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Modeling and Analysis of Hybrid Distributed Generation System using Homer Software

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Abstract:- The source of electrical supply are diesel generators which release carbon dioxide (CO2) resulting in environmental pollution and it is costly too for domestic consumers in rural zones. So, the need of an hour is to improve and provide efficient energy supply for rural areas in present scenario. Hybrid Smart grid is an example of power system through distributed resources attending the whole community as an independent electrical island with the bulk power system. After knowing overall loads result for this selected load we simulate this data through HOMER (Hybrid Optimization Model for Electrical Renewable) tool. Using HOMER software, the goal is to maximize energy output with least cost of energy from distributed energy resources (DERs) by optimization. Each section of model performance will be evaluated and at different conditions, sensitivity analysis will be performed for optimizing the system.

Key words: HOMER, DERs, Solar PV, Wind turbine, Generator and Economic.

1. Introduction

Electricity is greatest required for our daily life. So, the demand of electrical energy is increasing in world to satisfy demand and we have to generate more electrical energy. The generation of electricity has two methods either by conventional energy resources or by non-conventional energy resources. The conventional energy resources are diminishing in our life day by day. Shortly, it will be totally disappears from the earth and to find alternative method to generate electricity. Another key reason is that we are growing global warming phenomena for reducing fossil fuel consumptions.

The new source for generating the electricity should be economical, reliable and pollution free. The technologies of renewable energy include to generate power from renewable energy sources like solar PV (photovoltaic), micro hydro, wind, ocean wave, biomass, tides and geothermal but solar and wind are easily accessible in all conditions. But, solar energy has drawback in cloudy and rainy season because it could produce very less electrical energy so as to reduce these drawbacks. We can use two renewable energy resources so that any one of the source fails to generate electricity, other source will work at that time. And, we can use to combine both sources for generating electricity in good weather situation. Meanwhile, these resources are erratic in environment, then arrangements of two or more power generation technologies along with storage device can be used to improve the performance of the system.

Hybrid Renewable Energy System (HRES) combines two or more renewable energy resources with some conventional source like petrol or diesel generator along with storage in order to fulfil the required demand. HRES has good efficiency, reliability, lower cost and less emission. [1].

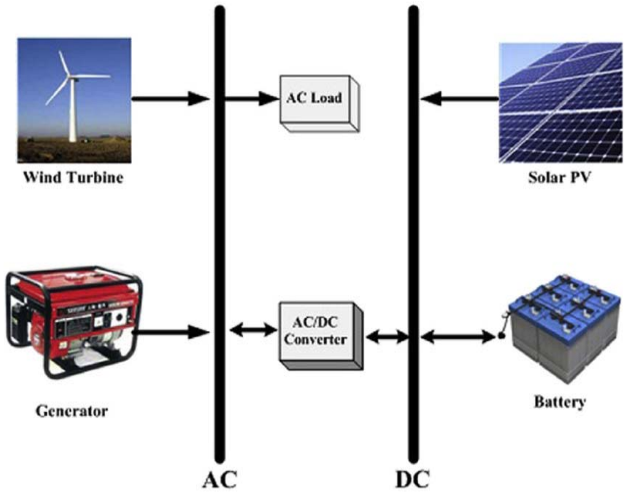


Figure 1: Hybrid Energy System

2. HOMER Energy Software

Using computer simulations, optimum configuration can be found by comparing energy production cost and the performance of different system configurations. So, the simulation tools are most shared tools for estimating the performance of the Hybrid systems. Hybrid Optimization Model for Electric Renewable (HOMER) is user friendly software produced by National Renewable Energy Laboratory (NREL) [2]. It practices on environmental data for the assessment, hourly simulations of the hybrid renewable energy system and performs optimization based on Net Present Cost.

Generally, HOMER performs three major tasks: simulation, optimization and sensitivity analysis. It represents the performance of a specific micro power system configuration for each hour of the year to determine life-cycle cost and its technical feasibility in the simulation process. It simulates various different system configurations that fulfil the technical constraints at the lowest life-cycle cost in the optimization process. And, it performs numerous optimizations under the range of input assumptions to gauge the effects of uncertainty or changes in the model inputs in the sensitivity analysis process [3]. Optimization decides the best value of the variables over which the system designer has control the mixer of components that make up the system and the size or quantity of each [4].

