Energy efficiency of polycrystalline cells installed in Laâyoune -Morocco

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Abstract— Presently, Moroccan government has authorized the introduction of electrical energy produced from photovoltaic technologies into the low-voltage electricity network under Law 58/2015, and in this context a project " Propre.Ma " has been proposed and managed by Cadi Ayyad University and funded by IRESEN, its primary objective is to provide useful information to investors on the performance of three technologies of silicon photovoltaic cells (polycrystalline, monocrystalline and amorphous) and to produce monthly and annual productivity maps Morocco using actual data collected from 21 installations in 21 cities. A study of the performance of the installation at the Laayoune Higher School of Technology (ESTL) was made by determining the performance, productivity, performance ratios and yields of polycrystalline p-Si panels for one year. The results obtained showed that the polycrystalline works better under the conditions of the city of Laayoune.

Keywords**: Renewable Energy, Grid-connected, Polycrystalline, Performance analysis.**

1 INTRODUCTION

Morocco has significant potential for renewable energies and energy savings, including high solar radiation (5kWh/m²/day), a large wind resource (6000 MW potential) and significant potential for systems mini-hydraulic (more than 200 sites) [1][2]. The launch of Morocco in the way of major projects "Renewable Energies", especially in the field of solar energy, wind and hydroelectric, will allow these local resources to contribute significantly to the economic and social development of the country. The main purpose of this paper is to evaluate the performance of 1,82kWp system constituted of polycrystalline silicon panels (p-Si) technologies for one year period under Laâyoune climate conditions. The collected data along one year and PVGIS solar radiation estimate tool have been used for this comparison, in order to investigate the performance of polycrystalline panels (p-Si).

2 PV SYSTEMS SPECIFICATIONS

2.1. Description of location

The 1,82KWp grid-connected PV systems are installed on the roof of High School of Technology-Laâyoune (ESTL)with a latitude of 27°07'50.4" North and a longitude 13°08'18.1"West. Laâyoune is the most important city of the Moroccan Sahara, it belongs to the region Laâyoune-Sakia El Hamra. It is located at the edge of the Atlantic 500 km south of the city Agadir. For Laâyoune's climate is almost desert like without excessive heat due to the low amount of rainfall. Temperatures rarely exceed 28°C due to the cool sea winds.

2.2 Pv Panels

The PV system was installed on the roof of block pedagogic building. It consisted of ten modules covering a total area of 11,725m² with an installed capacity of 1.82kWp within the range of typical domestic installations. Our photovoltaic installation module polycrystalline contains 7 *SOLARWORLD* modules of 260watts each one is facing equator and tilted by 30°. The characteristics of PV modules specifications are presented in Table 1.

TABLE 1 : PV MODULES ELECTRICAL CHARACTERISTICS.

Trade Mark	***SOLARWORLD***
Model	*SUNMODULE plus SW 260 poly*
Solar Cell	*Poly crystalline*
Max Power At STC (Pm)	*260W*
Max Power Point Voltage(Vmp)	*31,40V*
Max Power Current (Imp)	*8,37A*
Open Circuit Voltage (Voc)	*34,40V*
Short Circuit Current (Isc)	*8,94A*
Length	*1,675m*
Width	*1m*
Weight	*18Kg*

2.3. Inverter Sunny Boy 2000HF-30

The conception of our installation is represented in figure 1. In this conception an inverter is placed at the end of chain which aim to increase the number of DC/AC converter which leads to the possibility of extracting the maximum power [3]. It is possible to follow monthly and total production information by software adapted to the inverters, whose size is $348\times580\times145\ mm^3$ and it weighs about 18 kg. In table 2 we shows the specifications of Sunny Boy inverter 2000HF-30.

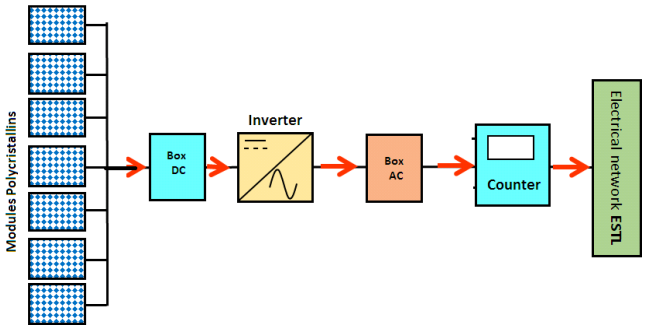

Figure 1: Schematic diagram of the PV system

TABLE 2 : SUNNY BOY 2000 HF INVERTER SPECIFICATIONS.

