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Performance Evaluation of Monocrystalline Solar PV Panel for ICT Office, Federal University Wukari

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Abstract:
The basic operation of the monocrystalline photovoltaic panel was conducted on daily bases for one week. The open circuit voltage (V_oc), short circuit current (I_sc), maximum voltage (V_m), and current (I_m) were measured and power and efficiency were computed. The monocrystalline solar module efficiency computed was 11.34% lower than the theoretical efficiency value with 7.66%. The open circuit voltage in the early hours was higher this indicates a better solar cell which depends on the technology and climate conditions. The variation of daily average time with maximum voltage and current as shown from the data obtained, that as the intensity of sunlight increased, the was a corresponding increase in the measured parameters. The maximum voltage and current obtained were 30.50 (V_m) and 5.70 (I_m) at 14pm the power computed was 173.85 W. The total amount of power obtained on 20 PV panels during daylight hours was 38.4 kw and the power utilized in ICT was 110 W. The result shows that monocrystalline photovoltaic panel impact positively, the Federal University Wukari ICT and its environmental energy mix and promote non-polluted energy source. With this, small and medium-scale companies and even individuals could be offered a simple, cheaper, and cleaner energy choice over which they have more control.

Keywords: Monocrystalline, Photovoltaic solar panel, Series connection, and solar module

INTRODUCTION

The need for energy played the most significant role for developing and developed countries. Energy takes various forms and diverse ways of harnessing it and consumption, every city, organization, and nation requires a simple eco-friendly source of energy [1]. The fossil fuel source will be exhausted after a certain period and the extraction process is complex and expensive. Because of these, it has become imperative to decide which energy source to investigate and to consider the simplicity of obtaining high efficiency. In addition, non-renewable sources of energy to a considerable extent played a key role in the increased environmental challenges negatively [2]. Therefore, working toward a renewable energy foundation that exceptionally low economical factor that is beneficial in every area is important.

The entire renewable energy bases on earth start up from the impact of solar radiation which can be without delay transformed to energy via using distinctive technologies. Even though it is maximum-price renewable energy technology, photovoltaic technology is the simple, easiest, and fast-growing area of renewable source [1].

Photovoltaic (PVs) constitute a key technological option to implement, the shift toward a decarbonized energy supply. Solar resources in Africa and most parts of the world are abundant and cannot be monopolized. Furthermore, as technology advances and production volumes increase dramatically every year, market prices for PVs will further decrease, following the trend of the past years. Yearly growth rates over the last decade were on average more than 40% making PVs one of the fastest-growing industries at present [3]. Business analysts predict the market volume reached N40 billion in 2010 and anticipate decreasing prices for consumers [3]. With relevant technology advancing, the scope of available PV modules is constantly expanding. There are two broad technological categories when it comes to commercially available PV cells: crystalline silicon and thin film [4]. These two covers all available solutions currently in the PV market.

The advent of PV modules makes it conceivable to adventure into this valuable resource and convert it to electricity and these modules make use of sun energy to generate electrical energy. Throughout the past decade, photovoltaic modules have been making tremendous progress in technical and economic areas. Consequently, this technology is one of the most surd after and the mounting capacity of diverse types of photovoltaic modules has been expanding in every sector. There are varied factors that impact the operations and performance of photovoltaic modules ranging from component type to operating conditions [5]. Many factors determine the performance of photovoltaic modules, and it can be grouped into two atmospheric and photovoltaic module arrangement parameters. Atmospheric parameters are the ambient temperature, the intensity of sunlight, the rate of wind, and moisture in the air however, the photovoltaic system arrangement parameters include photovoltaic arrangement parameters are inverter, interconnections, and controller [6]. [7], observed that the effect of dust scattering on the surface of the photovoltaic panel significantly lowers the output voltage performance than the PV panel with less dust or the neat panel in the same arrangement. [8], they also observed that heat transfer mode affects the photovoltaic system's general output. [9], equally reported that the angle of tilt or angle of inclination affects PV performance.

