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Performance study of a real photovoltaic power station under desert conditions: case study

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ABSTRACT

This work focuses on studying and analyzing the photovoltaic power plant of Oued Nechou located in the South of Algeria, in order to create its simulation model. This later can estimate its power production. To achieve this, all system parameters were introduced in the model according to the real data. Then, the characteristics of the photovoltaic panels were tested and plotted under different temperature and irradiation values to understand their influences on the electrical performances. In order to ensure the maximum energy production, photovoltaic panels were associated with converters controlled by a maximum power point tracking (MPPT) algorithm. Two different thin- film technologies of the PV panels (Amorphous silicon (a-Si) and cadmium telluride (CdTe) technologies) were simulated and tested under standard test conditions (STC) and compared with the real characteristics. The results show good accuracy. Subsequently, the real data of four seasons of the same year were introduced in the created model of Oued Nechou station. The obtained results of the simulation show that the performance of the produced energy is affected by the desert climatic conditions, especially the temperature and the solar radiation. However, the positive solar effect is higher than the negative thermal effect, which encourages investment by installing other photovoltaic stations in these areas known by the high and long duration of irradiance.

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1. INTRODUCTION

The strong growth of the worldwide population and technological development means an increase in energy demand. To answer these needs, it is necessary to provide new sources of energy for the electrical grid. Integrating renewable energy sources is a strategic direction to meet the constantly increasing global demand for electricity and to encourage sustainable energy development. Solar, wind, hydro, biomass, and geothermal energy are among the major renewable sources that offer clean and sustainable alternatives for electricity production [1]. Solar energy, thanks to its availability and accessibility, especially in regions with high solar potential, stands out among these technologies. Photovoltaic energy is among the most widely used renewable resources that convert solar radiation into electricity. It has several advantages. It reduces the dependence on fossil energies, which helps reduce greenhouse gas emissions, and contributes to the efforts to tackle climate change. Moreover, the PV energy can be installed in insulated zones devoid of stable electrical networks. Algeria is among the countries that have installed many photovoltaic power plants recently. Its area is estimated at more than 2,3 million square kilometers, of which 80 % is arid, and 20 % belongs to the African Sahara. Thanks to its huge area and the big solar potential, it is considered to be one of the best developed reservations in the world. The time of sunshine`s hours in Algeria exceeds 2500 h/year and can attain up to 3500 h/year which gives a medium solar potential of 2500 kWh /m^2 or about 6000 TWh (150 times actual Algerian consumption) [2]. Algeria installed more than 21 different photovoltaic power stations, including the 1.1 MW Oued Nechou PV station in the Wilaya of Ghardaïa, located in a desert area.

Research on the photovoltaic panels' performance installed in desert zones has been rather numerous in recent years, owing to the growing interest in solar energy in these regions with strong hours of sunshine [3]-[8]. These works aim to take up the technical and economic challenges related to the deployment on a large scale of PV solar energy in desert regions, while optimizing the performance and reliability of the installed systems. Photovoltaic panels installed in desert areas usually operate efficiently. Studies often show higher levels of electricity production than those observed in less sunny environments. However, excessive heat can also negatively affect the performance of solar panels. Research has shown that high temperatures decrease the efficiency of photovoltaic panels, resulting in a decrease in their yield [9]-[17]. In addition, desert areas are often characterized by strong winds carrying sand and dust [18]-[24], which can cover the solar panels and reduce their performance. Other researchers studied special anti-sand and anti-dust coating materials to protect the panels and reduce the accumulation of dirt [25]-[27]. All these struggles lead to thinking about the effectiveness of the photovoltaic panels in desert areas especially Algerian Sahara, to improve their efficiency. This highlights the technical performances and climate challenges faced by photovoltaic panels in the desert regions of Algeria, which are related to the deployment on the large scale of the installed photovoltaic solar energy. The objective is to create a model of the Ouad Nechou PV station and simulate its performance using real measured data. Different photovoltaic panel technologies installed in the studied PV station have been examined under Saharan climate conditions during the four seasons of the year.

The paper represents three essential parts. The first one will be devoted to the presentation of the studied PV station characteristics and the modeling part of photovoltaic (PV) panels (CdTe and a-Si). Then, the simulation results of the photovoltaic panels in different temperatures and irradiances were used to better understand their influences and confirm the model by comparison with real characteristics. The second one, the PV panels, will be associated with converters controlled by an MPPT algorithm. The simulation will be carried out under standard test conditions (STC) for the PV panels, sub-fields, and the whole PV power plant. All these results will be compared with real parameters. The third part presents the simulation results of Oued Nechou station, Ghardaia, under real temperature and illumination in four seasons. An analysis and comparison of the PV station performances will be carried out.

2. DESCRIPTION OF THE OUED NECHOU STATION

The photovoltaic power station of Oued Nechou is located in the Sahara of Algeria, about 15 km north of Ghardaïa. It is located at latitude of 32° 24N and a longitude of 3° 48E with an altitude of 566 m. This power PV station was established in 2014, it covers 10 hectares with a capacity of around 1.1 MW. The power plant is a "Pilot" project (Figure 1), divided into eight subfields; containing four photovoltaic technologies and two types of structures (fixed and motorized) (Table 1).

Figure 1. PV station of Oued Nechou

There are monocrystalline, polycrystalline, CdTe, and a-Si panels, of which about 20% of them are mounted on a motorized sun tracking system. These motorized panels use a single-axis solar tracker (two sub-fields are motorized; mono 105 kW$_C$ and poly 98.7 kW$_C$), and the other sub-fields, which represent 80% of the overall field, remain on fixed supports (CdTe 100.8 kW$_C$, a-Si 100,116 kW$_C$, two monocrystalline sub-fields 105 kW$_C$ and 255 kW$_{C,}$ and two other polycrystalline 98.7 kW$_C$ and 258.5 kW$_C$). The purpose of this study is to examine the performances and electrical quantities of the Oued Nechou-Ghardaia station, taking into account maximal power point tracking (MPPT) control of the converter. The outcomes of the simulation will be compared with the real data of the station when both of them receive the same inputs in order to evaluate the model and its performance. Then, based on real data, MATLAB software will be used to simulate the subfields, examining the station's behavior throughout four seasons of the year (Figure 2).

