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# Seasonal Variation and the Performance of Photovoltaic Panels Under El-Kharga Oasis Conditions, Egypt

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## Abstract

Solar energy is a promising renewable resource in Egypt, yet its performance is highly influenced by environmental factors such as high temperatures and seasonal variations, particularly in regions like El-Kharga Oasis in the New Valley Governorate. The harsh environmental conditions of El-Kharga, including seasonal variations in temperature and sunlight intensity, can significantly impact the efficiency of photovoltaic modules. This highlights the need for localized studies to evaluate how seasonal changes affect PV performance. A comprehensive 12-month outdoor study was conducted to assess the seasonal performance of mono-crystalline and polycrystalline PV modules under the extreme warm conditions of El-Kharga Oasis. Key parameters such as open circuit voltage, short – circuit current, module temperature, and power output were monitored systematically. The performance ratio of both module types was calculated for each seasonal to evaluate the impact of seasonal changes. The performance of both mono-crystalline and polycrystalline modules showed noticeable seasonal variations. Performance ratios dropped by approximately 24%, respectively, in summer (June) compared to winter (January). Seasonal performance followed the order: winter > spring > autumn > summer. These findings indicate that the lower temperatures in winter enhance PV module efficiency, while the extreme heat in summer reduces performance. Poly crystalline modules, with their superior thermal stability, are more suitable for regions with extreme seasonal variations, particularly high summer temperatures.

**Keywords:** Photovoltaic system, Mono-crystalline, Polycrystalline, Seasonal variation

## 1.Introduction

Egypt's population growth is increasing water needs, necessitating increased food production. Agricultural policy and urbanization are boosting food production in the Western Desert and New Valley Governorate. Groundwater from the Nubian sandstone aquifer is the primary source of water (Jalal, 2020). Most commercial irrigation pumps are powered in part by electricity or fuel. Similarly, remote and rural communities have limited or no connection to the national grid, which could lead to a total dependence on groundwater for domestic use in farms with fossil fuel-powered pumping systems (Abd Allah and Tawfik, 2019). Diesel-powered pumps are commonly used for irrigation. However, the limited service life, high maintenance costs, the emissions of toxic gases during combustion, and the rising worldwide oil prices necessitate the search for alternatives. Renewable energy could lessen the need for fossil fuels as scientists investigate solar-powered water pumping equipment. Due to its abundance and accessibility almost everywhere, particularly in remote areas, solar energy is a good alternative to diesel-powered water pump systems (Padhy et al., 2020). The solar industry's rapid growth is leading to a surge in competition among various photovoltaic technologies for market share (Adouane, 2020). Monocrystalline, polycrystalline, and thin-film solar modules are three main types, each with varying efficiency and cost. Monocrystalline cells use high-purity silicon alloy, while polycrystalline modules use cheaper, less effective materials (Galal et al., 2023). Solar-powered PV panels are rated based on their DC power output under Standard Test Conditions (STC) which includes 1000 W/m2 of sunshine intensity, 25°C cell temperature, and 1.5 air mass and The Normal Operating Cell Temperature (NOCT) rating is an additional option. This is accomplished with the rear side of the solar panel exposed to the breeze, 800 W/m2 of sunlight irradiance, an average air temperature of 20ºC, and an average wind speed of 1 m/s. They function below their STC or NOCT ratings, with departure from these rated conditions influenced by geographical location and seasonal variation (Ogueke et al.,2012). Variations in temperature, sunlight, clouds, wind, and other environmental factors can all impact module performance. One of the most critical elements impacting PV module performance is solar cell temperature (Jakhrani et al., 2011). The intensity of the irradiance affects the energy produced by PV systems. The IV and PV Curves' properties are altered by sun irradiation. As the Isc and VOC rise, the output generated power rises sequentially (Arjyadhara et al., 2013). Shade effects in photovoltaic result from cloud movement or factors causing shade, causing an optimal decrease in solar radiation compared to normal conditions (Satpathy ,2017). Galal, 2024 reported that the wind benefits the PV arrays by adding forced and natural convection, which cools them. However, it also has a drawback in that it disperses dust in the air, which builds up on the PV panel's face when winds stop. Kazem et al. 2017 reported that an increase in output current, voltage, and power under low relative moisture. Polycrystalline, monocrystalline, and amorphous silicon solar cells were compared in a desert environment by Mosalam Shaltout et al. (2000). In such climates, they recommend using polycrystalline cells for photovoltaic applications. El-Karaga Oasis is one of the largest in the New Valley Governorate, with a hot desert climate (Meteoblue, 2024). The summer months, June-August, experience temperatures ranging from 38-42 degrees Celsius, while winter temperatures from December-February range from 18-22 degrees Celsius, with nighttime lows of 5 degrees Celsius (Qarts journal, 2023). According to climate statistics for El-Kharaga-Meteoblue, 2024, EL-Karaga experiences dry and arid conditions in summer due to low humidity levels, with annual rainfall rarely exceeding 1-2mm. When it comes to the strength of solar radiation, the New Valley province is regarded as one of the best in Egypt. In Egypt's southern desert, there are typically between nine and eleven hours of sunshine per year (Jalal, 2020). This indicates that there are more chances to invest in different solar energy applications. This study shows the measurements and data analysis of two solar modules with various technologies that were tested outdoors between October 2021 and October 2022. This study's primary goal is to evaluate how different types of photovoltaic systems—both monocrystalline and polycrystalline are affected by seasonal climate variation in El-Kharga Oasis, New Valley Governorate, Egypt's desert environment.

