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Comparative Study of the Types of Photovoltaic Panels Used in Solar Pumping Systems in Dry Tropical Zones: Case of Adamawa Region in Cameroon

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Abstract

In the dry tropical zone where access to water is increasingly difficult for populations, solar pumping units are increasingly installed to provide water to population. In the local market, there are essentially two types of solar panels, namely monocrystalline and polycrystalline. However, the part of the local market is more dominated by the polycrystalline panel. In this work, comparative studies are carried out in order to characterize the two types of solar panels with regard to local constraints. Tests were carried out over the course of the sun to establish the performance of each type. The panels used have the same electrical characteristics and are connected to loads with same characteristics. Under the set operating conditions, the monocrystalline panel presents more performance than the polycrystalline panel. Although the local market is dominated by the polycrystalline panel, dust deposition tests on the surface of the panels show that the performance of the polycrystalline panel is more affected compared to the performance of the monocrystalline panel.

Keywords

Solar Pumping, Monocrystalline Cell, Polycrystalline Cell, Dry tropical Zone, Dustdeposit

1. Introduction

Solar pumping is one of the most widespread applications of photovoltaic systems [1]. Due to the difficulties of access to water in isolated rural areas and even certain towns in which the water distribution network is not reliable, populations are turning more and more towards the private installation of pumping units to meet their water consumption needs. Also because of the difficulties encountered in accessing electricity from the network, these populations are increasingly choosing photovoltaic electricity to power submerged pumps in wells and boreholes [2]. In the zone with a dry tropical climate, two types of solar modules are essentially found in photovoltaic pumping installations: these are the monocrystalline and polycrystalline modules because of their technology adapted for high irradiance [3]. However, in our study area, the polycrystalline module is the most popular compared to the monocrystalline module while the latter is more efficient in terms of yield [4].

Several reasons justify the choice of polycrystalline modules in the study area. The purchasing cost is more affordable for the largest population with a below-average standard of living. On the other hand, polycrystalline is preferred because of its performance in terms of yield even when sunlight is low compared to the monocrystalline module [5]. However, apart from temperature and sunshine which are extrinsic parameters influencing the production efficiency of photovoltaic modules [6] [7], there is in the area of study another significant influencing factor, namely the deposition of fine particles on the surface of the modules. Dust deposition is a very limiting factor in the production of photovoltaic current.

Massola locality, the study area is increasingly traversed by winds that are certainly weak, but filled with fine particles contributing to accelerate the deposition of dust [8] [9]. Hottel, in [10] were among the first to work on the impact of dust on photovoltaic modules. They recorded a maximum performance degradation of 4.7%. Another study of dust accumulation on a photovoltaic system installed in a village near Riyadh showed a 32% reduction in performance after eight months without the modules being cleaned [11]. The results of Abacar [12] show that photovoltaic modules left for a year without cleaning can see their output power degrade to more than 70% of its value when they are clean. According to the work of in [13] and in [14] the power loss due to dust depends on the type of dust. It will be within the framework of this study to carry out experiments using dust collected in the study area in order to establish the performance of the two types of photovoltaic modules when they are covered with equal masses.

Nowadays, photovoltaic systems are widely used, depending on their applications [14]. Some photovoltaic generators are used to reinforce power sources that are prone to load shedding, while others are used for use in isolated locations [15]. We therefore come across two types of photovoltaic systems: standalone photovoltaic systems and grid-connected photovoltaic systems [5]. The advantage of solar photovoltaic systems lies in the fact that their technology is easy to implement. In this work, photovoltaic energy is used for water pumping. The size of the system takes into account the water requirements of an isolated site and the equipment that needs to be controlled or used to deliver drinking water. The works exist in the literature on the use of photovoltaic systems for water pumping needs [16]. Pumps are selected based on equipment required to supply water. And the types of pump used have proven their efficiency, according to the work in [17].