Table 1. Types of sub-fields in the Oued Nechou station

Subfield number	Type	Power in sub-field	Nbr of strings/sub-field	Nbr of module/string	Module power
1	Mono (motorized)	105 kWc	21	20	250 Wc
2	Poly (motorized)	98.7 kWc	21	20	235 Wc
3	Cd-Te (fixed)	100.8 kWc	105	12	80 Wc
4	a-Si (fixed)	100.116 kWc	54	18	103 Wc
5	Mono (fixed)	105 kWc	21	20	250 Wc
6	Poly (fixed)	98.7 kWc	21	20	235 Wc
7	Mono (fixed)	255 kWc	51	20	250 Wc
8	Poly (fixed)	258.5 kWc	55	20	235 Wc
Total		1174016 Wc	349	150	

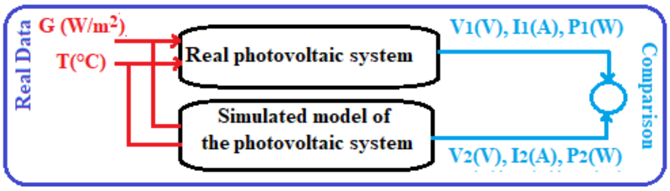

Figure 2. Scheme of the comparison between the real data of the station and the simulation results

3. SIMULATION OF A PHOTOVOLTAIC PANEL

The photovoltaic panel simulations can be used to evaluate the performance, from the panel to the whole system, under different environmental conditions, such as geographical location and weather conditions. At first, the photovoltaic system modelling assumes homogeneous modules, constant parameters, uniform irradiation and temperature, the absence of wiring losses and degradation, and idealized converters. Table 2 presents the characteristics of the four technologies used in the Oued Necho PV station (monocrystalline, polycrystalline, CdTe, a-Si). However, the PV panel simulation in this paper will be limited to the thin film and Amorphous technologies; the others were simulated and detailed in [6]-[10].

Table 2. Real characteristics of photovoltaic panels in the studied PV power plant

Parameter	Silicium monocrystalline panels	Silicium polycrystalline panels	Thin-film panels	Amorphous silicon panels
Rated power	250 Wc	235 Wc	80 Wc	103 Wc
Voltage in MPP	30.35 V	29.04 V	48.5 V	30.4 V
Current in MPP	8.24 A	8.1 A	1.65A	3.39 A
Open circuit voltage	37.62 V	36.94 V	60.8 V	41.1 V
Short-circuit current	8.79 A	8.64 A	1.88 A	4.00 A
Yield	15.35%	14.43%	11.1%	7.1%

3.1. Simulation of the inputs' effect on the performance of CdTe and a-Si panels

The electrical current-voltage characteristic (I (V)) of PV panels generally depends on the temperature to which it is subjected; the temperature variation has a significant effect on the current-voltage curve of photovoltaic panels. Several temperature values have been simulated in this part (10, 25, 40, 55, and 70 °C) with a fixed irradiation level (G = 1000 W/m²). The following Figures 3 and 4 represent the current-voltage characteristics I (V) and power voltage P (V). To investigate the influence of solar irradiance on the panels' performance, different irradiance levels are applied (0.2, 0.4, 0.6, 0.8, 1 kW/m^2) at fixed temperature (25 °C) as mentioned in Figures 3-10. It should be noted from these results that for the two simulated technologies, the obtained results in STC (1000 W/m^2, 25 °C) have values identical to those of real characteristics indicated in Table 2, which proves the validity of the PV models. Overall, temperature and illumination affect the current-voltage (I-V) and power-voltage (P-V) characteristics across different photovoltaic technologies. However, the open circuit voltage and short circuit current remain constant and equal to the real value characteristics. For both technologies, it can be noted that the temperature variation has a significant effect on the voltage curve of the photovoltaic panels, where the voltage is inversely proportional to the temperature, consequently to the power too (Figures 3, 4, 7, and 8). This means that in high temperatures, caused generally by the thermal effect of the solar irradiance, the produced PV power will be reduced. However, the irradiance does not have a direct remarkable effect on the voltage. On the other hand, the irradiance has a high effect on the current. The latter is proportional to the irradiance and, consequently, to the power as well (Figures 5, 6, 9, and 10). But the PV voltage is not affected in a remarkable way for different irradiance values. This means that in the regions where the solar irradiance has a high value and a long time during the day, such as Saharan regions, the power and the energy will increase. It is important to note that irradiance has a more significant effect on the output power than the temperature does, which means that the PV panel gains more advantages from solar energy than the losses it suffers due to high temperature. This makes the photovoltaic system available in Saharan regions. It should be noted from these results that the a-Si panel is less affected by temperature than the CdTe PV technology, which makes it more suitable for Saharan applications. However, its efficiency is less than that of the other PV technologies (monocrystalline and polycrystalline) [6]-[10].

