Design and cost study of a 25kW SPV system based on real performance in an Indian environment

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Abstract.

The present paper focuses on solar PV system design and includes a cost analysis based study of a 25kW off-grid photovoltaic (PV) system at Integral University, Lucknow, India (28.5616N, 77.2802E). The cost of the electricity generated by the 25kW PV system has been calculated on a weekly and monthly basis. Additionally, the 25kW PV systems offer an internal rate of return of about 1.714%. With no outside financial support, a solar 25kW PV system with a cost of INR 0.9724/kWh is anticipated for a project with a 25-year profitable life based on the assumptions used in this analysis. This translates into an additional payment of 14.06 Lacks INR over the more expensive rate of power generated by the system at 25kWh. An additional cost charge is not required to maintain this type of PV system, though, if financial support is greater than 50% of the initial investment cost. In essence, this system was developed for a small town in a region with a limited supply of grid electricity. In rural India, a 25kW PV solar system is also quite advantageous.

Keywords- PVsyst Simulation, Si-Poly PV Module, Grid-connected photovoltaic system, Performance ratio, Renewable energy.

1. INTRODUCTION

Traditional energy sources are running out, which is bad for the environment and makes it even more important to find other ways to get power. Solar energy is the most abundant, clean, and promising nonconventional energy source. As the worldwide growth of renewable energy (RE) investment becomes more prominent. Economic and technological research is required to determine the viability of these resources. This study looks at how solar PV systems are designed and how well they work based on data collected in the field. As a limitation of solar PV system technology, the environmental conditions such as temperature and sun irradiation variations are major concerns about the performance degradation [1]. Moreover, when it comes to power quality, these discrepancies provide considerable challenges also [2]. An equally difficult procedure is the incorporation of renewable energy [3]. Isolated solar PV systems deliver better power quality in contrast to grid-integrated systems. Batteries in isolated systems connected to maximum power point technique (MPPT) charge regulators can endure any radiation exposure and temperature variations [4]. In this article, a small Indian community's concept for a 25kW off-grid PV system, primarily for rural areas, is presented. Also, PVsyst software has been used to evaluate this rooftop system's performance based on a cost analysis [5]. Using the PVsyst application, it is possible to determine the amount of power that is generated, used, and wasted [6-7]. The gathered data is then used to perform the system's economical costing. Most of the study's data is annual, and the programme creates solar radiation data depending on the site's latitude and longitudinal data [8-11]. Then, for the given load, a variety of solar energy generation values are offered. An overview of PV system design is given in the second part, and the third section presents the results of the simulation. The paper's findings are then summarised in the concluding section.

2. DESIGN AND SPECIFICATIONS OF PV SYSTEM

The essential component of a PV system's design is the PV modules, which are linked together in a PV array in both parallel and series configurations. The size of the PV array is determined by the system's power rating. Vikram Solar PV modules (VSPV-CAAP-BC, 400Wp, Si-Poly) are used in the 25kW solar plant installation. Under ideal circumstances, each PV module can withstand a maximum voltage (42.5V) and current (9.72A) respectively. The combined maximum voltage and current for all PV modules is 42.5V and 43.6A, respectively [12-13]. This system also includes MPPT which is essential to extract the maximum power to the load. This system uses a generic universal MPPT controller with a maximum input current range of 30–45A and an output constant current of 14A. The entire setup is shown in Fig. 1 and Table-1 provides a list of every component. Fig. 2 displays the configuration of a 25kW stand-alone SPV system.

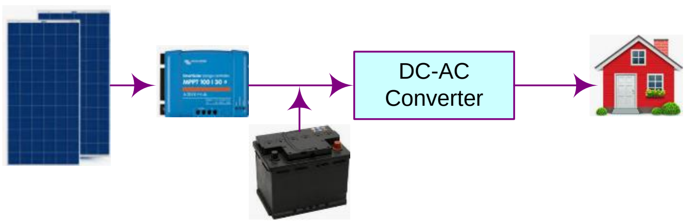
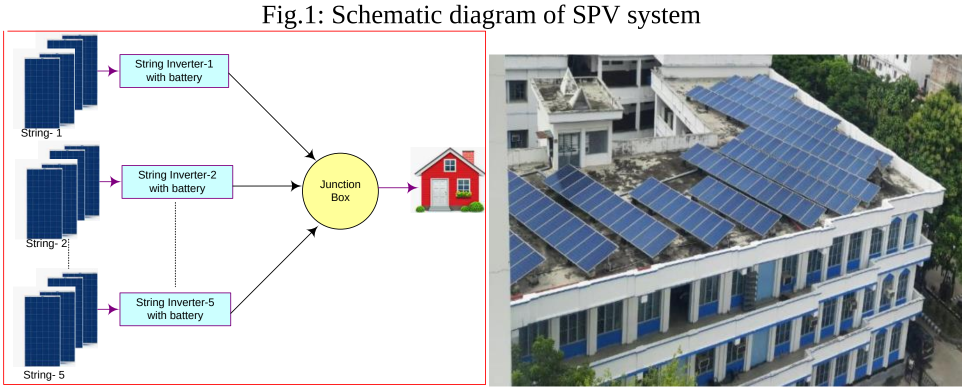


Fig.1: Schematic diagram of SPV system



(a) (b)

Fig. 2: (a) Layout (b) On site PV system of a 25 kW power capacity

Table 1: Specification of 25kW Off-Grid Solar System (Calculated for 6 hour backup)