3. Design of distributed generation system

A hybrid power plant is consisting of these two renewable energy sources into operation by proper utilization of these resources in a completely controlled mode. For example, hybrid energy system is a solar PV array together with a wind turbine to create more power output during the winter from the wind turbine whereas during the summer, the solar panels would create their peak power output. The output of the renewable system may be connected to the battery bank which is rechargeble and then to the load for developing constant power supply [5]. An inverter is used to convert DC power supply from battery into AC power when the load is AC. In figure 2, solar panel is used to convert solar irradiation into the electrical energy and it is a group of a various modules electrically connected in series or parallel or combination of these two for generating the required value of voltage and current.

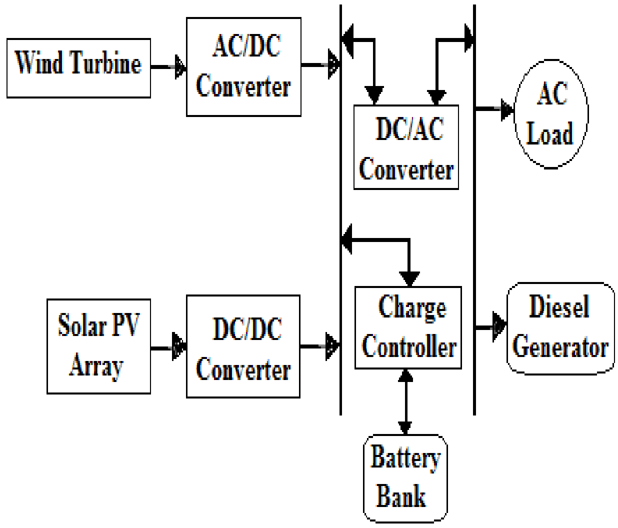


Figure 2: Design of Hybrid Distributed Generation System

Wind turbine is used to extract energy from wind by rotation of the blades of the wind turbine in vertical and horizontal type. Power generation is increases if the wind speed increases but the generated power is fluctuating. So, it can store in battery and then provide to the load in non-fluctuating form. Charge controller controls the sources which are to be active or inactive, charge battery and also gives power to the load [6]. As per the load requirement, we can choose size of battery bank so as it should satisfy the requirement of load for calculating the battery bank size. Therefore, we must necessity to catch following data like total daily load use in watt-hour (Wh) and total back up time of the battery and need to connect cell in series for increasing the size of battery bank so that we can get the larger size battery bank.

4. Component Description

A. Solar Photovoltaic (PV) Array

The following panel is selected after surveying for the cost of different products. National renewable lab energy database and National solar radiation database showed the study area in solar radiation [7].

An average of solar radiation is 5.04 kWh/m^2/day and a clearness index 0.6 was identified. In HOMER software, the modelled of solar PV array gives DC power output directly proportional to incident solar radiation. Operation and maintenance cost is nearly zero and its lifetime is 25 years [2].