The solar radiation in the Federal University Wukari is approximately 892W/m^2 and on the coordinate of latitude and longitude 7.87723 and 9.779 respectively and at the temperature of 36°C as in June which is rainy season.

The performance of a PV system is determined by the performance and failure of the individual components. Though, the performance of a photovoltaic module is affected by the strength and duration of sunlight [6].

The monocrystalline solar cells used in this work were bought from RUBITEC solar company limited in Lagos, Nigeria.

The monocrystalline photovoltaic cell comprises P-type and N-type semiconductor materials with different electrical properties combined. Each cell is composed of two layers of silicon. The joint between these two semiconductors is known as P-N junction. Photons in the sunlight hitting on the solar cell's front side are absorbed by semiconducting materials due to which electron-hole pairs are produced, after the solar cell is linked to a load electrons and holes close to the junctions moved away from each other [10]. [11] They added that the hole is collected at the positive terminal and electrons at the negative terminal. The difference between the electric potentials at the terminals causes the voltage across the terminals. The generated voltage at the terminals of the silicon solar cell is used to drive the current in the circuit.

Table 1: Some properties of monocrystalline solar panels compared with polycrystalline panel solar [13]

S/n	Parameters	Monocrystalline	Polycrystalline
1	Space	Less space to reach requires capacity	More space to reach the required capacity
2	Efficiency	About 16-21% depending on the weather condition	About 14-17 also depends on the weather condition
3.	performance	Perform better even in low sunlight	Deficient performance with low sunlight
4.	Temperature coefficient	High heat resistance	Low heat resistance
5.	Cost	expensive	Less expensive
6.	Appearance	Black color panel	Bluish color panel

This is because of its production technology. The disadvantages of this type of solar panel if set to form a solar panel will leave some empty spaces. A solar cell of this nature is round in structure [12]. One of the major challenges with the use of monocrystalline solar panel modules that have been widely used in various organizations today is the performance index, with respect to its daily variation of time in hourly efficiency. The type of photovoltaic solar panel and the intensity of solar radiation varies with time because of these, the analysis performance of solar PV systems for the information and communication technology office, Federal University Wukari becomes necessary so that it can serve as enlightenment and promotion on the use of the solar photovoltaic system within the university community and the public, also to promote the campaign for green energy sources within the university community.

MATERIALS AND METHODS

The figure below shows the monocrystalline solar panel used for the study. The system consists of 6-volt batteries and 12-volt battery connections, the monocrystalline silicon solar panels were placed between angel 39^o to 43^o(degrees) southward. the total number of photovoltaic panel and batteries used was 20 and 10, respectively. The dimension of the solar panel was 1580 mm x 808 mm x 40 mm, and the area of the solar panels was 1.380 mm x 0.808 m. The RUBITEC solar panel was mounted on each of the poles facing south at an optimum angle of tilt. The solar panels related to 6 mm diameter wire and about 10 m length to a solar charger controller of the rated voltage of direct current (DC) of 12V/24 attached to each pole by the side. The solar modules were connected in series to obtain maximum voltage. The charge controller displays the solar ampere, load ampere, battery volt, and discharge voltage. The charge controller was connected to a 12V, 100AHr battery. The batteries were connected through the charge controller to the GACIA LED 36W-12 which will automatically power it on at 19:00pm daily at this time the batteries were fully charged. Multimeter (Dg5274D) was used to measure voltage and current (A) from 8:00 am to 18:00 pm at every one-hour interval for the period of one week in the month of June 2021. A pyranometer was used to measure the amount of solar radiation. On a sunny day at noon, the direct beam radiation recorded on the coordinate surface is approximately 892W/m^2 this was a result of the period the research was conducted. The values obtained were used to compute the efficiency and power generated by the solar photovoltaic system in the experiment.

