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Experimental study of temperature effects on the photovoltaic solar panels performances in Algerian desert

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Abstract – *Photovoltaic panels are operated in the Algerian desert areas under high temperatures, especially, in the summer, when the temperature may be reached 70°C on the panel's surface. The high temperature has a significant negative impact on the photovoltaic panels performance. In this paper, an experimental study to track the effects of temperature on the photovoltaic panels performances in different situations has been realized. The obtained results approve the importance of the temperature effects on the electrical power of the photovoltaic panel. The temperature increases lead to decreases in the performance of the panel, where an output power that does not exceed 52% of the nominal power at a high temperature.*

Keywords*: Photovoltaic (PV) systems, Maximal Power (Pmax), Short-circuit current (Isc), Open-circuit voltage (Voc).*

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I. Introduction

In light of the rapid rise in population growth rates, the increasing demand for electricity around the world, the alarming increase in carbon emissions leading to global warming, the instability of the global oil and gas market, the constant prices fluctuation and the risks of political unrest and natural disasters such as the Corona pandemic. Many countries have been forced to reconsider their use of traditional energy sources and the tendency to invest in renewable energy and its equipment [1-3]; this will reduce carbon emissions and ensure energy security, especially, since renewable energies are formed in several forms, like the sun, the water, the wind, ...etc. The solar energy source is among the most powerful sources of renewable energy and it has, recently, witnessed a decrease in its production costs in a way that qualifies them to compete with Oil and Gas, as photovoltaic energy has become very popular among renewable energy sources [4]. This is since the main fossil fuel resources are being depleted continuously compared to solar energy generation which is a clean source and does not contribute to the carbon footprint on the environment [5].

In addition to having one of the most significant sun fields in the world, with more than 3500 hours of brightness annually, Algeria's climate is very conducive to the growth of solar energy [6,7]. An excessive rise in temperature affects the photovoltaic panels (PV) performance, as the increase in temperature [8,9]. With the increase in temperature, the current increases slightly and the voltage decreases more [10], therefore, productivity and efficiency decrease [11,12]. Several recent studies have proved the high negative impact of high temperatures on solar cell performances [13].

In this paper, our proposed experimental research work is carried out to test the performances of a mono-

crystalline solar panel under different temperatures for different seasons in the Algerian desert of the Oued Souf region. The object of this work aims at temperature negative effects on the efficiency of the photovoltaic panel, especially in summer when the temperature exceeds 50 degrees in the shade and 70 °C in the sun at full summer.

II. Material and method

The band gap of solar cells is reduced when temperature rises, which has an impact on electrical solar cell parameters such as maximum power (Pmax), short-circuit current (Isc), and open-circuit voltage (Voc) [14–17].

The maximum power, short-circuit current, and open-circuit voltage is the three key electrical characteristics that directly affect how much energy a solar panel can produce.

The general objective of this study is to track the influence of temperature on the energy production of a photovoltaic panel at different times of the year at El Oued Souf Algerian south region.

The study was carried out on different days of the year taking into account the same irradiance in all the experiments equal to: E = 900 W/m^2 and focused mainly on the effect of temperature on the photovoltaic panel performances.

In this study, the electrical characteristics of the used photovoltaic panel are summarized as shown in Table 1.

Table 1. Electrical characteristics of the photovoltaic panel

Electrical characteristics	PV panel type: Sunmodul SW 80 mono RHA/D
Maximum Power (Pmax)	80W
Open-circuit Voltage (Voc)	22.5V
Rated Voltage (Vmpp)	18.5V
Short-circuit Current (Isc)	4.66A
Rated Current (Impp)	4.53A

Figure 1 and Figure 2 show our experiment therefore, an appropriate controllable variable load was connected to the PV array. Environmental conditions were monitored using the following sensors:

- Sunlight sensor to measure global solar radiation;
- Temperature sensor for measuring the surface temperature of the PV panel.

