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Solar Simulation Model to Find Optimal Solution for Domestic Load

Mujeeb Jeelani Magray[1], Dharminder Kumar[2], Krishna Tomar[3]
[1, 2, 3]Department of Electrical Engineering, RIMT University, India

Abstract: Looking at the energy sector of India, it is the 3rd largest producer in the world and holds the largest grid in the world. Despite the presence of largest grid, still frequent power outage, delivery of low quality of power and unreliability of supply persistent in some areas. This unreliable power supply creates hindrance in the overall development of the region. On the other hand solar power is most widely used source of renewable energy, can be able to provide feasible solution. By installation of solar PV array in the premises of the load center the reliability will be increased. The power production from the PV is also cost competitive and environment friendly. As solar PV power is intermittent in nature, the most old and mature storage technology ,i.e. battery can be integrated to mitigate this intermittency nature. The present study examines the feasibility and optimizes the size of such system, while the cost competitiveness is kept at the center.
Keywords: solar PV, Simulation, optimization, storage technology, power quality

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].

Today's world run on energy. The power national grid often became unreliable and resulted into frequent power outage and deliver poor quality power. This may lead to damage the sophisticated devices installed at home. More over due to frequent power loss house hold activities halted and delayed. The proposed scheme tried to return the comfort to such consumers by taking the advantages of its sunny location through out the year and its reliability are enhanced by the integration of battery bank.

A. Modeling of the System

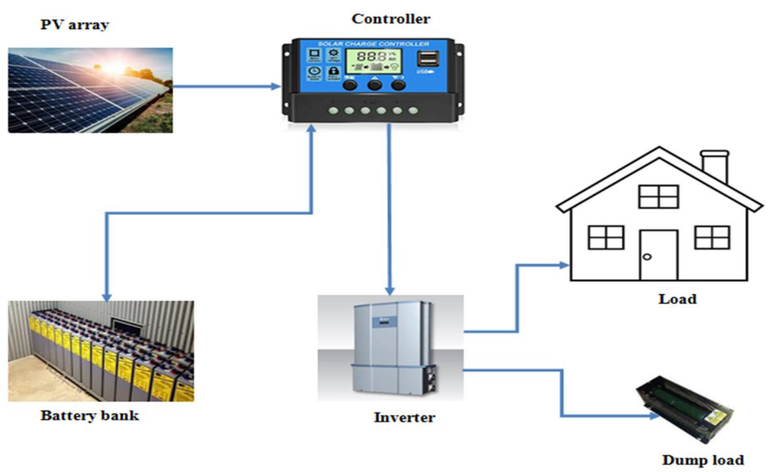

Fig. 1 Solar PV standalone system

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The operating principle of the standalone solar can be briefly described as follows. The solar system produce energy during sunny hours and cater to the local load. In the event of excess energy production the battery stores the energy and during deficit battery discharges to meet the load demand. In this way, a reliable and sustainable energy supply would be guaranteed for 24 h a day 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 converter along with a dump load to release the excess energy when battery is already in full charging condition.

B. Load Profile

The proposed system is designed to serve a daily load of 86kWh/day with a peak load of 14 kW. However, this represents the average load demand. Besides, the power demand will rise due to the increasing number of devices in near future. However the actual data is not collected from the site. The system is mainly design to cater the domestic demand or household load. It can be also seen that the peak demand of the load is occurring in evening time. The power production of the scheme is only in day time for cater load during night battery arrangement is done. The model is synthesized in HOMER software by adding randomness of day, to create a quite reasonable load profile.

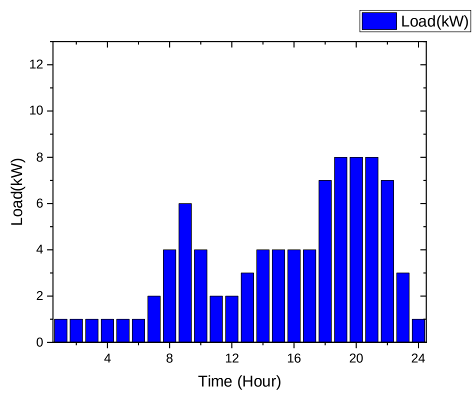

Fig 2 Hourly load demand

C. Solar Energy Resource

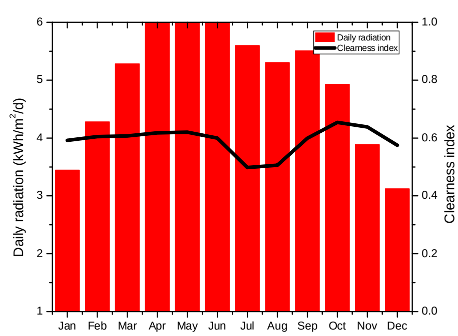

Fig. 3 Monthly variation in solar radiation and clearness index

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 5.24 kWh/m^2/day with clearness index of 0.588, the installed capacity of the PV array is 35 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.

