International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

Performance Evaluation of 100kWp Roof-top Grid-connected PV System installed in Northern India

Premananda Pany, Najib Hamisu Umar, Pallavi Gupta, Birinchi Bora

Abstract: ***The performance of 100 kWp roof-top grid-connected PV system was evaluated. The plant was installed at PGDM building in Sharda University, Greater Noida in northern India. The plant was monitored from March 2018 to February 2019. Performance parameters such as system efficiency, performance ratio, capacity utilization factor, and degradation rate were obtained. The plant performance result was compared with the estimated results obtained from SAM and PVsyst software. The total annual energy output was found to be 16426 kWh. The annual average system efficiency and capacity utilization factor of the plant was found to be 15.62 % and 14.72 % respectively. The annual performance ratio and annual degradation rate were found to be 76% and 1.28%/year respectively. The annual performance ratio obtained from SAM and PVsyst was found to be 78% and 82% respectively. It was noticed that the measured performance ratio was highly relative with the one obtained from SAM software.***

Keywords: Photovoltaic System, Performance, Degradation, Simulation Software.

I. INTRODUCTION

In recent years, the utilization of renewable energy sources has become the significant reasons for the rising demand for electrical energy, which are preventing global warming and preventing environmental pollutions. Solar photovoltaic (PV) system is regarded as the major sustainable energy due to its eco-friendly and available [1-3]. However, the operating performance and degradation of a PV system are affected by environmental factors such as solar radiation, temperature, atmospheric humidity, and dust [5-7]. Modeling softwares for renewable energy have been developed to design and optimize the hybrid power system. This is in order to avoid oversize and to reduce the cost of installation. The performance and economic analysis could be performed using these softwares[7, 8]. In this work, the System Advisor Model (SAM) and PhotoVoltaic systems (PVsyst) software were used for the complete analysis. This paper evaluates the performance of 100kWp grid-connected roof-top installed in northern India. The performance results are also compared with the estimated results obtained from SAM and PVsyst software.

Manuscript published on 30 September 2019
* Correspondence Author
Dr. Premananda Pany*, Electrical & Electronics Engineering Department, Sharda University, Greater Noida, India. Email: pnpany@gmail.com
Najib Hamisu Umar, student, ECE department, Sharda University Greater Noida, India. umarnajibhamisu@gmail.com.
Dr.Pallavi Gupta, Electronics & Communication Engineering Department, Sharda University, Greater Noida, India. Email: pallavi.gupta2@sharda.ac.in
Birinchi Bora, Senior Research Scientist at National Institute of Solar Energy, Gurugram. India, birinchibora09@gmail.com.

II. METHODOLOGY

A. *Climatic characteristics and layout of the PV plant*

The 100kWp roof-top grid-connected PV plant is installed at PGDM building in Sharda University, Greater Noida located in northern India. The location has geographical coordinates of 28.51° N and 77.41° E latitude and longitude respectively. The locations classified as composite climate since it constitutes winter, summer and summers seasons. High temperature is observed during summer (March to June) and low temperature is observed during winter (November to February). There is little rainfall throughout the year with an annual rainfall of 753mm. the annual average temperature is 25.50C and annual relative humidity is 58.20%. The plant has a total of 324 modules, 18 modules are connected in series making 18 strings. The module is polycrystalline silicon having 72 solar cells. The rated power and rated efficiency of the module are 310W and 16.21% respectively. Two inverters having rated capacity of 50kW were used to convert DC to AC. The side view of the PV plant is illustrated in figure 1. The plant was monitored from March 2018 to February 2019.

Figure 1: Side view of the power plant

B. *Analysis on performance*

In this paper, performance parameters such as performance ratio (PR), system efficiency, capacity utilization factor (CUF), and degradation rate (D_R) were used to assess the performance and degradation of the plant [9-11].

(i) System Efficiency (η_{sys})

$$\eta_{sys} = \eta_{PV} \times \eta_{inv}$$

But,

$$\eta_{PV} = \left(\frac{P_{DC}}{G_t \times A_m}\right) \times 100$$

$$\eta_{inv} = \frac{P_{AC}}{P_{DC}}$$

Where, η_{PV} is the PV efficiency, η_{inv} the inverter efficiency, P_{DC} the DC power output in kW, P_{AC} the AC power output in kW, Gt the total in-plane radiation in W/m^2, and $A_m$is the module area in m^2.

