EXPERIMENTAL ANALYSIS OF 3.6 kW ROOFTOP GRID CONNECTED THIN FILM PHOTOVOLTAIC SYSTEM IN CAIRO.

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PV-grid connected systems are worldwide installed because it allows consumer to reduce energy consumption from the electricity grid and to feed the additional energy back into the grid. The system needs no battery so therefore the system price is very cheap comparing to the other PV systems. This paper presents the results obtained from monitoring a 3.6 KWp thin film photovoltaic system installed on a flat roof of 4 meter height on Cairo, Egypt. The system was monitored for one year starting from January 2010 till December 2010 and all the electricity generated was fed into the 220V, 50Hz low voltage national grid through Sunny boy 3800 inverter. Monthly, daily and annual performance parameters of the PV system are evaluated which include: generated KWh per day, system efficiency, inverter efficiency, array efficiency, solar irradiation, Capacity factor and around the year. The average generated KWh per day was 15.65KWh/day, the average solar irradiation per day was 5.6 KWh/m2/day, the average PV array efficiency was 4.22%, the average inverter efficiency was 94.55%, the average system efficiency was 4.02% and the capacity factor was 18.12%. The analysis of the obtained results shows clearly how the variation of the solar irradiation and weather conditions around the year affects on the performance parameters of the thin film PV grid connected system in Cairo.

Keywords: Solar energy, PV array, grid connected power system

1. Introduction

As a solution for the depletion of conventional fossil fuel energy sources and serious Environmental problems, focus on the photovoltaic (PV) system is increasing around the world. In the future, the establishment of utilization technology for stability and reliability of PV systems will take on more significance in this area as high-density grid-connected PV systems will be interconnected with distribution networks. Therefore, total three units of 1.2 kW grid-connected PV systems have been installed on the roof of renewable energy lab in Egypt since Jan. 2010. The Monitoring system has been constructed for measuring and analyzing the performance of PV systems to observe the overall effect of meteorological conditions on their operation characteristics by field test. During one year of monitoring period, the performance of PV systems has been evaluated and analyzed not only for component perspective (PV array, grid tied inverter) but also for global perspective (system efficiency, capacity factor, electrical energy). The loss factors of PV systems and components such as a grid tied inverter and PV have been also reviewed.

2. System description

The PV system is installed on the rooftop of a renewable energy lab, Cairo, Egypt. It consists of ninety modules covering a total area of 70 m2 with an installed capacity of 3.6 kWp within the range of typical domestic installations. The Pfixx TF-ASI-40 B modules are each of 40Wp capacity and

comprise 39 solar cells. The modules have an efficiency of 4.2% under standard test conditions and are connected in series-parallel combination (5 in series * 6 in parallel) for each array. The modules are fixed, inclined at an angle of 30 degree equal to the latitude of Cairo, facing south at an azimuth angle of 0 degree. The roof is approximately 4 m height and the modules are mounted on metal frames that were 1.5 m height. A single phase Sunny Boy SB 3800 inverter is used to convert DC to AC which is fed directly into the grid. The inverter has rated maximum efficiency of 95.6% and maximum AC power of 3800 W.

Table 1: The data sheet of the solar module

PV Module	**Specification**
Type	TF-ASI 40B (PF 40)
PIN junction	Double junction
Number of cells	39 series connected
Weight	14.4 Kg
Nominal power	40 Watt
Maximum dc system voltage	1000 V
Maximum output power Voltage	47 V
Maximum output power Current	0.86 A
Open circuit voltage	63 V

Table 2: Data sheet of the sunny boy 3800 inverter

Inverter	**Specification**
Input Maximum dc Power	4040 Watt
Maximum dc Voltage	500 V
PV - voltage range at MPPT	200-400 V
Maximum dc Current	20 A
Output Maximum ac Power	3800 Watt
Nominal ac power	3800 Watt
Maximum current	18 A
Efficiency Maximum Efficiency	95.6%
Weight	38 Kg

3. Results and discussions

A 3.6 KWp grid connected PV system installed in Cairo, Egypt was monitored between January 2010 and December 2010 and its performance parameters were evaluated on monthly, seasonal and annual basis.The average generated KWh per day was 15.65KWh/day, the average solar irradiation per day was 5.6 KWh/m2/day, the average PV array efficiency was 4.22%, the average inverter efficiency was 94.55%, the average system efficiency was 4.02% and the capacity factor was 18.12%.These results show it is highly imperative to develop evaluation, analysis and application technology of thin film PV grid connected system in Egypt.

