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Research

A CASE STUDY ON COST ANALYSIS AND LOAD ESTIMATION OF HYBRID RENEWABLE ENERGY SYSTEM USING HOMER PRO

Saba MUNIR[1,*], Ausnain NAVEED[2], Raja Tahir IQBAL[3], Mohtasim USMAN[4]

[1,2,3,4] *University of Azad Jammu and Kashmir, Department of Electrical Engineering, Muzaffarabad, Pakistan*

ABSTRACT

Pakistan is facing serious energy deficiency issues. Moreover, emission of polluted gases must be minimized to reduce the air pollution. The emission of harmful gases can be lessened by the implementation of renewable energy resources. Such issues can be curtailed through proper planning on national and gross root level. In this study, load estimation and cost analysis for the installation of optimized hybrid model of renewable energy resources in electrical engineering department of University of Azad Jammu & Kashmir has been presented. In order to analyze load and estimate the cost, different scenarios are generated on Hybrid Optimization Model for Electric Renewables (HOMER) Pro software. On the basis of these scenarios, the system having less cost of energy and emission of polluted gases is proposed as the optimal system to power the department.

Keywords: Cost analysis, HOMER Pro, Load estimation, Renewable energy

1. INTRODUCTION

The world is switching to Renewable Energy (RE) due to the fossils depletion and cost-competitive solutions. Also, the innovation in renewable energy technologies allows to combine different RE sources and produce electricity. These RE sources consist of solar energy, tidal energy, wind power, geothermal, micro-hydropower and biomass [1]. Energy intake is intensely inclined to the latest global trade and the fast-growing industry. Global population growth is another issue contributing towards the surge in energy consumption [2]. Typically, most of human energy needs are met from non-renewable energy sources like fossil fuels. However, there are two main problems with growing dependence on fossil fuels to meet energy demand; loss of fossil fuels and rising carbon dioxide emissions which is a major cause of increase in global warming [3]. In Pakistan, power outage is a major problem that is often addressed by conventional production [4]. The economic and technical feasibility analysis for the operation of the conventional and a new hybrid system is presented in [5]. Two micro grid systems were evaluated on the economic aspect in which one was dependent and other was independent. The analysis shows that for interconnected system, the installation of photovoltaic cell and the wind turbines are more effective. In [6], an economic analysis of a standalone hybrid power system for application in Tehran has been presented. The study shows the incident solar radiation, equipment characteristics, electric load profile, and hydrogen fuel design parameters of a hybrid power system. Another work presented in [7] shows that the on grid system is more economic as compared to the off grid system because extra amount of batteries need to be used in the off grid system. Based on solar radiation, a similar study explained the technical feasibility of a standalone system that meets the 2.5% load requirement of the city of Mecca using Homer Pro [8]. A feasibility analysis of wind, solar or hybrid system performance in the west coast of Saudi Arabia is presented [9] where the potential of hybrid energy system in that region was evaluated. A hybrid optimization model of RE resources used to design a small grid at remote sites, islands, on grid and off grid systems where these resources can be used as a mix and or as an independent source to meet power shortages is presented in [10]. The proposed model is analyzed by using Homer Grid. Changing cost of fuel and the atmospheric hazards are the key factors in the study to stimulate the use of RE resources for generating power.

In this work cost analysis and load estimation for the Department of Electrical Engineering (DEE) in University of Azad Jammu and Kashmir (UAJ&K) has been done. DEE is an educational institute which operate five days a week. The average working hours of DEE is 8 hours and the department fulfills its demand through grid. Whereas, a generator of 25KW is used to fulfill the load requirement during the load shedding hours. Given the fact, cost of the existing system is very high which can be lessened by using renewable energy resources. However, it requires proper load and economic assessment. The software which is used for this work is HOMER Pro 3.14 software. The reason for choosing this software is that this software efficiently performs three types of working; optimization, sensitivity analysis and simulation. Moreover, the software defines the quantity of the components, thus, making it easy to find the best optimal result for the system.

* Corresponding author, e-mail: sabamunir298@gmail.com (S. Munir)
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2. CASE STUDY

Pakistan is facing serious energy deficiency issues which can be resolved easily through proper planning. The country's vision of clean and green Pakistan strives for minimum emission of polluted gases to reduce air pollution. Power obtained through conventional sources is also a reason for emission of harmful gases. This emission of harmful gases can be minimized by generating power through RE resources.

In this study, load estimation and cost analysis of DEE located in UAJ&K has been studied. Different scenarios are generated on a clean energy software known as HOMER PRO for the feasibility study of hybrid RE generation. The software is used to analyze and perform the cost analysis on the system. Various gird connected configurations of the system are also studied and on the basis of generated scenarios, the optimal result is find out for the system. The system having low cost of energy is defined as the best system. Moreover, emission of polluted gases is also taken into account where the best solution reduces the harmful emission of gases.

