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Design and Simulation of Small Scale Solar PV System for Department Staff Room of an Educational Institute

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ABSTRACT
This paper tries to find the feasibility of utilizing an off grid solar PV system and grid connected solar photovoltaic (PV) system for meet the load demand of a department faculty room, as a case study. The solar PV both off grid and grid connected systems has been designed, to serve the required electrical load. The energy demand of the study place estimated 14.26 kWh/day for the design and simulation of the off grid solar PV system and grid connected solar photovoltaic (PV) system using HOMER software. The results showed that for off grid solar PV system the 5 kW size PV plant with 25 numbers of 1 kWh battery is enough to meet the load. With this optimum size the COE (Cost of energy) is minimum with 0.128 $/kWh. For the grid connected solar PV system it has been found that the 4 kW size PV plant with grid connection is enough to meet the load. This is the optimum size where the COE (Cost of energy) is minimum with 0.0477 $/kWh.

***Keywords* -** Solar PV system, Grid connected PV system, COE, Battery, Optimization.

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I. INTRODUCTION

Most of the used electrical energy in the world is produced by the fossil fuels, while the future plans of the government is to make India strong in renewable energy field [1]. The government is looking for the renewable energy sources because there the amount of fossil fuels are reducing day by day and the dramatically increased in fossil fuel price which increase the conventional electricity production cost. Among the different renewable sources solar energy is the most promising renewable energy sources as it is abundant in the nature [2]. There are two ways to produce electricity from solar energy to electricity, on is direct way where solar PV is used to produce electricity and another one is indirect process where solar thermal process is used for electricity production. The use of the renewable energy sources are not only reduces the expenses of the fossil fuels but other important reasons behind using renewable energy is, it is clean, reduce the amount of greenhouse gas emission resulting from fossil fuels [3]. Therefore in this study solar PV has been studied for best use in the academic institute.

Mustafa Hussein et al. presented the study of solar-Wind Hybrid power system analysis for Duhok city at Iraq. HOMER software is used and in results they show that hybrid system is better cost efficient than Duhok residential power grid [1]. Ghose et al. analysed a wind-solar hybrid power system design for Statesboro, Georgia [2]. Ahamed et al. they focus on modeling optimization of hybrid micro-grid of renewable energy efficiency with HOMER software, using solar PV, wind power for a real time data of selected location which has future use in relation to increased demand for energy. The cost of the energy is based on peak load demand profiles considered for residential, industrial, commercial sector and fuel cost, initial capital cost and operational and maintenance cost. It is also essential that hybrid system modules of optimal specifications be selected to ensure the minimal energy cost and efficiency of all load demand [3]. Kumar et al. designed and analyze the system to supply power to a remotely located ATM machine [4]. Dash et al. presented a relative study involving a stand-alone and a grid connected hybrid power system for a particular area in Odesa. HOMER-POR software is used and it gives the most feasible combination of hybrid system with lowest NPC and COE. In simulation result it is clear that grid/PV/converter configuration is optimum [5]. Abuah et al. studied the analysis of autonomous

Hybrid Wind-PV renewable system with load variation. The process depends in a various factors such as geographical location, solar irradiance, weather conditions and load consumption [6]. G. Sandeep et al. studied the Optimal Combination and Sizing of a Stand-alone Hybrid Power System Using HOMER. They presented a simulated model of stand-alone hybrid power system which is a combination of PV, Wind and Diesel with converter battery storage system. HOMER is used for the analysing of solar irradiance and wind speed data at JNTUK.it performs the energy balance configuration for each hour. The cost estimation of any feasible combination for installing and operating over the life time at a particular area can successfully be analysed using the proposed methodology [7]. Mannai et al. designed to find the optimal simulation that minimizes the total net present cost of the generation and cost of the energy while taking into consideration the interaction between the system and the national grid. To achieve the goal the as late of the discharged adaptation of the Hybrid optimization of electric energy (HOMER Pro) software is used to simulate and realize sensitivity analysis that helps assess the effect of uncertainty or changes within the veriables [8]. Rabehi presents the Optimal Design and Comparison between Renewable Energy System with Battery Storage and Hydrogen Storage. HOMER is used to simulate and in order to view about the technoeconomic feasibility. The comparison between the cost of the system and their performance on Algeria weather conditions has been analyzed. As results the system battery proved to be less expensive than the hydrogen storage, as well as, the hybrid system (PV, WECS) proved to be cost effective [9]. Kosh M Kuriakose et al. analyzed the solar PV-Wind hybrid grid connected system at proposed site was simulated using HOMER Pro software and to develop economical feasible hybrid system [10]. Ahammed et al. studied the optimization of the hybrid renewable energy system using HOMER Pro. The paper studies the possibilities of the wind and solar renewable energy systems are discussed [11].