## 2. Materials and Methods

### 2.1 The study area

El Kharga, New Valley Governorate, Egypt, which is bounded by latitudes 25.05 and 25.30 N and longitudes 30.20 and 30.40 E, is where the study was carried out. Figure (1) depicts Egypt's solar radiation. Temperature, open circuit voltage (VOC), short circuit current (Isc), and power (P) were monitored once a week from 8 am to 5 pm for each module between February 10, 2021, and September 30, 2022. Rain, wind, cloud cover, relative humidity (RH), and the highest and lowest temperatures were all retrieved from the weather website (https://www.accuweather.com).

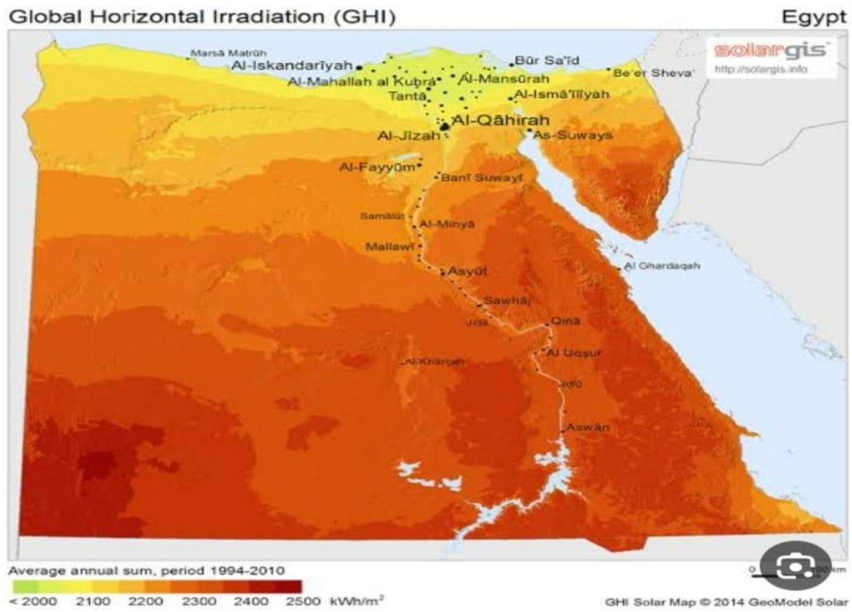


**Figure (1): Solar radiation map in Egypt**

**2.2 photovoltaic modules**

A system in El-Kharga Oasis was created using two photovoltaic modules: mono-crystalline (table 2 and Figure 3) and poly-crystalline (table 1 and Figure 2). Two modules were attached to a wooden frame such that they would remain at a 30° angle to the south, facing the sun. The front and rear heights of these modules are 1.0 and 1.35 meters, respectively, above the ground. A multimeter was used to measure the open circuit voltage (VOC), short circuit current (Isc) (Figure 4). A digital thermometer was used to measure the module's temperature (Figure 5). Power (P) was calculated by multiplying the open –circuit voltage (VOC) and the short-circuit current ($I_{SC}$) accordance with Amusan and Otokunefore (2019).

$P=V_{OC} * I_{SC}$ (1)

We tracked the seasonal changes in monocrystalline and polycrystalline modules' power, temperature, open circuit voltage, and short circuit current. The performance ratio (PR) is defined as the ratio of the power output produced (Pm) under actual operation conditions to the power output under the standard test condition (STC), calculated using the equation proposed by Hashim and Abbood (2016): PR = Pm at any condition / Pm at STC (2)

**Figure (2): The monocrystalline photovoltaic module is angled 30 degrees southward to face the sun.**

**Figure (3): The polycrystalline photovoltaic module is angled 30 degrees southward to face the sun**

**Figure (4): The digital millimeter is used to measure short circuit current ($I_{SC}$) and open circuit voltage (VOC)**

**Figure (5): Module temperature is measured using a thermometer**

**Table (1): Electrical and physical properties of poly-crystalline silicon modules**

| | |
|---|---|
| **Company** | Aproflex |
| **Model** | PRO (Proflex solar) |
| **Standard** | ICE 61215 |
| **Tracking No.** | PRPV-61215 |
| **Rated power** | 50 W |
| **Rated voltage** | 17.8 V |
| **Rated current** | 2.81A |
| **Open circuit voltage** | 22.1 V |
| **Short circuit current** | 2.98 A |
| **Photovoltaic module rated at** | 1000W/M |
| **Solar irradiance** | 1.5 AM |
| **Cell temperature** | $25^{℃}$ |
| **Maximum series fuse rating** | 10A |
| **Maximum system open circuit voltage** | 750VDC |
| **Cell type** | Polycrystalline |

**Table (2): Electrical and physical properties of mono-crystalline module**

| | |
|---|---|
| **Company** | Danyang RI Shang lighting technology |
| **Rated power** | 50 W |
| **Rated voltage** | 18 v |
| **Peak voltage** | 20 open |
| **Circuit voltage** | 20 v |
| **Peak voltage** | 18 v |
| **Production period** | 20181010 days |

## 3. Result and discussion

### 3.1 Seasonal variations and the performance of tested modules

Seasonal variations in meteorological conditions affect how well solar systems work. Ambient temperature as a function of incident solar radiation is one of the significant variables that changes with the four seasons (Vasisht et al., 2016). Measurements of the ambient temperature, module temperature, open circuit voltage, short circuit current, and generated power for mono- and poly-crystalline systems were made at 12 p.m. on sunny days between November 6, 2021, and October 14, 2022.

