Economic Feasibility Analysis of Hybrid Energy Systems for Remote Area Electrification

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Abstract

This paper proposes a hybrid power generation system application for remote area. The complete analysis of hybrid power generation for remote area electrification is performed which gives the cost analysis, power optimization using the software HOMER PRO. The performance of proposed system is compared with the metrological data for the optimizing the hybrid renewable energy system at the villages of KORBA. The two villages which are considered are senha and (pahadgawn) pali. There is two proposed energy system; the first one consist of PV module alone and second one consist of PV module with hydro i.e. hybrid power station. Also the second site is first optimized with PV alone only and then hybrid with the hydro. Both the optimization PV alone and hybrid PV-hydro is compared.

I. Introduction

Chhattisgarh is the middle heart of the India which belongs to one of the Asian countries. Chhattisgarh is the state of power but in some places of the Chhattisgarh, we are facing some troubles in the field of electricity such as in some mountain/hilly areas and some forest area or in some remote villages. We have presented here the survey report of one of the type of village area which is facing problem of power crisis. Senha and Pahand Gawn (in pali) are such type of two places which are located in korba district at Chhattisgarh in geographical map of the world between 22°,35' N latitude and 82°,75' E longitude. Demand of electricity is increasing day by day with the importance of living standard, development of industries, development of agriculture production as well as progress of country. Due to the failure in the generation of power capacity as per the demand. That is why, to reduce uprising demands other options are preferred.

The first module consists of PV panel, battery for Storage and power converter. The Second module consists of PV panel, battery for Storage, hydro unit and power converter. All the data of (senha and (pahadgawn) pali) KORBA is taken from NASA (National Aeronautics and space Administrator). Also the flow rate data of hydro is taken from the madwa plant champa and darri plant KORBA. The same capacity hybrid system is developed in HOMER software and a complete cost analysis is compared for both the systems.

II. Survey Optimization Report

A. Survey An effective survey should be planed carefully and maintain all the legal liability. As survey is come to find the crisis of power, present energy, life style and the sources available there etc. The survey report of all the data is collected from the village senha and pahand gawn where the people have very simple way of living. The houses present in these villages are 50 to 95 respectively. The report is briefly discussed according to the study.

B. Overcome of Survey

The outcome of the survey is presented in table 1 and table 2 respectively for both the sites. The data is obtained from the CREDA.

Table 1: - Profile of location -1 (PV system alone)

NAME	Senha (KORBA), Chhattisgarh, INDIA
Latitude & Longitude	22°,35 N, 82°,75 E
Total number of houses	50
Average numbers of family members	05
Total Population	250
Load Present	0 Kw

Table 2: - Profile of location -2 (PV/hydro hybrid system)

NAME	Pahand (Pali), KORBA, Chhattisgarh, INDIA
Latitude & Longitude	22°,35 N, 82°,75 E
Total number of houses	95
Average numbers of family members	05
Total Population	475
Load Present	5 Kw

C. Load Estimate

The load estimation of the selected site is presented in table 3. The data elaborates the actual existing load of the area and the required load as per the survey for both the areas.

Table 3 – Load estimation of selected rural areas

Rural Area	Actual Existing Load	Required Load as Per Survey
Location -1 (senha)	0 kW	13.20 kW
Location -2 (pahandgawn)	5 kW	27.647 kW

The experimental data and research analysis gave as brief information about the solar energy and micro hydro energy distribution in korba district at two different locations senha and Pahand Gawn and it help to develop hybrid renewable energy system consisting of hydro and solar that is constantly replenished. Lots of village in India are undeveloped and they have not transportation, no sufficient communication, no reliable energy source therefore such type of hybrid system are useful for fulfilling their energy requirement.

III. Simulation of Proposed System

In this section base on the survey report for the two rural sites as per the availability of solar radiation and water source standalone and hybrid system has been adopted. The system is designed to fulfill the power requirement of the remote as per the survey report of the two specific rural sites located in KORBA District. Also the cost optimization is performed in HOMER software for all the three proposed system i.e PV alone for senha site., PV alone and hybrid PV/hydro for Pahand Gawn. From the survey report it is clear that the load required for the Senha Site is 13.20KW and Pahand gawn is 27.64 KW.

