# Optimal design of Photovoltaic Power System Using HOMER for a residential load

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***Abstract:*** **In most developing countries, for the proper utilization of solar energy the system designed should be optimized. This paper presents the design and analysis of photovoltaic (PV) system to supply electricity. A stand-alone optimization simulation model is developed using the HOMER software. The radiation data for Talwandi Sabo, Punjab is collected for the every month of the year. Simulation model is used to find the best system model based on particular load. The optimization results shows that a PV array of capacity 6 Kw produces 14,080 Kwh/yr. Results shows that the Net present Cost (NPC) is 76,307 US$, levelized cost of energy 1.211/kwh and operating cost is $5,067/year.**

***Keywords: Optimal design, HOMER, Photovoltaic system, Net Present Cost***

## I INTRODUCTION

Now a day we cannot imagine our life without electricity. With the increase of agricultural, domestic and industrial applications, the demand for electricity is increased to great extent, so it becomes hard to fulfill this demand by non-renewable energy sources alone. These non-renewable energy sources emit a large amount of greenhouse gases, which has remarkable effect on our environment. Due to all these factors, the demand for renewable energy sources has increased remarkably. There are number of renewable energy resources like solar, wind, hydro, biomass, energy from oceans and geothermal. Among all these resources solar energy is the energy which can be widely accessed.

Sun radiates the energy at the rate of 3.8*1023 Kw per second [1]. In solar photovoltaic applications solar energy is directly converted into electricity. Photovoltaic cells are made of semiconductor materials, which absorbs the sun radiations and convert back to electricity. Different photovoltaiccells are joined in series/parallel with environmentally protected lamination to make PV modules. These PV modules are assembled together to make PV array [2]. The minimum life time of PV modules is 20 to 30 years.

### *A HOMER*

Hybrid Optimization Model for Electrical Renewables (HOMER) is a free software application developed by National Renewable energy Laboratory (NREL) in United States. It is used to design and evaluate the technical and financial options for the off-grid and on-grid power systems for the remotes, stand-alone and distributed generation applications. Homer shows the results in the form of tables and graphs [3]. The optimized result shows the list of configurations available based on the input data we have entered ordered by the Net Present Cost (NPC). It automatically shows the best configuration at the top. It can simulates the components ranging PV, wind, hydro, fossil fuel generator, battery, AC/DC converters, electrolyzed, hydrogen tank and reformer[4].

A several research has been done on the optimization of photovoltaic systems for certain places. Optimization of photovoltaic system is done for the residential load located near Siliguri, West- Bengal with HOMER software tool [5]. A. A. Hassan et. al. [6] presents a study and design of a complete stand-alone photovoltaic (PV) system for providing the electrical loads in an emergency health clinic. Study show that the sizing of PV stand-alone system depends on the load data, the solar resource data and the investment cost of system components. M. a. Salam et. al. [7] discussed the design and analysis of Photovoltaic (PV) system to supply lighting load for Renewable Energy Lab, Sohar. K. E. Okedu et. al. [8] investigates the energy efficiency of renewable energy system considering an isolated AC diesel generator and considered two cases with twodifferent load profiles to show that the load profiles affects the responses of the renewable energy system and the cash flow summary of some of the system equipment. A. M. Widatalla et. al. [9] investigate and optimize combined PV/Diesel system as a main electricity source for a hotel, in Khartoum-Sudan. A. Patel et. al. [10] give the the optimal designing of grid connected solar photovoltaic power system for a residential building of Jabalpur city, Madhya Pradesh, India. Optimization is carried out using HOMER. M. Jain et. al. [11] have done the optimization of the solar photovoltaic cell for a residential building of Malviya Nagar, Jaipur(India) that has total roof area of 576 m^2. V. A. Ani [12] presented the simulation and optimization study of a stand-alone photovoltaic power system for an orphanage. He has taken the solar resources for the design of the system from the National Aeronautics and Space Administration (NASA). A. H. Al-Hamdani [13] have studied the weather conditions data for Baghdad City such as temperature, solar radiation intensity, relative humidity and wind speed and determine the optimum system of solar-powered lighting to The Energy and Renewable Energies Technology Center at the University of Technology.

