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Performance analysis of 10MWp grid-connected photovoltaic system in the Mediterranean climate using PVsyst software

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Abstract

This paper presents performance analysis and assessment of a simulated 10MWp grid-connected Photovoltaic System in the Mediterranean climate of Alexandria, Egypt using PVsyst simulation tool. The Photovoltaic plant was designed to achieve the highest performance. The system has a performance ratio of 84% when using polycrystalline module type and 83% using monocrystalline modules, the energy injected into the grid for the full year of 153.5 GWh/year and 152.6 GWh/year using polycrystalline and monocrystalline modules respectively, as results under the total amount of incident energy in collector plan of 2279.5 kWh/m2.day. The system showed a good performance and viability of installation. However, it is not on one of the hottest spots in Egypt, but as per cities planning and electrical energy distribution in the country, this result would give a good indicator helping taking the decision before starting any installations of photovoltaic power plants in Egypt for future projects, especially locations with a Mediterranean climate.

Keywords: Solar energy, photovoltaic systems, pvsyst; simulation tool, performance analysis

1. Introduction

Nowadays Egypt is seeking to be independent of the fossil fuels as a main source of energy thus, the government takes a lot of steps and decision to support all types of renewable energy but especially for the PV systems as it can be considered as one of the easiest and feasible type of energy to be harnessed. Photovoltaic systems energy production is a very promising clean energy available in the whole world. By the time PV systems showed a declination of the prices and an increase in the technologies such as modules technology which has reached more than 500 watts per panel. The tracking technologies also have been developed to harness more energy.

PV power estimation is very vital step before installing any system as it helps avoiding any mistake in the installation process as well as the decreasing the time consumption thus decreasing the costs.

[1] evaluated the performance of 1MW grid-connected PV power plant and the losses of the system in Sothern region of Tamilnadu, there results showed that it is viable to install they site in various locations. Another study, [2] studied the performance of 1kW PV system using PVsyst software, they found that the PR of the system was 0.724.A stand-alone PV system for a farm in Egypt was designed by [3] using PVsyst software. Two types of PV panel 450 W and 260 W were used in this study, the results showed that the 450 W panels required area of 50.07 m^2 and performance ratio of 63.69% while the 260W panel needed 55.02 m^2 and performance ratio of 62.27%. The performance analysis of 190 kW_p solar PV power plant installed in India was studied by [4] they have concluded that the average annual measured energy

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yield was 812 kWh/kW$_p$ while the predicted energy yield was 823 kWh/kW$_p$, the performance ratio of the system was found to be 74%. [5] designed a PV system using PVsyst software for an academic institute, they analyzed the system theoretically in parallel with the simulation. The changed the azimuth angel in order to achieve more specific energy production. Their results showed that the PR increase as the load demand decrease. Furthermore, the comparative study for various azimuth angel showed that zero azimuth gives maximum production. The performance of grid connected solar PV plant was evaluated using PVsyst software in [6], the results showed PR of 76.4 % and injected energy to the grid of 1416.98 MWh. [7] compared between two grid connected PV Systems in Kathmandu and Berlin, the study showed that the energy generated from Berlin simulated system is lower than the energy generated from Kathmandu by 30%. [8] simulated a 15 kW$_p$ grid-connected PV system using PVsyst software, their results gives yearly PR of 0.794 and energy production of 32.272 MWh/year.[9] designed and studied the performance of 250 kW grid connected PV system in Iraqi covering 1858 m^2 using PVsyst software, the PR of the simulated system was 75% with energy production of 346.692 MWh/year.[10] studied the feasibility to install 200 kW grid connected monocrystalline PV system in Dubai using PVsyst software, the total energy production for the system reached 352.6 MWh/year and PR of 81.67%.

The main novelty of this work is that it is the first study of performance to a grid-connected simulated system located in Alexandria, Egypt and its viability. This study aims to investigate the performance and evaluate the losses of a simulated PV system in the Mediterranean climate to study the viability to install the system and change some design parameter to be a good fit for the climate as well as considering the costs of installation.