2. Materials and Methods

2.1. Study Area

The study area of this research work is located in Massola village, a locality in the Ngaoundere municipality, region of Adamawa/Cameroon. The geographic coordinates are 7˚25'0"North, 13˚32'28"East. The average irradiance is 5.8 kWh/m^2/day. The average wind speed is estimated at 83 m/s. The average annual temperature is 21.8˚C with the month of March being the hottest which has an average maximum temperature of up to 32˚ and the lowest average temperature around 17˚C.

2.2. Panels Use for Experimentation

Two types of panels available on the local market are used in this study. This is a monocrystalline panel and a polycrystalline panel whose characteristics are presented in **Table 1** following. The panels have the same electrical characteristics. The choice of two panels with the same characteristics allows simultaneous experiments to be carried out with pumps of the same power.

Table 1. Panels characteristics.

Parameters	Monocrystalline	Polycrystalline
Maximum power (W)	50	50
Maximum power voltage (V)	18	18
Maximum power current (A)	2.78	2.77
Open circuit voltage (V)	21.6	19.2
Short circuit current (A)	2.9	3
Number of cells	36	36
Tolerance	± 3%	/

2.3. Pumps

The pumps used for the experiments are model XY-DC500. It is a submersible solar pump with a brushless and silent motor. The characteristics are presented in **Table 2** following:

Table 2. Pump characteristics.

Parameters	Monocrystalline
Power (W)	50

Continued

Voltage (V)	12 V
Max Head (m)	5
Max Flow (L/H)	800

2.4. Experimental Methods

The experimental tests are carried out in two phases. Initially, it was a question of connecting monocrystalline and polycrystalline photovoltaic modules to loads with the same characteristics. The modules are oriented to south and on an inclined plane of 22 degrees. The values of current, voltage and power, irradiance and surface temperature are recorded at 15 minutes intervals on the two modules. Secondly, the tests consist of sprinkling the surfaces of the panels with dust powders taken from the study site and packaged in quantities of 10 grams as shown in **Figure 1** below.

Figure 1. Packaging of dust powders.

The tests in this case consist of applying the same mass of dust particles while ensuring homogeneous distribution on the surface of each module. The masses applied range from zero grams to 60 grams on each of the modules by steps of 10 grams. For each of the applied masses, the current, voltage, power, irradiance and temperature are measured. **Figure 2** shows the experimental bench made up of the crystalline and polycrystalline modules as well as the other elements of the system.

Figure 2. Experimental bench.

3. Results and Discussion

3.1. Comparative Study of Modules under Local Conditions

Figure 3 and Figure 4 represent respectively the current and voltage responses of monocrystalline and polycrystalline modules coupled to submersible pumps. We can clearly see that the current produced by the monocrystalline module is greater than that produced by the polycrystalline module at each measuring point, i.e. a peak of 2.7 A compared to 1.2 A under strong sunlight. The intensity of the current produced by the monocrystalline module at the end of the day is approximately equal to the average of the current produced by the polycrystalline module in full sunlight, i.e. around 1 A.As for voltage, the difference between monocrystalline and polycrystalline is not so pronounced, because the values obtained revolve around the values of open circuit voltages under full sunlight. However, at the end of the day the voltages across the modules are equal. Figure 5 shows the temporal profiles of the powers delivered to the pumps by the solar panels. We see that the curves obtained almost perfectly match the shape of the current curves in Figure 3. We can see that the power provided by the monocrystalline panel is much greater than the power provided by the polycrystalline panel at all measurement points. Under the local test conditions, it can be seen that the monocrystalline module produces more current to the pump than the polycrystalline module. Therefore, the monocrystalline module can be recommended as being the most suitable for photovoltaic applications in the study area.