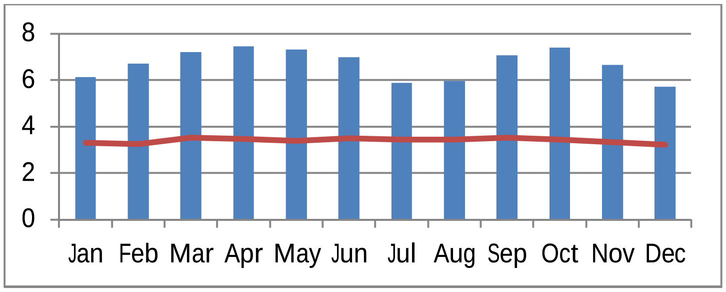

Fig. 4 Daily mean renewable energy production and load demand

E. Energy Distribution on a Typical Day

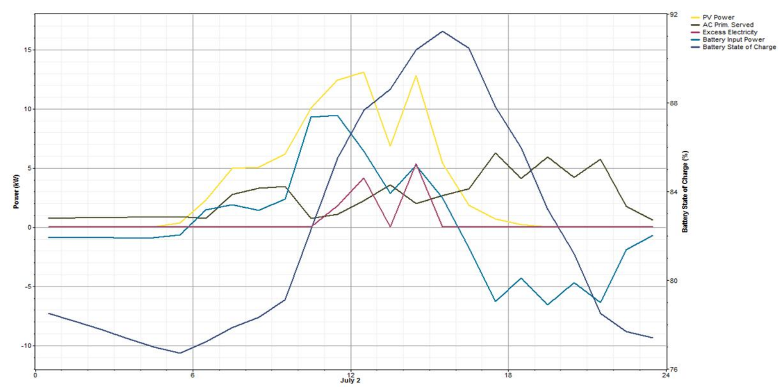

Fig. 5 Energy distribution Pattern

The above figure shows the distribution of energy through out the day. 2nd July is considered for the purpose. It is observed that the power output from the PV shown in yellow color is feed to the Primary load. The line shown in maroon color shows the excess electricity which occurs only during the peak production hour of solar PV array. The blue line shows the state of charge of battery which charges during day time and discharge during night time to complete one cycle. The battery discharging is shown in the line below zero.

F. Sensitivity Analysis

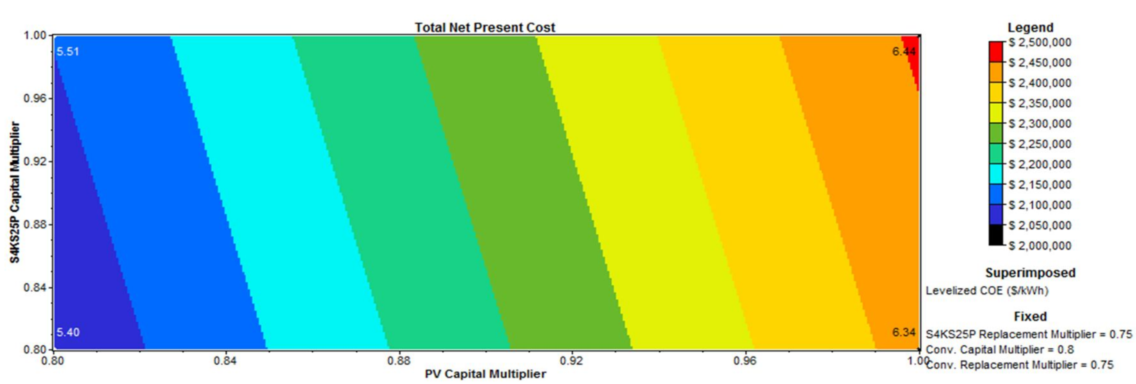

Fig. 6 Surface Plot of electricity charge

The cost reduction and technological development of renewable energy systems in recent years has been encouraging in Indian context. Hence, it is presumed in the study that the system cost is likely to decrease in future. In order to simulate the declining cost for the long term analysis; a 20% reduction in PV, Inverter and Battery cost has been incorporated in the estimation. When merely the PV cost is reduced by the by 20%, the total NPC and COE are reduced by 14.21% and 14.22% respectively. When the Inverter cost reduced by 20% and 25% in its replacement the NPC and CoE slashed by 0.71% and 0.70%. Similarly when the battery capital reduced by 20% and replacement reduced by 25% the NPC and CoE reduced by 2.65% and 2.66 % respectively. When the combine decline of all the components are observe the NPC and CoE are slashed by 17.58% and 17.57% respectively. In all these supposition, operating cost is found to be increased a bit with renewable fraction and capacity shortage of 1 and 0.20 respectively.

G. *Economic Analysis*

The fig. shows the overall optimization result of the hybrid 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 COE, renewable fraction and capacity shortage. The optimal configuration is the one having lowest NPC which comprises of 35 kW_P PV,35 No of S4KS2P battery, 8kW converter. The COE is found to be 6.556/kWh and100% renewable fraction and capacity shortage of 8%.