2.1 Existing system

The existing system of the department consists of a grid supply and a backup generator. The power demand is met through grid and a 25 kW generator is used to meet the load demand during power curtailment hours. The department has constant load of 15kW for 8 hours in a day. Since the department works for 8 hours 5 days a week, hence, a constant load curve for all the weekdays can be seen in Figure 1 for a better understanding of load estimation. System model of the existing system has been shown in Figure 2. The Cost of Energy (CoE) is $0.287, whereas, the Initial Capital Cost is $30,000 and the Net Present Cost (NPC) is $90,090M. Most importantly, the Carbon Emission of the existing system is 16,069 Kg/yr with a Fuel Rate of 661 L shown in Figure 3.

3. PROPOSED SYSTEM

A combination of renewable energy sources has been employed in the proposed system. Cost and load analysis was done on all combinations. The optimal plan is evaluated based on these costs and load analysis. Energy Costs and Current Costs are considered and based on these costs the greatest effect is obtained. The arrangement of low energy costs is considered the appropriate system.

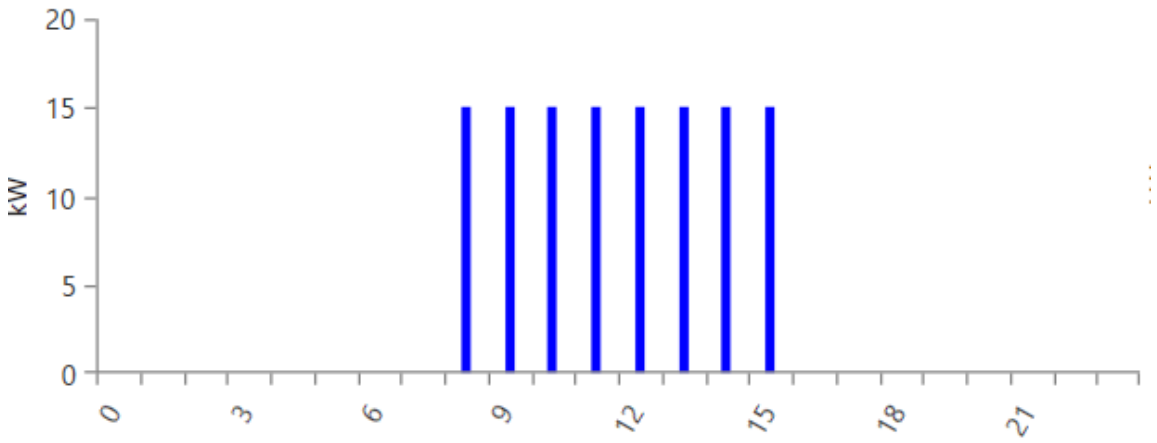

Figure 1: Daily load profile of existing system

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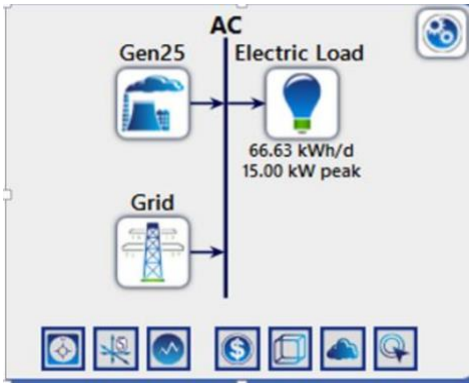

Figure 2: Schematic of existing system

Gen25 (kW)	Grid (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Hours	Production (kWh)	Fuel (L)
25.0	999,999	CC	$0.287	$90,090	$4,648	$30,000	261	1,631	661

Figure 3: Cost estimation of existing system

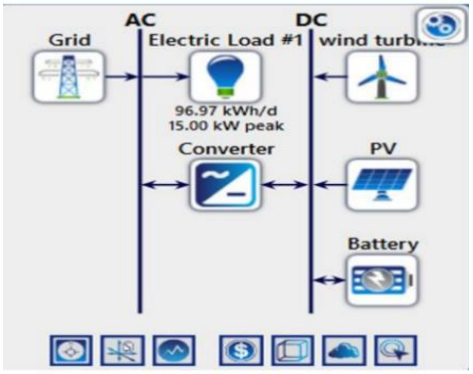

Figure 4: System model of scenario 1

Table 1: Configuration of system for Scenario 1

Storage	PV	Wind	Grid
5 batteries	20KW	20KW	Unlimited

PV (kW)	wind turbine	Battery	Grid (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Capital Cost ($)	Production (kWh)
20.0	20	1	999,999	20.0	CC	-$0.0344	-$28,171	-$3,394	$15,700	92.1	7,000	33,871

