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Effects of Weather and Environmental Conditions on the Power Productivity of Photovoltaic Module in Kirkuk City

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ABSTRACT

From the beginning of March to the end of August 2022, research is conducted to determine how sensitive monocrystalline solar modules are to variations in environmental factors such as dust and high temperature buildup as well as cloud cover in Kirkuk's environment. In order to evaluate how different environmental factors, affect a solar photovoltaic (PV) module, an experiment was conducted using three solar modules that were identical in all respects. The modules are cleaned on a regular basis in the morning in order to monitor the effect that the accumulation of dust will have on the surface of the dirty module during the months of April and May. According to the findings, the collection of dust has a significant impact on the daily energy yield of the module that has not been cleaned. On the other hand, this impact lasts for a very long time. The influence on the cloud cover can be seen very immediately. Because of this constraint, solar photovoltaics (PV) panel are an unstable source of power for remote devices, which strongly emphasizes the difficulties associated with frequently cleaning the surface of the module.

1. Introduction

The increased energy consumption that accompanied the industrial revolution gave rise to concerns about the environment and the sources of energy, which ultimately resulted in an increase in the average temperature of the earth and a reduction in the utilization of fossil fuels. It is generally accepted that fossil fuels make up more than 80 percent of the world's total energy consumption and serve as the dominant source of energy worldwide [1]. The excessive consumption of various types of non-renewable resources may contribute to the acceleration of global warming as a result of the large emissions. Scholars and engineers have been inspired to search for alternative environmentally acceptable resources as a result of the challenges associated with fossil fuels and the major environmental concerns [1-3]. As a result, the researchers have been looking into ways to use solar power, which is a form of renewable energy, to mitigate the effects of those problems. In the year 1839, Edmond Becquerel made the discovery that led to the development of the photovoltaic (PV) system. Because PV panel do not produce any pollutants, they are considered to be a kind of sustainable energy [10-12]. As a result of the factors that were discussed earlier, solar panels are currently utilized in the majority of countries throughout the world as a primary source for the generation of electrical energy. The installation of solar panels does not have any adverse effects on the surrounding environment, such as an increase in carbon dioxide emissions or global warming. In addition, solar panels derive their power from the sun, which is an endless supply of usable energy. [4-5]. Although there is a direct correlation between the amount of energy produced and the intensity of the radiation, there is also a correlation between the angle of irradiance deflection and the amount of intensity of the sun's radiation. Therefore, the output power ratio of the PV module is dependent on the angle of irradiance as well as the intensity of the irradiance. The optimal and most productive angle is a normal angle, which indicates that the PV panel is exposed to sunlight in a way that is typical.

Even though the solar modules have a low efficiency, the environmental circumstances may further diminish their output and efficiency, which will throw the system into an unstable state.

Numerous research projects have been carried out in various parts of the world to investigate the impact that dust has on the performance of solar systems [4–6]. However, these investigations were conducted in a particular location. In point of fact, [11] found that there was a greater degradation on PV performance.

In addition, [9] demonstrated that the output power was decreasing at a rate of 17.4% every month. In addition, research into the influence that cloud shadows have on distributed solar power has also been conducted in the state of Massachusetts [10]. Observations and analysis of the solar irradiation and the operation of photovoltaics demonstrated that there were inadequate step variations in load levels to generate difficulties with voltage flickering. Also explored was the cloud cover's effect on the amount of photovoltaic energy produced in South Africa [8]. However, over the area of the study, no such work has been done for at least one month to investigate the effects of dust and even cloud cover on the efficiency of the PV module.

This work is an attempt to research the impacts of dust deposition (during the months of March and August) and cloud cover on a monocrystalline solar module from March to the end of August 2022 in Kirkuk city in Iraq. The location of this study is Iraq. As a result, conducting an analysis of the effects of these elements is of the utmost significance in order to ensure accurate planning of the utilization of solar photovoltaic energy.