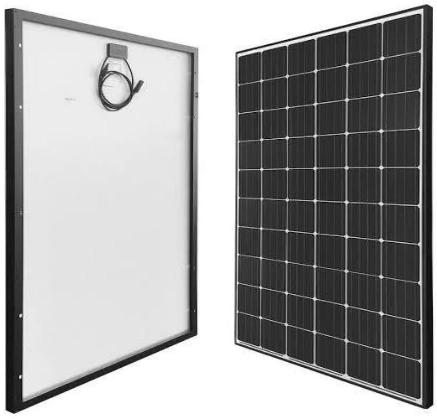

Figure 1: Monocrystalline Photovoltaic Panel used.

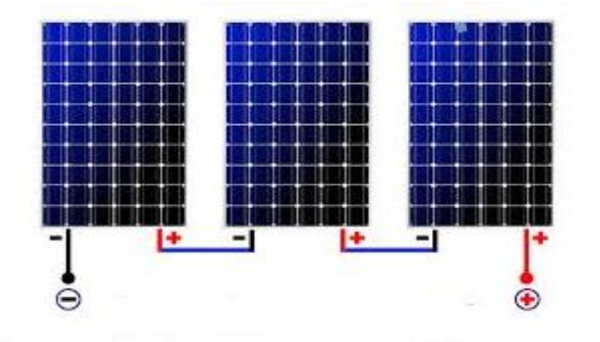

Figure 2: PV panel in series connection

The efficiency of the PV module was computed using eqn. 1 below [14]

$$Efficiency\ of\ solar\ panel\ (\eta) = \frac{current\ x\ voltage}{incident\ solar\ flux(w/m^2)\ x\ area\ of\ solar\ panel\ (m)^2}\ x\ 100\% \quad (1)$$

RESULTS

Table 2: Average daily reading of voltage and current of monocrystalline PV module at average temperature 36℃ and radiation intensity of 892W/m^2 for a week in month June 2021.

Time (GMT)	Open circuit voltage (V_{oc})	Maximum Voltage (V_m)	Short circuit current (I_{sc})	Maximum Current (I_m)	Power (W)
8:00	35.82	30.30	2.43	1.82	55.15
10:00	35.53	30.40	2.05	1.53	46.51
12:00	34.66	30.42	5.81	4.50	136.89
14:00	34.43	30.50	6.54	5.70	173.85
16:00	33.76	30.30	6.08	4.83	146.35
18:00	32.87	30.20	4.07	2.33	70.37