II. AIM AND SCOPE

Solar energy is one of the most promising energy sources in the world. The amounts of fossil fuels are decreasing day by day so everyone is looking towards the renewable energy sources. In this situation the researchers are doing huge research on the solar energy to find its suitable application to minimize the dependence on fossil fuels. From the literature review it has been found that, there are several researches have been going on the solar energy. In this present work it has been tried to find the feasibility of the solar PV system to meet the energy demand for the EEE department faculty room in Siddharth Institute of Engineering & Technology, Puttur, Andhra Pradesh.

In this proposed work an off grid solar PV system and a grid connected solar PV has been designed to find the techno economic performance of the Solar PV system. In this study the aim is to find the feasibility of the solar PV system to meet the energy demand of one department staff room of an educational institute.

III. PROPOSED DESIGN

In this study the HOMER software has been used to find the performance of the small scale solar PV system for that particular load. There are two designed has been analysed to find the comparison between the performance of the grid connected solar PV and the off grid solar PV system.

The off grid solar PV system design has been shown in Fig 1. The electrical load for the study is 14.26 kWh/day. Here all the loads are considered as AC load. The Fig 2 illustrates the grid connected solar PV system. For the particular location the average solar radiation is 5.33 kWh/day.

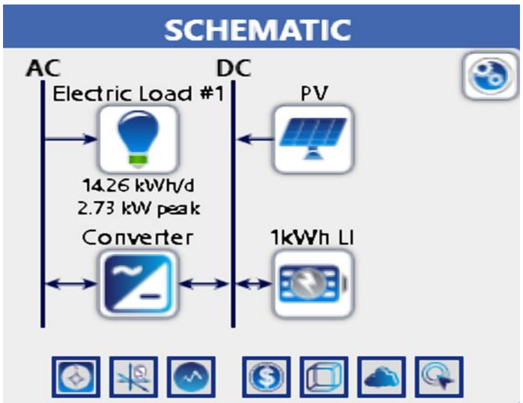

Fig 1. Off grid solar PV system

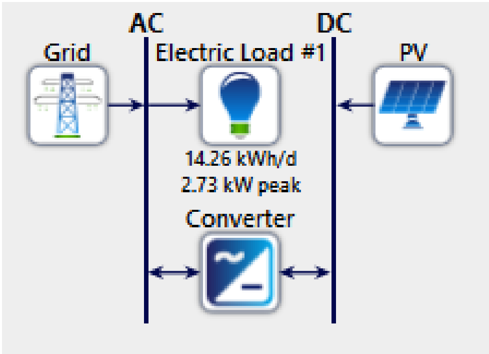

Fig 2. Grid connected solar PV system

Architecture								Cost			
				PV (kW)	1kWh LI	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)
				5.00	25	2.67	CC	$0.128	$7,509	$117.90	$6,234

Fig 3. Optimization Results

Production	kWh/yr	%
Generic flat plate PV	8,970	100
Total	8,970	100

(a)

Consumption	kWh/yr	%
AC Primary Load	5,430	100
DC Primary Load	0	0
Total	5,430	100

(b)

Quantity	kWh/yr	%
Excess Electricity	3,132	34.9
Unmet Electric Load	44.8	0.818
Capacity Shortage	60.0	1.10

(c)

Fig 4. Details of the power output from solar PV

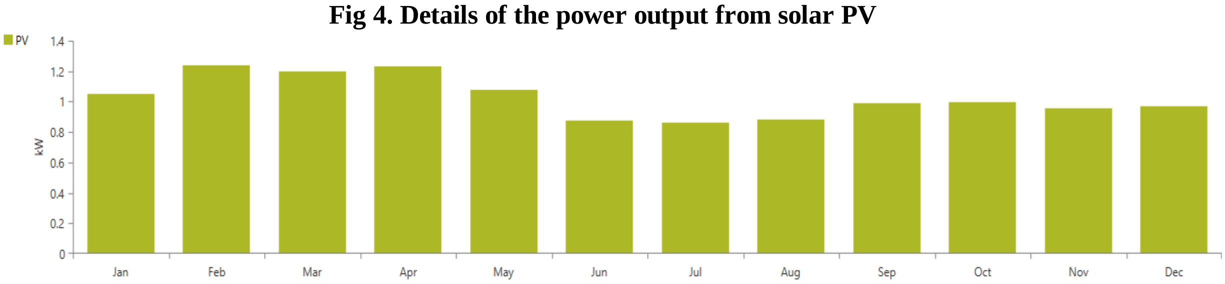

Fig 5. Monthly average electrical analysis of off grid PV system

Architecture							Cost			
			PV (kW)	Grid (kW)	Converter (kW)	Dispatch	COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)
			4.00	999,999	2.87	CC	$0.0477	$3,801	$61.54	$3,135
				999,999		CC	$0.100	$5,631	$520.49	$0.00