3.1 Solar irradiation

Site data during the monitored period showed that the average solar irradiation per day was 5.6 KWh/m2/day, the maximum value of the solar irradiation is 7.1 KWh/m2/day in June and the minimum value was 4 KWh/m2/day in December as shown in Fig.1.

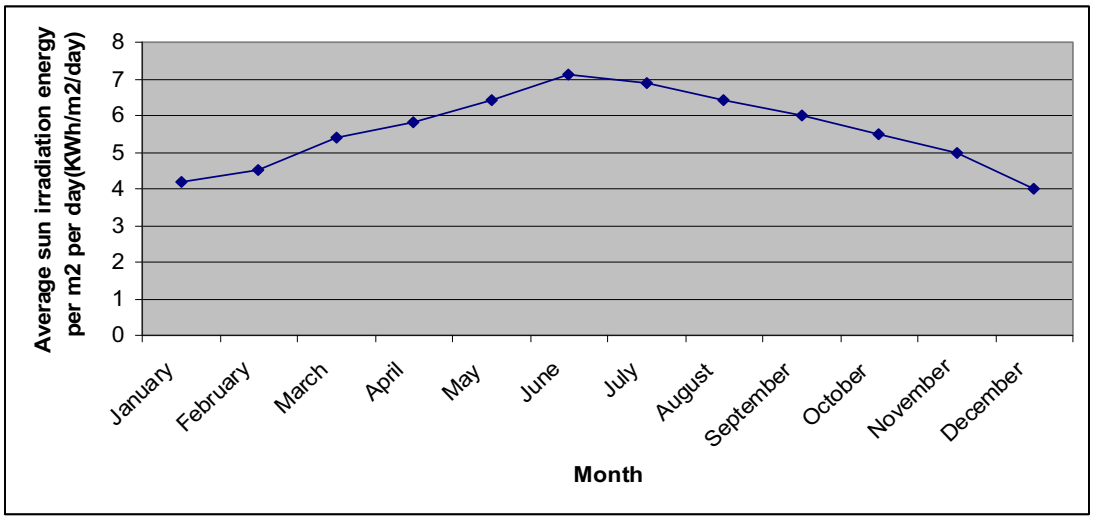

Fig.1: Average solar irradiation Energy per day for each month

3.2 Capacity factor

The capacity factor (CF) is a means used to present the energy delivered by an electric power generating system. If the system delivers full rated power continuously, its CF would be unity. The capacity factor (CF) is defined as the ratio of the actual annual energy output to the amount of energy the PV system would generate if it operated at full rated power for 24 h per day for a year. The average capacity factor of the system per month is 18.12%; the highest value of the capacity factor is 20.8% in June while the lowest value is 16.2% in December as shown in Fig.2.