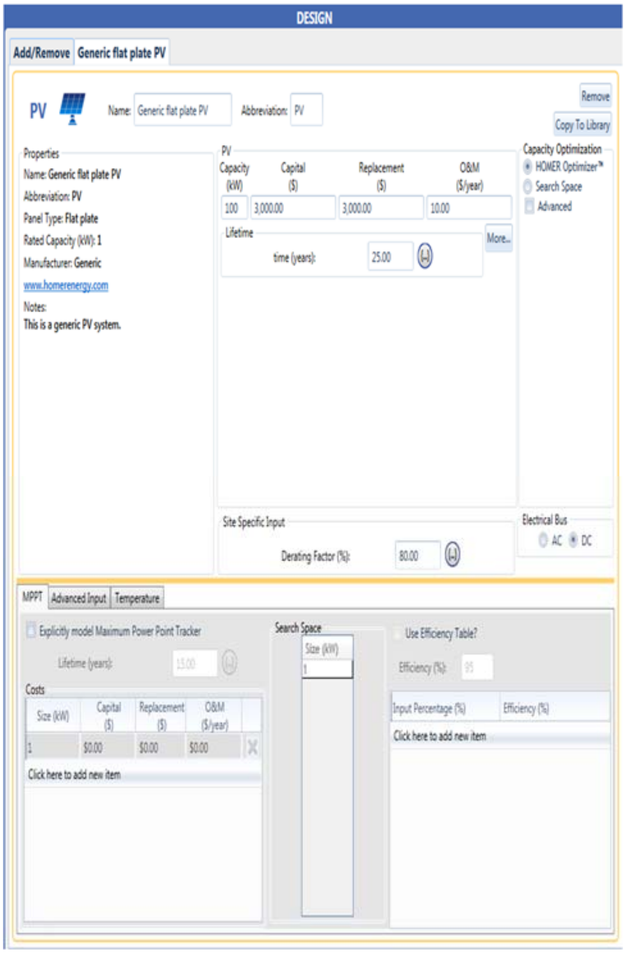


Figure 3: Solar PV Panel

B. Wind Turbine Generator

For this assignment, the wind turbine is taken 1kW power rating; installed cost is taken about $2307/kW. In this case, the wind turbine replacement cost is considered about 80% of capital cost after 20 year service life. Hub height is considered 25m. 0, 1, 2, 3 and 4 wind turbines are considered for simulation. Annually, the average wind speed for the location is 3.27 m/sec with the anemometer height at 50 meters. Figure 4 shows graph of the average wind speed at our study site.

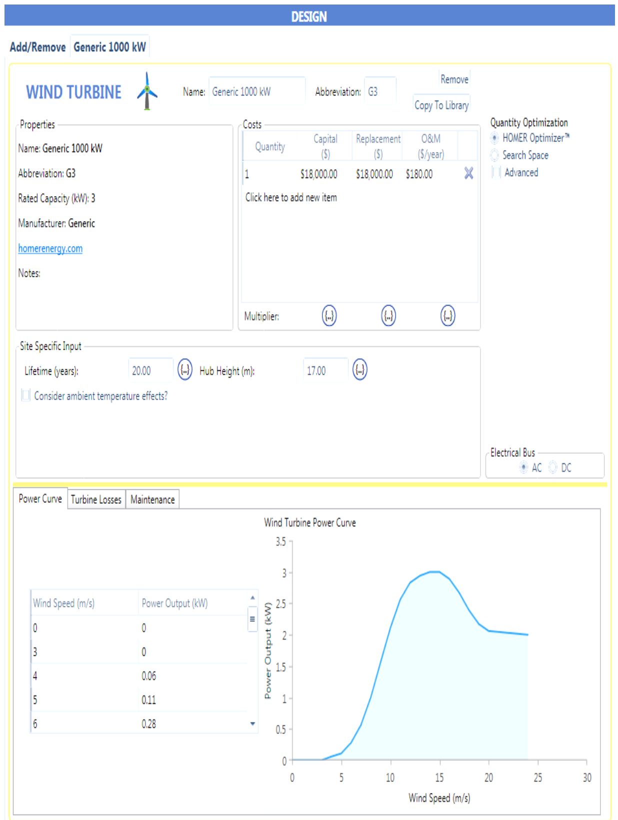


Figure 4: Wind Turbine Generator

C. Diesel Generator

For the proposed model, Diesel Generator has two simulations of rated capacity 4 KW and 10 KW respectively and delivers AC power in the given system. The operation and maintenance cost of the generator is $0.030/hr. Diesel can be transported between nearest pump to site. Therefore, the transportation cost of the diesel is approximately $0.5/litre. Diesel generators do not permit running cost at less than the minimum load ratio of 30%. Lifetime operation of generation is about 15000 hr. and 0, 4, 8 and 12 kW Diesel Generators are studied. When hybrid energy system generate sufficient amount of power, diesel generators work as a backup for the site.