2. Research Method and Parameters

This investigation discusses the performance analysis of a simulated 10 MW photovoltaic system located in the Mediterranean climate using PVsyst solar modelling software. By designing the system to achieve the highest performance then analyze the simulated data of the system to recommend installing the site for the future projects in Egypt depending on the energy injected to the grid and the performance ratio of the system. After analyzing the data, the project was used to change some design parameter to find out the difference in energy produced with respect to the economic analysis of the system. The module type technology was the specified parameter to test if it fits the weather of the location or not.

3. System Description and Configuration

To achieve a high performance system, the components and system configuration should be carefully selected based on the energy demand and the weather file of the location. The coordinates of the simulated project are 31.2058 latitude and 29.9245 longitude with 5 m elevation. All the system parameters and components are shown in Table 1.

Table 1. System design parameters

Location	Alexandria, Egypt
System AC Capacity	10MW
Number of modules	228528
Area	55778 m^2
Number of arrays	8
Orientation Type	Fixed
Tilt Angle	30^o
Modules in Series per Array	18
Number of Inverters per Array	6
Number of Strings per Array	1587
Module Models and Manufacturer	Polycrystalline-JKM350PP-72-DV, Monocrystalline- JKM 350M-72, Manufacturer JinkoSolar
Inverter Type and Manufacturer	1560kW ABB_ULTRA_1500_0_T Manufacturer ABB
Number of Inverters	48 inverters

4. Results and Discussion

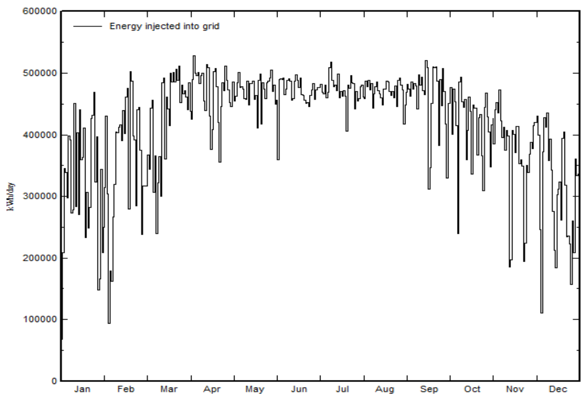
This section presents the performance analysis of the simulated system. The results shown in this section discuss the performance ratio, energy injected into the grid and system losses. Furthermore, the study shows the difference between using monocrystalline and polycrystalline types of modules.

The results show that the system performs very good with a PR of 84% using polycrystalline module technology and 83% using monocrystalline module technology.

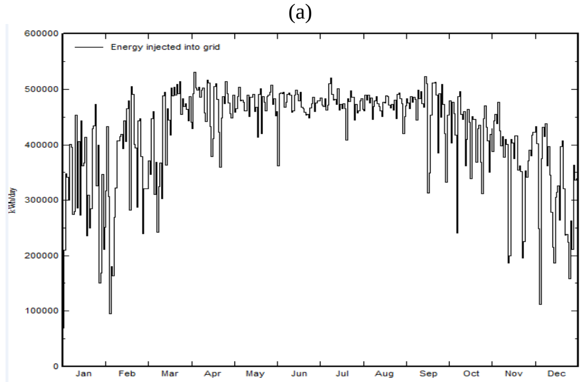
The energy injected into the grid using monocrystalline module technology is 152.6 GWh/year while using polycrystalline module technology injects 153.5 GWh/year. Table 1 shows that the injected energy from the polycrystalline modules is higher in the whole year as well as the performance ratio.