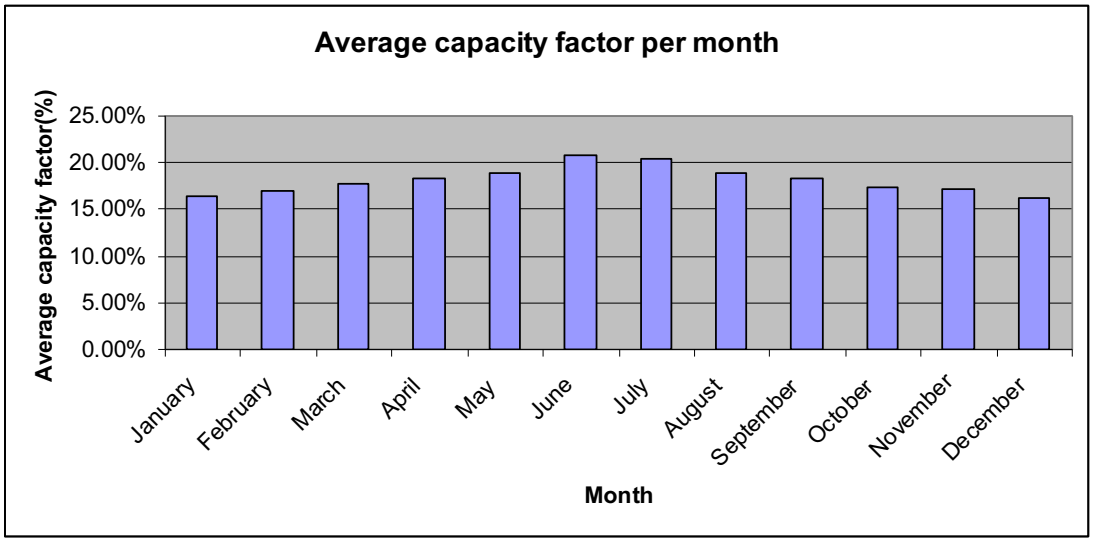

Fig.2: Average capacity factor per month

3.3 Array and Final yield

The average generated KWh per day from the PV system around the year is 15.65 KWh, the highest value is 18 kWh in June while the lowest value is 14 kWh in December as shown in Fig.3.

The average generated KWh per day from the PV Array around the year is 14.8 KWh, the highest value is 16.92 kWh in June while the lowest value is 13.3 kWh in December as shown in Fig.3.

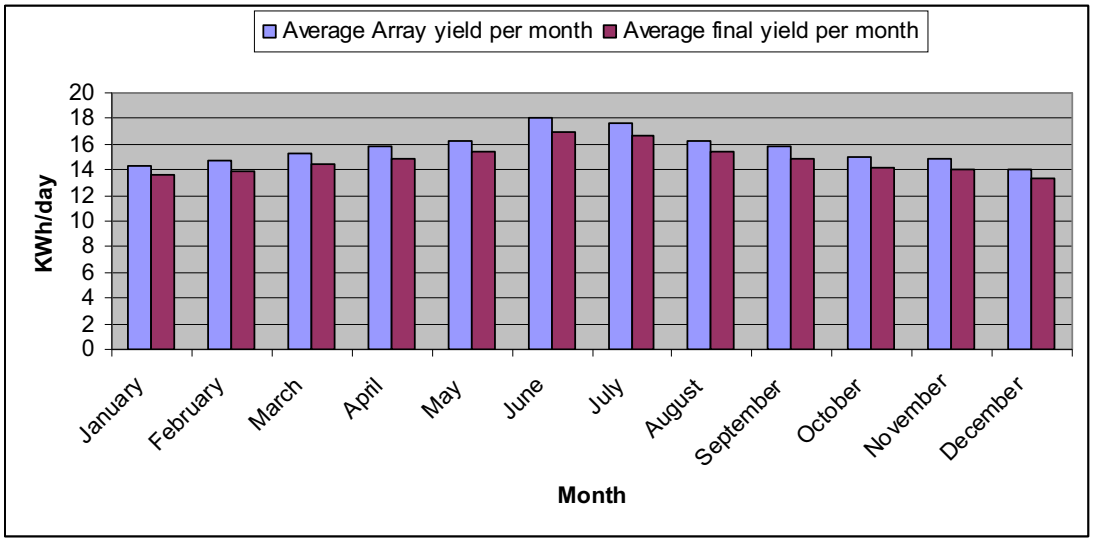

Fig.3: Average generated kWh/day for each month

3.4 Performance ratio

The performance ratio indicates the overall effect of losses on a PV array's normal power output depending on array temperature and incomplete utilization of incident solar radiation and system component inefficiencies or failures. The Performance ratio of a PV system indicates how close it approaches ideal performance during real operation and allows comparison of PV systems independent of location, tilt angle, orientation and their nominal rated power capacity. The PV system efficiency is compared with the nominal efficiency of the photovoltaic generator under standard test conditions. Performance ratio is also defined as a ratio of the final yield divided by the reference yield and it represents the total losses in the PV system when converting from DC to AC. Fig.4 shows variation of monthly average monthly performance ratio over the monitored period. The performance ratio varied between 70.0% in July and 86 % in January and the annual average performance ratio is 77.75%.