An autonomous renewable energy system is designed using Solar and Solar/hydro resources. **Figure 1-4** shows the HOMER implementation of the designed model which shows the implementation of the proposed model. PV indicates photovoltaic cell which is connected to the DC grid and hydro resources are connected to AC grid. The Generator on the figure is the hydro generator and its run using water sourceas fuel. A bidirectional converter is used which can be used both as rectifier and inverter. The battery used as storage system of the system connected to DC grid which can store extra energy produced from grid and PV.

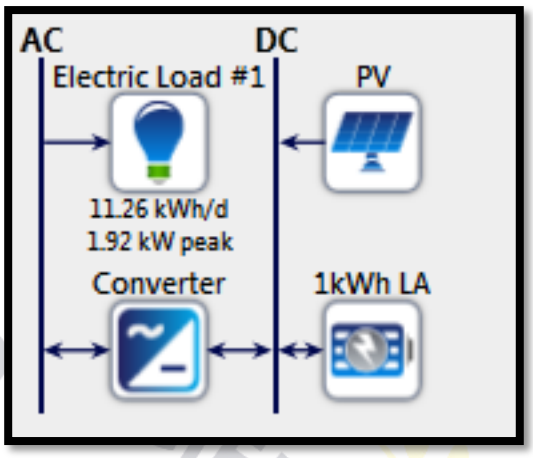

Figure 1:- HOMER Implementation of PV system Alone (Senha Site)

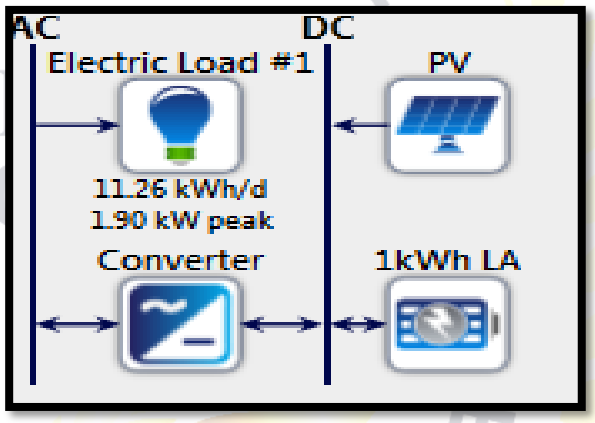

Figure 2:- HOMER Implementation of PV system Alone (Pahand Site)

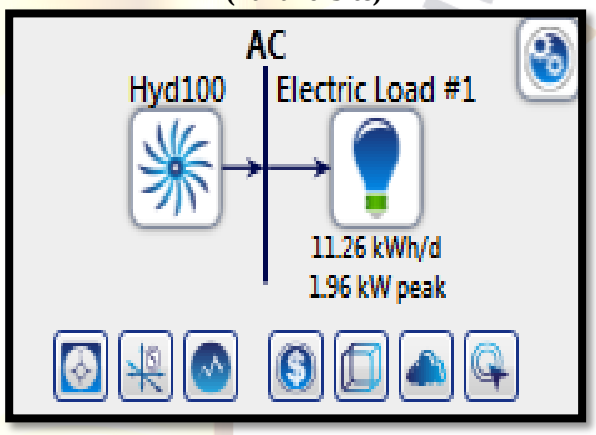

Figure 3:- HOMER Implementation of Hydro system Alone (Pahand Site)

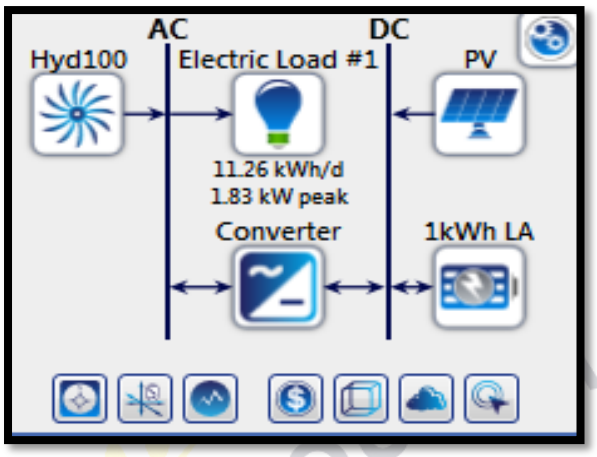

Figure 4:- HOMER Implementation of Hybrid PV/Hydro systems (Pahand Site)

IV. Results & Discussion

The implemented model with proper data for both the rural locations shows the optimization analysis of the system. The four different energy models are simulated in HOMER for the selected systems based on the site survey. The cost analysis is performed in this section with overall comparison of all the four systems. The results show the equipment sizing, total net present cost (NCP), initial cost, fuel cost, operation and maintenances cost (O&M), total fuel. Cost analysis is a technique used to compare the total cost of a proposed system for the two locations with its benefits, using monetary unit. This enables the calculation of the net cost or benefit associated with the program. Analysis the cost of the particular project is essential to appraised and compared, as an option for choosing the best approach. A specific approach is followed for the entire cost analysis process that has been done. In this entire analysis process the detail costing information for individual equipment, maintenance and operation cost, and fuel cost have been discussed. The optimized results are presented in table 4.