2. Photovoltaic Theory

2.1 Solar irradiance

Solar radiation is the most important factor to consider when trying to achieve the desired output power ratio from the PV module. There are two components that make up the irradiance: the initial is the straight ray that travels to the Panel surface, and the second is the reflected irradiance that travels in the opposite direction after being returned from the PV panel surface. It is important to note that the irradiation is not sufficient to provide photovoltaic cells with the energy they need to generate electricity

[8]. The direct irradiance that was received by the PV surface can be calculated using Equation 1.

$$I_D = I_{DN} \cos\theta \ldots\ldots..(1)$$

Noted: I_D is represented the straight irradiance, θ is the direct angle, and I_{DN} is direct irradiance.

Photovoltaic, more commonly abbreviated to PV panel for short, are responsible for the direct transformation of solar power into electricity.

The phrase "photovoltaic effect" generally refers to the formation of a potential difference at the junction of two different substances in exposure to visible or other electromagnetic radiation. This potential difference can be used to generate electrical current.

Photovoltaics is the umbrella term for the field of research that investigates the process of converting solar energy into electrical energy.

3.Materials and Hypothesis

3.1 The Methodology

The test is performed using a three-360 w solar panel installed on a metal stand. The electric parameters like voltage & current were measured to examine the impact of environmental numerous impacts. The impact of fog, dust, dirt, and direct solar at the energy discount turned into evaluated & analyzed. The impact of dust or dirt may be quantified through evaluating the performance of panel uncovered to dirt & without dust or kind or dirt. In this work, the measurements are including a silicon panel of vicinity 2 m^2, MTS inverter turned into used for size of producing the the voltage, current, and the temperature and something associated with the solar panel. The experimental examine turned into carried out in the Kirkuk city. The ambient temperature fluctuates between 15 to 50 ºC during the measurements. The sun photovoltaic panel turned into examined and the parameters the power and ambient temperature, etc., wished for the assessment of the structures have been measured at interval of 10 hours between 8 AM and 6 PM. The ambient temperature and the incident solar radiation depth turned into measured the use of the inverter.

3.2 Experimental Setup

In this part of the research, an integrated solar energy system was established with a capacity of 1 kilowatts, 3 solar Panels and 2 batteries of 200 amp/hour 360 watts (all information is in Table 1) A smart MTS invertor was used to take measurements and data.

Table 1. Specifications of the PV module

Parameter	Value
Model	Tata BP 184459
Average power	360 W
Open circuit voltage	12V
Short circuit current	2A
Number of cells	60
Dimensions	2*1*0.1 m^3
Weight	25 kg

Figure 1: Solar panel (360 W) of each panel

Figure 2: Full Solar system showing the invertor device and the batteries

Figure 1 represents the practical part and its details that were already explained. It is noted that the solar panels are divided, and this is what can be made good to collect the most possible energy, and even if there is shadow or dust on part of the panels and the cells, the rest of the panel will not be affected as a result of the panel division into two parts, meaning that the first part does not affect the second part and vice versa. The readings were taken as shown in Figure 1, where a laptop was used, and a program was installed to take the readings directly from the inverter that was connected between the batteries and the solar panels.

4.Results

Power results were obtained from data collected during six consecutive months. These results are the Power that was obtained during six months, starting from the month of March until the end of the month of August, and data were collected for all days of the months.

It is worth noting that the data for the days were collected for ten hours per day, starting from eight in the morning until six in the evening. As for the data below, the highest value was taken in one day.

Through the figures below, it can be noted that the graphs of all shapes are not regular, for example, the month of March, the graph starts with a few values and then increases or decreases until the last day and that the value of the Power (the Y axis) increases or decreases according to the days and this is all the result of weather conditions For those days, rainy and cloudy days were recorded, in addition to dusty days in the months of March, April and May. There are even days when work was disrupted as a result of dust or dust storms. From this, we can see the main reason behind the instability of the Power curves in the first three figures, which refer to the month of March, April, and May.

As for the curves in the last two figures, which represent the month of June through August, the curves seem almost stable and oscillate around almost constant Power values, and the reason behind this is the similarity of weather conditions in these two months and the absence of exceptional weather conditions, for example, dust in these two months, except that the temperature rose Significantly in July and August. The data shows the average amount of power obtained during each day of the month. The figures (3-9) shows the average power of the day in each month.

