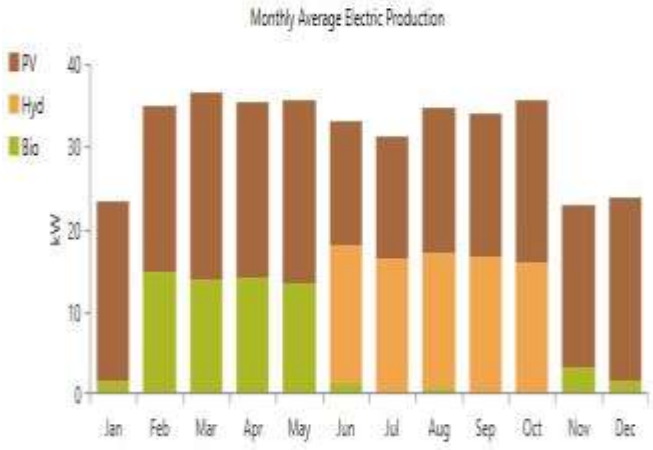

Fig -5: Monthly average electricity production

Fig 1 shows the simulation of proposed system. Various combinations of hybrid Systems has been obtained with Solar PV, Micro Hydro, Biogas, batteries and convertors from the HOMER optimisation simulation. Figure 7 presents a screen shot containing the summary of simulation outcomes.

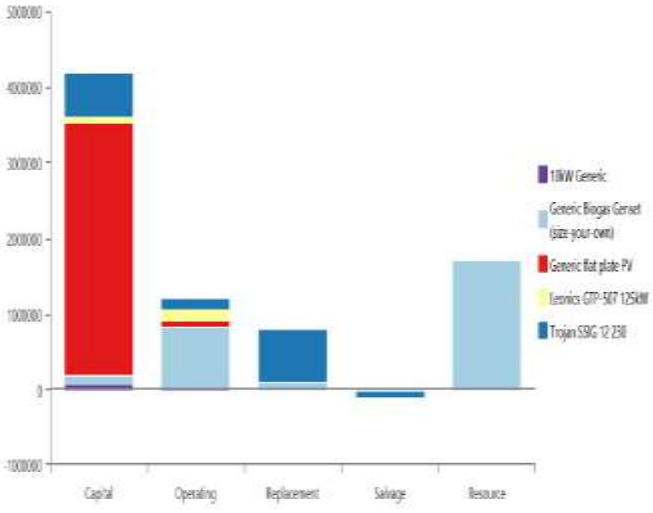

Fig -6: Cost flow summary

All possible hybrid system configurations are listed in ascending order of their Total net present cost. The best possible is shown in first rows of HOMER optimization result. Figure 5 shows monthly average electricity production. The Fig. 6 and fig, 7 shows the cost flow summary and total load and generation graph for optimal hybrid system. The table 3 shows detail generation and cost of each component of best combination of hybrid system

Table -3: Architecture of proposed hybrid system

Architecture	PV	80 kW
	Battery	132 batteries
	Hydro	15.7 kW
	Bio	30 kW
	convertor	74 kW
Cost	COE	1.91 Rs
	NPC	74.77462 Rs
	Operating cost	160000 Rs
Unmet load	Capacity Factor	23.6 %
	Levelized cost	0.957 Rs
PV	Mean output (kW)	19.1
	Capacity factor	23.6 %
	Levelized cost	0.957
Hydro	Mean output (kW)	6.86
	Capacity factor	43.7 %
	Levelized cost	0.0978
Bio	Mean output (kW)	15.8
	Capacity factor	16.3 %
	Fuel consumption (	32.4
	Fixed generation	27.2
Batteries	No. of batteries	132
	String size	4

PV (kW)	Bio (kW)	SSIG	Hyd (kW)	Leon (kW)	Dispatch	COE (₹)	NPC (₹)	Operating cost (₹)	Initial capital (₹)	O&M (₹)	Total (L)	Elec Prod (kWh/yr)	Hours	Product (kWh	Capital (₹)	Product (kWh)	Capacity	Mea
80.8	30.0	132	15.7	74.1	CC	₹1.91	₹7.48M	₹1,60,250	₹4.17M	₹61,380	32.4	2,69,978	2,721	42,919	32,33,110	1,66,930	15.7	6.86
116	30.0	244		73.2	LF	₹2.18	₹8.50M	₹1,19,125	₹6.04M	₹42,565	12.8	2,55,992	1,065	16,989	46,29,025	2,39,003		
160		360	15.7	128	CC	₹2.57	₹10.0M	₹77,670	₹8.42M	₹42,780	0	3,91,310			64,14,330	3,31,181	15.7	6.86
202		360		135	CC	₹3.06	₹12.0M	₹95,465	₹10.00M	₹43,212	0	4,16,341			80,63,717	4,16,341		