Table 4: Optimized cost analysis of alone system and hybrid system

Rural Area Location	Cost/NPC (Rs.)	Cost/ COE (Rs.)	Cost / Operating cost (Rs./yr)	Cost/Initial capital (Rs.)
PV alone Senha Site	71642.28	1.34956	595.7449	63940.78
PV alone Pali Site	55898.4	1.053144	1166.055	40824.2
Hydro alone Pali site	638180.1	12.01377	13795	459845
Hybrid system Pali site	638180.1	12.01377	13795	459845

The energy model implemented for proposed site as selected are simulated. The system consists of Photo voltaic system, LA battery, Converter, DC bus, AC bus and load. The optimization is performed in HOMER The overall cost optimized results are presented in table 5. Figure 5-8 shows the cost analysis of selected Site with PV alone & PV/hydro systems.

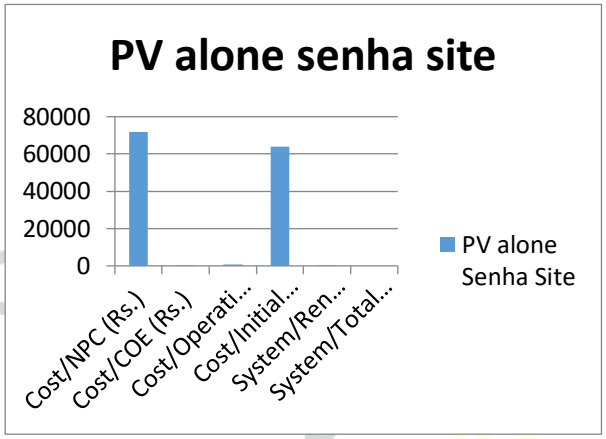

Figure 5: Optimized cost analysis of PV alone system Senha Site

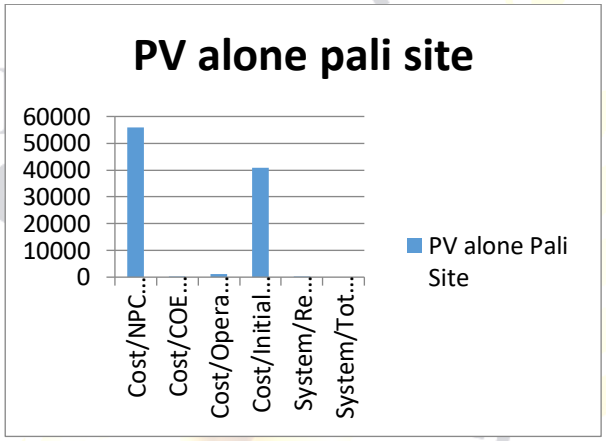

Figure 6: Optimized cost analysis of PV alone system Pali Site

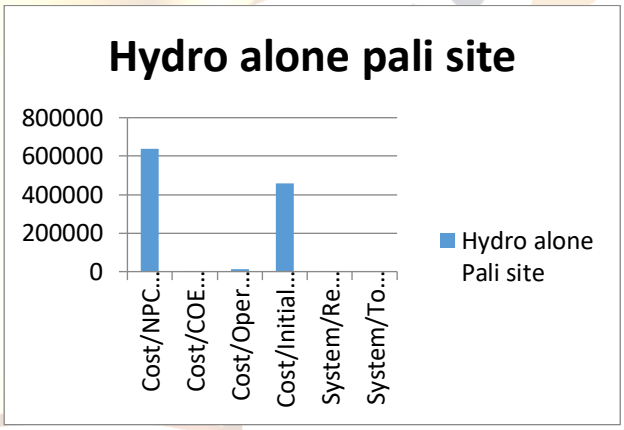

Figure 7: Optimized cost analysis of hydro alone system at Pali Site

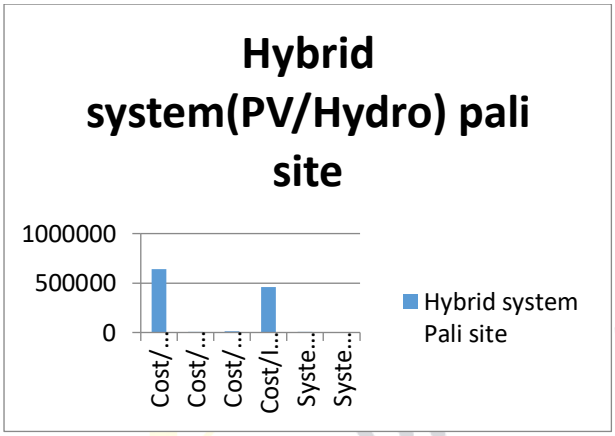

Figure 8: Optimized cost analysis of hybrid system at Pali Site

Comparative optimized cost analysis

The major power produce in the Chhattisgarh as energy solution run by thermal units and now its reservations is also under the threat. The availability of coal and CO_2 emission is a great threat to the power sector thus an alternative energy solutions are necessary to adopt. Economy of the country tremendously affected by electricity crises and resource of energy as well. To moderate the dependency on conventional source and to decentralize the power system, RET could play vital role in this regard. There are lots of locations and opportunities to establish RES based power plants- which can solve the major electricity problem in INDIA. In this work, through analysis and development the autonomous hybrid renewable energy system power plant can provide a better solution towards developing a sustainable energy solution for rural INDIA. The comparative cost analysis is performed and it is clearly observed from the figure 9. From the figure for all the four systems of two rural sites NPC, COE, Operating cost, Initial Cost and fuel cost is compared individually. The overall cost of the hybrid system (PV/Hydro) is less compare to the alone PV system and Hydro System i.e. approx 1,111,832 Rs.