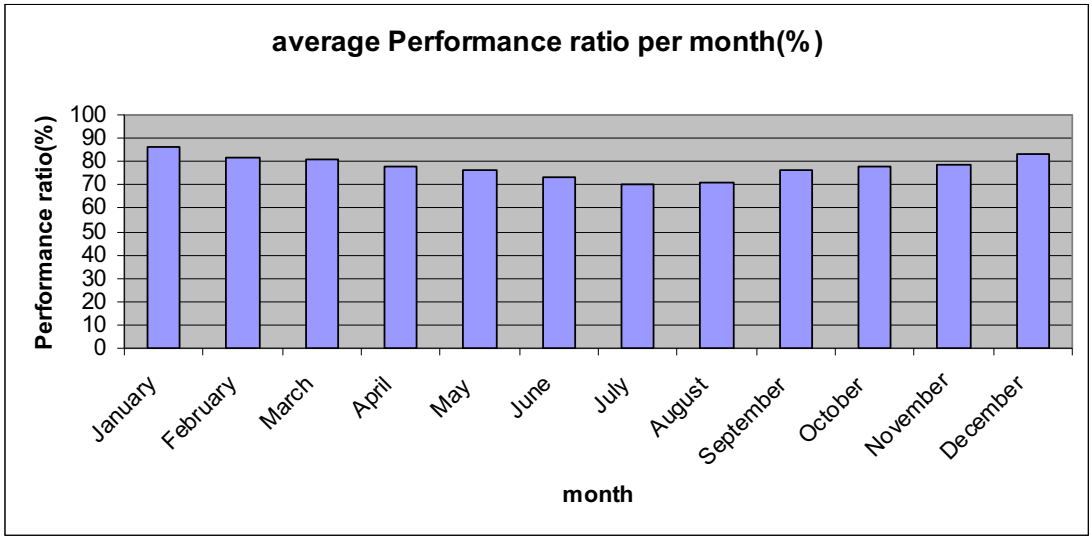

Fig.4: Average Performance ratio per month for each month

3.5 Ambient and PV temperature

The average ambient temperature is 21.7 degree Celsius, the highest value is 28.5 in June while the lowest value is 13 in January as shown in Fig.5.The average PV temperature is 38.4 degree Celsius, the highest value is 46.5 in June while the lowest value is 29 in January as shown in Fig.5.