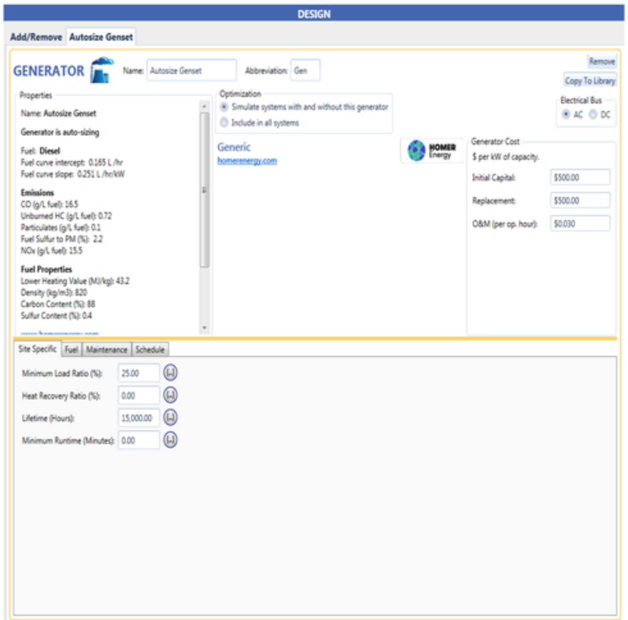


Figure 5: Diesel Generator

D. System Converter

Here, converter is used to perform both as rectifier and an inverter which depends on the direction of power flow. A converter is used to convert and maintain power flow between DC and AC link, size of converters are considered like 1.5, 3 and 7.5 kW, replacement cost is taken as 80% of the capital cost, the lifetime of the converter will end for 15 years, efficiency of converter is around 90%, the operation cost for such type of converter is $7200, replacement cost is $3054.77 and maintenance free converter system is assumed.

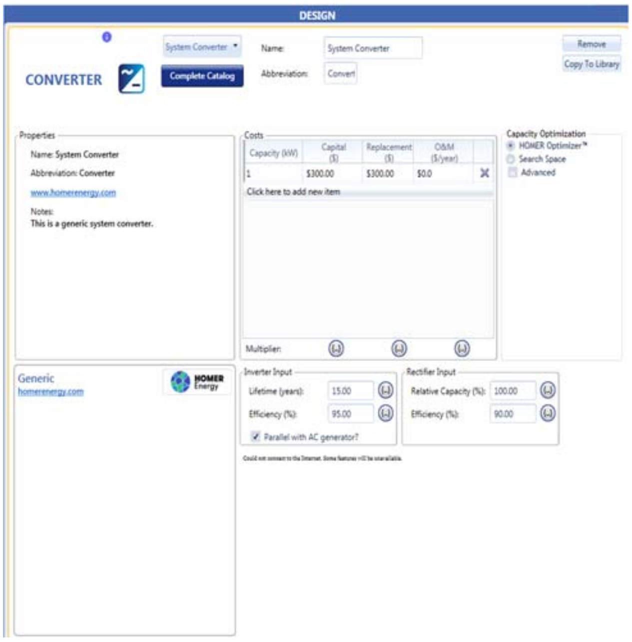


Figure 6: System Converter

E. Battery Bank:

DC battery is used to store and maintain the energy when peak load appears by HOMER. Assumption is made that battery properties remain constant throughout its lifetime and are not affected by external factors.

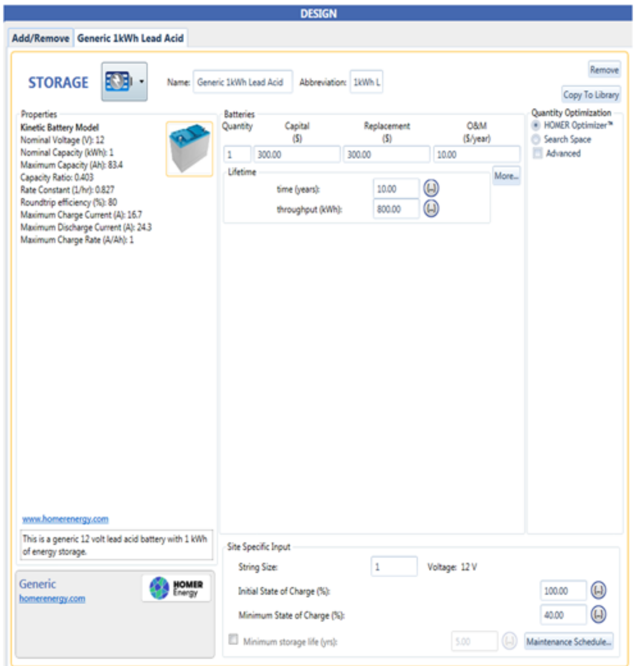


Figure 7: Battery Bank

The nominal capacity of the selected battery is 2.94 kWh with nominal voltage of 12V for single battery and the amount of energy stored in a single battery is 2.94kWh, maximum charge current is 57A, round-trip battery efficiency is taken as 85%. Replacement cost for battery is assumed about 70% of its capital cost.

5. Optimization Results and Discussion

The Judicious and effective use of energy is to enhance competitive positions and maximize profits (minimize costs) [8]. The Aim of this project is to achieve and maintain optimum energy procurement and utilisation, throughout the organization and to minimise energy costs waste without affecting production and quality. The following steps are performed in this project for computing the desired plot:

- Step 1: Draw the schematic diagram (figure 8) of selected Hybrid Energy System.
- Step 2: Enter the specifications (figure 9) of all the selected resources and electrical load
- Step 3: Calculate the results in figure 10 and 11 for optimization analysis and sensitivity analysis.