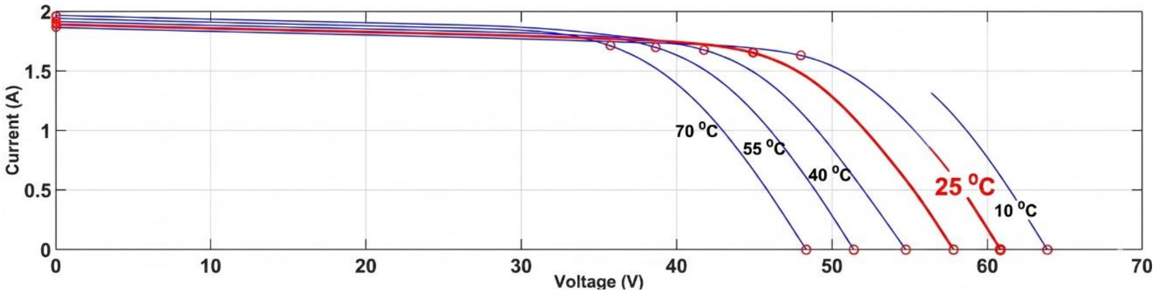

Figure 3. Characteristic I(V) for various temperatures (G = 1000 W/m²) CdTe PV

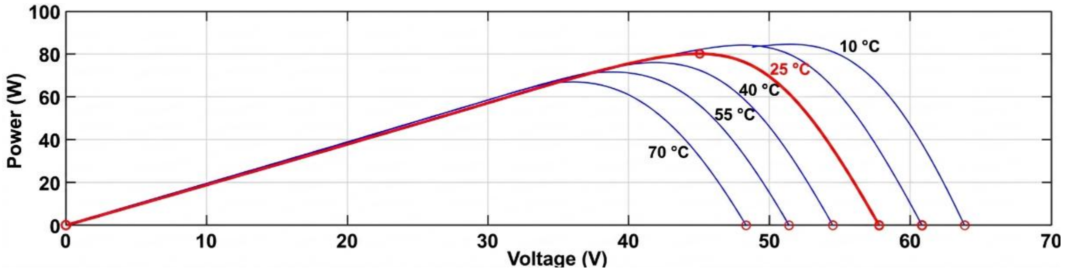

Figure 4. Influence of temperature on P-V curve under (G = 1000 W/m²) CdTe PV

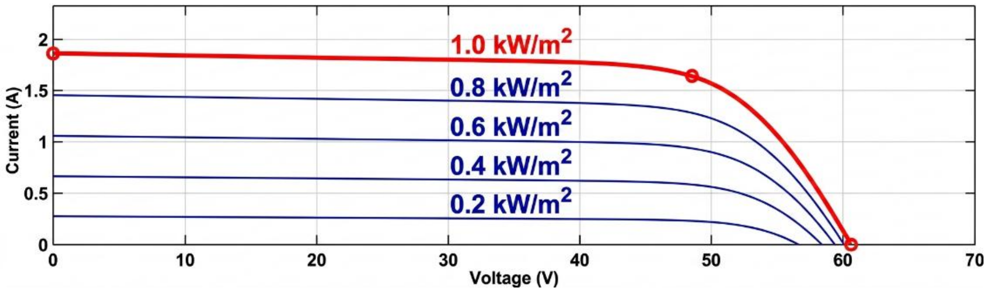

Figure 5. Characteristic I(V) under varying illumination levels (T = 25 °C) CdTe PV

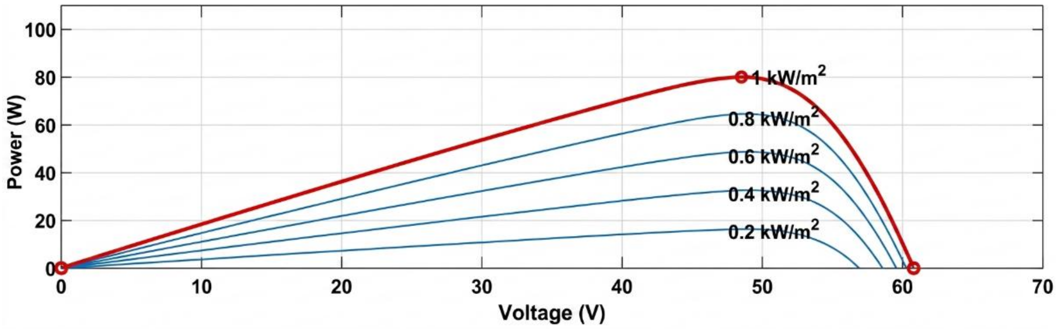

Figure 6. Variation of the P-V curve with respect to illumination intensity at (T = 25 °C) CdTe PV

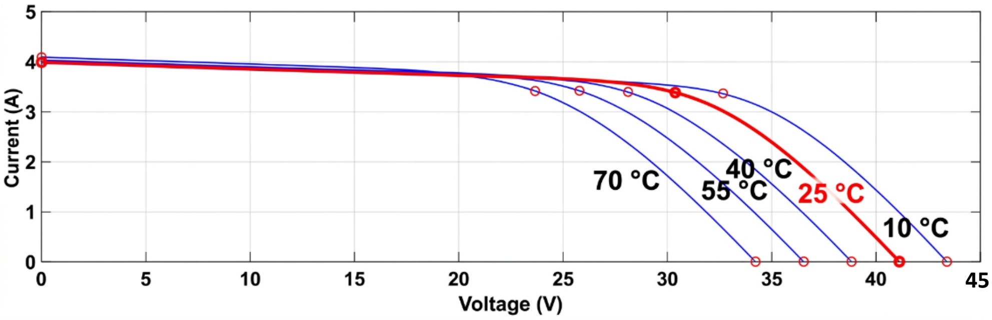

Figure 7. I-V behavior measured across temperature variations (G = 1000 W/m², a-Si PV)