			PV (kW)	S4KS25P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
			35	35	8	$ 2,039,900	36,125	$ 2,501,695	6.556	1.00	0.08
			35	40	8	$ 2,068,400	40,157	$ 2,581,743	6.696	1.00	0.07
			35	45	8	$ 2,096,900	44,190	$ 2,661,791	6.878	1.00	0.06
			40	35	8	$ 2,293,900	36,125	$ 2,755,695	7.159	1.00	0.07
			40	40	8	$ 2,322,400	40,157	$ 2,835,743	7.332	1.00	0.07

Fig 7 Optimization result of pumped storage

II. CONCLUSION

In this study the standalone PV system is examined for domestic load. The results are showing promising for such combination. It concludes that with the integration of battery, the power output of the system increases, the capacity shortage is only 8% which increases the system reliability, the schemes employed in the study are also complementary in nature, the levilised cost of energy is estimated as 6.556 INR/kWh, proposed scheme is also having negligible emission and hence eco friendly.

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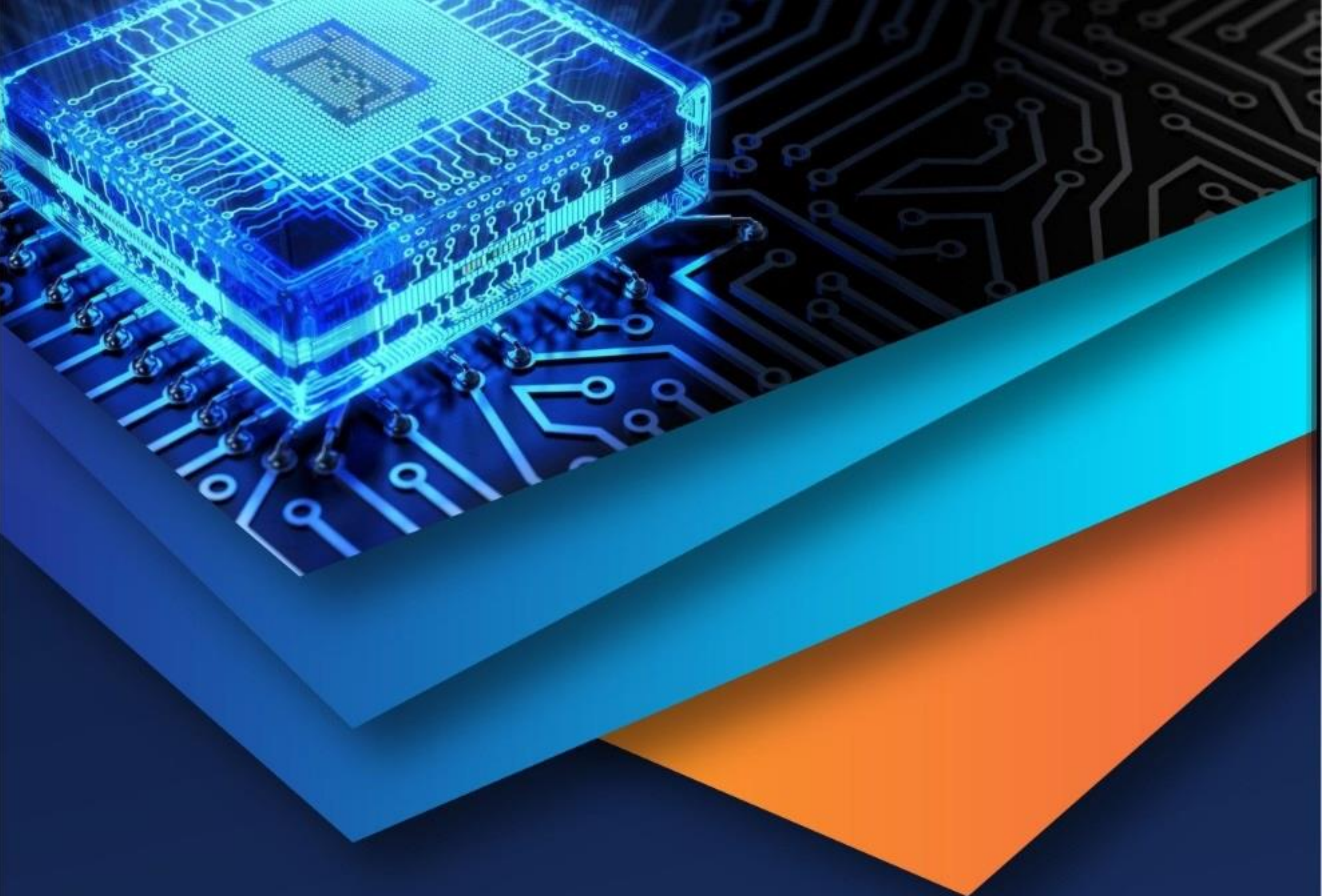

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