## II PROPOSED SYSTEM

A PV array consists of different components to supply electricity. The PV array is used to trap sun light and the electricity produced by PV array is DC, which is converted to AC by using inverter. The current can be stored in a battery for the night use. A generator is used for backup supply. So the components of PV system are PV array, inverters, battery, generator and load.

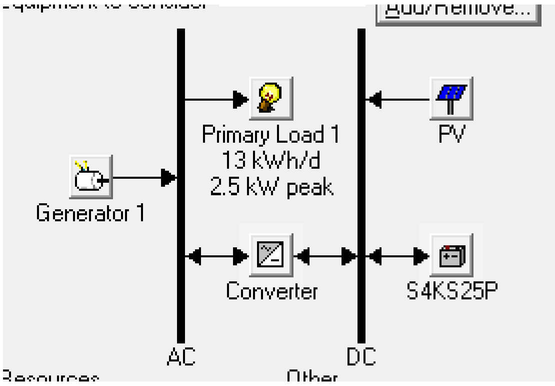



Fig. 1. Photovoltaic System

***A PV array data***

The size of PV array taken is 3kw and capital and replacement cost is 3000$. The operation and maintenance cost for the PV panels is taken as 0$. Output of PV array is DC. The lifetime of panels is 20 years, operating factor is 80%, slope 20 degreeand ground reflectance is 20%. The size of PV array considered are 0 kw, 3 kw, 5 kw, 6 kw, 8 kw, 10 kw and 12kw.

***B Load data***

The load taken is different bulbs, fans, heaters and other electrical appliances. The average load is 13.5 kwh/d. the load is maximum for the time period of 6:00 pm to 11:00 pm and is minimum from 11:00 pm to 5:00 am. The daily and seasonal load profiles are shown in the figure.

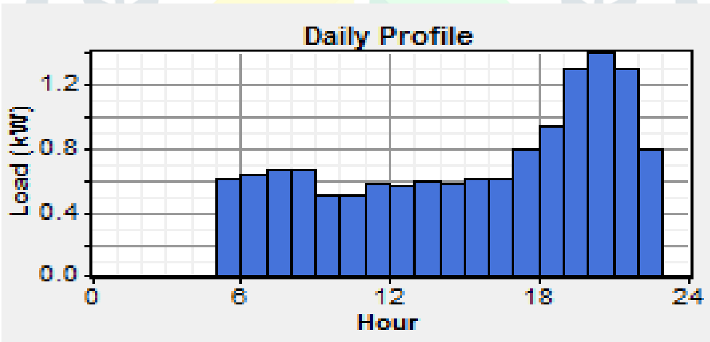



Fig. 2. Daily load profile

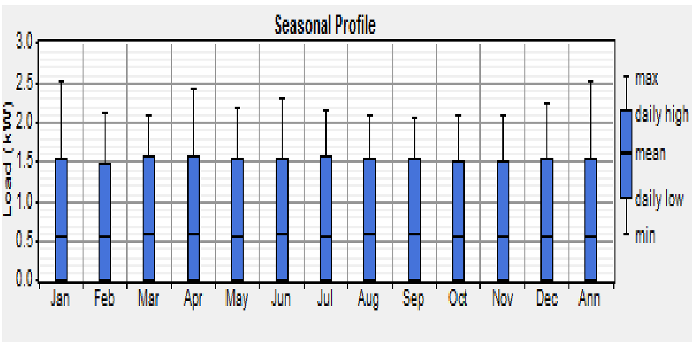



Fig. 3. Seasonal load profile

### *C Converter data*

Converter here can act as inverter (DC to AC) or rectifier (AC to DC). The capital and replacement cost for the converter is 2000$. Its operation and maintenance cost is 18$/yr. the lifetime of the inverter is 15 years and efficiency is 90%. The size considered are 1 kw, 2 kw, 3 kw, 4 kw and 5 kw.

### *D Generator Data*

Generator is used as a backup power supplier. The capital and replacement cost of generator is 1500$. The operation and maintenance cost considered is 0.1$/hr. the lifetime operating hours are 15000. The size to be considered are 1 kw, 2 kw, 3 kw and 4 kw.