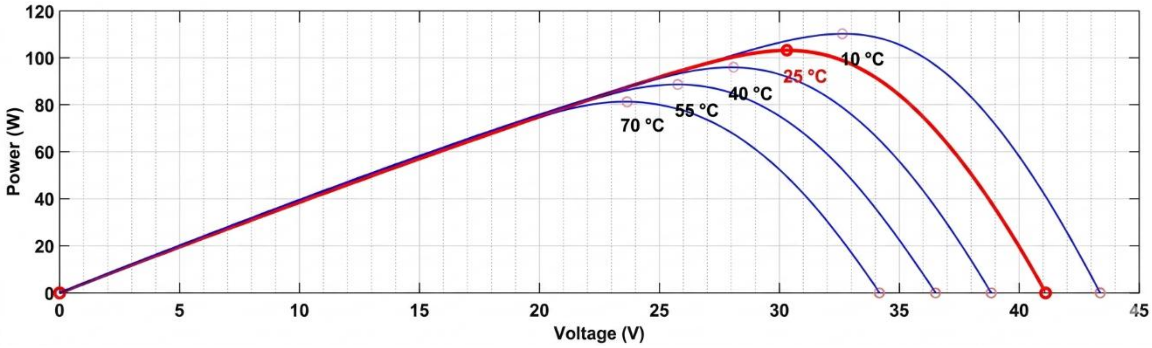

Figure 8. P(V) for a range of temperatures (G = 1000 W/m², a-Si PV)

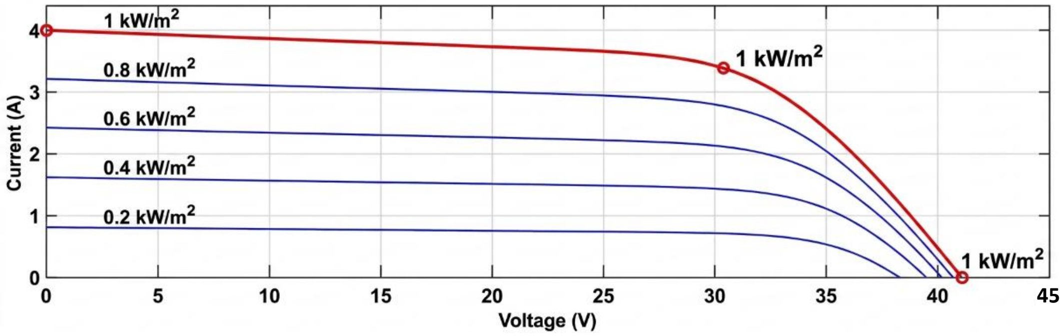

Figure 9. I-V for several levels of illumination (T = 25 °C, a-Si PV)

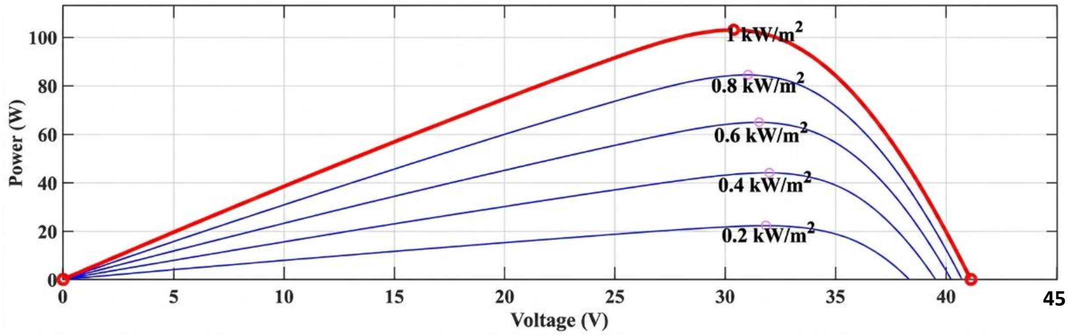

Figure 10. Characteristic P(V) at diverse illumination intensities (T = 25 °C, a-Si PV)

3.2. MPPT control of the photovoltaic system

After modeling and analyzing the PV panels, this part analyzes the association of the PV panels into boost converter for the photovoltaic system to make it closer to the real case in the Oued Nechou station. The converter is equipped with MPPT control, which makes the system operate at its maximal operating point (V_{mpp} et I_{mpp}), in order to maximize the output produced power of the photovoltaic panel, regardless of the variations in weather conditions (temperature and irradiation). The regulation system is based on an algorithm for automatic variation of a duty cycle "α'' to set the voltage and power to the appropriate values (Figure 11). The diagram illustrated in Figure 11 consists of a photovoltaic panel, a boost (DC/DC) converter controlled by MPPT based on the voltage and current measurement of the PV output. The output of the DC/DC is the input of DC/AC, which ensures the conversion to AC current in order to inject the current into the grid. The same step was realized with monocrystalline and polycrystalline panels in the six subfields of the same station in previous works [6]-[10].

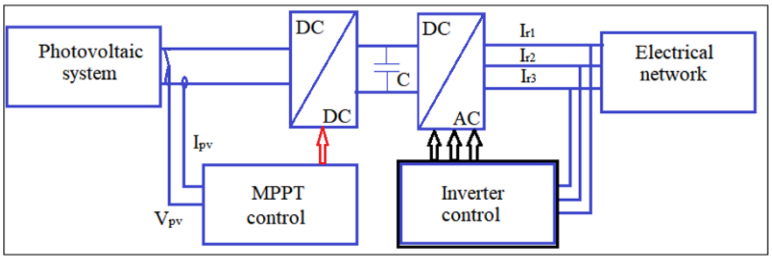

Figure 11. Schematic diagram of the MPPT converter in the PV power plant

3.3. Simulation results of both PV technologies in STC

This section presents the different simulation results obtained in STC (G = 1000 W/m^2, T = 25 °C), for CdTe and a-Si PV panels in order to validate their models and the converter MPPT control by comparing (V_{mpp}, I_{mpp}, P_{mpp}) of the real characteristics with those obtained by simulation. After that, the simulation will be carried out for the subfield of CdTe (N°3 in Table 1) and a-Si PV panels (N°4 in Table 1), taking into account the MPPT control as well as the comparison with the real nominal photovoltaic powers indicated in the Oued Nechoun station. Considering that the other technologies (monocrystalline and polycrystalline) have already been studied previously in [6]-[10]. Then, the simulation of the whole Oued Nechoun PV power plant will be carried out in STC and compared with the nominal indicated power, as shown in the following figures.