Each time we switch the load, we use metering devices to capture the current and voltage and log the data to the laptop. Between July and November, this is done.

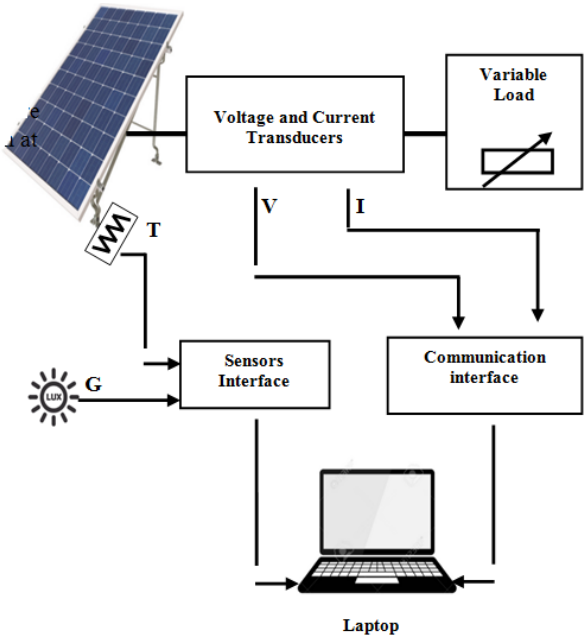

Figure 1. Measurement system setting up

Figure 2. Photographic view for experimental outdoor

III. Results and analysis

III.1. Open-circuit voltage as a function of the temperature

The greatest voltage that may be obtained from a solar panel is called the open-circuit voltage (Voc), and it happens when the current value is zero.

Figure.3 shows the open-circuit voltage (Voc) of the photovoltaic panel with the temperature change. It is clear that we certify the increase in temperature adversely affected the open-circuit voltage (Voc). The highest value was recorded at a temperature equal to 25°C (22.45V) on the date 21 November 2021.

In July, the lowest value of Voc was recorded at 19.05 V. This is due to the significant rise in temperature, which reached the vale of 69°C. As the temperature increases, the open-circuit voltage values decrease.

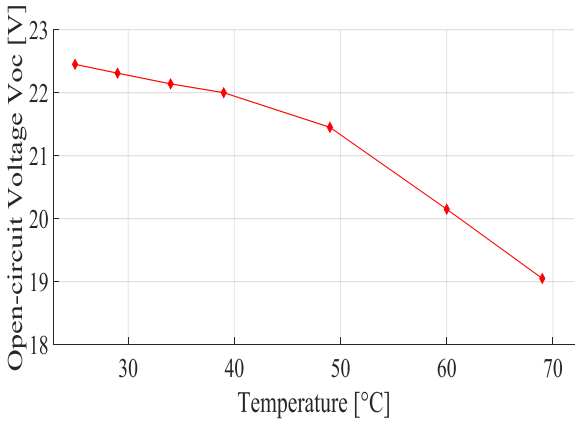

Figure 3. Temperature dependence on open-circuit voltage (Voc)

III.2. Maximal power as a function of the temperature

The output power of the PV panel strongly depends on solar irradiance falling upon its surface and the temperature change.

Figure 4 shows the change in the output power by changing the temperature. At a temperature equal to 25°C, the output power is at its maximum and equal to 68.98 W. These are on 21 November 2021.

In July and at a temperature equal to 69°C the output power reaches a very low value compared to the other situation.

The temperature change has an important significant effect on the output power produced by the photovoltaic panels. As the temperature increases, the output power decreases remarkably as shown in Figure 5.

The output power does not exceed 52% of the nominal one recorded at T = 69°C. This result was recorded in July.

