

# Performance of Grid-Connected Photovoltaic System in south Algeria: Adrar city

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**Abstract**—This paper presents results obtained from monitoring a 28 kWp photovoltaic system installed on the rooftop of a Research Unit in Renewable Energies in the Saharan Medium (URER-MS), Adrar, Algeria. The system was monitored in month June 2017. The analysis shows that the value was in the performance ratio and the efficiency of the PV module, system, and the inverter, were 82.4 %, 13%, 12.6 %and 93.8 % in June 2017 respectively. The average DC/ AC power of the PV array was 147.5 kWh/month and 43kWh/month respectively. The observation and analyses exploitation of the collected data can help to evaluate the performance of the PV system connected to the network in the Saharan area of south Algeria (Adrar).

**Keywords**—Grid-connected PV; performance analysis; Saharan region

## I. INTRODUCTION (HEADING 1)

The demand for electrical energy produced by power plants in Algeria was constantly increasing due to the growth of population and the development of various industrial sectors [1]. The grid-connected photovoltaic system is a key technology to solve the power deficit problem. The efficiency of the grid-connected photovoltaic (PV) systems depends on several factors such as the climatic characteristics of the site, in particular, solar irradiation, ambient temperature and wind speed; in addition the technological characteristics of the systems like the inverter, the PV module technology, the orientation and tilt of the PV generator [2]. The Algerian government adopts an energy policy to use solar energy, the aim is to reach to install 22 GW of solar and wind energy plants by 2030 [3]. These stations are spread across the entire national territory and there are several solar power plants in the Algeria Desert which supply power to the electricity grid. Insolation (solar radiation) in the Algeria Desert is among the best available in the Arab Maghreb. The aim of this paper is to present results obtained from field performance monitoring of 1.75 kWp grid-connected photovoltaic (PV) system installed in the Saharan area of south Algeria (Adrar), data collected during the month November were analyzed to evaluate the suitability of PV systems for installation in the Saharan area. The aim of this paper is to present results obtained from

field performance monitoring of a 28 kWp roof mounted PV system in Algeria, Adrar. The PV system is described while different performance evaluation parameters are presented based on collected data. The performance parameters calculated include: DC/AC output power of PV array, PV module, system and inverter efficiency and Performance ratio (PR).

## II. MATERIALS AND METHODS

### A. Location and meteorological data

The grid-connected photovoltaic (PV) system is installed on the rooftop of a Research Unit in Renewable Energies in the Saharan Medium (URER-MS), Adrar, Algeria (see Fig. 1). The meteorological data for the year 2014 (like monthly mean Solar irradiation  $H$ , maximum ambient temperature  $T_{max}$ , relative humidity  $RH$ , wind speed  $W_s$ ) were collected from the meteorological station New Energy Algeria (NEAL). Table 1 shows that the maximum solar irradiation is observed during March to October 2014 and minimum is found during November to January 2014. Maximum humidity varying from 26% to 43% observed during November to February 2014 while maximum wind speed of 3.6 m/s found in April 2014.



Fig. 1. View of the PV plant installed in the roof of URER-MS, Adrar.

The temperature is over then 27.5°C (Range: 27 °C to 47 °C) at during the period from March to October 2014.

**TABLE I. METEOROLOGICAL OBSERVATIONS OF THE SITE.**

	<b>G</b> <b>(KWH/m<sup>2</sup>)</b>	<b>Tmin</b> <b>(°C)</b>	<b>Tmax</b> <b>(°C)</b>	<b>RH</b> <b>(%)</b>	<b>Ws</b> <b>(m/s)</b>
January	4.36	8.12	22.67	38	2.8
February	5.49	10.91	26.06	26	2.9
March	6.64	12.93	27.98	21	3.2
April	7.73	17.92	32.72	14	3.6
May	7.8	23.88	39.76	12	3.4
Jun	8.1	27.07	42.42	11	3.1
July	7.48	32.83	47.93	8	3
August	6.96	31.26	45.86	13	3.3
September	6.16	29.22	43.93	15	3.4
October	5.48	22.11	37.15	18	3
November	4.23	14.59	27.28	35	2.8
December	4.26	6.94	20.68	43	2.8

### B. PV system

The 28 kWp PV system has 112 numbers of solar modules covering a total area of 110 m. The system is organized into three sub-arrays connected in parallel with the PV inverter SMA of 11kW. The nominal power of two PV sub-array is around 10.5 kWp and the third PV sub-array is around 7kWp. The PV module details are shown in table 2.