(ii) Capacity utilization factor

The capacity utilization factor (CUF) is defined as the ratio of actual annual energy generated by the PV system $(E_{AC.a})$ to the amount of energy the PV system would generate $(P_{PV\ rated})$if it is operated at full rated power for 24 h per day for a year.

$$CUF = \frac{E_{AC.a}}{P_{PV\ rated} \times 24 \times 365} \times 100$$

(iii) Performance ratio

Performance ratio (PR) is the ratio of efficiency of the PV system to its efficiency at standard test condition (STC) i.e. at temperature 25^{0}C, and solar radiation of 1000 W/m^2.

$$PR = \frac{Final\ energy\ output(kWh)}{Rated\ DC\ power\ (kW)} \times \frac{PV\ reference\ irradiance\ (kWh/m^2)}{Total\ inplane\ irradiance\ (kW/m^2)}$$

(iv) Degradation rate (R_D)

Degradation is the gradual deterioration of the characteristics of a component or of a system which may affect its ability to operate within the limits of acceptability criteria and which is caused by the operating conditions. Degradation Rate (R_D) can be calculated as:

$$R_D = \frac{initial\ PR - final\ PR}{initial\ PR}$$

III. Results and Discussion

A. *Solar radiation and PV energy output*

The annual average solar radiation was found to be 180.83 kWh/m^2/month. The highest solar radiation (204.31 kWh/m^2/month) was observed in the month of March, while the lowest solar radiation of (141.22 kWh/m^2/month) was noticed in the month of July. The results show that the highest solar radiation was noticed in summer, while the lowest solar radiation was noticed in the winter season (see figure 2). The total annual energy output was found to be 16426 kWh. The maximum energy output was noticed in March (16067 kWh) due to highest solar radiation in the month, whereas, the minimum energy output was noticed in July (12922 kWh) due to lowest solar radiation in the month. The results indicate that the PV energy output significantly depends on seasonal change, which is maximum in summer and minimum in winter(see figure 2). In addition, relative humidity was analyzed to observe its impact on the PV system. It was observed that energy output decreases with an increase in relative humidity and vise-vasa.

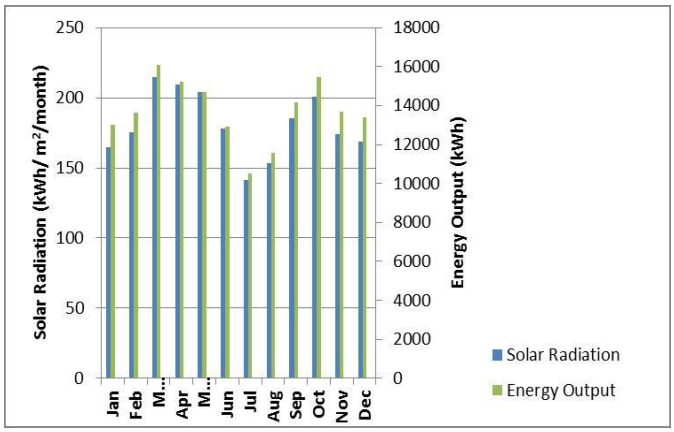

Figure 2: Solar radiation vs Energy Output

B. *Capacity utilization factor and System efficiency*

The annual average CUF was found to be 15.62 %. It was observed that CUF is higher in the month of March (18.34 %) as a result of high energy output in the month. The lowest CUF was found in the month of July (11.98 %) as a result of low energy output in the month (see figure 3). The PV system efficiency depends on module and inverter efficiency. However, the average annual PV system efficiency obtained from the plant was found to be 14.72 %, which is higher compared to earlier studies performed on roof-top PV plant. The highest efficiency was observed in winter, while the lowest efficiency was observed in summer (see figure 3).