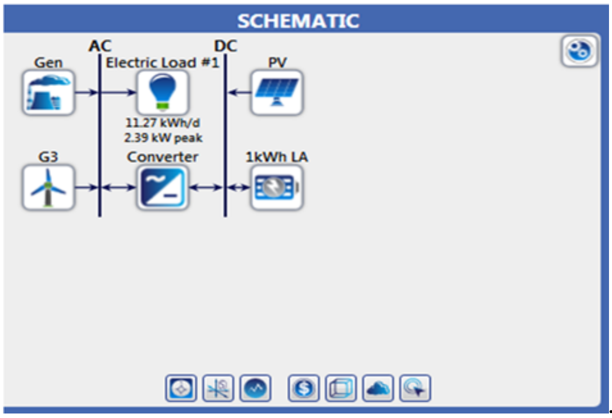


Fig. 8: Schematic Diagram

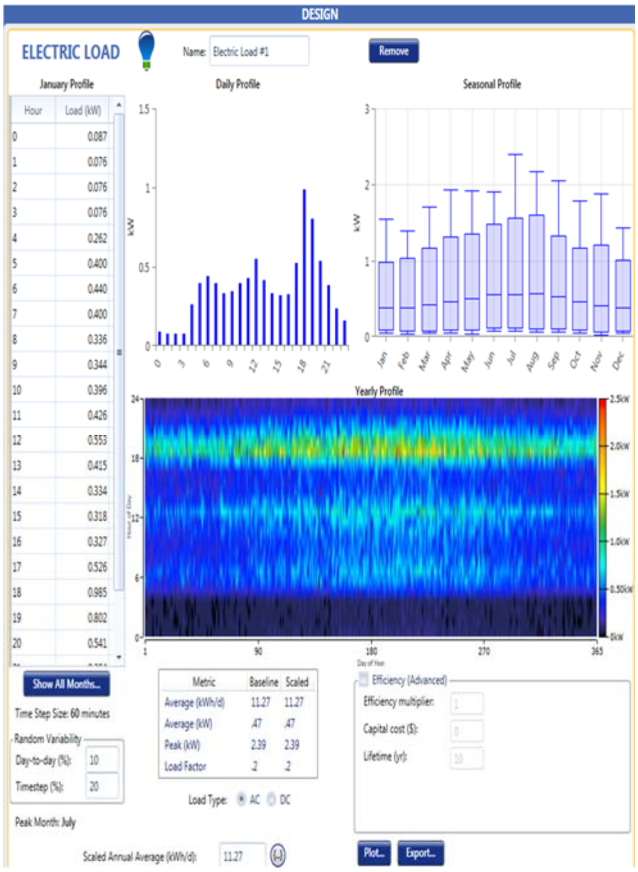


Figure 9: Electrical Load Specifications

The user interface of the Homer energy software provides the ability to optimize cost of installation and operation. The results are generated by software for both sensitivity analysis and optimization analysis [9] Also comparison of various combinations of resources is done so as to use the resources effectively. After receiving the desired data for the customized set of parameters, users can save the track of the parameters that they tested.