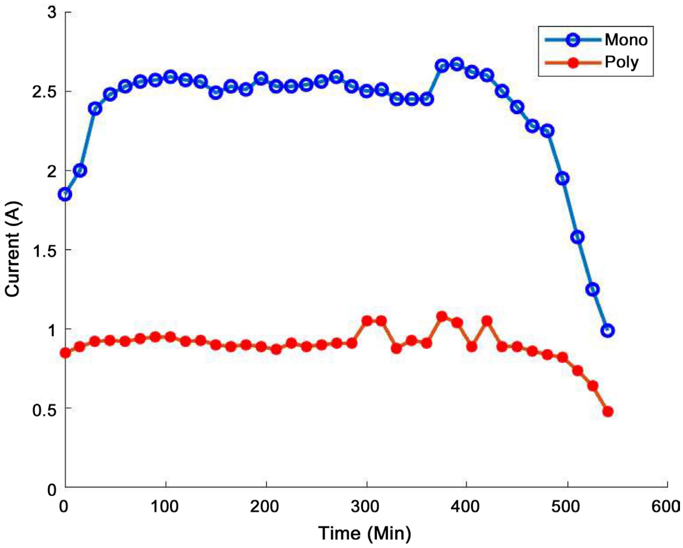

Figure 3. Temporal profiles of currents.

3.2. Comparative Study of Modules Covered in Dust

Figure 6 and Figure 7 present the current and voltage responses of the monocrystalline and polycrystalline modules connected to loads of the same characteristics at different masses of dust deposited on the surface of the modules. As for

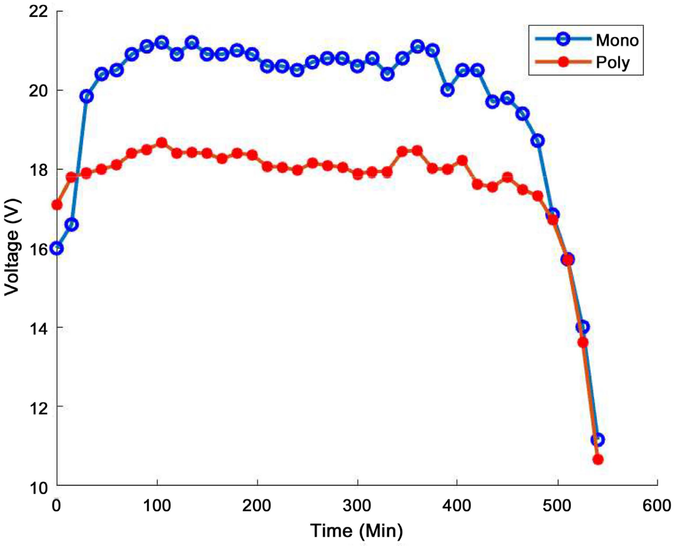

Figure 4. Temporal profiles of Voltages.

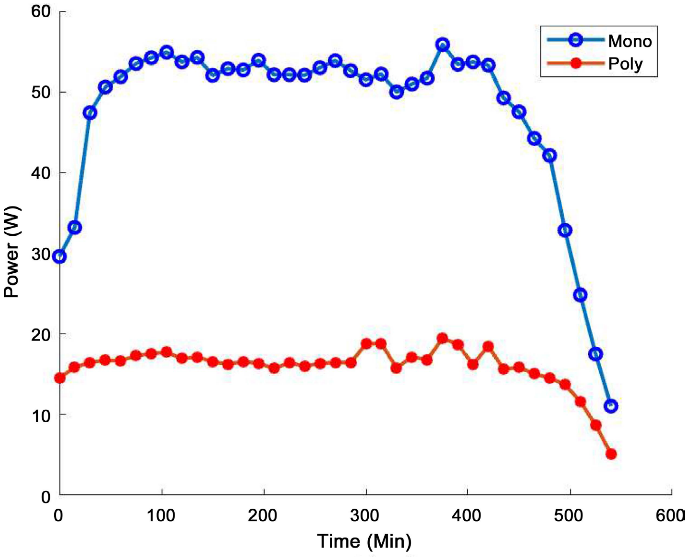

Figure 5. Temporal profiles of Powers.