During the winter months of February and March 2022, when the temperature module (Tmod) was 35.2 ℃ and the ambient temperature (Tamb) was 21 ℃, the maximum short circuit current of mono-crystalline (mc-si) was 2.05 A. In July 2022 (summer), the mono-crystalline's lowest short circuit current was 1.7 A at Tmod of 47.4 ℃ and Tamb of 36 ℃ (Figure6). The winter month of January 2022 saw the greatest mono-crystalline open circuit voltage of 22.6 V at Tmod of 31.6 ℃ and Tamb of 18 ℃. In April 2022, a spring month, the mono-crystalline's lowest open circuit voltage was 20.3 W at Tmod of 46 ℃ and Tamb of 37 ℃ (Figure6). In March 2022, a winter month, the monocrystal line's maximum power was 46.125 W at a temperature module (Tmod) of 34.5 ℃ and an ambient temperature (Tamb) of 33 ℃. The summer month of June 2022 had the lowest monocrystalline power, at 35.87W at Tmod 52.4 ℃ and Tamb 41 ℃ (Figure6). In March 2022, a winter month, the poly-crystalline (pc-si) short circuit current reached its maximum of 3.13 A at Tmod of 35.5 ℃ and Tamb of 33 ℃. The summer month of July 2022 had the lowest poly-crystalline short circuit current (2.55 A) at Tmod of 48.2 ℃ and Tamb of 36 ℃ (Figure 7). In January 2022 (the winter month), the poly-crystalline's greatest open circuit voltage was 21.5 V at Tmod of 32.3 ℃ and Tamb of 18 ℃. In May 2022 (spring), the poly-crystalline's lowest open circuit voltage was 19.1V at Tmod 44.2 ℃ and Tamb 42 ℃ (Figure7). March 2022 (winter month) had the maximum poly-crystalline power at 66.982 W at temperature module (Tmod) of 35.5 ℃ and ambient temperature (Tamb) of 33 ℃, while July 2022 (summer month) had the lowest power at 51.53 W at Tmod of 48.2 ℃ and Tamb of 36 ℃ (Figure 7).