Table 2. Injected energy into the grid and the performance ratio

Month	Energy injected to the grid (kWh)		PR	
	Monocrystalline Module	Polycrystalline Module	Monocrystalline Module	Polycrystalline Module
January	9811422	9892630	0.884	0.891
February	10033069	10112670	0.878	0.885
March	13340400	13430786	0.854	0.86
April	14075258	14161978	0.84	0.845
May	14618432	14703497	0.826	0.831
June	14124514	14201242	0.818	0.822
July	14671191	14741452	0.8	0.811
August	14564806	14631263	0.8	0.812
September	13842903	13909215	0.81	0.819
October	12970697	13044571	0.834	0.839
November	11120082	11197395	0.859	0.865
December	9464522	9541495	0.879	0.886
Yearly	152637297	153568195	0.837	0.842



(a)



(b)

Fig. 1. Daily system output energy (a) using monocrystalline module (b) using polycrystalline module

Fig. 1 illustrates the daily energy injected to the grid for the whole year Fig. 1 (a) show the injected energy of using monocrystalline module while Fig. 1 (b) shows when using polycrystalline module. It is shown that the maximum energy injected into the grid was in summer while the minimum in winter.

The daily input of the global incident irradiance on the collector plan and the energy output from the system for one year are shown in Fig. 2.

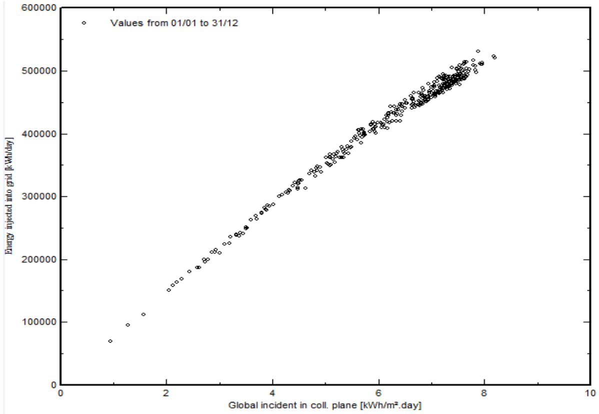
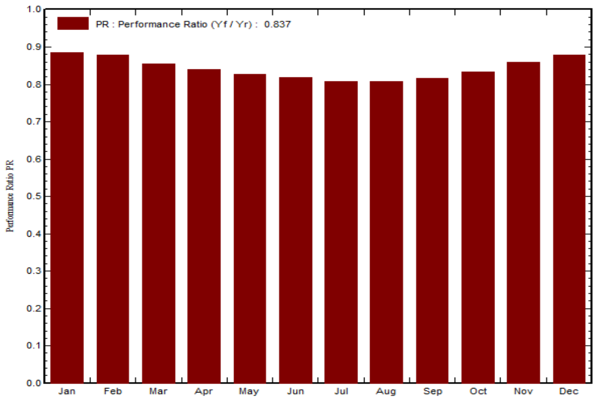
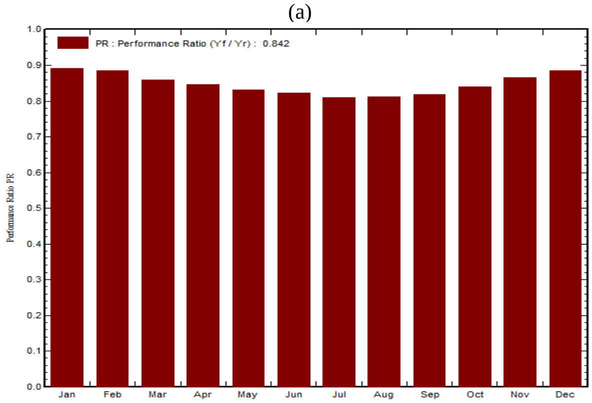


Fig. 2 Daily output/input diagram for the system

Fig. 3 shows the distribution of the performance ratio for the system in the full year, Figure 3 (a) using monocrystalline module and Fig. 3 (b) using polycrystalline module, the performance ratio tends to increase in the cold weather while it decreases at the highest energy ambient temperature.