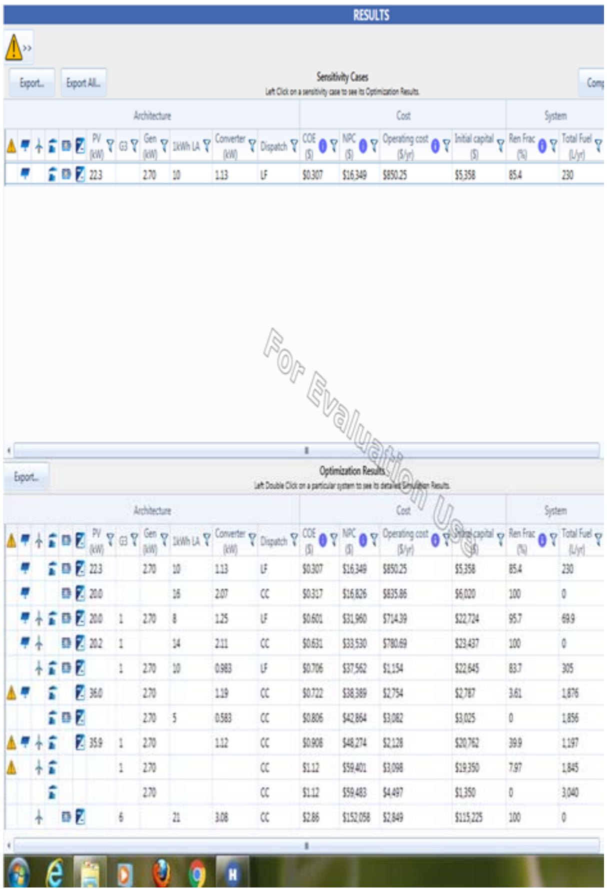
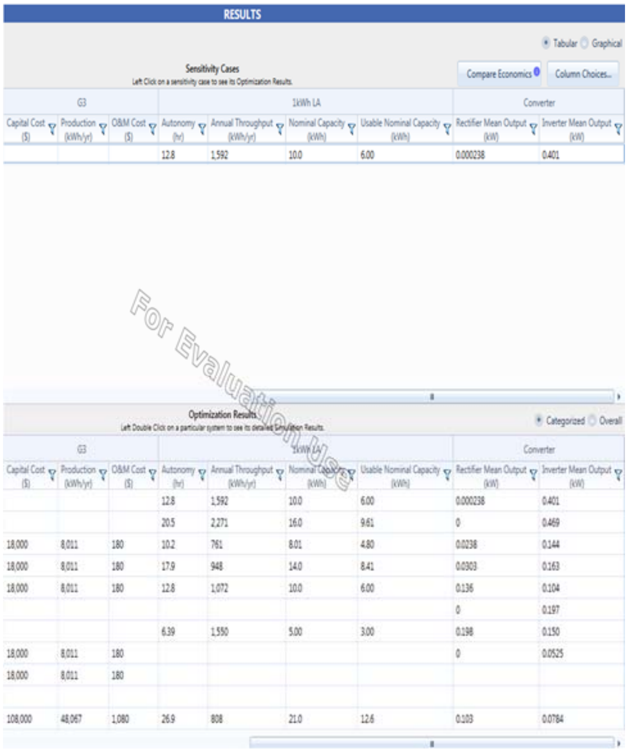


Figure 10: Results (a)



G3			1kWh LA				Converter	
Capital Cost ($)	Production (kWh/yr)	O&M Cost ($)	Autonomy (hr)	Annual Throughput (kWh/yr)	Nominal Capacity (kWh)	Usable Nominal Capacity (kWh)	Rectifier Mean Output (kW)	Inverter Mean Output (kW)
			12.8	1,592	10.0	6.00	0.000238	0.401

G3			1kWh LA				Converter	
Capital Cost ($)	Production (kWh/yr)	O&M Cost ($)	Autonomy (hr)	Annual Throughput (kWh/yr)	Nominal Capacity (kWh)	Usable Nominal Capacity (kWh)	Rectifier Mean Output (kW)	Inverter Mean Output (kW)
			12.8	1,592	10.0	6.00	0.000238	0.401
			20.5	2,271	16.0	9.61	0	0.469
18,000	8,011	180	10.2	761	8.01	4.80	0.0238	0.144
18,000	8,011	180	17.9	948	14.0	8.41	0.0303	0.163
18,000	8,011	180	12.8	1,072	10.0	6.00	0.136	0.104
							0	0.197
			6.39	1,550	5.00	3.00	0.198	0.150
18,000	8,011	180					0	0.0525
18,000	8,011	180						
108,000	48,067	1,080	26.9	808	21.0	12.6	0.103	0.0784

Figure 11: Results (b)

6 Conclusion

The combination of solar-wind hybrid energy system requires only initial investment and the cost of the system depends on the chosen system, wind resource on the site, electric costs in the area and the battery bank required. The result from the HOMER software shows that in the case of solar PV, diesel generator with battery and inverter has the less total cost compared to solar PV, wind turbine, diesel generator with battery and inverter. So, it is most economical solution for all three cases of optimization for the load. Solar PV, wind turbine, diesel generator with battery and inverter system is also a very good alternative solution having little higher cost of electricity and net present cost. Although the cost of electricity from the proposed system is higher than the cost grid electricity but due to the necessity of environmental protection and far-seeing the current living standard of rural communities such hybrid system will play a very good role for the country like India having deficit electricity.

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