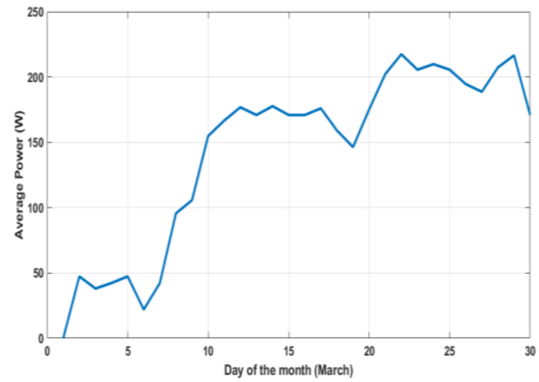

Figure 3: The power of March 2022

Through the figure 3, as can be seen in the figure, the first few days of the month experienced heavy downpours, resulting in a lower-than-desired amount of energy being collected.

The weather has grown somewhat clearer, and it is also evident that the energy gathered in the latter days of the month has increased as a result.

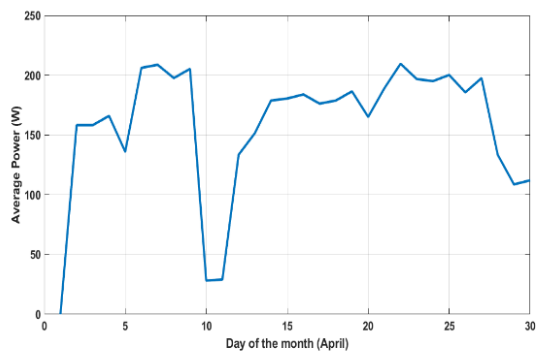

Figure 4: The power of April 2022

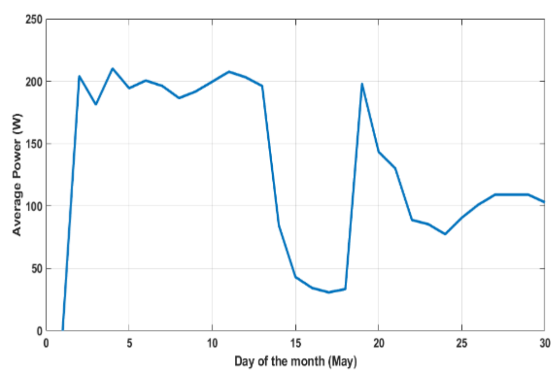

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Figure 5: The power of May 2022

In Figure 4, the same thing occurred throughout the month of March. However, the weather in April is significantly different, particularly in the days that follow the fifth day of the month. This is due to the fact that the city of Kirkuk had been exposed to highly dusty days. This month was also plagued by a significant amount of dust, and there were very few cloudy or rainy days