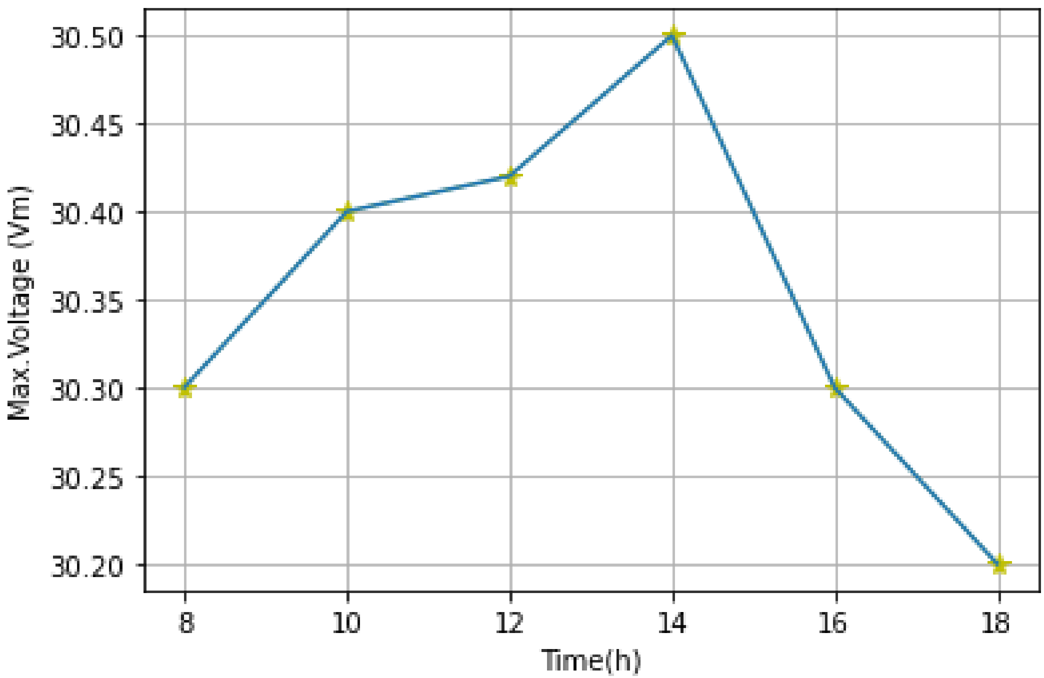

Figure 3: V_m versus h as sunlight intensity changes with time

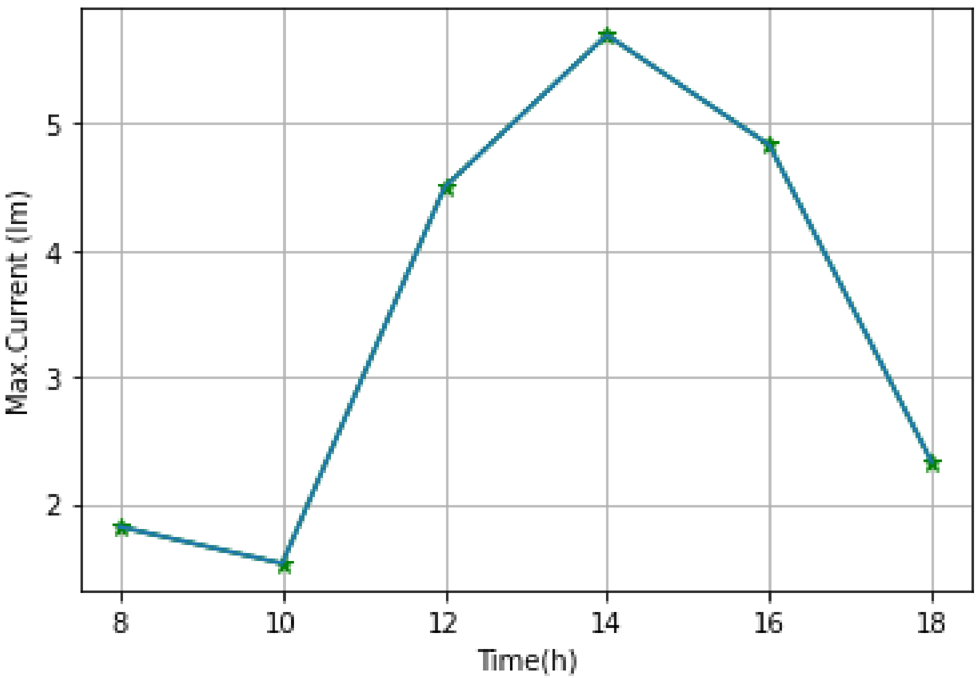

Figure 4: I_m versus h as sunlight intensity changes with time

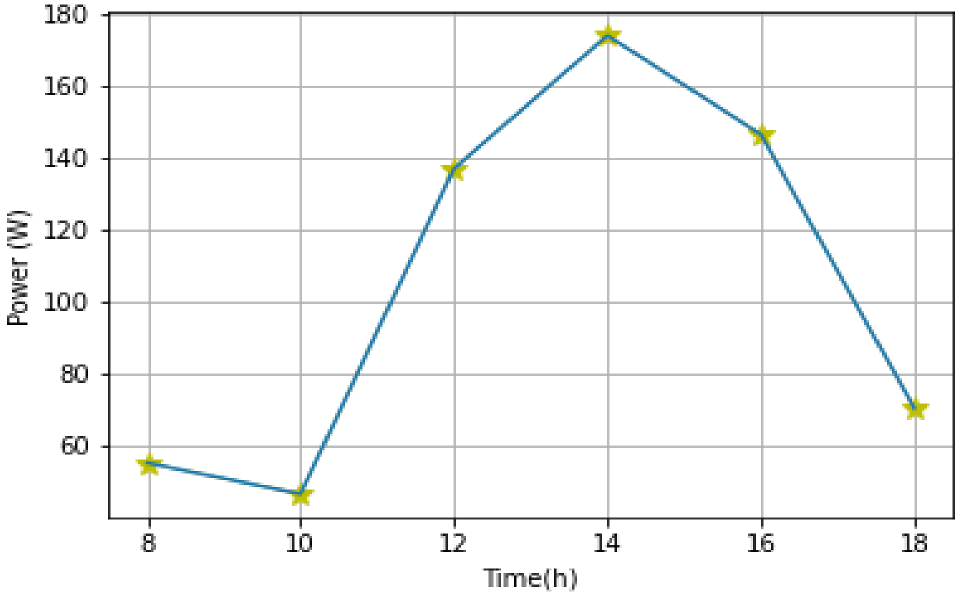

Figure 5: W versus h as the sunlight intensity with time

DISCUSSION

As the sunlight intensity gradually increases at the early hour of the day, the open circuit voltage, and short circuit current also increases steadily till 14pm that was where the maximum power voltage and current of 30.50 V_{mp} and 5.70 I_{mp} were obtained. More so gradual decrease of sunlight energy was observed from 14pm to 18pm and the open circuit voltage, short circuit current, maximum voltage, current equally drop as shown in Table 2 above. These observations were consistent with the study of photovoltaic systems that, solar panels are nonlinear energy foundations and the action points of the system also change along with the change in climate state. Therefore, the maximum voltage (V_m), current (I_m), power (W) output values and performance of photovoltaic systems depend on climate parameters [15]. The figure 3, 4 and 5 shows the daily average variation of time with maximum voltage (V_m), current (I_m), and power (W). These graphs follow the same trend with the open circuit voltage (V_{oc}) and short circuit current (I_{sc}) these shows the characteristic of a monocrystalline PV module at an average temperature of 36℃ and intensity of solar radiation of 892W/m^2 .