Input DC		
Max DC Power		*2100W*
Max DC input voltage		*700V*
MPP voltage range		*175-560V*
Rated input voltage		*530V*
Min DC input Voltage		*175V*
Start input voltage		*220V*
Max input current		*12A*
Max input current per string		*12A*
Number of MPP tracker		*1*
String per MPP tracker		*2*
Output AC		
Rated AC Power at 230V, 50Hz		*2000W*
Max AC apparent Power		*2000VA*
Nominal AC voltage		*220V/230V/240V*
Max output current		*11,4A*
Power factor at rated power		*1*
Feed-in phase		*1*
Connection phases		*1*
Efficiency	*Maximum efficiency* η_{max}	*96,3%*
	European weighted efficiency η_{EU}	*95%*
Dimensions (W×H×D)		*348×580×145mm³*
Weight		17Kg
Operating temperature range		-25 to +60°C
Maximum permissible value for relative humidity		100%
Air pressure range		79,5KPa to 106KPa

3 RESULTS AND DISCUSSIONS

In order to analyze and evaluate the energy related performance of PV systems technology (p-Si), some important parameters are to be computed using data collected during its operation in a given location. These parameters include: total energy generated by the PV system E_{AC}, monthly and annually system efficiency $\eta_{sys,m}$ $\eta_{sys,y}$ reference yield Y_R, final yield Y_F and performance ratio PR which are described by IEC 61724:1998 and the international energy agency task II database on photovoltaic power system [4] and an environmental performance.

PVGIS is one of the several simulation tools which is developed to help engineers and researchers in the design, the performance assessment and the feasibility of solar PV power plants in worldwide. This system allows us to determine the real performance of our installation because it makes it possible to calculate long term average values of the irradiation [5] [6]. Figure 2 show the monthly tilted solar irradiation in Laayoune generated from the PVGIS.

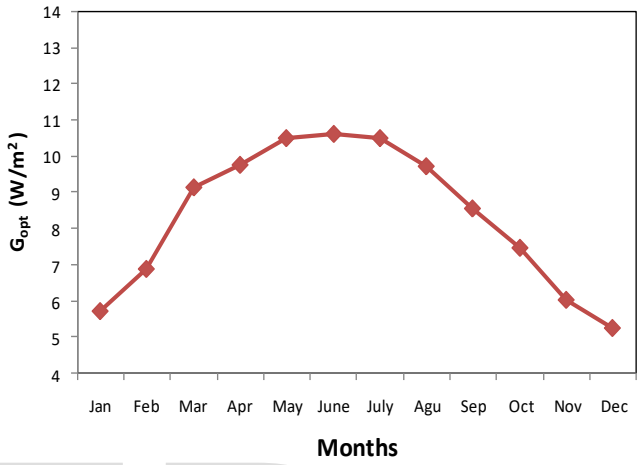

Figure 2: Daily average radiation amount according to month

3.1 Production analysis

The instantaneous energy output was obtained by measuring the energy generated by the PV polycrystalline system after the DC/AC inverter on 5 min intervals. Figure 3 shows the monthly total energy generated by the PV system over the monitored period which varied between 232kWh in October and 318kWh in April. Annual total energy generated by the PV system was 3415kWh.

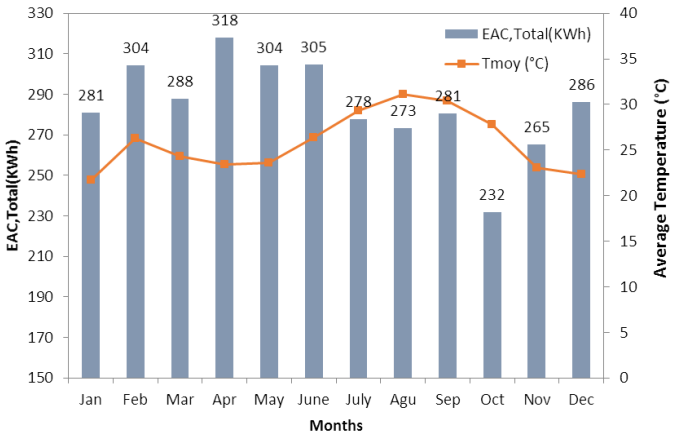

Figure 3: Monthly total energy generated in between March 2018 and February 2019

3.2 System efficiency

Figure 4 shows the monthly energy generated and and system efficiency over the monitored period of PV module. The system efficiency varied between 9,7% in October and 14,5% in February. The annual average system efficiency $\eta_{sys,y}$ was 12,27%.