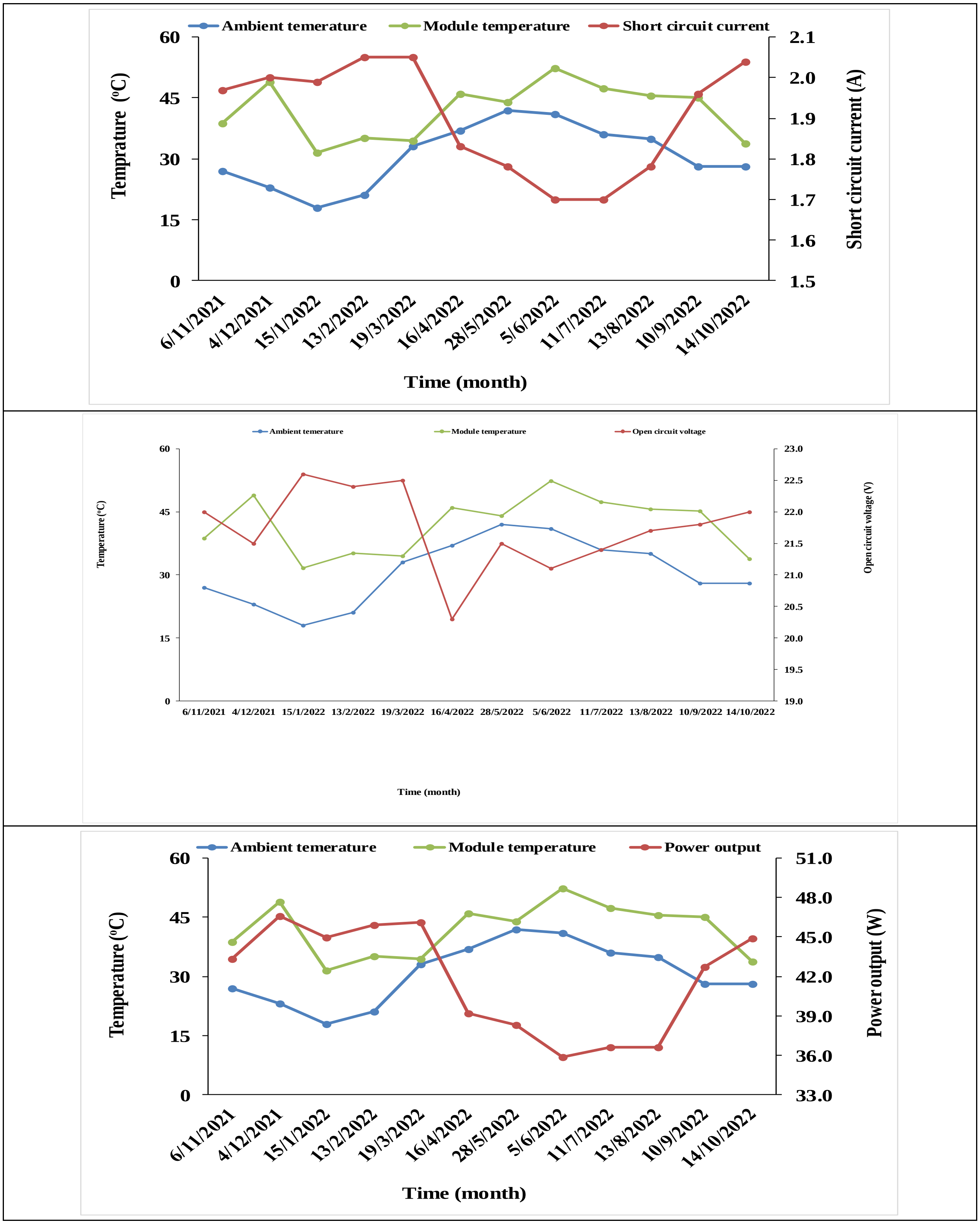


**Figure (6): Short circuit current, open circuit voltage and power output with seasonal variations for mono-crystalline-module**

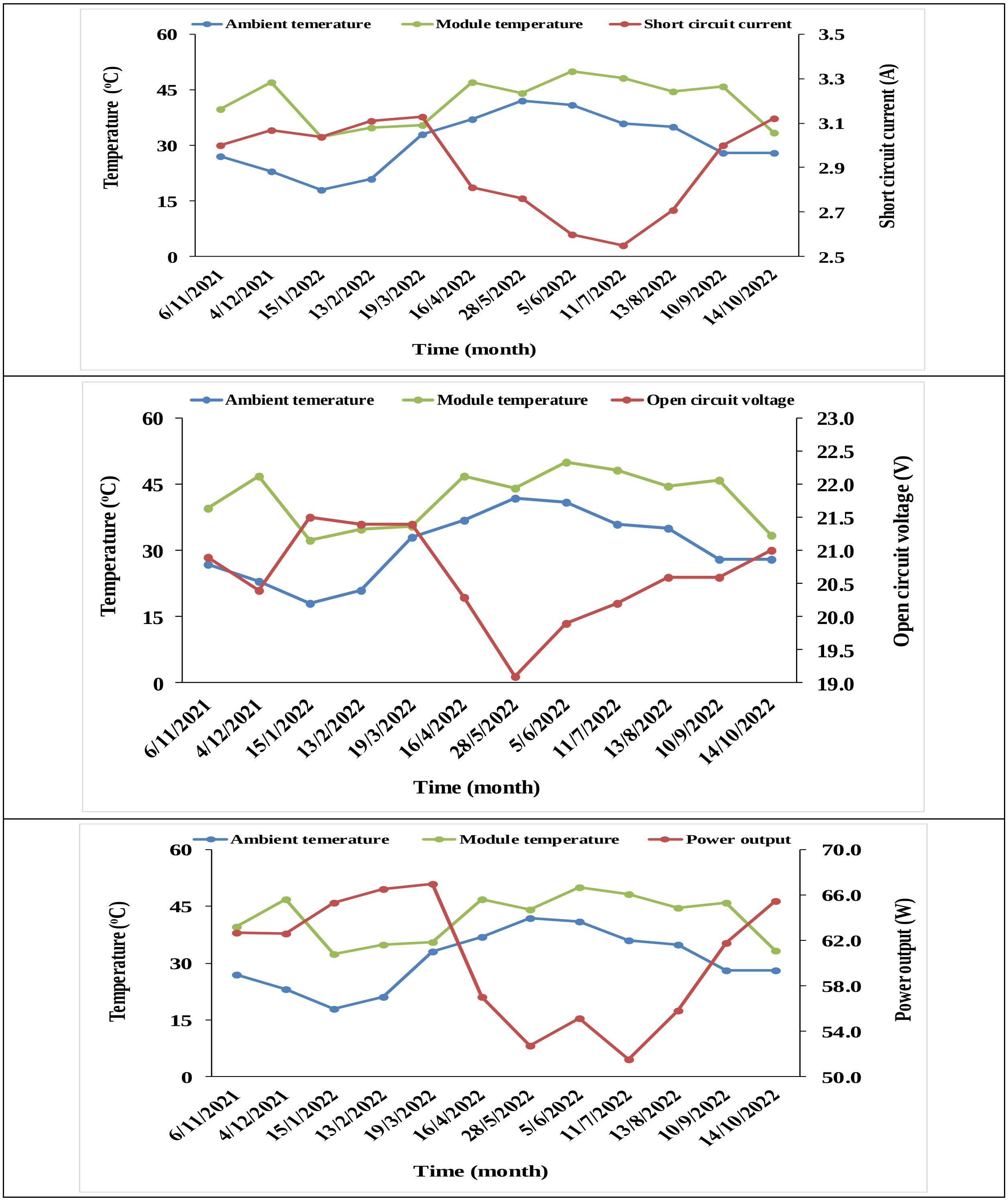


**Figure (7): Short circuit current, open circuit voltage and power output with seasonal variations for poly-crystalline module**

In order to facilitate comprehension, the one-year (test period) was separated into four distinct seasons: spring (20th March to 21st June), summer (22nd June to 22nd September), fall (23rd September to 20th December), and winter (21st December to 19th March). In summer season, the maximum and minimum module power for mono-crystalline were 42.73 and 1.90 W, respectively. 19.0 V was the lowest open circuit voltage while 22.1 V was the highest. According to Table 3, the largest and lowest short circuits current were 1.96 and 0.1 A, respectively. The temperature range of the temperature module (Tmod) was 29.9 to 57.4 °C. The maximum and minimum power for poly-crystalline were 61.63 and 2.9 W, respectively, the open circuit voltage was 21.8V at its greatest and 18.1V at its lowest. The maximum short circuit current was 3.0 A, while the lowest was 0.16 A (Table 3).