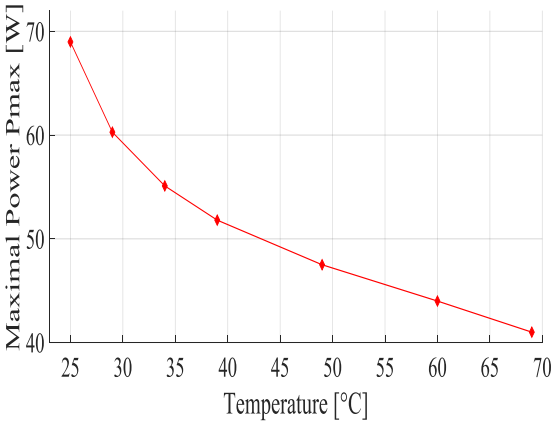

Figure 4. Temperature dependence of maximum power (Pmax)

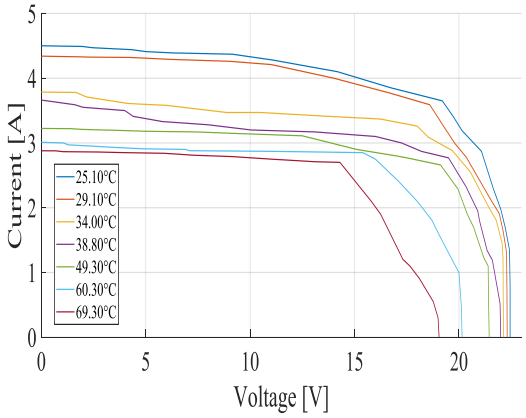

Figure 5. V-I characteristic of a PV panel

III.3. Short-circuit current as a function of the temperature

The short-circuit current (Isc) is the current passing throng a photovoltaic panel when voltage is equal to zero. Figure 7 represents the current sugar circuit as a function of the temperature variation from 20 °C up to 70°C. It shows the change in the Short-circuit current when the temperature changes. The highest value was recorded at T = 25°C, the Short-circuit current (Isc) decreases very significantly when the temperature rises.

The value of the short-current was close to the value of the current record on the data plate at T = 25°C. These results certify and confirm that the temperature increase greatly affects the short-circuit current.

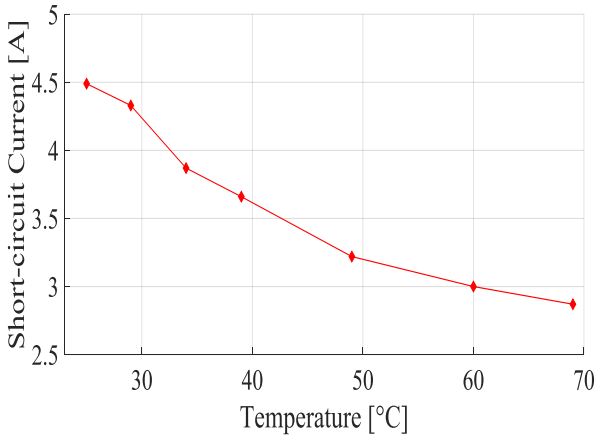

Figure 6. Temperature dependence of Short-circuit current (Isc)

IV. Conclusion

Experimental research work was carried out to test the performances of a mono-crystalline solar panel under different temperatures for different seasons in the Algerian desert of the Oued Souf region.

- The efficiency of solar cells is significantly impacted by temperature.
- The main effect of increasing temperature for mono-crystalline photovoltaic panels is the reduction in the open-circuit voltage values. As a result, the output power declines, which lowers the efficiency of the panels.
- When studying the power budget, the temperature must be strongly taken into account because the output power of mono-crystalline panels may be reduced by 48% in areas characterized by high temperatures.
- According to testing findings, solar panels operate best in the Algerian desert when the temperature varies between 25°C and 34°C. If there is a choice between two sites, it would be preferable to choose one with a low temperature if the irradiance is the same to get higher solar panel performance.

Declaration

- The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.
- The authors declare that this article has not been published before and is not in the process of being published in any other journal.
- The authors confirmed that the paper was free of plagiarism.

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