**TABLE II. PV MODULES SPECIFICATIONS AT STANDARD TEST CONDITIONS (STC).**

<b>PV module</b>	<b>Specifications</b>
Maximum Power (P <sub>max</sub> )	250 W
Peak efficiency	15.30 %
Open Circuit Voltage (V <sub>oc</sub> )	36.99V
Short Circuit Current (I <sub>sc</sub> )	8.768 A
Maximum Power Voltage (V <sub>max</sub> )	30.75 V
Maximum Power Current (I <sub>max</sub> )	8.131 A
Maximum system voltage	1000V

### C. Grid-connected inverter

The output terminals of the PV power panels are connected to an inverter SMA of 11kW. The inverters are tied to the national grid (SONELGAZ). The technical characteristics of the SMA inverter specifications are summarized in Table 3:

**TABLE I. SMA SMC 11000TLRP-10 INVERTERS SPECIFICATIONS.**

<b>Inverter</b>	<b>Specification</b>
Maximum dc power	2000 W
Maximum dc voltage	500 V
PV – voltage range at MPPT	150 – 400 V
Maximum dc current	10.75 A
Maximum ac power	1500 W
Nominal ac power	1300 W
Nominal ac voltage	230 V / 50 Hz
Nominal ac current	5.7 A
Efficiency	94.2%

### D. Monitoring and data acquisition

The monitoring of the diverse measurements such as solar irradiance, ambient and module temperature, outputs DC/AC voltage and current assured by the data logger (SMA Sunny WebBox), the measurement data recorded on 5 min intervals. Fig. 2 present the monitoring system, which is composed from the sensors, the data logger, and PC to recover the data measurements.



**Fig. 2.** View of monitoring system: sensors, data logger and PC.

## III. RESULTS AND DISCUSSION

### A. Methodology

In this paper, the performance of the grid-connected has been analysed during summer (on month June). Results obtained give an indication of system performance installed in the Saharan area of south Algeria (Adrar) for environmental impact appraisal of PV generated electricity. The performance parameters calculated include: DC/AC energy output, PV efficiency, system efficiency, inverter efficiency, performance ratio. The performance analysis of grid connected PV system based on the performance parameters cited in the introduction, which are defined in IEC 61724[4]–[6]: The expressions of  $\eta_{PV}$ ,  $\eta_{inv}$ ,  $\eta_{sys}$ ,  $PR$  are presented as below:

$$\eta_{PV} = \left( \frac{E_{DC}}{H_{tA}} \right) \times 100\% \quad (1)$$

$$\eta_{inv} = \left( \frac{E_{AC}}{E_{DC}} \right) \times 100\% \quad (2)$$

$$\eta_{sys} = \left( \frac{E_{AC}}{H_{tA}} \right) \times 100\% \quad (3)$$

$$PR = \frac{Y_F}{Y_R} \quad (4)$$

### B. Measurements data analysis

The meteorological parameters like ambient temperature, the PV panel surface temperature, the room temperature, global solar radiation and the power output array were acquired in the Unit of Research URERMS Adrar. Fig. 3 shows the average values of solar irradiance, ambient and module temperature are recorded during June 2017. This

month is characterized by the maximum solar irradiance is  $600 \text{ W/m}^2$ , and the high ambient temperature was  $45 \text{ }^\circ\text{C}$ . While the maximum of the PV module temperature has reached to  $57 \text{ }^\circ\text{C}$ .

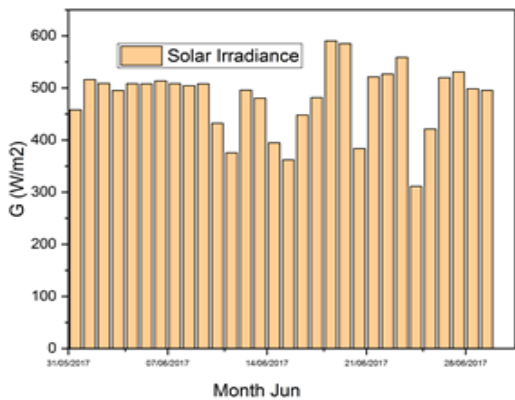
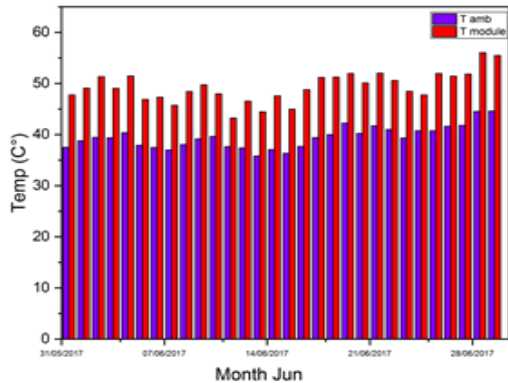


Fig. 3. Variation of solar irradiance, ambient and module temperature in monitoring period.