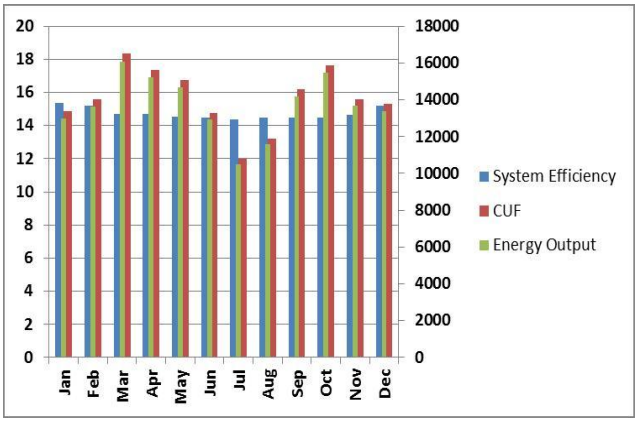

Figure 3: Energy output vs System Efficiency and CUF

C. *Performance ratio and Degradation rate*

The PV plant average annual PR was found to be 76%. The PR was highest in December (79%), while the lowest PR was obtained in May (71%) (See figure 4). It can be observed that PR decreases as the ambient temperature increases and vise-vasa. The study shows the PV system has a good performance during winter and rainy season, while the PV performance is low in summer. The annual degradation rate of the PV plant was found to be 1.28%/year. This value is slightly higher than the standard degradation rate given by the manufacturers, which is 1.0%/year. The increase in the degradation rate may be as a result of the climatic factor of the site location.

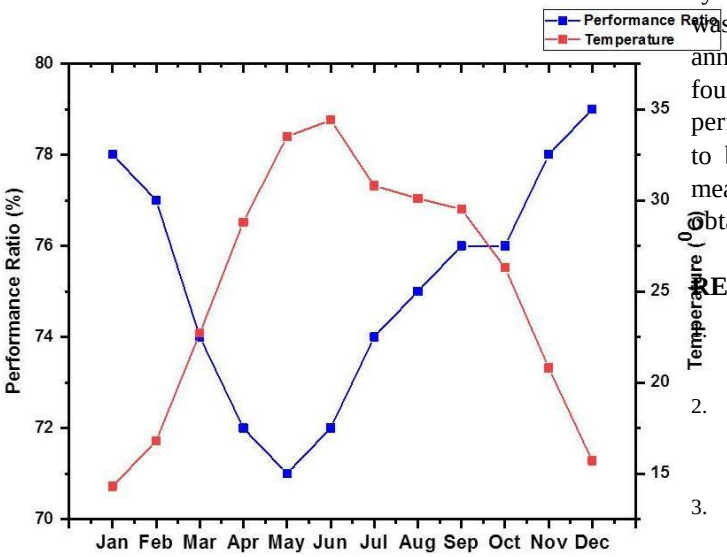

Figure 4: Performance ratio vs Temperature

D. *Simulation assessment of performance results*

The annual average performance ratio obtained from SAM and PVsyst software was found to be 78% and 82% respectively. It was noticed that measured PR (76%) was nearly matched with the PR gotten from the SAM Software (see figure 5).