3.3.1. CdTe photovoltaic panel (80 Wc)

Among the advantages of CdTe PV panels is that they can be lighter and more flexible than traditional solar panels, which makes them suitable for a variety of applications, including curved or irregular surfaces. In addition, on the manufacturing side, this type of thin-film panel can be relatively lower-cost. The simulation results of the CdTe PV panel under STC conditions are illustrated in Figures 12, 13, and 14. It should be noted that the values of current, voltage, and power obtained by simulation are the same as mentioned in the real characteristics (Table 2) (current in MPP: I = 1.65 A, voltage in MPP: V = 48.5 V, rated power: P = 80 W).

This proves the validity of the PV model and MPPT control applied to the converter. As shown by Table 1 of the real characteristics, Figures 15, 16, and 17 present the simulation results of the PV station sub-field N°3, which is the association of 12 PV modules (In series) and 105 strings (In parallel). The sub-field delivers a power equal to 100.8 kWc in STC. According to the analysis of the simulation results, it is clear that the obtained current increased with the number of parallel associations of panel strings. It is exactly equal to (1.65 A × 105 = 173.25 A) (Figure 15). While the obtained sub-field voltage equals the number of PV serial modules by the voltage in MPPT, which led to an increase in the voltage (48.5 V × 12 = 582 V) (Figure 16). Consequently, the total power can be obtained in two ways: either the product of the total voltage by total current (173.25 × 582 = 100.8 kW) or the total number of modules by the power of one module (Figure 14) (105 × 12 × 80 = 100.8 kW), which is equal to the value obtained in Figure 17.

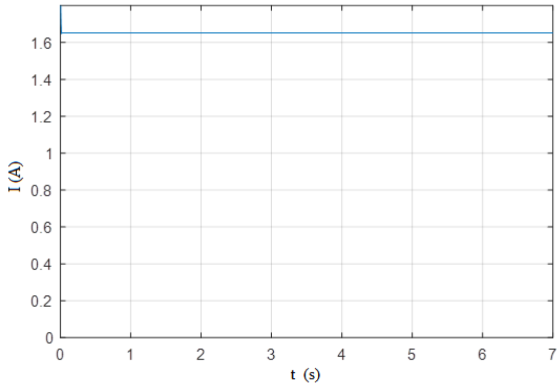

Figure 12. CdTe panel 80 W current

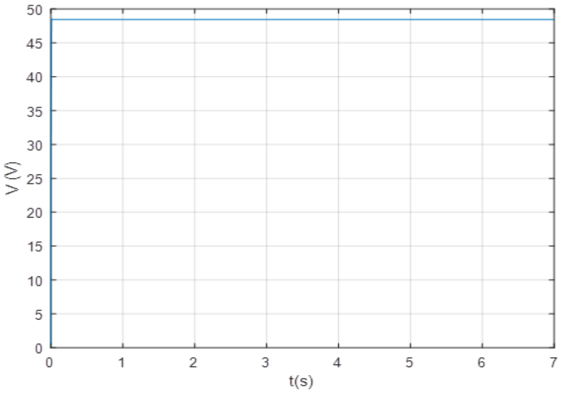

Figure 13. CdTe panel 80 W voltage

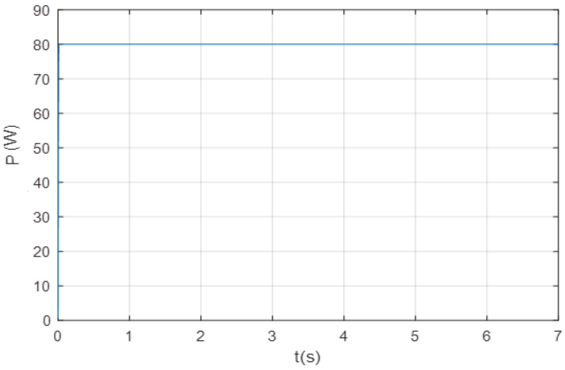

Figure 14. Output power of the CdTe panel 80 Wc

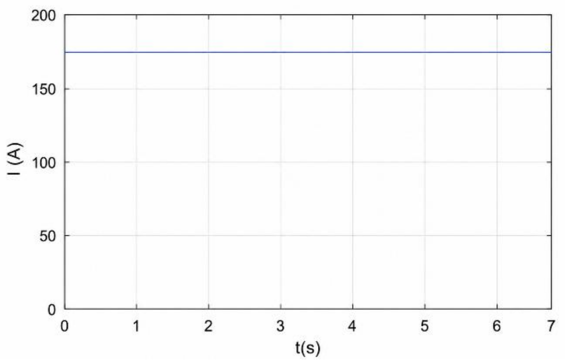

Figure 15. Subfield current N°3 after the converter (PV CdTe 100.8 kWc)