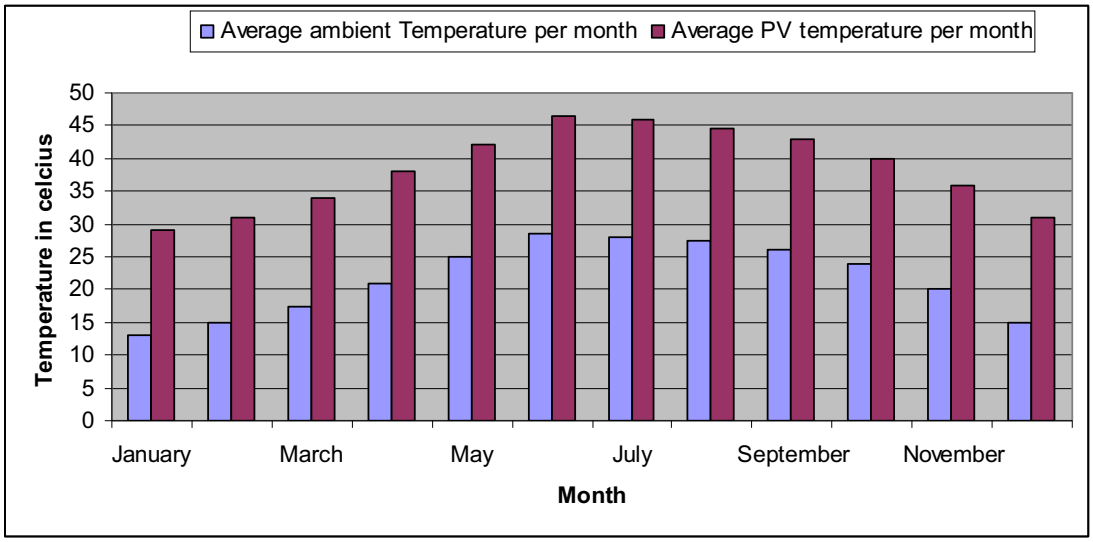

Fig.5: Average ambient and PV temperature per month for each month

3.6 System efficiency

The average system efficiency is 4.02%; the highest value is 4.8% in January while the lowest value is 3.8% in June and July as shown in Fig.6.

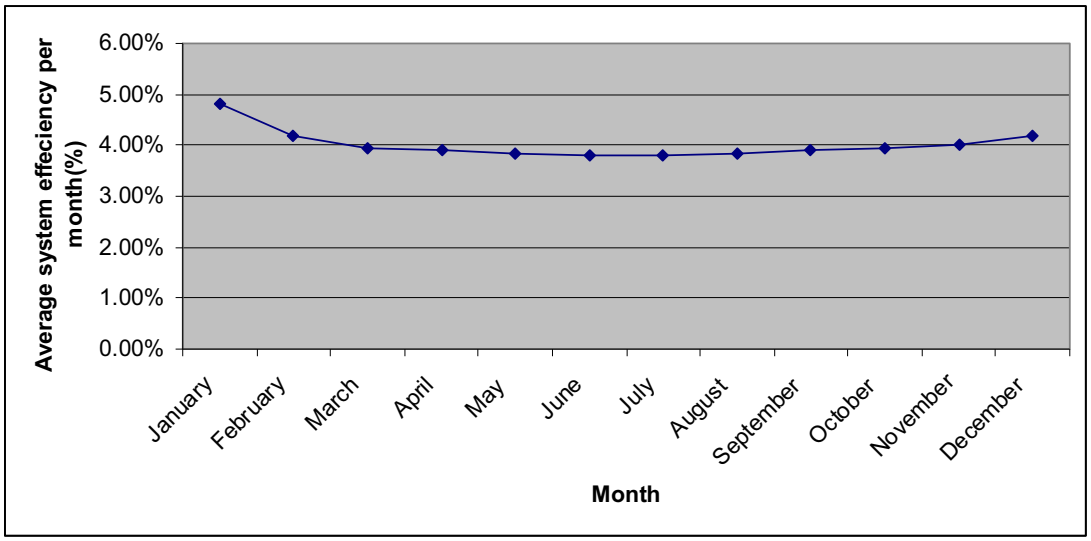

Fig.6: Average system efficiency per day for each month

3.7 PV Module efficiency

The average PV efficiency is 4.22%; the highest value is 5% in January while the lowest value is 4% in June and July as shown in Fig.7