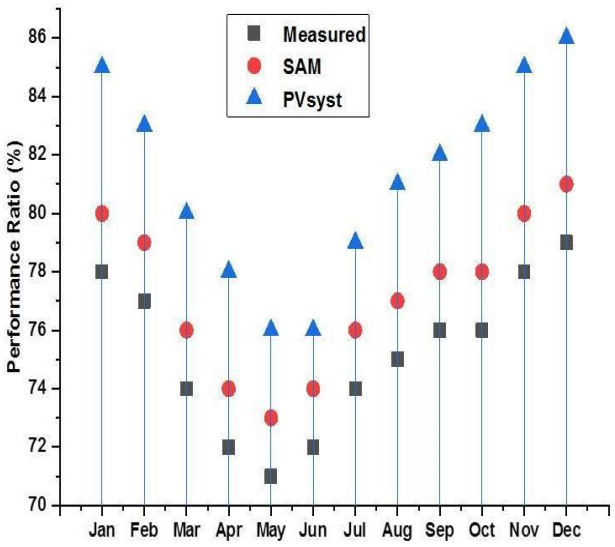

Figure 5: Comparison of performance ratio

IV. CONCLUSION

The performance of 100 kWp roof-top grid-connected PV system was evaluated. The plant was installed at PGDM building in Sharda University, Greater Noida in northern India. The plant was monitored from March 2018 to February 2019. Performance parameters such as system efficiency, performance ratio, capacity utilization factor, and degradation rate were obtained. The plant performance result was compared with the estimated results obtained from SAM and PVsyst software. The annual average solar radiation was found to be 180.83 kWh/m2/month, and total annual energy output was found to be 16426 kWh. The annual average system efficiency and capacity utilization factor of the plant was found to be 15.62 % and 14.72 % respectively. The annual performance ratio and annual degradation rate were found to be 76% and 1.28%/year respectively. The annual performance ratio obtained from SAM and PVsyst was found to be 78% and 82% respectively. It was noticed that the measured performance ratio was highly relative with the one obtained from SAM software.

REFERENCE

1. Laronde, R., Charki, A. and Bigaud, D. (2012) 'Lifetime estimation of a photovoltaic module subjected to corrosion due to damp heat testing', Journal of Solar Energy Engineering, 135(2), 8
2. Ottersböck, B., Oreski, G. and Pinter, G. (2017) 'Comparison of different microclimate effects on the aging behavior of encapsulation materials used in photovoltaic modules', Polymer Degradation and Stability, 138, 182–91
3. Polverini, D., Field, M., Dunlop, E. and Zaaiman, W. (2013) 'Polycrystalline silicon PV modules performance and degradation over 20years', Progress in Photovoltaics, 211, 004–1015
4. Rajput, P., Sastry, O.S. and Tiwari, G.N. (2017) 'Effect of irradiance, temperature exposure and an Arrhenius approach to estimating weathering acceleration factor of Glass, EVA and Tedlar in a composite climate of India', Solar Energy, 144, 267–77
5. Ehsan, F.A. (2016) 'The Impact of the Environmental Condition on the Performance of the Photovoltaic Cell', American Journal of Energy Engineering, 4, 1-7
6. Birinchi, B., Arun, K., Sastry, O.S., Renu, D., Manander, B., Takumi, T. and Bandyopadhyay, B. (2016) 'synergistic effect of air mass on outdoor performance for different PV module in India', International Journal of Green Energy, 13(6), 580–584
7. Pradesh, U. (2016) Effect of Temperature, Irradiation, Humidity and Wind on Ideal Double Diode PV System Performance. In: EEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), 4-6 July 2016, Delhi, India. IEEE, pp. 1–5
8. Najib, H.U., Birinchi, B., Chandan, B. and Panwar, B.S. (2018) 'Comparison of different PV power simulation softwares: case study on performance analysis of 1 MW grid-connected PV solar power plant', International Journal of Engineering Science Invention, 7(7), 11-24
9. Al-Sabounchi, A.M., Yalyali, S.A. and Al-Thani, H.A. (2013) 'Design and performance evaluation of a photovoltaic grid-connected system in hot weather conditions', Renewable Energy, 53, 71–8
10. Sunanda, S. and Chandel, S.S. (2014) 'Review of software tools for hybrid renewable energy systems', Renewable and Sustainable Energy Review, 32, 192–205

AUTHORS PROFILE

Ph.D in Electrical Engineering with specialization Power electronics & drives from MNNIT, Allahabad. Currently working as Associate Professor in EEE Department at Sharda University. Have 17 years of experience in the field of Teaching, Research & Industry. Published research papers in the area of Power Electronics, Electric vehicle in various international journals and conferences.

Najib Hamisu Umar is Ph.D Reserch Scholar at Sharda Univerdity, Greater Noida. Delhi NCR. India. He is currenty working in Module Reliablity and Renewable Energy Conversion. Email: umarnajibhamisu@gmail.com.

Dr.Pallavi Gupta, she is an Associate Professor at Sharda University, Greater Noida. Her area of research is Electronics such as designing of sensors, now interested in photovoltaic system
Email: pallavi.gupta2@sharda.ac.in

Birinchi Bora is a Senior Research Scientist at National Institute of Solar Energy, Gurugram. India. He Specialized in Reliability of Photovoltaic System, Energy Modeling and Solar Cell Characterization. Email: birinchibora09@gmail.com.