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Alternate Energy Sources for a Community Health Center in Punjab: A Step towards Self Reliant Energy

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Abstract: India's health sector is vast and it is present on every corner of the country. Rural India's health infrastructure majorly rely on Government Sponsored Health and Well being centers. Most of the medical diagnosis equipment are sophisticated in nature and requires high quality of electricity. But these center often experience power outage and poor quality of power, which creates a challenges for diagnosis and treatment of patients On the other hand these areas received good amount of sun shine and these challenges can be eliminate by putting Solar PV with adequate storage battery. The present study aims to find out the feasibility of such scheme with its optimal size.
Keywords: solar PV, storage, power reliability, simulation, optimization

I. INTRODUCTION

The most important supplier of energy for the earth is the sun. The whole of life depends on the sun's energy. It is the starting point for the chemical and biological processes on our planet. At the same time it is the most environmentally friendly form of all energies, it can be used in many ways, and it is suitable for all social systems [1].

Solar PV systems are usually intermittent, unpredictable and weather dependent. Therefore, a continuous and reliable power supply is hardly possible without energy storage. By employing an energy storage system (ESS), the surplus energy can be stored when power generation exceeds demand and then be released to cover the periods when net load exists, providing a robust back-up to intermittent renewable energy [2]. The ESS is thus a critical component and powerful partner to ensure sustainable supply of renewable energy [3], and the European Commission finds it will play a key role in enabling the world to develop a low-carbon power supply system [4]. The poor power quality and frequent outage creates hindrance to provide better quality health service in the locality. In the current pandemic scenario to vaccinate people the vaccine must be stored in cold reserve which required continuous supply. In this backdrop the present work try to evaluate the optimal size of standalone PV system to cater the need of a local community Health and well being center in Punjab, India. India continuously strives to provide better health care facility and other associated services. The proposed scheme consider such efforts in its advantage.

A. Modeling of the System

The proposed system involved in this study is equipped with a power generator (PV array and battery), an end-user (load) and a control station. The system is considered to be operated in stand-alone mode. The study is conceived with a community health and well being center in Punjab. The operating principle of the standalone solar can be briefly described as follows. The solar PV system produces energy during sunny hours. During the time of excess energy production the battery stores the energy and during deficit it is taken from the battery to cater the load. In this way, a reliable and sustainable energy supply would be guaranteed if the charging and discharging rates as well as the capacity are sufficient. The primary components of the system is PV array, battery, balance of system as inverter and charge controller.

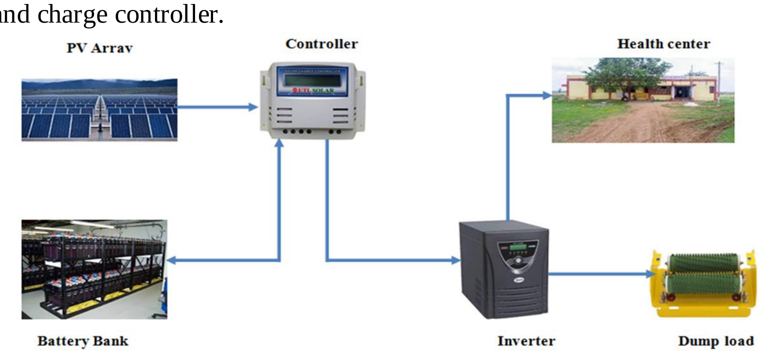

Fig. 1 Standalone PV system

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B. Load Profile

The proposed system is designed to serve a daily load of 138 kWh/day with a peak load of 23 kW. However, this represents the average load demand. Besides, the power demand will rise due to the increasing number of equipment in near future. The system is mainly design to cater the load for a community health center. It can be also seen that the peak demand of the load is occurring in day time . The power production of the scheme is possible for sunny hours, for cater load during night battery arrangement is done. Therefore in this study the daily base load to be served by the proposed scheme is assumed as138 kWh/day and then synthesized in HOMER software by adding randomness of day, to create a quite reasonable load profile. The load of the proposed scheme is taken as constant in all the months for the simulated year.