Fig 6. Optimizations Results

Production	kWh/yr	%
Generic flat plate PV	6,436	82.7
Grid Purchases	1,348	17.3
Total	7,784	100

(a)

Consumption	kWh/yr	%
AC Primary Load	5,205	70.6
DC Primary Load	0	0
Grid Sales	2,163	29.4
Total	7,367	100

(b)

Quantity	kWh/yr	%
Excess Electricity	100	1.28
Unmet Electric Load	0	0
Capacity Shortage	0	0

(c)

Quantity	Value
Renewable Fraction	81.7
Max. Renew. Penetration	136

(d)

Fig 7. Details of the power output from grid connected PV system

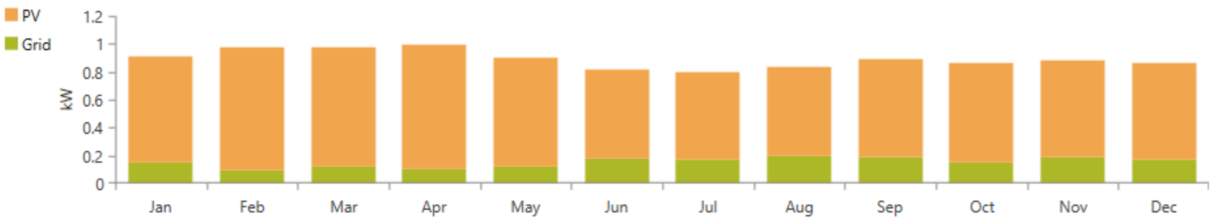

Fig 8. Monthly average electrical analysis of grid connected PV system

IV. RESULTS & DISCUSSION

Fig 3 illustrates the optimum results of the off grid PV system. From the figure it has been shown that the 5 kW size PV plant with 25 numbers of 1 kWh battery is enough to meet the load. With this optimum size the COE (Cost of energy) is minimum with 0.128 $/kWh.

Fig 4 (a – c) show the details of the power output from the off grid PV system. 4(a) shows that the total 8970 kWh/year electricity is generated from the optimum system. Fig 4(b) shows the AC load amount which is 5430 kWh/year and Fig 4(c) shows that the amount of excess electricity is 3132 kWh/year which is near about 34.9% of the total electricity production.

Fig 5 shows the monthly average electricity production from the off grid PV designed system. From the figure it has been shown that in the month of April the electricity production maximum.

Fig 6 illustrates the optimum results of the PV-Grid hybrid system or the grid connected PV system. From the figure it has been shown that the 4 kW size PV plant with grid connection is enough to meet the load. This is the optimum size where the COE (Cost of energy) is minimum with 0.0477 $/kWh.

Fig 7 (a – d) show the details of the power output from the design system. 7(a) shows that the total 7784 kWh/year electricity is produced out of which 82.7% is produced by PV and remaining 17.3% is taken from grid to meet the energy demand. Fig 7(b) shows the AC load amount which is 5205 kWh/year and sale 2163 kWh/year to the grid. Fig 7(c) shows that the amount of excess electricity is 100 kWh/year which is about 1.28% of the total electricity production. Fig 7(d) shows that the renewable fraction is 81.7%. In the system it has been shown that throughout the year 1348 kWh electrical energy has been purchased from grid whereas 2163 kWh electrical energy has been sold to the grid in a year. Fig 8 shows the monthly average electricity production from the designed system.

V. CONCLUSION

Solar energy is one of the most promising energy sources in the world. The amounts of fossil fuels are decreasing day by day so everyone is looking towards the renewable energy sources. In this situation the researchers are doing huge research on the solar energy to find its suitable application to minimize the dependence on fossil fuels. In this proposed work an off grid solar PV system and a grid connected solar PV has been designed to find the techno economic performance of the Solar PV system. The results showed that for off grid solar PV system the 5 kW size PV plant with 25 numbers of 1 kWh battery is enough to meet the load. With this optimum size the COE is minimum with 0.128 $/kWh. For the grid connected solar PV system it has been found that the 4 kW size PV plant with grid connection is enough to meet the load. This is the optimum size where the COE is minimum with 0.0477 $/kWh. It is concluded that an off grid solar PV system and grid connected solar photovoltaic (PV) system are technically and economically viable technology for the electrification of a department faculty room.

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