Fig -7: Summary of simulation result

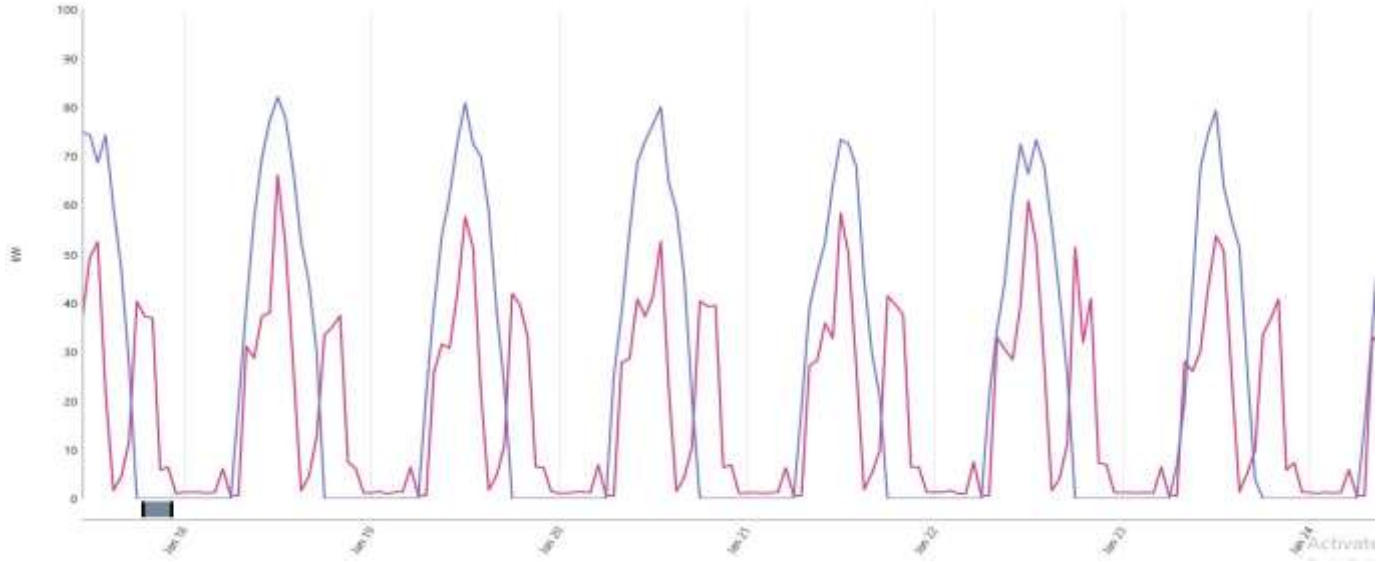

Fig -8: Total electrical load and electricity produced

5.CONCLUSIONS:

The objective of this study was to find a best combination of a hybrid power system to fulfill electricity demand in rural area. The hybrid system has been modelled in HOMER and simulations have been made to determine the best system which can fulfill the village load.The development of a technically feasible and economically viable hybrid solution for power generation of one village named Panahalghar bring out a least-cost combination of a PV, micro hydropower, biogas generator and batteries that can meet the demand. With the following capacities PV of 80.8 kW, hydro capacity 15.7 kW, and generator 30 kW respectively, estimated value of the levelized cost of energy obtained from the lifetime cost analysis is 1.91 Rs/kWh.

The max energy produced by PV 166.930 MWh/yr, Hydro 60.129 MWh/yr and biomass 42.919 MWh/yr. Project lifetime is considered around 25 years and Total NPC of system is Rs. 74.77 lakh, capital cost Rs. 41.7 Lakh, operating cost Rs. 1, 60,250 and cost of energy is around to be 1.91 Rs. /unit this is less than the current utility grid price of Maharashtra state. Finally it is concluding that hybrid system is technically and economically feasible and Environmentally Friendly Configuration.

REFERENCES

[1] Bahramara, S., M. Parsa Moghaddam, and M. R. Haghifa, "Optimal planning of hybrid renewable energy systems using HOMER: A review." Renewable and Sustainable Energy Reviews 62 (2016): 609- 620.

[2] Ravi R. Kundankar, Dr. P. K. Katt, "Hybrid energy system for remote and rural villages," 2018 International conference on Power, Energy, Environment and Intelligent control, Noida, Apr 13 – 14, 2018.

[3] Ravi R. Kundankar, Dr. P. K. Katt, "Hybrid energy assessment for remote areas." International Journal of Engineering Technology Science and Research Volume 4, Issue 11, November 2017ISSN: 2394 – 3386.

[4] Rohit Sen, Subhas C. Bhattacharya, "Off-grid electricity generation with renewable energy technology in India: An application of HOMER." Renewable Energy 2014; 62: 338-398.

[5] Omar Hazem Mohammed, Adel A. Elbase, "Optimal Design of a PV/Fuel Cell Hybrid Power System for the City of Brest in France." First International Conference on Green Energy 978 – 1 – 4799 – 3602 – 1/14.

[6] Vivek kumar soni and Prof. Ranjeeta Khare, "Optimal Sizing of HRES for Small Sized InstituteUsing HOMER." IEEE 2nd International Conference on Electrical Energy Systems (ICEES)978-1-4799-3739-4/14.

[7] HOMER® Pro Version 3.7 User Manual. Available at: https://www.homerenergy.com/pdf/HOMERHelpManual.pdf

[8] Census 2011. Available at: http://www.census2011.co.in/data/village/554711-panhalghar-kh-maharashtra.html.

[9] ISRO Solar calculator android app. Available at: https://www.isro.gov.in/isro-develops-solar-calculator-android-app.

[10] Fathima A. H., Palanisamy K., "Optimization in microgrids with hybrid energy systems" — a review. Renew Sustain Energy Rev2015; 45:431–46.

[11] Banosa R, Manzano-Agugliarob F, Montoyab FG, Gila C, Alcaydeb A, Gómezc J. "Optimization methods applied to renewable and sustainable energy" — a review. Renew Sustain Energy Rev 2011; 15:1753–66.