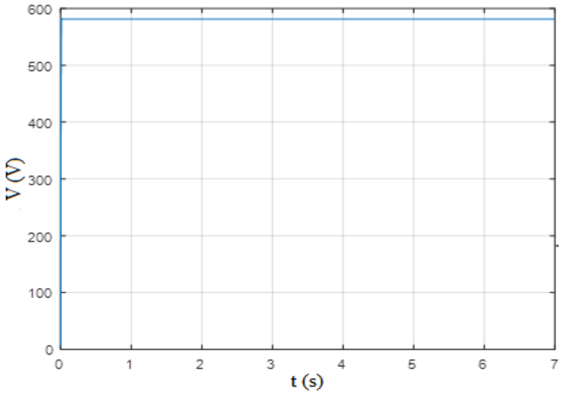

Figure 16. Voltage of the subfield N°3

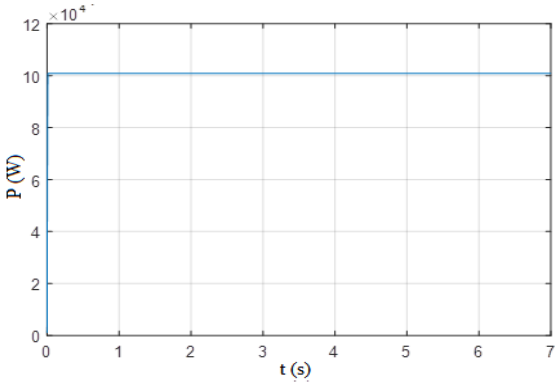

Figure 17. Output power of the subfield N°3

3.3.2. Amorphous silicon photovoltaic panel 103 Wc

The simulation results in STC conditions of the a-Si PV panel of the sub-field N°4 are illustrated in Figures 18 to 20. As previously mentioned, these figures show the values of current, voltage, and power obtained by simulation; they are the same as those mentioned in the real characteristics (Table 2) (current in MPP: I = 3.39 A, voltage in MPP: V = 30.4 V, rated power: P = 103 W). This confirms the validity of the a-Si PV model and the MPPT control applied to the converter. It is to be noted that this sub-field delivers a power equal to 100.11 kWc in STC. It is an association of 18 PV modules (in series) and 54 strings (in parallel). The simulation results confirm that the obtained current is increased with the number of parallel associations of panel strings. It is equal to (3.39 A × 54 = 183 A) (Figure 21). While the obtained sub-field voltage equals (30.4 V × 18 = 547 V) (Figure 22). Therefore, the total power can be obtained in two ways, either the product of the total voltage by total current (183×547 = 100.11 kW), or the total number of modules by the power of one module (54×18×103 = 100.11 kW), which is the same value obtained in Figure 23.

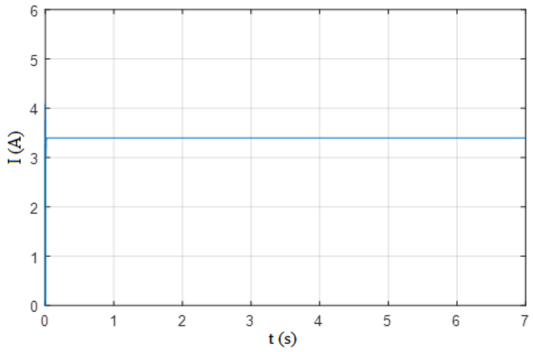

Figure 18. Current of the a-Si panel 103 Wc

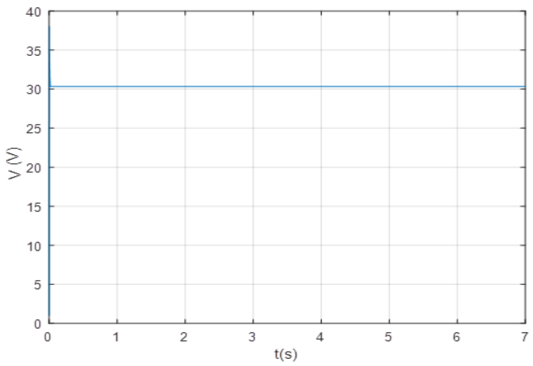

Figure 19. Voltage of the a-Si panel 103 Wc

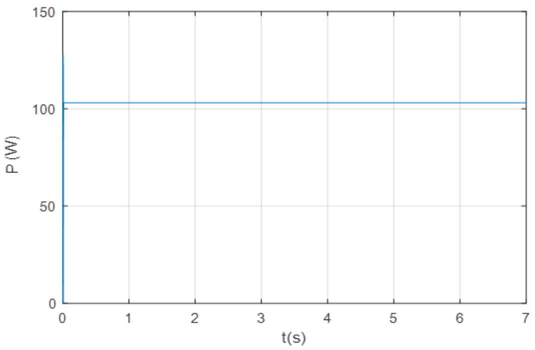

Figure 20. Output power of the a-Si panel

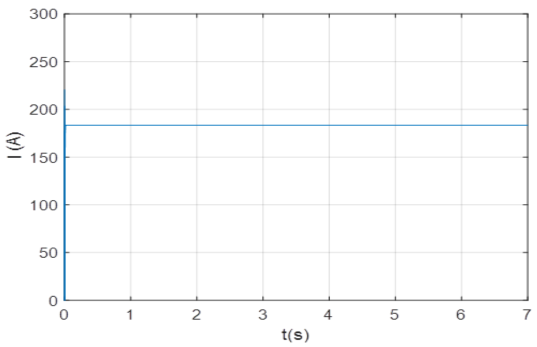

Figure 21. Current of the subfield N°4

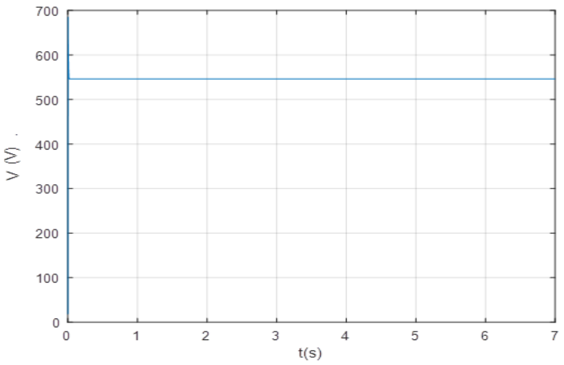

Figure 22. Voltage of the subfield N°4

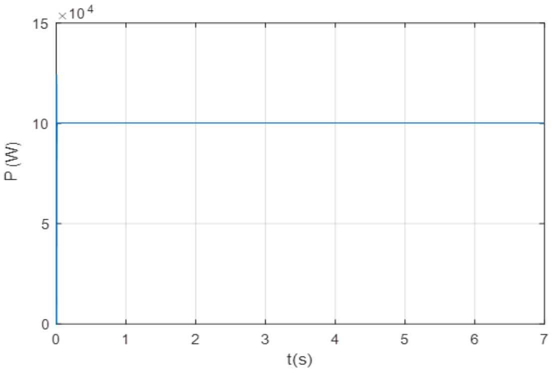

Figure 23. Power at the output of the N°4 subfield (amorphous PV 100.11 kWc)

After proving the results of the panels in different conditions, as well as the sub-fields studied in this paper and those analyzed before [6]-[10], the whole PV power plant of Oued Nechou has been simulated in STC. The simulation results of the total obtained power are presented in Figure 24. It can be observed clearly that the total obtained power of the whole PV plant of Oued Nechou precisely equals the indicated power in the real characteristics (Table 1). This is explained by the high accuracy of the developed model and demonstrates the validity of the PV power station's model, which allows the use of this model for performance evaluation and fault detection. After this step, the real input climate data (temperature, humidity) will be introduced in the model of the PV power plant of Oued Nechou to evaluate its performance during the four seasons of the year, as it will be presented in the next section.

