Life-Cycle Cost Analysis of a Solar Energy Based Hybrid Power System

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Abstract— *The importance of life-cycle cost analysis of an integrated solar power system is explained in this paper. To analyze the energy power and cash flow computations, there exist many commercial types of energy audit softwares like Emat, Optimizer, Homer, Energy gauge, Treat and so on. Among the aforementioned audit softwares, homer software is selected since it consists of several built-in options to perform audit studies. Homer software basically utilizes the concept of finding the total net present cost to represent the life-cycle cost of the total system. This software is vividly used for obtaining the optimized energy audit solutions to integrate several equipments embedding into a single workable system.*

Keywords— Audit, homer, life-cycle cost, integrated solar power system.

I. INTRODUCTION

In general, the total Net Present Cost (NPC) summarizes all the existing costs and revenues that occur within the complete project life time into a single lump sum amount along with the future cash flows discounted using the specified discount rate respectively. Costs usually may include capital cost, replacement cost, operating and maintenance cost, fuel cost, the cost of purchasing electricity from the power grid company, and other miscellaneous costs like penalties resulting from pollutant emission levels of a diesel generator. Revenues generally includes income from selling power to the power grid, any salvage value that occurs at the end of the project life time tenure.

The primary focus of this paper is to simulate a system which basically consists of a solar photovoltaic (PV) array system along with a battery, a converter module to facilitate the conversion process from alternating current (AC) to direct current (DC) and vice versa, a generator and a primary load to consume the generated energy and also to analyze the total cash flow analysis involved in the above mentioned hybrid configuration. For accomplishing the task of simulating, homer audit software is selected and total cost benefit analysis is examined and drafted in a tabular form mentioning all the cost details.

Few researchers [1],[3],[4] have already been started working in this area to demonstrate the difficulties in building a hybrid system in a optimized manner where cash flow analysis is needed [6] to ensure better economic prospects of any organization. Section I tells about introduction part, section II mainly illustrates about the modeling aspects of a solar based hybrid system, section III explains about the cost analysis, section IV shows all the simulation results which comprises of cost details, section V throws light on conclusion part which is followed by references further.

II. MODELING OF HYBRID SYSTEM

The development of any hybrid system basically needs a strong economical support. Sometimes, even an economical retrofit analysis may be needed for expanding an existing system to cut down the major expenses considerably. For achieving this task, a simulation based study and analysis is required to know about the overview of the project expenditures and whether it is feasible option to go for a retrofit (or) building a new system. Technological progress is possible only with the help of better economical background. Hence, it has become mandatory to depend upon the simulation softwares in order to examine the cost aspects [2],[5]. Fig.1 shows the schematic view of solar energy based hybrid system. The advantage of this system is to encourage the usage of solar photovoltaic technology since it is abundantly available and reduces the usage of non-renewable based resources like diesel to the maximum possible extent.

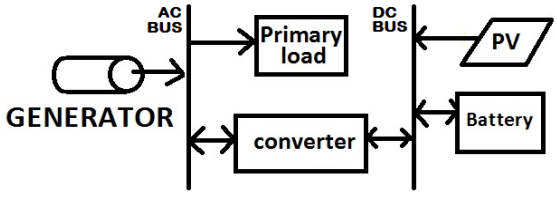

Fig. 1: Solar energy based Hybrid power system.

A virtual model is created in homer as shown in Fig.1 and then specified further all the input values like solar data of a particular region, capital cost of various equipments like generator fuel, PV system expenditure, battery cost and converter cost. As a part of a case study, a daily load

profile of a firm (or) organization is specified hourly basis and pictorially it is represented in Fig.2. On x-axis, time (in hour) is considered and on Y-axis, Load (in kW) is considered. The maximum peak load demand is 5kW at 12 noon as shown in Fig.2.

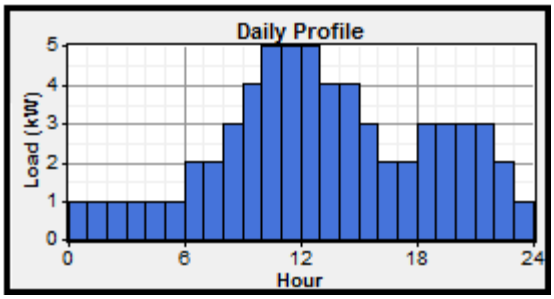

Fig. 2: Daily load profile in kW

III. COST ANALYSIS

A case study is considered examining the life time cost calculations. Hence, the cost details are represented below. Individually all the required input data is shown in Table. 1,2,3 and 4 respectively.