the current, it can be seen that the current generated by the monocrystalline module is greater than that generated by the polycrystalline module. The polycrystalline module is therefore more affected by the deposition of dust collected in the study area than the monocrystalline module. As for the voltage, for dust masses of zero grams and 10 grams, the voltage of the polycrystalline module is higher than the voltage of the monocrystalline module, but from 20 grams and more, the voltage of the monocrystalline module is rather higher to the voltage of the polycrystalline module. By combining the performance responses of the modules under local operating conditions and their performance against dust deposition, we can see that monocrystalline modules are more appropriate for photovoltaic pumping installations in the study area (dry tropical climate), subject to other limiting factors such as the purchase cost of the panels.

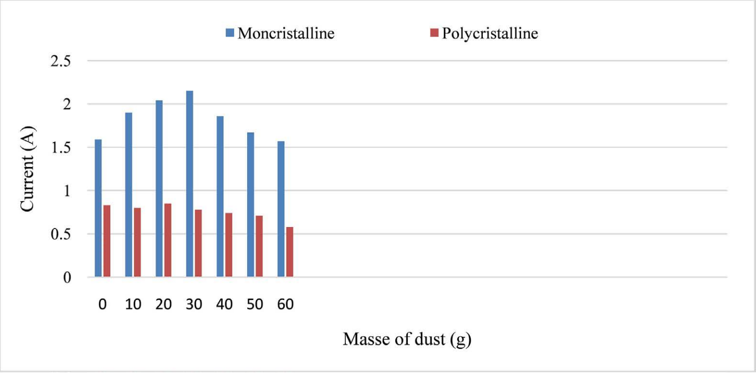

Figure 6. Current profiles at different dust masses.

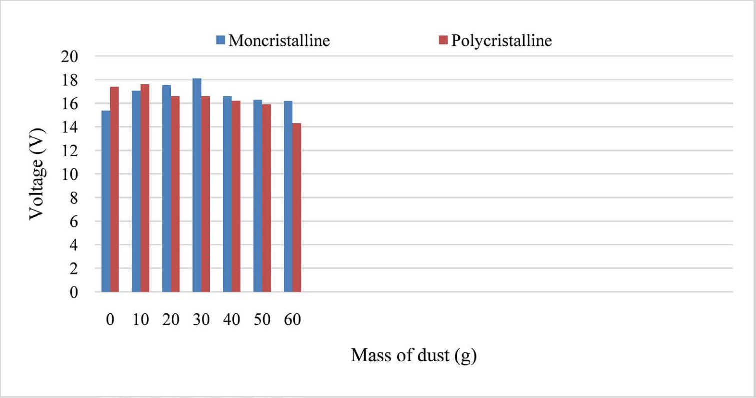

Figure 7. Voltage profiles at different dust masses.

The implementation of the experimental system takes into account, on the one hand, the large photovoltaic energy deposit in this locality and, on the other hand, the various climatic parameters that can affect photovoltaic cells. The work in [18] shows that this location is exposed to aerosols and high humidity. This is why the type of photovoltaic module used in **Figure 2** is recommended.

4. Conclusion

The choice of types of photovoltaic modules in solar pumping applications obeys several criteria which are sometimes technical, scientific, economic and depending on the constraints of use and operation. The present work made it possible to carry out a comparative study between the monocrystalline and polycrystalline module, first under a local environment and then performance tests following dust deposition were carried out. The results obtained made it possible to realize that the monocrystalline module provides a higher power than the polycrystalline module when the two types of panels are coupled to the same load and operating in the atmospheric and meteorological conditions specific to the dry tropical climate prevailing in the area of study. Regarding the performance of modules covered by dust deposits, tests have shown that the polycrystalline module is more influenced and the power supplied decreases more compared to that supplied by the monocrystalline. Ultimately, we can conclude that in the dry tropical zone and where solar modules are subject to dust deposits, the monocrystalline module is most suitable for photovoltaic pumping applications.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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