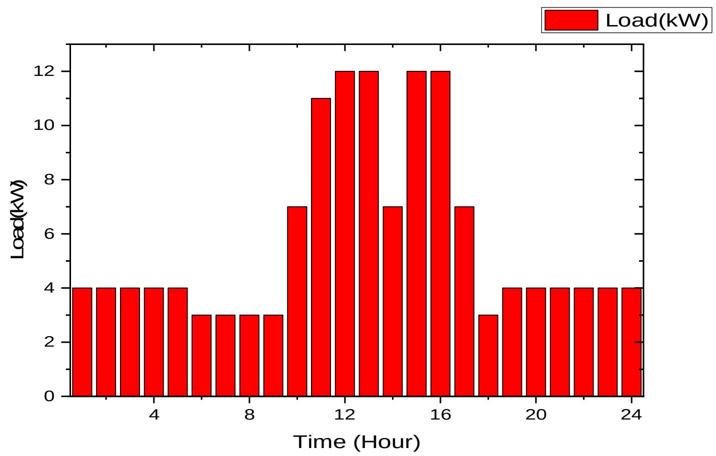

Fig 2 Hourly load demand

C. Solar Energy Resource

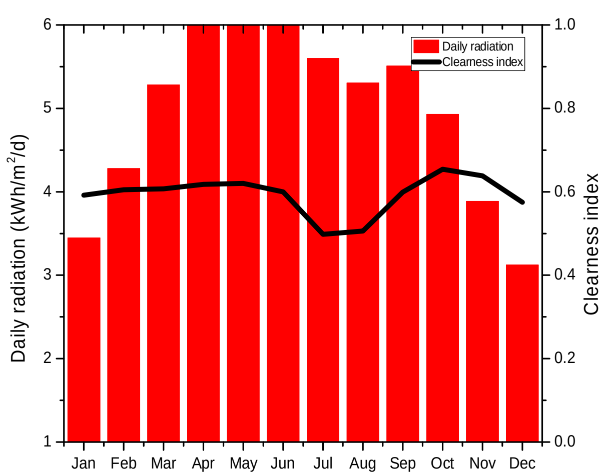

Fig. 3 Monthly variation in solar radiation and clearness index

For the proposed scheme solar energy plays an important role. With the advancement in technology the power production from the PV array is increasing. The power production from the PV array is dependent on the weather condition at which it is being installed. Typical variation of solar radiation in India is found to be 4-6 kWh/m^2/day. The study is conducted at 27.59 degree latitude and 79.59 degree longitude. And for the proposed site monthly average daily solar radiation found to be 5.12 kWh/m^2/day with clearness index of 0.588, the installed capacity of the PV array is 40 kW$_P$.

D. Daily Mean Renewable Energy Production And Load Demand

The daily average PV power generation for each month of the year are presented in the below fig. It can be observed that the PV power can alone managed the load through out the year. This is a favorable characteristics since maximum portion of electricity demand could meet by the proposed system. The blue bar shows the PV power average generation in every month and the maroon line shows the average daily demand.

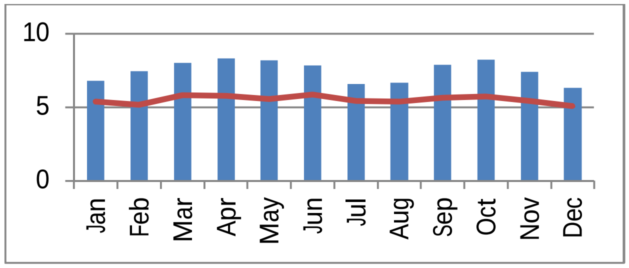

Fig. 4 Daily mean renewable energy production and load demand

E. Hourly energy balance of the proposed system

An example of the hourly simulation result during one typical week is illustrated in the below fig. to analyze the energy balance of the proposed system. It is obvious that the available PV output is first used to cover the local power demand, and accordingly charge the battery unit and thus increases the state of charge of the battery. When energy deficit exists, the battery units are launched, thus the State of charge of battery bank decreases as they release the stored power.

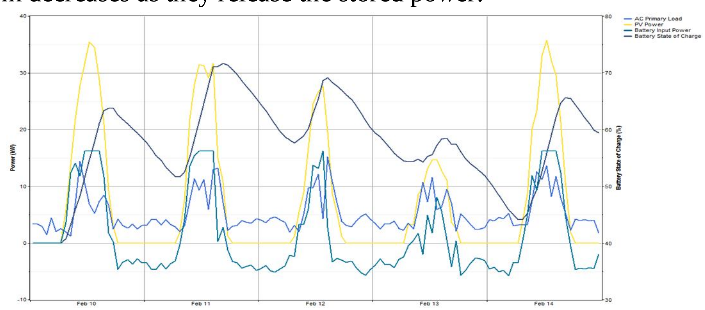

Fig. 5 Hourly energy balance

The above figure shows the hourly energy balance of the proposed scheme. It is seen that when the power output from the PV array is not sufficient discharge of battery occurs to meet the load demand and hence the State of Charge of battery unit decreases. And when the power output from the PV array exceeds the load demand the excess power is feed to the battery to increase the State of charge of battery which is shown in blue line. The line below zero shows the variation of battery charging though input power from the system.

F. Economic Analysis

The figure shows the overall optimization result of the system which is generated in the HOMER software. Each row in the table represents a viable system configuration. The first 3 column shows icon , next three column indicate number or size of each component the next six column shows key simulation results, such as capital cost of the system, operating cost, Net present cost, levelized cost of energy, renewable fraction and capacity shortage. The optimal configuration is the one having lowest NPC which comprises of 40kW$_P$ PV,60 No of S4KS25P battery, 20 kW converter. The COE is found to be 5.687/kWh and100% renewable fraction and capacity shortage of 5%.

