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Design and cost analysis of 1 kW photovoltaic system based on actual performance in Indian scenario☆

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Summary The exhaustion of conventional resources and its effect on climate requires an urgent call for the substitute power resources to convene up the current power requirement. Solar energy is an endless, unsoiled and prospective energy source among all other nonconventional energy options. As more concentration is being done on focal point for the development of renewable energy capital globally. To ascertain their viability it is necessary to do the economic and technical assessments of these resources. This paper presents designing aspects and assessments of solar PV system based on field and actual performance. The study is based on design of solar PV system and a case study based on cost analysis of 1.0 kW off-grid photovoltaic energy system installed at Jamia Millia Islamia, New Delhi (28.5616° N, 77.2802° E, and about 293 m above sea level) India. Both monthly and weekly costs of energy produced by the 1 kW PV system have been calculated. In addition, the solar PV 1 kW system can give internal rate of return of about 1.714% on investment. Based on assumptions used in this study, solar 1 kW PV system of Rs. 0.9724/kWh is estimated for a project with profitable life of 25 years with no other financial support. This translates to Rs. 80,000 payment over the livelier cost of energy of 1 kWh generated by the system. However, if the financial support is more than 50% of the initial investment cost, no further payment fee is necessary to support this type of system. Basically this system has been designed for small home located at the place of availability of grid power is rare. 1 kW PV solar system is also very useful in rural areas of India. India as a subcontinent receives great amounts of solar radiation annually.

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Introduction

Photovoltaic is a technology that reliably converts solar radiation into electricity. There are different types of modules depending on power ratings. Every module has a number of solar cells. Solar cells are fabricated by means of semiconductors such as silicon. Photovoltaic cells generate electricity in clean and reliable manner which is the prime concern for today's environment. Variation in temperature affects the efficiency of solar module greatly (Parlak, 2014). Due to these variations this technology faces enormous challenges in its power quality performance (Patra et al., 2015). Integration of renewable energy is also a tedious process (Pinto and Panda, 2014). Solar photovoltaic standalone systems have better power quality as compared to grid integrated systems. In standalone systems batteries connected with MPPT charge controller tolerates all fluctuations of temperature and radiation associated with environment (Wu et al., 2013).

In this paper, 1 kW PV system is designed for small home mainly for rustic areas sited in India. This is small roof top system and its performance based on cost analysis has evaluated using PVsyst software (Mermoud, 2012). PVsyst software uses the information of solar radiation to calculate generated power, used power and unused power (Irwan et al., 2015; Metwally and Farahat, 2011). Then the economical costing of the system is performed on the generated data. Mainly the study includes the data for one year and the information about the solar radiation is generated by the software itself based on the latitude and longitudinal information of the site. Then for the specified load it gives different values about the generation of solar energy. The second section gives a brief introduction about the designing of PV system, followed by simulation results in the third section. Then the final section concludes the finding of the paper.

PV system design

Designing of PV system mainly consists of PV modules, large no. of PV modules are connected in parallel and series combination called PV array. The size of PV array depends on power rating of the system. 1 kW solar system is designed by using 200 W Moserbaer (MBPV CAAP BC 200Wp) PV Si-Poly modules. The maximum voltage and current rating by each module is 27.6 V and 7.26 A respectively at ideal conditions.

All six PV modules are connected in parallel so maximum voltage is 27.6 V and maximum current is 43.6 A. MPPT is also extremely crucial part of this system so selection of MPPT is also really significant. In this system Generic Universal MPPT controller is used which has maximum input current range is 30—45 A at 14 A output constant current. List of all components are shown in Table 1 and complete system is shown in Fig. 1 (How are u operating a 27.6 V inverter from two batteries of 12 V each?).

Table 1

Particular	Company	Quantity	Investment (in Rs.)
PV modules	Moserbaer	5	48,000
Batteries	Exide	2	25,000
MPPT controller	Generic	1	2000
Inverter	Microtech	1	5000
Total			80,000

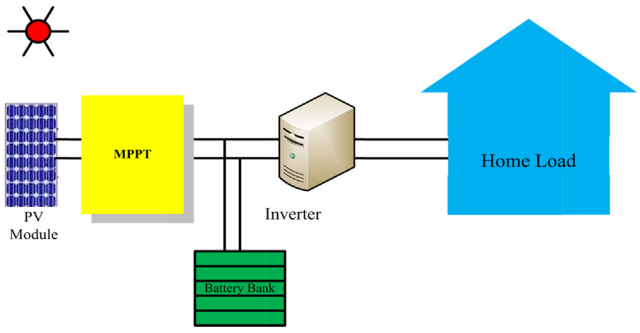

Figure 1 System model.