For winter season, the Tmod for monocrystalline varied between 52.9 and 17.1 °C. 49.64W was the highest power while 0.55W was the lowest. The open circuit voltage varied between 23.4 and 18.3 V. According to Table 5, the minimum and highest short circuit currents were 0.03 and 2.2 A, respectively. The lowest power for poly-crystalline was 0.41 W, while the greatest power was 68.45 W. 18 V was the lowest open circuit voltage while 22.8 V was the highest. According to Table 4, the maximum short circuit current was 3.85 A, while the lowest was 0.02 A.

In autumn season**, t**he lowest and maximum power for mono-crystalline were 0.0 W and 45.8 W, respectively. The open circuit voltage was 22.9 V at its maximum and 14.5 V at its lowest. According to Table 5, the maximum short circuit current was 2.18 A, while the lowest was 0.0 A. The lowest power for poly-crystalline was 0.0 W, while the maximum power was 66.86 W. 22.4 V was the highest open circuit voltage, and 14.1 V was the lowest. According to Table 5, the lowest short circuit current was 0.0 A, while the maximum was 3.07 A.

For Spring season, mono-crystalline, the maximum and minimum power were 47.216 and 0.0 W, respectively. The highest and lowest open circuit voltage were 23.0 and 18.5 V, respectively. The highest and lowest short circuit current was 2.09 to 0.11 A, respectively (Table 6). For poly-crystalline, the maximum and minimum power were 68.58 and 3.32W, respectively. The highest and lowest open circuit voltages were 22.0 and 18.0 V, respectively. The highest and lowest short circuits current was 3.31 and 0.17 A, respectively (Table 6).

**Table (3): Summer Season Performance Parameters**

| Variable | Mono-crystalline | | | | | | | Poly-crystalline | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std Error | Std Dev | Variance | Min | Median | Max | Mean | Std Error | Std Dev | Variance | Min | Median | Max |
| **Ambient Temperature (°C)** | 36.06 | 0.40 | 4.33 | 18.71 | 24.00 | 37.00 | 43.00 | 36.06 | 0.40 | 4.33 | 18.71 | 24.00 | 37.00 | 43.00 |
| **Wind Speed (m/s)** | 24.48 | 1.02 | 10.40 | 108.10 | 2.00 | 25.00 | 55.00 | 24.48 | 1.02 | 10.40 | 108.10 | 2.00 | 25.00 | 55.00 |
| **Relative Humidity (%)** | 22.61 | 0.79 | 8.44 | 71.21 | 8.00 | 21.00 | 44.00 | 22.61 | 0.79 | 8.44 | 71.21 | 8.00 | 21.00 | 44.00 |
| **Clouds (%)** | 4.19 | 1.30 | 13.92 | 193.79 | 0.00 | 0.00 | 67.00 | 4.19 | 1.30 | 13.92 | 193.79 | 0.00 | 0.00 | 67.00 |
| **Open Circuit Voltage (V)** | 20.12 | 0.06 | 0.64 | 0.44 | 19.00 | 20.05 | 22.10 | 20.12 | 0.06 | 0.64 | 0.44 | 18.10 | 20.00 | 21.80 |
| **Short Circuit Current (A)** | 1.88 | 0.08 | 0.90 | 0.74 | 0.10 | 1.93 | 1.96 | 1.88 | 0.08 | 0.90 | 0.74 | 0.16 | 2.08 | 3.00 |
| **Power (W)** | 37.54 | 1.60 | 17.77 | 316.05 | 1.90 | 38.71 | 42.73 | 37.54 | 1.60 | 17.77 | 316.05 | 2.90 | 42.12 | 61.63 |
| **Front Module Temperature (°C)** | 43.06 | 0.56 | 5.90 | 34.78 | 29.90 | 43.25 | 56.80 | 43.06 | 0.56 | 5.90 | 34.78 | 29.70 | 43.75 | 57.00 |
| **Back Module Temperature (°C)** | 43.82 | 0.58 | 6.02 | 36.21 | 29.90 | 44.05 | 57.40 | 43.82 | 0.58 | 6.02 | 36.21 | 29.90 | 44.70 | 57.40 |