Figure 5: Cost estimation of scenario 1

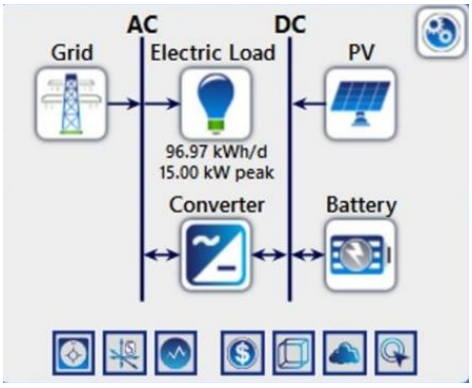

Figure 6: System model of scenario 2

Table 2: Configuration of system for Scenario 2

Storage	PV	Grid
5 batteries	20KW	Unlimited

PV (kW)	wind turbine	Battery	Grid (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Capital Cost ($)	Production (kWh)
20.0		1	999,999	17.2	CC	$0.0384	$21,083	$768.61	$11,146	77.9	7,000	33,871

Figure 7: Cost analysis of scenario 2

3.1. Scenario 1 (PV, Wind, Grid, Battery Storage)

System model for this scenario is shown in Figure 4 and the specification of this scenario are given in Table 1. It can be observed that Scenario 1 comprises of PV, wind, battery and grid. Here two buses are present; AC and DC buses. Converter, wind, and load are connected to the AC bus, whereas, PV and battery storage are connected to the DC bus. It should be noticed in Figure 5 that the CoE of Scenario 1 is $0.0344, the NPC is $28,171M and initial capital cost is $15,700M. However, the carbon emission rate is -14,510 kg/yr which is very low.

3.2. Scenario 2 (PV, Battery Storage, Grid)

System model for this scenario is illustrated in Figure 6 and the arrangement of this scenario are given in Table 2. It can be observed that Scenario 2 contains a combination of PV, Grid and Battery Storage installed together. Similar to Scenario 1, AC and DC buses are involved in this scenario as well. Grid, Load and Converter is connected with AC bus whereas PV and Storage is connected with DC bus. It can be observed from Figure 7 that the CoE for Scenario 2 is $0.0384 and the NPC is $21,083M. Although, the initial capital cost is $11,146M, but, the carbon emission rate is 14,27kg/yr.

3.3 Scenario 3 (Grid, Battery Storage, Wind)

System model for this scenario is presented in Figure 8 and the specification of this scenario are mentioned in Table 3. It can be observed that Scenario 2 consists of conventional grid, battery storage and wind. Here, again two buses are being used; grid, electric load and converter are connected to the AC bus and wind turbine along with battery storage is connected to the DC bus. As shown in Figure 9, the CoE for Scenario 3 is $0.0365, the NPC is $25,182M and Initial Capital Cost is $8,554. However, the carbon emission rate is 3.31kg/yr which is lesser than Scenario 2 but higher than Scenario 1.

A detailed comparison of the existing system and all the three scenarios is presented in Table 4. It should be observed that the existing system has a high energy cost when compared with all the three proposed scenarios. However, the CoE of scenario 1 is the lowest among all the three scenarios which is $0.0344. Also, the carbon emission rate of the existing system is very high when compared with all the three posed scenarios. Whereas, this rate is minimum for Scenario 1 which is the biggest persuasion to adopt this system.

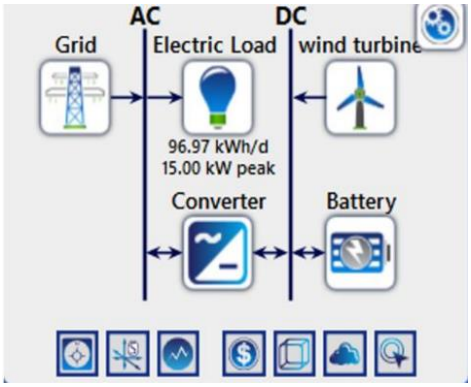

Figure 8: System model of scenario 3

Table 3: Configuration of system for scenario 3

Grid	PV	Load
Unlimited	20KW	15KW

PV (kW)	wind turbine	Battery	Grid (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)
	20	1	999,999	19.3	CC	$0.0365	$25,182	$1,286	$8,554	56.3

Figure 9: Cost estimation of Scenario 3

Table 4: Comparison of cost for all scenarios

	INITIAL CAPITAL COST	NET PRESENT COST	CARBON EMISSION	COST OF ENERGY
EXISTING SYSTEM	$30,000	$ 90,090M	16,069 (Kg/year)	$0.287
SCENARIO 1	**$15,700**	**$28,171M**	**-14,510 (Kg/year)**	**$0.0344**
SCENARIO 2	$11,146	$21,083M	1,427 (Kg/year)	$0.0384
SCENARIO 3	$8,554	$25,182M	3,351(Kg/year)	$0.0365

4. CONCLUSION

The DEE in UAJ&K is operated by using grid and diesel generator. This existing system has a very high carbon emission rate which is not aligned with the energy policy of the country. Moreover, the CoE or in other words the average of NPC of electricity generation of the existing system is very high. Also, the generator is being used to supply power during the load shedding hours, but, diesel itself is a very high priced commodity. Therefore, a cost effective solution given in shape of Scenario 1 should be adopted that is capable of reducing the CoE from **$0.287** to **$0.0344,** which means CoE decreases **88.0139%.**

SIMILARTY RATE: 12%

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