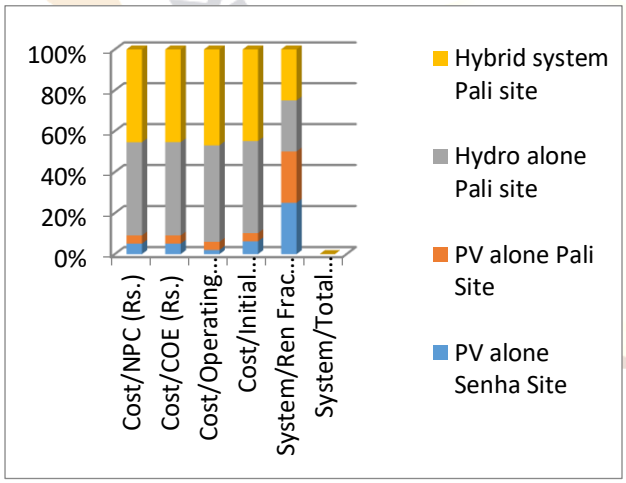

Figure 9: Optimized comparative cost analysis of proposed system

V. Conclusion:

Simulation, modeling and optimization were performed in this study to design a hybrid off grid power system to meet the electric loads of 50 houses in Senha and 90 houses in Pali. The micro grid hybrid power system includes two power generators; solar PV power system for Senha site and PV alone, hydro alone and Hybrid system integrated with batteries and inverter for pali site. Input information on the primary loads, solar resources at both sites are survey, the technology options, component cost, constraints, and controls were determined. Simulation and optimization analysis was used to test the performance and the cost of the proposed hybrid micro grid system. The results show that the solar PV system alone fulfills the requirement of 50 houses in senha site. Solar PV/hydro Generator/Battery/ Inverter power system meets the yearly electrical demand of the selected 90 houses in pali. The proposed PV/ hydro,Battery/Inverter hybrid system offers the best option for power generation compared to PV/Diesel/Inverter; Generator/Battery/Inverter and Generator only. The PV/Generator/Battery/Inverter option offers the best penetration of renewable resources (highest renewable fraction, fren = 100%), the lowest levelized cost of energy (1,111,832 Rs.), with the Zero carbon dioxide (CO2/yr) emissions. The monthly average Electric production of the system photovoltaic production is 35% and hydro is 70% total net present cost NPC , Capital cost and cost of energy for such a system. Total net present cost NPC 638180 Rs., capital cost of energy 12 Rs, intial cost 459845 Rs and operating cost is 13795 respectively for one year payback time is 20 years.

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