**Table (4): Winter Season Performance Parameters**

| Variable | Mono-crystalline | | | | | | | Poly-crystalline | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std Error | Std Dev | Variance | Min | Median | Max | Mean | Std Error | Std Dev | Variance | Min | Median | Max |
| **Ambient Temperature (°C)** | 18.37 | 0.53 | 6.30 | 39.63 | 3.00 | 18.00 | 34.00 | 18.40 | 0.53 | 6.28 | 39.49 | 3.00 | 18.00 | 34.00 |
| **Wind Speed (m/s)** | 38.31 | 1.31 | 15.48 | 239.71 | 10.00 | 36.00 | 80.00 | 38.18 | 1.31 | 15.50 | 240.38 | 10.00 | 36.00 | 80.00 |
| **Relative Humidity (%)** | 20.71 | 1.02 | 11.93 | 142.28 | 0.00 | 18.00 | 54.00 | 20.92 | 1.03 | 12.14 | 147.46 | 0.00 | 18.00 | 54.00 |
| **Clouds (%)** | 20.88 | 2.41 | 28.37 | 804.64 | 0.00 | 1.00 | 100.00 | 21.09 | 2.40 | 28.37 | 804.91 | 0.00 | 1.00 | 100.00 |
| **Open Circuit Voltage (V)** | 22.27 | 0.07 | 0.85 | 0.72 | 18.30 | 22.50 | 23.40 | 21.39 | 0.07 | 0.81 | 0.65 | 18.00 | 21.60 | 22.80 |
| **Short Circuit Current (A)** | 1.30 | 0.05 | 0.61 | 0.38 | 0.03 | 1.50 | 2.20 | 1.92 | 0.08 | 0.94 | 0.88 | 0.02 | 2.08 | 3.85 |
| **Power (W)** | 28.87 | 1.16 | 13.63 | 185.78 | 0.55 | 33.60 | 49.64 | 40.98 | 1.69 | 20.03 | 401.09 | 0.41 | 44.81 | 68.45 |
| **Front Module Temperature (°C)** | 28.17 | 0.65 | 7.61 | 57.84 | 16.40 | 27.20 | 51.50 | 27.81 | 0.66 | 7.80 | 60.87 | 3.15 | 26.85 | 50.00 |
| **Back Module Temperature (°C)** | 29.06 | 0.67 | 7.86 | 61.70 | 17.10 | 28.10 | 52.90 | 28.83 | 0.66 | 7.85 | 61.62 | 16.40 | 27.85 | 52.40 |

**Table (5): Autumn Season Performance Parameters**

| Variable | Mono-crystalline | | | | | | | Poly-crystalline | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std Error | Std Dev | Variance | Min | Median | Max | Mean | Std Error | Std Dev | Variance | Min | Median | Max |
| Ambient Temperature (°C) | 26.07 | 0.59 | 6.79 | 46.11 | 5.00 | 27.00 | 40.00 | 26.07 | 0.59 | 6.79 | 46.11 | 5.00 | 27.00 | 40.00 |
| Wind Speed (m/s) | 34.84 | 1.26 | 14.64 | 214.41 | 10.00 | 31.50 | 81.00 | 34.84 | 1.26 | 14.64 | 214.41 | 10.00 | 31.50 | 81.00 |
| Relative Humidity (%) | 15.88 | 0.54 | 6.26 | 39.14 | 0.00 | 16.00 | 30.00 | 15.88 | 0.54 | 6.26 | 39.14 | 0.00 | 16.00 | 30.00 |
| Clouds (%) | 48.53 | 6.09 | 33.33 | 111.43 | 0.00 | 54.00 | 100.00 | 48.53 | 6.09 | 33.34 | 111.43 | 0.00 | 54.00 | 100.00 |
| Open Circuit Voltage (V) | 21.43 | 0.13 | 1.48 | 2.18 | 14.50 | 21.90 | 22.90 | 20.60 | 0.11 | 1.28 | 1.63 | 14.10 | 20.90 | 22.40 |
| Short Circuit Current (A) | 1.20 | 0.06 | 0.65 | 0.40 | 0.00 | 1.26 | 2.18 | 1.79 | 0.08 | 0.95 | 0.91 | 0.00 | 1.85 | 3.07 |
| Power (W) | 26.23 | 1.21 | 13.95 | 194.60 | 0.00 | 27.48 | 45.80 | 37.72 | 1.72 | 19.86 | 394.61 | 0.00 | 39.41 | 66.86 |
| Front Module Temperature (°C) | 33.17 | 0.86 | 7.17 | 51.41 | 17.30 | 33.25 | 48.40 | 33.12 | 0.24 | 7.01 | 49.11 | 17.20 | 32.80 | 47.20 |
| Back Module Temperature (°C) | 33.78 | 0.97 | 7.55 | 56.97 | 17.30 | 33.45 | 51.00 | 33.68 | 0.80 | 7.40 | 54.71 | 17.30 | 33.30 | 49.80 |