			PV (kW)	S4KS25P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
			40	60	20	$ 2,676,337	65,395	$ 3,512,304	5.683	1.00	0.05
			40	70	15	$ 2,700,002	69,239	$ 3,585,112	5.758	1.00	0.05
			40	70	20	$ 2,733,337	73,460	$ 3,672,400	5.872	1.00	0.04
			40	60	30	$ 2,743,007	73,836	$ 3,686,880	5.965	1.00	0.05
			50	40	20	$ 3,112,337	49,265	$ 3,742,112	6.042	1.00	0.05
			50	50	15	$ 3,136,002	53,109	$ 3,814,920	6.074	1.00	0.04
			40	70	30	$ 2,800,007	81,901	$ 3,846,976	6.151	1.00	0.03

Fig 6 Optimization result of pumped storage

II. CONCLUSION

In this study the standalone PV system is examined. The results are showing promising for the Community health and well being center. It concludes that with the integration of battery, the power quality and output of the system increases, the schemes employed in the study are also complementary in nature, the capacity shortage is 0.5% which also increases reliability of the scheme, the levilised cost of energy is estimated as 5.683 INR/kWh, proposed scheme is also having negligible emission and hence eco friendly.

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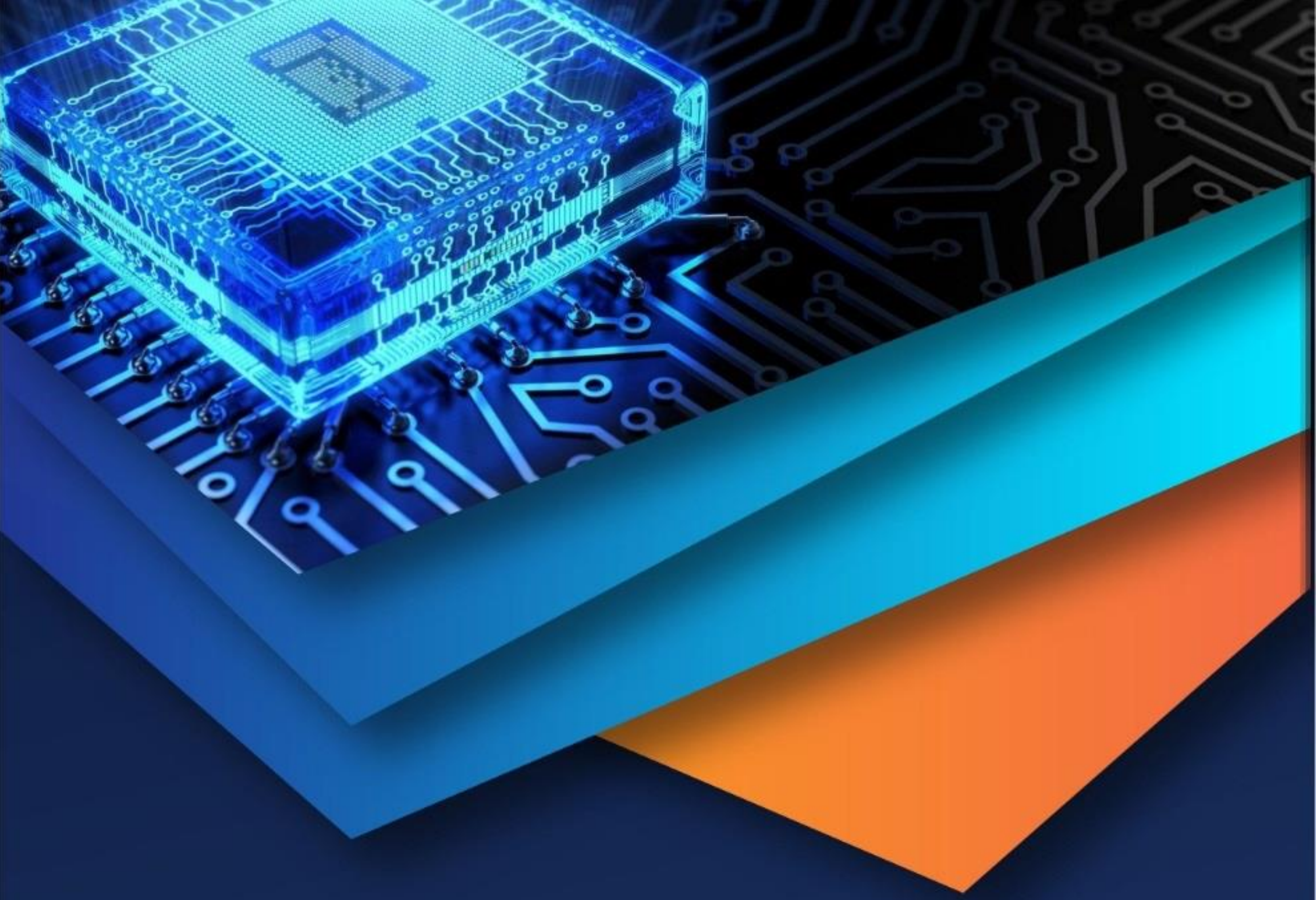

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