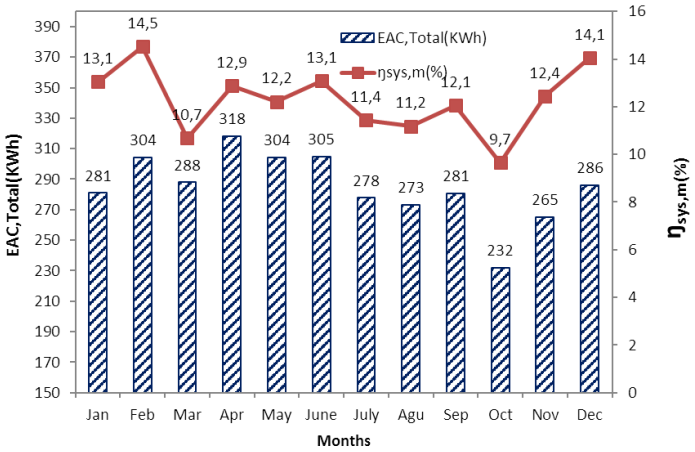

Figure 4: Monthly energy efficiency between March 2018 and February 2019

3.3 Reference and Final yields

Figure 5 shows the monthly average daily final yield and reference yield. The final yield varied between 4,25h/day in October and 6,18h/day in February. For the average annual final and reference yield were 1945h/year and 2387,4h/year respectively.

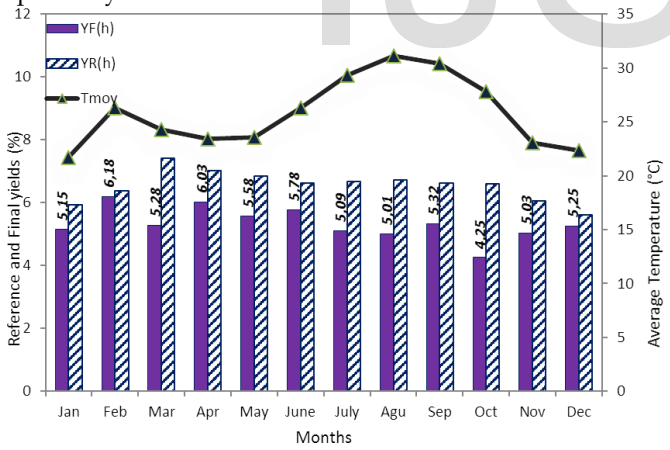

Figure 5: Monthly average daily Final and Reference yields of PV polycrystalline system March 2018 and February 2019

3.3 Performance Ratio

Performance ratio is an important parameter to evaluate the performance of a relative efficiency of a PV system. Figure 6 show PR of polycrystalline (p-Si) PV panel's, its values change in range of 64% and 97%. PR of polycrystalline (p-Si). For our installation and under climate conditions of site the yearly average value of PR of polycrystalline (p-Si) was 81,8%.

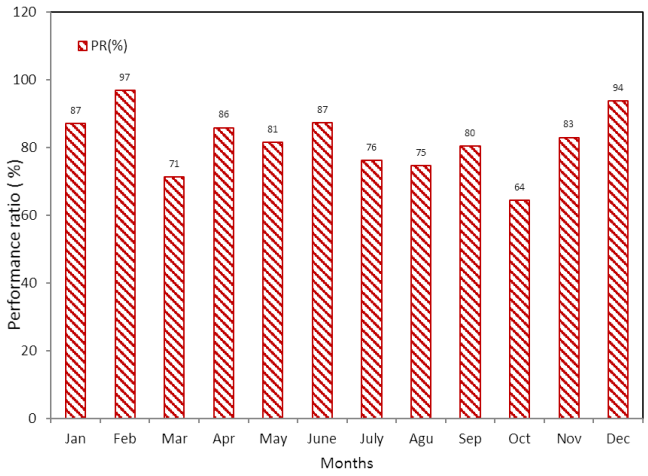

Figure 6 : Performance ratios of PV polycrystalline system March 2018 and February 2019

4 Conclusion

The present paper investigates the performance analysis of 1.82kWp grid-connected PV systems includes 7 polycrystalline panels (p-Si) installed on the roof of block pedagogic building at the High School of Technology- Laâyoune (Morocco). Meteorological data of the site were derived from PVGIS database and by using real data of production for one year operation. Monthly and annual performance indicators were calculated. The following conclusions can be drawn for the period of investigation from March 2018 to February 2019:

- *Total electrical energy generated was 3415kWh*
- *Average annual system efficiency of the PV system was 12,27%.*
- *Average annual performance ratio of the installation was 81,8%.*
- *Average annual daily final yields was 1945h/year*

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