Simulation results

The performance of 1 kW PV system has evaluated using PVsyst software. The initial cost of the considered system is approximately Rs. 80,000. This investment includes the cost of PV module, MPPT controller, batteries and inverter mainly for home use. Information for the load and the daily consumption of energy is given in Table 2. The load specified for the dedicated system needed 8109 Wh energy per day.

Monthly energy production by the PV system is calculated using PVsyst software. According to simulated data maximum global irradiation were found in the month of May (222.1 kWh/m^2) but effective global irradiation is low (199.3 kWh/m^2) due to temperature effect on PV modules. In the month of March the horizontal global irradiation is low but available solar energy is maximum (267.6 kWh) as compared to other month. Annual solar energy produced by the system is 3101.2 kWh while the energy supplied to the user

Table 2

Load	Quantity	Power consumption	Uses	Energy
Lamp (LED/Fluo)	5	15 W	11 h/day	825 Wh/day
TV/PC	2	80 W	6 h/day	960 Wh/day
Domestic appliances	5	60 W	15 h/day	4500 Wh/day
Other uses	5	60 W	6 h/day	1800 Wh/day
Total				8109 Wh/day

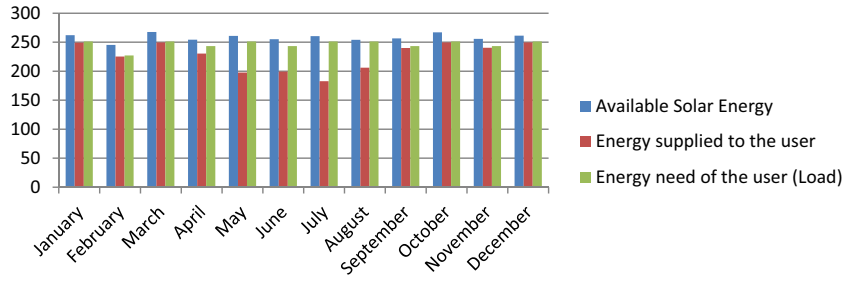

Figure 2 Solar radiation data.

is 2933.4 kWh. 167.8 kWh energy has not consumed may be due to the reason that either the load is not available during generation or batteries may reach their storage capacity of charging. This unused energy can be used either by increasing the storage capacities of the batteries or by increasing the consumption during generation time (Fig. 2).

Conclusion

In this paper, a 1 kW PV system is studied for small homes only for rustic areas sited in India. Performance of the system and cost analysis for the designed system has been evaluated using PVsyst software. The desired PV system generates 3101.2 kWh/year solar energy, but only 2933.4 kWh/year solar energy is supplied to the user and 167.8 kWh energy unused may be due to battery full condition or low energy demand during generation. The energy produced by the PV system is also calculated month wise. Also the effect of global radiation on the generation of solar energy is depicted. Comparison of energy generated by PV, energy supplied and needed by user is also calculated.

Conflict of interest

None declared.

References

Irwan, Y.M., Amelia, A.R., Irwanto, M., Fareq, M., Leow, W.Z., Gomesh, N., Safwati, I.,2015. Stand-alone photovoltaic (SAPV) system assessment using PVSYST software. In: 2015 International Conference on Alternative Energy in Developing Countries and Emerging Economies, vol. 79. Elsevier, pp. 596—603.

Mermoud, A., 2012. Pvsyst: Software for the Study and Simulation of Photovoltaic Systems. ISE, University of Geneva, www.pvsyst.com.

Metwally, H.M.B., Farahat, M.A., 2011. Performance analysis of 3.6 kW rooftop grid connected photovoltaic system Egypt. In: International Conference on Energy Systems and Technologies (ICEST 2011), Cairo, Egypt, 11—14 March.

Parlak, K.S., 2014. PV array reconfiguration method under partial shading conditions. Electr. Power Energy Syst. 63, 713—721.

Patra, S., Kishor, N., Mohanty, S.R., Ray, P.K., 2015. Power quality assessment in 3-U grid connected PV system with single and dual stage circuits. Electr. Power Energy Syst. 75, 275—288.

Pinto, S.J., Panda, G., 2014. Performance evaluation of WPT based islanding detection for grid-connected PV systems. Electr. Power Energy Syst. 78, 537—546.

Wu, Y.C., Chen, M.J., Huang, S.H., Tsai, M.T., Li, C.H., 2013. Maximum power point tracking on stand-alone solar power system. Three-point-weighting method incorporating mid-point tracking. Electr. Power Energy Syst. 52, 14—24.