Table 1. Generator details

Size (kW)	Capital (in dollars)	Replacement cost (in dollars)	O & M cost (in dollar/hour)
110	10000	8000	0.67

Table 2. PV initial cost details

Size (kW)	Capital (in dollars)	Replacement cost (in dollars)	O & M cost (in dollar/hour)
10	150000	15000	150

Table 3. Converter cost details

Size (kW)	Capital (in dollars)	Replacement cost (in dollars)	O & M cost (in dollar/hour)
10	1000	650	8

Table 4. Battery cost details

Quantity	Capital (in dollars)	Replacement cost (in dollars)	O & M cost (in dollar/year)
2	1500	1000	100

Since the software takes the values in terms of dollar, the values are mentioned in dollar. Hence, the various cost curves of the inputs given to the system are represented in Fig. 3, Fig. 4, Fig. 5 and Fig. 6 below.

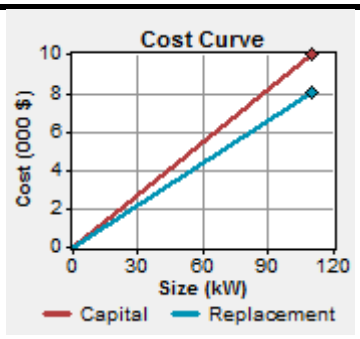

Fig.3 Generator cost curve

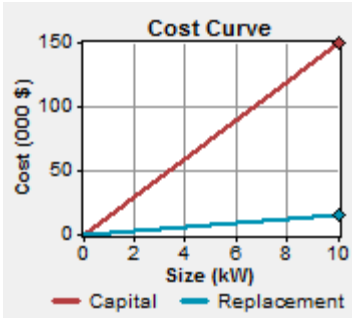

Fig.4 PV cost curve

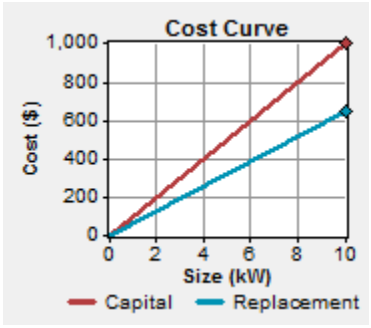

Fig.5 Converter cost curve

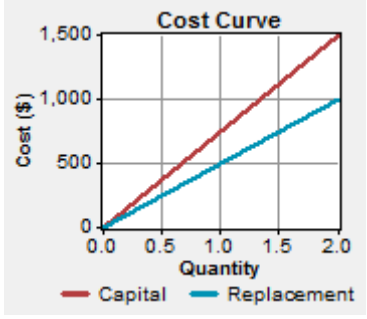

Fig.6 Battery cost curve

IV. SIMULATION RESULTS

The model which has been designed in homer is simulated further to obtain the life-time cost details.

	PV (kW)	Label (kW)	S4KS25P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)
	10	110		10	$ 161,000	110,232	$ 1,570,138	5.481
		110			$ 10,000	129,460	$ 1,664,939	5.812

Fig.7:Optimized results

The Fig. 7 depicts the simulation results which clearly mention the optimized values of operating cost, Net present value (NPV), Cost of Equity (COE) respectively. The software clearly estimates the initial costs when

hybrid system is considered and compares the results with the existing conventional system which consists of only generator. The first line of result signifies the simulated output for a hybrid system which consists of a PV, generator, converter and battery, where as the second line tells about the result of the system consisting of a generator alone. Fig. 8 and Fig. 9 show the optimized simulated cost parameters. Thus, it is evident that, one can easily find out the feasibility of the system and can access whether the system is profitable (or) else resulting in a significant loss.

Component	Capital ($)	Replacement ($)	O&M ($)
PV	150,000	4,677	1,918
Generator 1	10,000	44,822	63,714
Converter	1,000	271	102
System	161,000	49,770	65,734

Fig.8:Optimized simulated results

Fuel ($)	Salvage ($)	Total ($)
0	-2,621	153,973
1,297,009	-702	1,414,843
0	-50	1,323
1,297,009	-3,374	1,570,139

Fig.9:Optimized fuel and salvage results

V. CONCLUSION

A study on modeling of a solar based hybrid model has been done and simulated to obtain the life-cycle cost particulars. Emphasis has been given on finding out life cycle cost of a hybrid model. The model has been simulated in homer environment. The results clearly show about the cost details so that, retrofit analysis or addition of equipments can be done to the existing system.

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