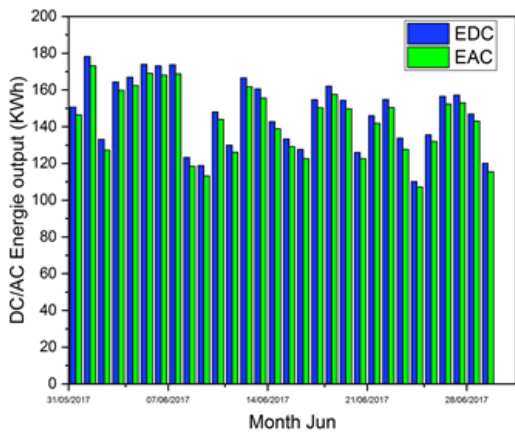


Fig. 4. DC/AC output power for PV stations over the monitored period.

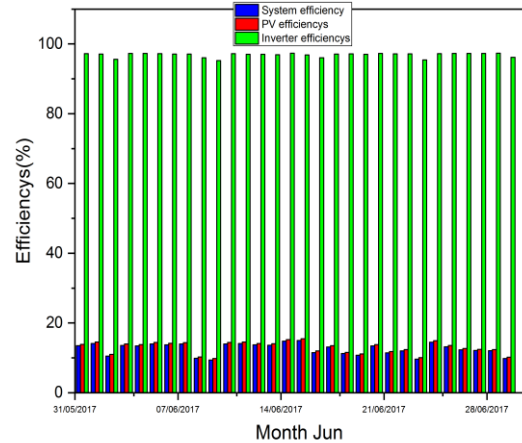


Fig. 5. DC/AC output power for PV stations over the monitored period.

Fig. 4 show the measurements data of the DC output power of PV array and AC output active power of inverter for PV stations during the month June. The average DC power of the PV array was  $147.5 \text{ kWh/month}$  in June 2017; on the other hand, the average AC power was  $143 \text{ kWh/month}$ . It is seen that power output had a linear relationship with solar irradiance [7]. Fig. 5 shows the monthly average daily PV module, system and inverter efficiency over the monitored period. The system efficiency and PV modules were  $12.6\%$  and  $13\%$  in June 2017 respectively. The monthly average daily inverter efficiency was  $93.8\%$  in June 2017.

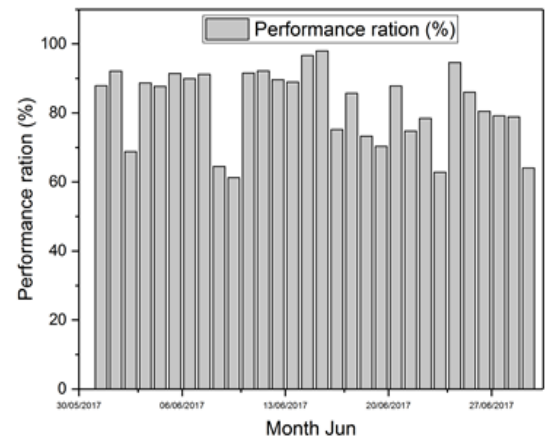


Fig. 6. Monthly average daily performance ratio over the monitored period.

Performance ratio (PR) 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, the performance ratio can be calculated by the equation (4). The PR 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.

Fig. 6 shows a variation of monthly average daily performance ratio over the monitored period. The monthly average daily of the performance ratio was 82.4% in June 2017.

#### IV. CONCLUSION

The 28 kWp grid-connected PV system installed on the rooftop of the Unit of Research in Renewable energy URERMS, in southern- west of Algeria (Adrar) was monitored during June 2017. Various parameters were evaluated on monthly basis to analyze the effect of desert environment (Adrar) on the performance of grid-connected PV system. From the experimental results obtained, the following conclusions can be drawn:

- The average DC/ AC power of the PV array were 147.5 kWh/month and 43kWh/month respectively.
- The monthly averages daily of the system efficiency, PV module and inverter efficiency were 12.6 %, 13%, and 93.8 % respectively.
- The monthly average daily of the performance ratio was 82.4 %.

As a conclusion, the integration of the grid-connected photovoltaic system with the national grid SONELGAZ is considered satisfactory.

In the future, the collected data for the long term will be used for studying the relationship between performance indices of the grid-connected PV and each climatic parameter.

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