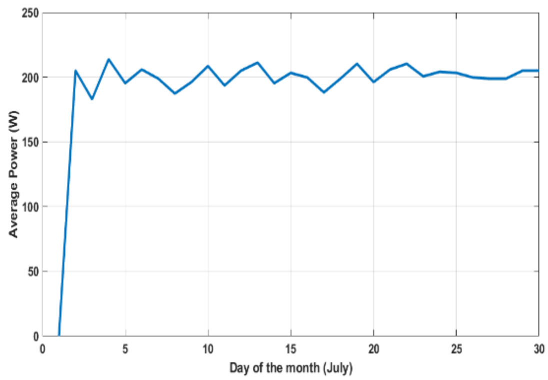

Figure 6: The power of June 2022

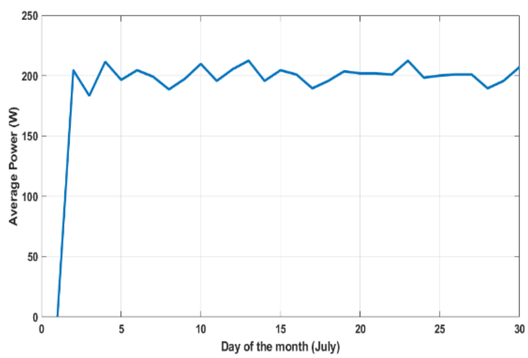

Figure 7: The power of July 2022

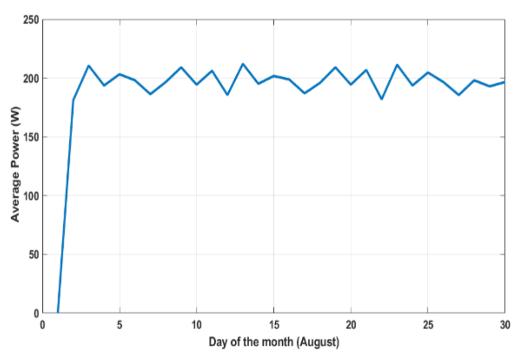

Figure 8: The power of August 2022

In figure 5, the dusty days were in the days between 13 to 17 of the month of May that can be seen from the figure, where the power in this span was very low.

Figure 6-8 which represents the month of June through August respectively where once can be seen that the aduring the days.

In figure 9, we are comparing the six plots in one to give more intention about our results. From the figure, one can see that there are lots of variation in the values that is because of the weather conditions difference during the months changing from the rainy to cloudy to sunny and we have many dusty days during the selected months. From this figure, which is the final form of comparison between the energy obtained during the months of testing, it turns out that the energy obtained from solar cells is greatly affected by the environmental, atmospheric, and physical conditions to which the solar systems are exposed. On the contrary, the clear atmosphere can produce very high energy that reaches the energy of the inverter used in the solar system.

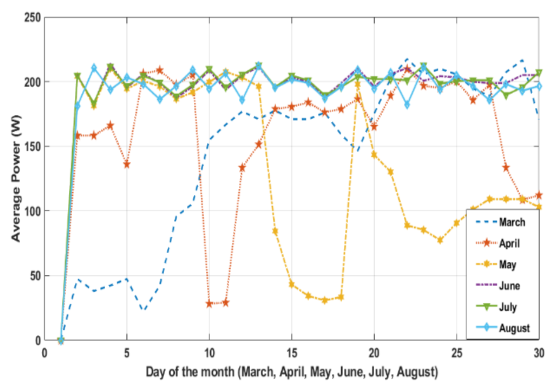

Figure 9: Comparison among the powers in 6 months

In the figure below, the reader or researcher will be able to see the data that was taken directly from the sun, which represents the energy obtained and according to the months mentioned previously.

In the end, it is necessary to know the average energy obtained during the month, which is as mentioned in the Table 2:

Table 2. Average data of each month

March	April	May	June	July	August
143.6	157.5	130.3	194.34	194	191.03

Figure 10 represents the average power of each month over 30 days.

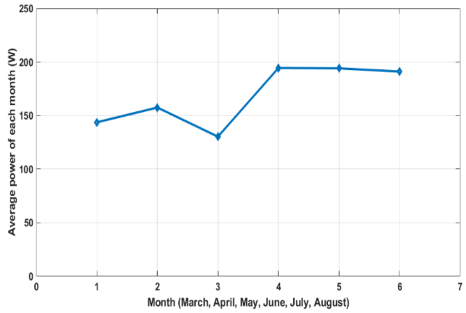

Figure 10: Average power of each month

5.Conclusions

A practical investigation was accomplished to test the performance of a solar energy system with a capacity of 1 kilowatt, which is equivalent to three solar panels and one inverter, in addition to two batteries, each with a capacity of 200 amps. Data were collected for 6 consecutive months, starting from the month of March until the end of the month of August. The data was collected by a program specialized in collecting information on solar systems, and after completing the data collection process, the data was analyzed according to months.

Through the results, it was found that solar systems are directly affected by dust and dirt and have an adverse effect on the system's performance in collecting energy from the sun and thus converting solar energy into electricity. In addition to dust and dust, clouds also have a direct impact on performance, and this is what appears on some cloudy days in March and April. As for dust, the effect can be observed at the end of April as well as at the beginning of May.

Through the foregoing information, it is recommended to clean the solar cells and make them bright, because this will increase the performance and efficiency of the cell and thus increase the electrical energy.

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