3.4. Simulation of Oued Nechou station in four seasons using measured values

To predict the behavior and performance of the Oued Nechou station during the year and fix the problem of missed data (caused by maintenance, sensor, and device faults), the measured real data (temperature, irradiance) of the 15th day of a selected month in each season has been inserted into the PV power system model. All the real measurements were plotted during the 14 hours of the day from 06:32 h to 20:32 h, as illustrated in the figures below using the real data (Figures 25 and 26). It is observed that the temperature and solar irradiation are variable during the day, mainly because of the position of the sun and the PV system. They show low values at sunrise, peaks at midday (with temperatures exceeding 47 °C in September and the irradiation reaches 1100 W/m² in March and summer). Then, a gradual decrease is noticed toward sunset. The temperatures drop quickly, and the nights are quite cool. These variations are typical for desert climates, with a long daytime heat and clear sky enhancing solar output, and rapid cooling at night. In Saharan regions, the irradiation can be extremely high due to the frequent clear skies and the absence of clouds that reduce the solar illumination. Moreover, they are characterized by the long day duration, which increases the captured PV energy and reduces the consumption of battery energy. Figure 27 represents the simulated power output generated by the eight subfields installed in the station during four seasons. Below is the performance analysis for each season.

3.4.1. Performance of the station during the spring (real data, March 15th, 2016)

In spring, the sample day selected based on the available data is March 15th, 2016. The illumination reaches extremely high values of the order of (1100 W/m^2). However, by coincidence, some clouds cause its decrease at the ninth hour of the day (at 15:32). Then, it resumes its normal value in clear sky. In this case, the power takes on a profile similar to that of the illumination. Generally, during the spring, the climate is balanced. While panels' temperature increases to 37 °C during the day and then decreases relatively during the cold night. This is due to the conditions that are closer to the standard STC, represented by the high level of illumination and the relatively balanced average temperature, the maximal power of the PV station reaches (1.079000 MW), which is the highest value compared to the other seasons. This value is closer to the maximum value delivered by the Oued Necho PV station in STC (1.1 MW) (Figure 24). This means that the PV power plant production is higher in spring.

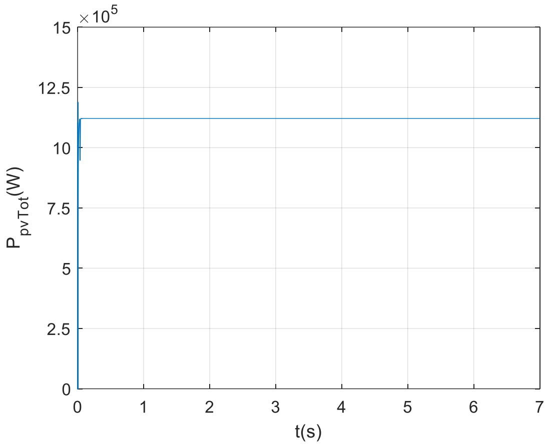

Figure 24. Output power of all the PV power plant of Oued Nechou (1.1 MWc)

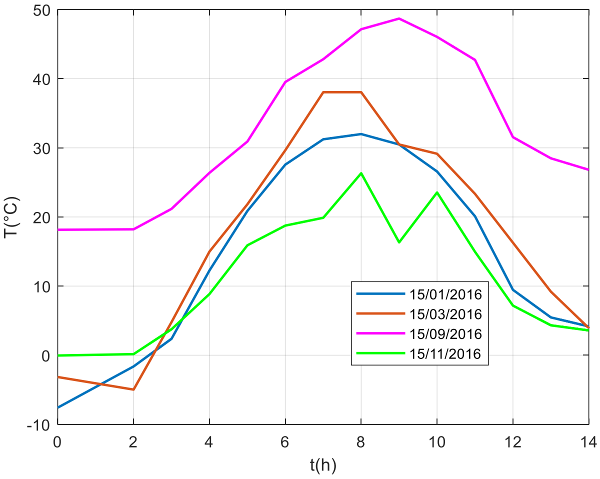

Figure 25. Real variation of PV temperature in 2016

3.4.2. Performance of the station during summer (real data September 09th, 2016)

According to the available useful data, the sample summer day was September 09th, 2016. Generally, during the summer months in the Saharan region, the sky is always clear. This is confirmed by the illumination rate, which is continuous during all the day and can even exceed (1000 W/m^2). It is clear that in this month the temperature level is lower than in the first months of summer, but the noticed temperature of the photovoltaic panels increases from 16 °C to 48 °C. Then, it decreases to 27 °C. As proved in the previous simulation (Figures 4 and 8), the high temperature decreases the produced power, here it reaches (0.977823 MW).

3.4.3. Performance of the station during the fall (real data, November 15th, 2016)

The meteorological data and the power obtained on the autumn day, November 15th, 2016, are presented in Figures 25 to 27. It is observed that the illumination rate is very disturbed because of the partial passages of the clouds, where it does not reach (1000 W/m^2). Therefore, the temperature takes a similar profile. It reaches up to 26 °C, so it is closer to the STC. However, the produced power reaches a maximum value equal to (0.962370 MW), but it is lower than the previous cases. This means that the effect of the illumination decrease on the produced power is greater than the effect of the temperature increase. Moreover, the day duration is very short, which means that the energy is lower.