**Table (6): Spring Season Performance Parameters**

| Variable | Mono-crystalline | | | | | | | Poly-crystalline | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std Error | Std Dev | Variance | Min | Median | Max | Mean | Std Error | Std Dev | Variance | Min | Median | Max |
| Ambient Temperature (°C) | 33.42 | 0.63 | 7.21 | 52.00 | 13.00 | 34.00 | 47.00 | 33.42 | 0.63 | 7.21 | 52.00 | 13.00 | 34.00 | 47.00 |
| Wind Speed (m/s) | 27.49 | 1.04 | 11.81 | 139.37 | 5.00 | 26.00 | 56.00 | 27.49 | 1.04 | 11.81 | 139.37 | 5.00 | 26.00 | 56.00 |
| Relative Humidity (%) | 16.39 | 0.79 | 8.96 | 80.32 | 4.00 | 14.00 | 50.00 | 16.39 | 0.79 | 8.96 | 80.32 | 4.00 | 14.00 | 50.00 |
| Clouds (%) | 16.75 | 2.22 | 25.36 | 643.23 | 0.00 | 0.00 | 92.00 | 16.75 | 2.22 | 25.36 | 643.23 | 0.00 | 0.00 | 92.00 |
| Open Circuit Voltage (V) | 21.42 | 0.07 | 0.77 | 0.59 | 18.50 | 21.50 | 23.00 | 20.34 | 0.06 | 0.70 | 0.49 | 18.00 | 20.40 | 22.00 |
| Short Circuit Current (A) | 1.19 | 0.05 | 0.57 | 0.32 | 0.11 | 1.33 | 2.09 | 1.81 | 0.08 | 0.87 | 0.72 | 0.17 | 2.02 | 3.31 |
| Power (W) | 25.67 | 1.25 | 12.67 | 160.63 | 0.00 | 28.33 | 47.22 | 37.92 | 1.52 | 17.35 | 301.04 | 3.32 | 41.51 | 68.58 |
| Front Module Temperature (°C) | 40.39 | 0.65 | 7.32 | 53.62 | 18.20 | 40.90 | 55.00 | 40.22 | 0.66 | 7.47 | 55.72 | 15.50 | 40.55 | 56.10 |
| Back Module Temperature (°C) | 41.36 | 0.67 | 7.58 | 57.38 | 18.80 | 42.30 | 57.10 | 41.15 | 0.67 | 7.60 | 57.79 | 18.60 | 41.95 | 56.70 |

The performance of both modules might be organized in the following descending order based on the measured parameters: winter > spring > fall > summer. According to Nelson (2003), the solar cell's reverse saturation current will rise in tandem with its temperature, resulting in a considerable decrease in the open circuit voltage. Additionally, the PV material's band gap narrows, which causes the photovoltaic produced current to slightly rise. As the operating temperature of PV modules rises, electrical efficiency falls (Hashim and Abbood, 2016).

### 3.2 Comparing of the Monthly performance ratio of monocrystalline and polycrystalline modules

The performance of monocrystalline and polycrystalline modules was monitored across for seasons: winter, spring, summer and autumn. Results showed that the power output of both modules decreased significantly in summer due to higher module temperatures. The performance ratio (PR) in Figure 8 illustrates In June, the monocrystalline silicon performance ratio dropped by nearly 24% from January. The polycrystalline silicon performance ratio only slightly decreased to about 15% in June. This indicates that polycrystalline modules are more thermally stable under extreme summer conditions. According to Hashim and Abbood (2016), monocrystalline modules lost more than 15% of their performance in May, but they are expected to recover more than 20% in June or July.