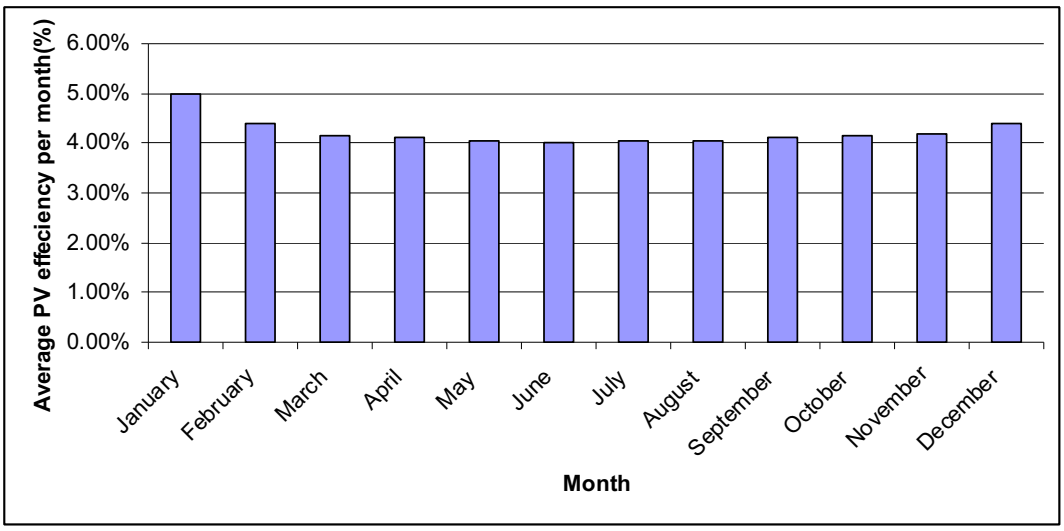

Fig.7: Average PV efficiency per day for each month

3.8 Inverter efficiency

The inverter efficiency is 94.55%; the highest value is 95.6% in January while the lowest value is 94% in June and July as shown in Fig.8

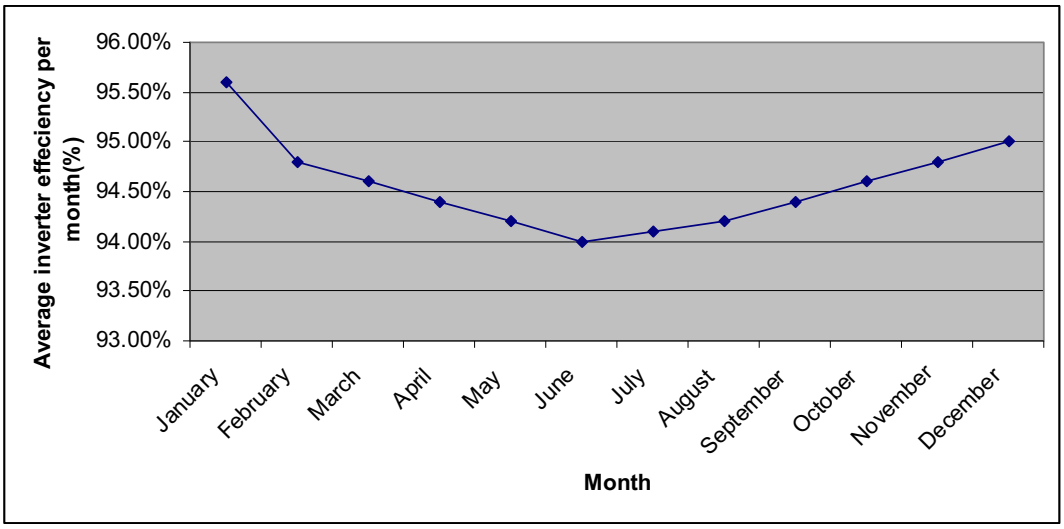

Fig.8: Average inverter efficiency per day for each month

4. Conclusion

Over the first year, the system has demonstrated successfully the potential of grid connected photovoltaic for Egypt. As barriers to the widespread use of photovoltaic in Egypt will be progressively overcome, lessons learned from the monitoring of the system will help duplicate this achievement elsewhere. In this project, we also focused on demonstration and social aspects, which, in the future, may help the introduction of photovoltaic to Egypt.

Comparison of results from this study with those obtained from other studies for the same system(the same PV and Inverter) in Holland where the PV modules are manufactured and tested revealed that the PV system's annual average daily final yield of 4.35 KWh/KWp/day is higher than those reported in Holland(2.55 KWh/KWp/day). It is comparable to results from some parts of Spain and Greece but it is higher than the reported yields in most parts of Europe. The PV system has the highest PV module capacity factor compared to the other reported systems. Due to the relative high ambient temperature in Egypt the PV and inverter efficiency are lower than the values reported in Europe. Despite low average PV and inverter efficiency compared to Europe, the high average solar irradiation level, improve Egypt's suitability.

5. References

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