When the distance of the sun is the shortest and when the sun is at its peak, that is directly at the center of the sky. The efficiency of the photovoltaic module with an area of 1.28 m^2 was obtained as 11.34%, this is close to the manufactural standard efficiency of the monocrystalline photovoltaic module of 16-19%, and the maximum power computed for each panel during the day was 1920W, and the maximum power and voltage obtained was 38.4k and 2400V. The data obtained below shows the raw data of the electrical open circuit voltage, and short circuit current for a week, for the KC125 and EPV-50 modules achieved daily for a period of a week. The power utilizes by ten (10) computer systems in the ICT was 110 W. The physical limits of the measured voltage and current can be seen below.

Parameter	Range/Limit
Voltage (V)	0-3
Current (A)	0-7
Module power (W)	P>0

The results above correlate with the values obtained in this research work.

CONCLUSION

This study has shown that the practical efficiency of the monocrystalline photovoltaic panel was lower than the theoretical efficiency of the solar panels. On a clear weather day as the sun rises from 7:00am within an interval of three hours, the amount of solar radiation is low but from 12 noon to 14:00pm the solar radiation increases steadily to around 17:300pm and it decreases to zero at about 18:00pm. The research work was also compared to data obtained from the KC125 and EPV-50 modules archived daily for a period of a week. The performance of the photovoltaic system is highly affected by weather conditions and the types of solar cells. It is recommendable that more research be done on other photovoltaic modules in the same environmental conditions and compare it efficiency with the monocrystalline solar panel used in this work.

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