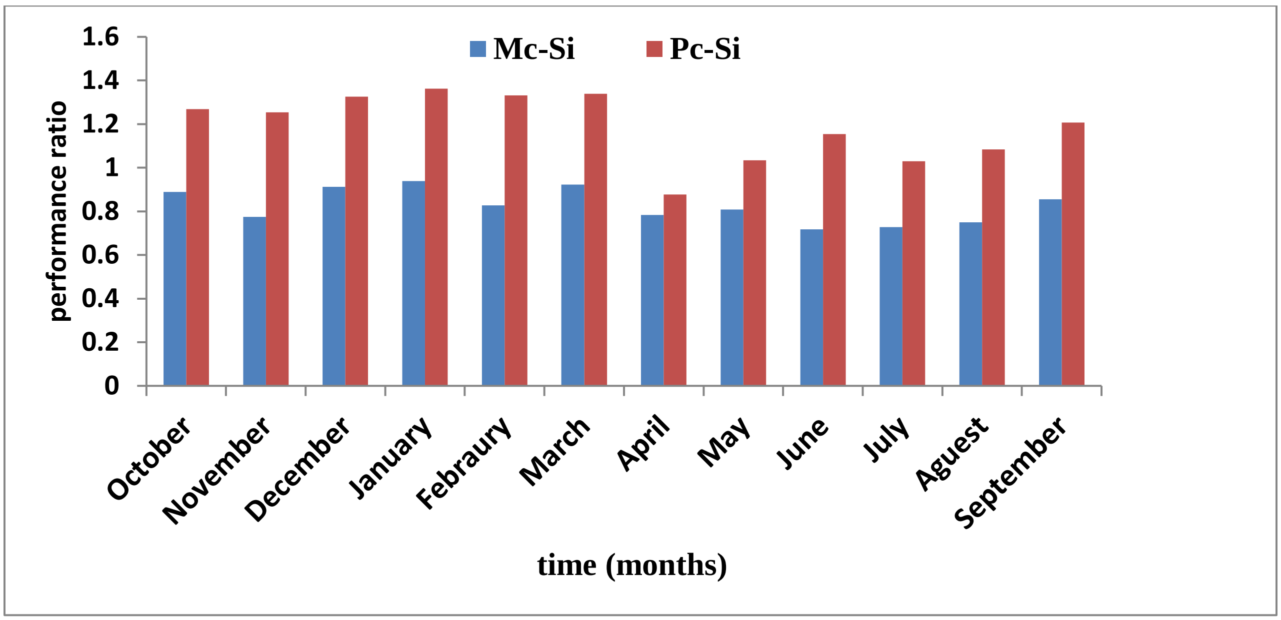


**Figure (8): Monthly performance ratio of both tested modules**

## Conclusion

The research carried out in the El-Kharga oasis emphasizes the considerable influence of seasonal changes on the efficiency of mono-crystalline and poly-crystalline solar panels. The energy output of the system is significantly influenced by module temperature (Tmod), which exhibits inverse relationship with power generation. In contrast to the fall and summer, the power values for mono- and polycrystalline materials were higher in the winter and spring. Summertime has the lowest shot-circuit current and wintertime has the highest short-circuit current for mono- and polycrystalline. In the summer, mono- and poly-crystalline open circuit voltages at their lowest, while in the winter, they were at their greatest. The findings indicated that polycrystalline modules exhibit better thermal stability and higher overall performance compared to monocrystalline modules in desert environments. These findings underline the importance of considering seasonal climatic conditions when evaluating solar module performance in regions like EL-Kharga oasis.

### Reference

Abd Allah, W. E., & Tawfik, M. A. (2019). Design and operating assessment of solar PV underground water pumping system in Upper Egypt. *Miser Journal of Agricultural Engineering, 36*(2), 565-586.

Adouane, M., Al-Qattan, A., Alabdulrazzaq, B., & Fakhraldeen, A. (2020). Comparative performance evaluation of different photovoltaic modules technologies under Kuwait harsh climatic conditions. *Energy Reports, 6*, 2689-2696.

Amusan, J., & Otokunefor, E. (2019). The effect of cloud on the output performance of a solar module. *International Journal of Engineering Science, 9*(2), 19665-19671.

Arjyadhara, P., Ali, S., & Chitralekha, J. (2013). Analysis of solar PV cell performance with changing irradiance and temperature. *International Journal of Engineering and Computer Science, 2*(1), 214-220.

Galal, E. M., Abed-Mawgoud, A. S., Hamed, M. H., & Ali, G. A. M. (2023). The performance of polycrystalline and monocrystalline solar modules under the climate conditions of El-Kharga oasis, New Valley governorate, Egypt. *International Journal of Thin Films Science and Technology, 12*(3), 207-215.

Galal, E. M. (2024). *Effect of some climate factors on groundwater pumping using solar energy technique under New Valley conditions, Egypt* [Doctoral dissertation, New Valley University]. Department of Soils and Water, Faculty of Agriculture.

Hashim, E. T., & Abbood, A. A. (2016). Temperature effect on power drops of different photovoltaic modules. *Journal of Engineering, 22*(5), 129-143.

Healing Waters. (2021). *What are solar pumps & how they work*. Healing Waters Media. https://healingwaters.org/what-are-solar-pumps-how-they-work/

Jakhrani, A. Q., Othman, A. K., Rigit, A. R., & Sam, S. R. (2011). Determination and comparison of different photovoltaic module temperature models for Kuching, Sarawak. In *IEEE Conference on Clean Energy and Technology (CET)* (pp. 1-5). IEEE.

Jalal, E. M. (2020). *Factors affecting the irrigation water efficiency from well using solar energy in the New Valley governorate* [Master's thesis, Assiut University]. Department of Soils and Water, Faculty of Agriculture.

Kazem, H. A., Chaichan, M. T., Al-Waeli, A. H. A., & Mani, K. (2017). Mediterranean green buildings & renewable energy. In *Proceedings of the Mediterranean Green Buildings & Renewable Energy Forum* (pp. 379-385). Springer.

Meteoblue. (2024). *Climate data for Al-Kharga*. https://www.meteoblue.com/en/weather/historyclimate/climateobserved/al-kharaga_egypt_352628

Mosalam Shaltout, M. A., El-Hadad, A. A., Fadly, M. A., Hassan, A. F., & Mahrous, A. M. (2000). Determination of suitable types of solar cells for optimal outdoor performance in desert climate. *Renewable Energy, 19*(1-2), 71-74.

Nelson, J. (2003). *The physics of solar cells: Properties of semiconductor materials*. Imperial College Press.

Ogueke, N. V., Abam, F., Nwaigwe, K. N., Okoronkwo, C. A., & Ugwouke, E. (2013). The effect of seasonal variation and angle of inclination on the performance of photovoltaic panels in southeastern Nigeria. *Research Journal of Applied Sciences, Engineering and Technology, 5*(3), 794-800.

Padhy, A., Vishal, B., Verma, P., Dwivedi, G., & Behura, A. K. (2020). Fabrication of parabolic trough hybrid solar PV-T collector using a-Si thin film solar cells in Indian perspective. *Materials Today: Proceedings, 38*, 56-62.

Qarts Journal. (2023). *Air and soil temperatures in Al-Kharga: A study in applied climatology*. https://qartsjournal.com/air-and-soil-temperatures-in-al-kharaga

Satpathy, P. R., Jena, S., Jena, B., & Sharma, R. (2017). Comparative study of interconnection schemes of modules in solar PV array network. In *2017 International Conference on Circuit, Power and Computing Technologies (ICCPCT)* (pp. 1-6). IEEE.

Vasisht, M. S., Srinivasan, J., & Ramasesha, K. (2016). Performance of solar photovoltaic installations: Effect of seasonal variation. *Solar Energy, 131*, 39-46.