3.4.4. Performance of the station during the winter (real data January 15th, 2016)

In the winter season, the sample real data was taken on January 15th, 2016. In the Sahara weather, the sky is often clear. Therefore, the illumination takes its continuous dome shape during an interval longer than that of November. It reaches a maximum value of (960 W/m^2). On the other hand, during the cold night on this winter day, the panels' temperature decreases to (-7 °C). Then, it increases to 37 °C during the day, and it starts dropping again. In this case, the power level takes the same profile as that of the illumination. Thanks to these climatic conditions, relatively close to the standard STC conditions with clear sky, the total power of the station can reach a significant maximum value around noon (1.024200 MW). According to the power analysis of the four seasons of the year, it is to be noted that the illumination is more intense in spring March 15th, 2016, where it reaches very high values closer to (1100 W/m^2). However, the presence of clouds contributes to its decline in other seasons. The clouds' effect is more significant in the case of autumn, when the level of illumination is little disturbed, November 15th, 2016. In November, the short duration of sunshine, combined with disrupted production, resulted in the acquisition of lower energy. It should be noted that the duration of sunshine is very high during spring and summer, which leads to more energy production than usual. In addition, it should be noted that the temperature and the power are proportional to the illumination. The Oued Nechou PV power station gave maximum power during the month of March, when the illumination and the temperature are closer to the STC conditions, in which the panels deliver their nominal power in this case. The obtained results, along with those analyzed previously [6]-[10], which confirm trends observed in other photovoltaic deployments in desert environments of other studies [28], [29]. High temperatures and irradiation significantly reduce efficiency, while thin-film modules demonstrate better thermal stability and tolerance to diffuse light than crystalline silicon-based technologies.

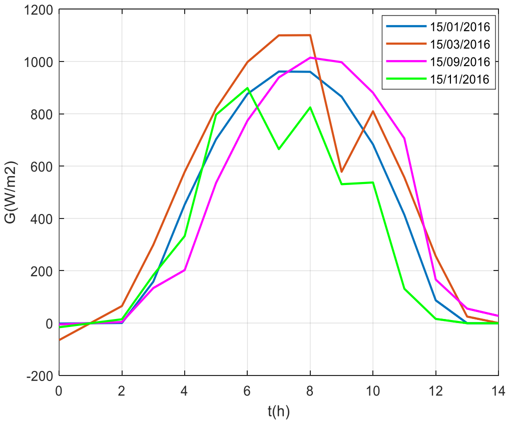

Figure 26. Real variation of irradiance in 2016

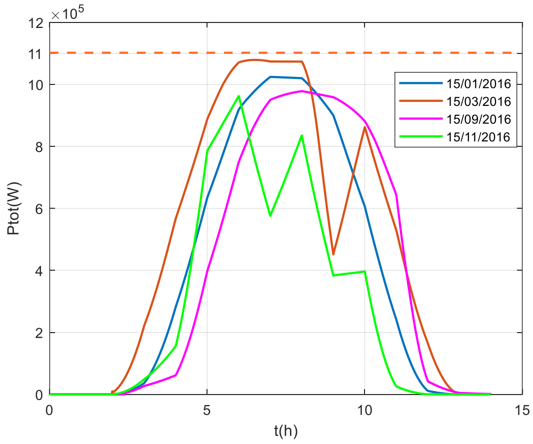

Figure 27. Overall produced power of Oued Nechou PV station in four seasons in 2016

4. CONCLUSION

This paper has been devoted to the modeling and study of the electrical performances of Oued Nechou photovoltaic power plant in Ghardaïa under several scenarios and with the use of real data. The use of on-site measured data strengthens the reliability of seasonal comparisons and provides a solid basis for developing predictive models adapted to desert conditions. In order to create a model of the PV station and simulate its real behavior, the analysis was subdivided into three parts: First, the photovoltaic panels used in the PV power plant have been modeled and simulated under different weather conditions. Then, the simulation results have been compared with the real characteristics of the PV panels. Good agreements were found between them, which proved the precision of the PV models. In order to be closer to the real behavior of the PV power station, the photovoltaic panels were associated with DC/DC converters, like the real case. The MPPT control algorithm has been applied to this latter to maximize the produced power and simulate the real case. Then, the operation of two technologies used in the studied PV plant (CdTe and a-Si panels) was simulated under the standard conditions and compared with the real characteristics. The simulation was also carried out in STC for both subfields of (CdTe N°3, and a-Si panels N°4) in the PV power station. The comparisons of the simulation results with the real data and characteristics of Oued Nechou station, as well as between the power, voltage and current of the sub-fields were carried out for each subfield on the other hand. On the other hand, the overall operation of the station was simulated and compared under STC conditions. It was found that the simulation model closely replicates the real PV station behavior. After proving the validity of the created model of the PV power station that can simulate its real behavior, the Oued Necho PV power plant has been simulated in four seasons during the year (2016), by integrating real temperature and illumination data into the Simulink model. Then a comparison between the powers obtained by the station for each season has been analyzed. Seasonal analysis revealed that the PV station performance under Saharan climatic conditions is more influenced by sunlight availability than temperature. The highest efficiency occurred in March due to favorable transitional weather closer to STC, while winter and autumn showed slight declines due to shorter daylight hours and clouds, which reduce the produced power and energy. To improve the desert PV power plant's performance, it is recommended to optimize the highest tilt to avoid sand, dust, and improve the air flow, avoid unstable sandy areas, and add cooling and cleaning systems.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis

I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting

Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

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

ETHICAL APPROVAL

The authors of this paper fully applied the rules of ethics during the experiments and the writing of the paper.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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