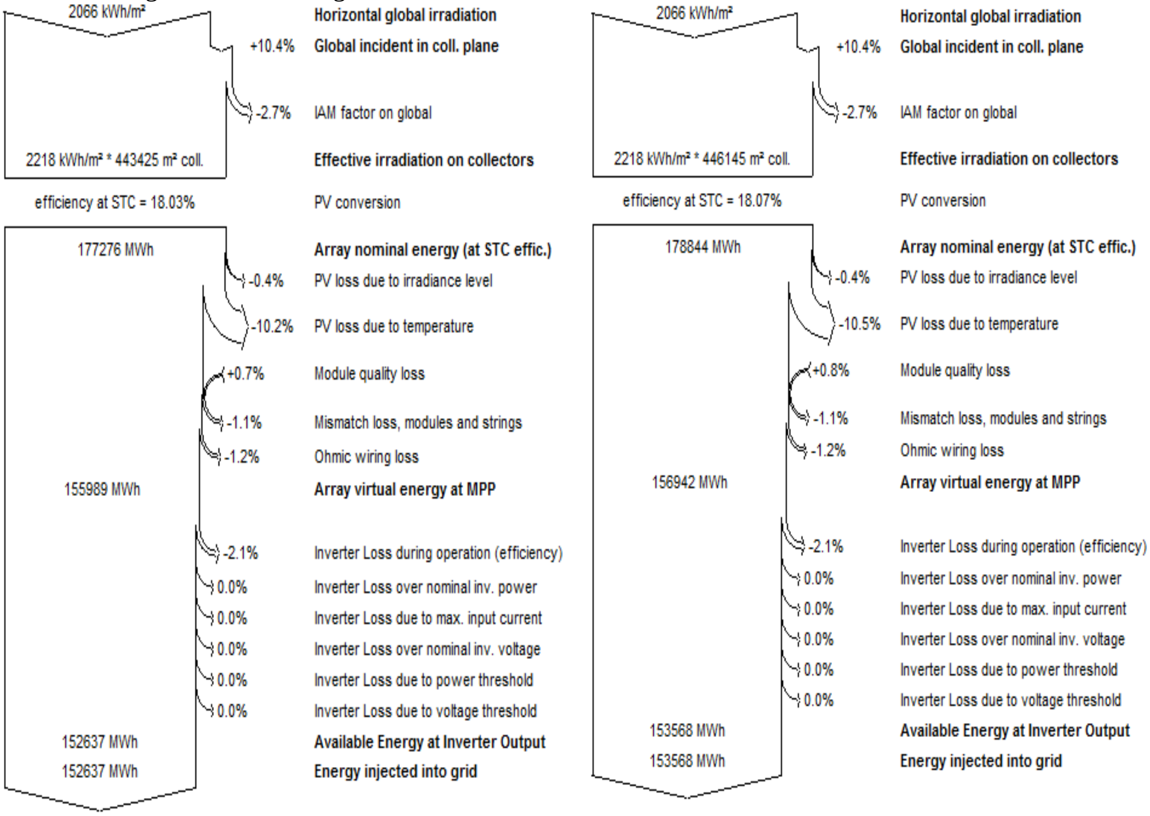
(a)



(b)

Fig. 3. Performance ratio (PR %) (a) Using monocrystalline module (b) Using polycrystalline module

The generated energy from the PV array is affected by several factor such as the thermal parameters, module quality losses, and module temperature, AC and DC wiring losses, all this factors can be divided into main losses which are the system losses and array losses the losses the whole losses are presented in the losses diagram shown in Fig. 4.



(a) (b)

Fig. 4. Losses Diagram (a) using monocrystalline module (b) using polycrystalline module

5. Conclusion

In conclusion, the system is feasible to be an actual PV project it performs with a good performance ratio reached 84% and the injected energy to the grid reached 153.5 GWh/year. Furthermore, the polycrystalline module technology is more preferable and cost effective for the system in this climate as it showed higher performance ratio and energy production taking in consideration the advantage of its low cost with respect to the monocrystalline technology in such a project it would decrease around 28 million LE.

For future work, power prediction with performance analysis for number of locations in Egypt need to be studied in order to show the energy potential. Moreover, study the tracking technology to check its suitability to the metrological data of Egypt with respect to the cost.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ibrahim M. Ibrahim concuted the research; Ibrahim M. Ibrahim, Ahmed S. Shehata, Ali I. Shehata analyzed the data; Ibrahim M. Ibrahim wrote the paper; all authors had approved the final version.

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