### *E Battery data*

The battery is used to store the electricity generated from the solar panels for use later in a day. The battery taken here is Surrette 4KS25P which is having 4V nominal voltage. It is having nominal capacity 1900 Ah and lifetime throughput 10,569kwh. Minimum life of battery is 4 years.

### *F Radiation data*

The radiation data is taken for the place Talwandi Sabo, Punjab, where scaled annual average solar radiation are 7.57 kwh/m^2/d. The clearance index is .803 average. The plot for the radiation data is shown in the figure4.

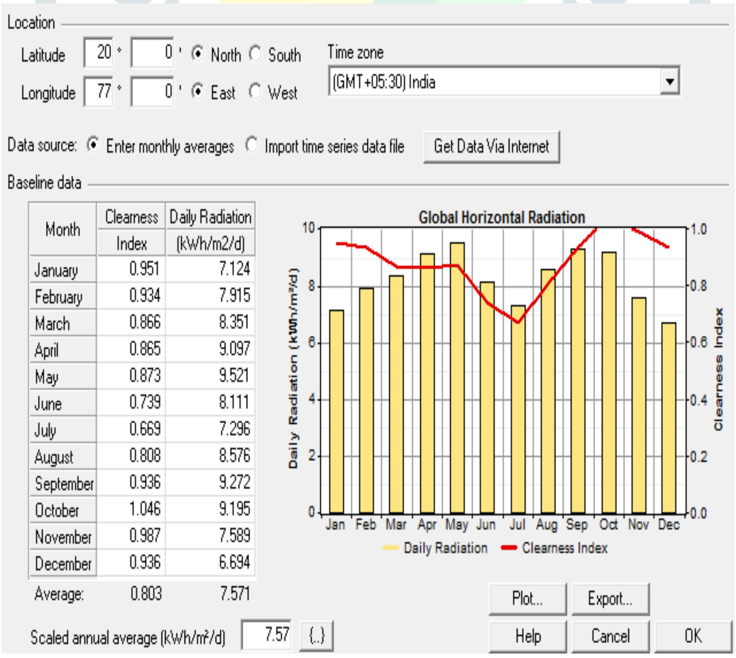
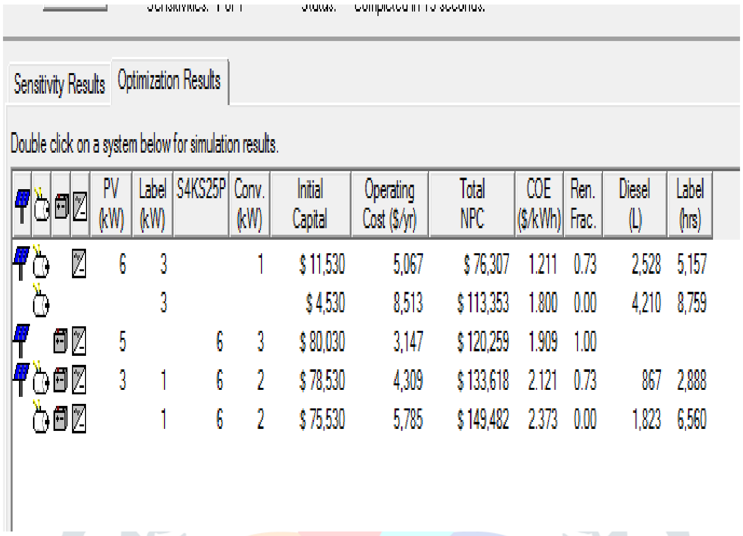



Fig. 4. Global horizontal radiation

## III OPTIMIZATION RESULTS

Figure shows the optimization results for the stand-alone system. HOMER automatically choose the best configuration based on the total net present cost and renewable fraction. The configuration best suited consists of 6kw PV array, 3 Kw generator and 1kw converter. The initial capital cost of the system is $11,530, operating cost is $ 5,067 and net present cost is $76,307. The renewable fraction for the system is 0.73.