Particular	Company	Qty	Type	Efficiency	Lifespan	Price/ Qty	Investment cost
Solar Panels 25kW, 400W/ panel	Vikram Solar	63	Mono/ Poly	Up to 19%	25 Years	INR 12-15K/Panel	INR 7.56- 9.45L
5kVA String Inverter	Luminous	5	Off-Grid Solar Inverter	97%	5 Years	INR 45-50K /Inverter	INR 2.25-2.50L
150Ah, 12 Solar Power Battery	Exide	25	Tubular Solar Battery (C10)	-	3-5 Years	INR 13-15K/Battery	INR 3.25-3.75L
Other Accessories and Structure	Fasteners, cable ties, crimping tools, Earthing supplies, lighting interrupters, solar panels, 150 square metres space, 1 junction box, 220 metres of cable, and 150 metres of AC cable are needed.					INR 4-5K/kW: Thumb rule	INR 100-125L
						Total:	**INR 14.06-16.95L**

3. SIMULATION AND RESULTS

The installation and performance analysis of a 25kW PV system is carried out using the PVsyst tool. The beginning cost of the system under consideration ranges from 14.06-16.95 Lacks INR (Table-1). Specifically for household use, this investment will pay for a PV module, an MPPT controller, batteries, and an inverter. Table 2 provides data on the load and daily energy usage. The dedicated system's load required 110 kWh of electricity per day. PVsyst software is used to estimate the PV system's monthly energy output. As shown in Fig. 3 and Table 3, due to the influence of temperature on PV modules, the maximum global irradiation was only achieved in May month. May has the most solar energy compared to other months, and PVsyst simulates the highest generation in May month. The lowest insolation was received in the months of January and December, but because of temperature change, it is at its minimum in the month of December. Same thing happened with the simulated results using PVsyst. The minimum energy was recorded in the month of December, which validates the accuracy of the installed system. It's possible that the 3.67 MWhr of energy was generated throughout the year, which can also be use for the charging of batteries. Increases in battery storage capacity or higher consumption levels during the generating phase are two ways to utilise the unused energy. Fig. 3 shows the comparison of power generation, and it is compared with the simulation software PVsyst, for the validation of the installed system.

Table 2: Energy usage per day and load

S. no.	Load type	Quantity	Power Consumption	Uses	Energy (kWh/day)
1.	AC	4	2 Tons (2100 Watt)	6	50.4
2.	Fridge	1	2kW	6	12
3.	TV	1	80 W (Max.)	6	0.48
4.	Lights	1	2kW	6	12
5.	Pumps	1	5.5kW	6	33
				Total:	**110 (Approx.)**

Table 3:Performance ratio evolution of SCADA and PVsyst

Months	Temp. (ºC)	Insolation (kW/Hr)	SCADA		PVsyst	
			Energy (MWhr)	%PR	Energy (MWhr)	%PR
Jan	13.53	3.55	2.64	70.53	3.15	93.14
Feb	20.72	4.29	3.63	98.38	3.67	98.38
Mar	27.73	5.89	4.82	81.83	4.92	82.38
Apr	33.31	6.37	4.75	72.33	4.89	73.33
May	38.15	6.5	4.94	76.58	5.27	77.44
Jun	38.75	6.08	4.13	70.82	4.32	79.18
Jul	31.96	3.95	3.05	85.23	3.62	85.23
Aug	28.19	3.73	3.13	85.00	3.86	87.37
Sep	26.82	4.51	3.54	82.89	3.65	83.74
Oct	23.37	5.01	3.85	81.43	3.93	83.25
Nov	18.59	3.94	3.15	86.44	3.26	90.35
Dec	13.47	3.55	2.52	92.03	2.89	92.6
Average	**26.21**	**4.78**	**3.67**	**81.95**	**3.95**	**85.5325**
Total	**-**	**-**	**44.15**	**-**	**47.43**	**-**

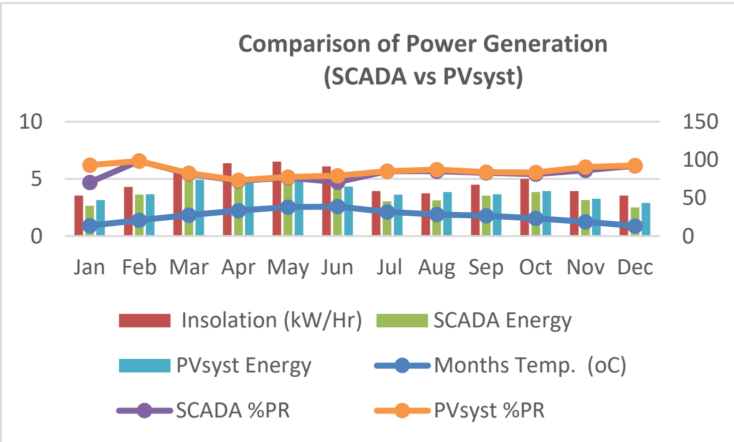


Fig. 3: Comparison of Power Generation (SCADA vs PVsyst)

4. CONCLUSION

In this study, a 25kW PV system for small communities in rural India is evaluated. The performance and cost analysis of the intended system have been evaluated using the PVsyst program. Due to the influence of temperature on PV modules, the maximum global irradiation was only achieved in May. The biggest amount of solar energy is also available in May compared to other months, and the generation is also maximum during the month of May, which is simulated using PVsyst. The lowest insolation was received in the months of January and December, but because of temperature change, it is at its minimum in the month of December. The same thing happened with the simulated results using PVsyst. The minimum energy was recorded in the month of December, which validates the accuracy of the installed system. It's possible that the 44.15 MWHr of energy was generated throughout the year, which can also be used for the charging of batteries. A monthly estimate of the PV system's energy output is also provided and demonstrates how radiation from the sun affects solar energy generation. It is also computed to compare the energy generation results with PVsyst that was produced by the solar PV system.

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