Sensitivity Results Optimization Results

Double click on a system below for simulation results.

| PV (kW) | Label (kW) | S4KS25P | Conv. (kW) | Initial Capital | Operating Cost ($/yr) | Total NPC | COE ($/kWh) | Ren. Frac. | Diesel (L) | Label (hrs) |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 3 | | 1 | $ 11,530 | 5,067 | $ 76,307 | 1.211 | 0.73 | 2,528 | 5,157 |
| | 3 | | | $ 4,530 | 8,513 | $ 113,353 | 1.800 | 0.00 | 4,210 | 8,759 |
| 5 | | 6 | 3 | $ 80,030 | 3,147 | $ 120,259 | 1.909 | 1.00 | | |
| 3 | 1 | 6 | 2 | $ 78,530 | 4,309 | $ 133,618 | 2.121 | 0.73 | 867 | 2,888 |
| | 1 | 6 | 2 | $ 75,530 | 5,785 | $ 149,482 | 2.373 | 0.00 | 1,823 | 6,560 |

Fig. 5. Optimization results

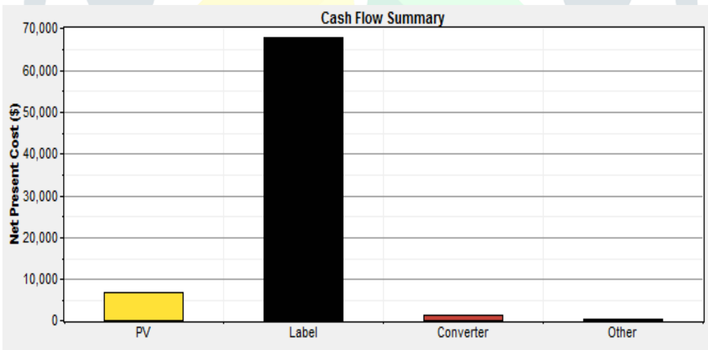



Fig. 6. Cash flow graph

PV Output graph and the monthly average electrical production is shown in figure7 and figure 8 respectively.

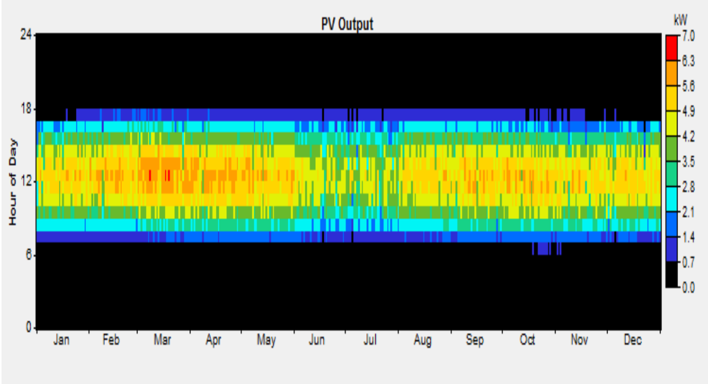



Fig. 7. Sensitivity analysis for PV output

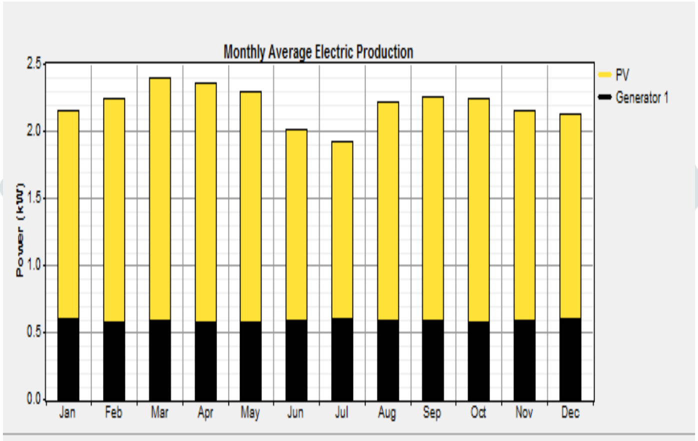



Fig. 8. Average monthly electricity production

## IV CONCLUSION

A model is proposed for the supply of the demand having components PV array, converter, generator and battery. The proposed system consists of 6kw PV array, 3kw generator and 1 kw converter. The results obtained from the optimization gives the initial capital cost of the system is $11,530, operating cost is $ 5,067 and net present cost is $76,307 and the renewable energy fraction 0.73.

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