A Novel Methodology For Modelling PV Module Based On Monitored Data

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***Abstract*—Renewable energy is gaining tremendous attention in both academia and industry in an effort to diminish greenhouse emissions. This research focus on how to optimize the use of solar energy by sizing the appropriate panels to be used. The research used Matlab software to simulate the I-V and P-V Curve characteristics of a 200W PV module by varying the irradiance and temperature of the study Area. The result shows that the output power of the Photo Voltaic (PV) module increases as the irradiance of the environment increases. Also, the output of the PV module decreases as the temperature increases. At the highest irradiance with the lowest temperature of 25°Cin the study area the efficiency of the PV module is 75%, this shows that the use of 200W PV module is not economical in the study Area. This research therefore recommends that for optima used of a PV module the irradiance and temperature of the area must be monitored in order to size the right PV module to be used.**

***Keywords*—(Photo-Voltaic, MATLAB, I-V Curve and P-V Curve)**

1. INTRODUCTION

Developing alternative energy resources with high efficiency and low emission has become of great importance with increasing concerns about fossil fuel deficit, high oil prices, global warming, and damage to environment and ecosystem [1]. There is a need for energy source that will eliminates the aforementioned problems. Solar energy resources has been used as an alternative energy source. However, there are problems associated with the used of solar energy which are technical and climatic conditions. Therefore, there is a need to know the best renewable energy option that will be suitable for different location. The aim of this research is to model the mathematical output of a PV Solar of capital city of Nigeria using MATLAB. The modeling and simulation of photovoltaic (PV) have made a great transition and form an important part of power generation in this present age. Many researchers used circuit based approach to characterize the PV module of which the simplest model is the current source in parallel to a diode [2, 3]. Finally, the main objective of present paper is to shed further light on the modeling techniques applied for photovoltaic cells characterizations and investigating as well, the environmental ones (temperature - and irradiance -levels).

11. Factors Affecting the Solar panel Characteristics

i. EFFECT OF THE PV TECHNOLOGY TYPES

There are different types of PV cells. Recently, Scientist at the NTNU University discover the organic solar cells. As technology keeps getting better, so is the conversion efficiency of the solar cells. Many author has compared and reviewed the output of various types of solar cells and the effect of various cell characteristics. A wide range of PV technologies are currently available. Popular among them include silicon based mono and poly crystalline, thin-film technologies of amorphous silicon (a- Si), cadmium telluride (CdTe), copper-indium-gallium- dieseline (CIGS), multi-junction & emerging technologies such as Organic PV (OPV) and Concentrating PV (CPV) technologies. PV types differ according to the material, manufacturing process, efficiency and cost [4, 5, 6, 7]

ii. VARIATION IN SOLAR RADIATION.

The performance of PV modules under varying light conditions will differ significantly, which in turn has a severe impact on the yield of PV systems. Variations in the intensity of solar radiation falling on a PV module affect many of its parameters, including Isc, Voc, power, FF and efficiency. In general, for a given solar radiation, when the cell temperature increases, the open circuit voltage *Voc*, drops slightly, while the short circuit current increases [5].

iii. SHADING

Shading results in mismatches in the generated currents of individual cells of a module. Even partial shading on a single cell can significantly reduce the power output of the entire module as if all the cells were shaded. A shaded cell produces much less current than the unshaded ones. Since cells in a module are connected in series, same current has to flow through all the cells. If more current than the shaded capability is forced through a shaded cell, it will be overheated and might be damaged [5].

iv. **IRRADIANCE**

Irradiance has a direct effect on PV module output. An increase in irradiance increases the PV output. Irradiance also affects the PV cell temperature and thus affects the PV output. Solar radiation is measured using pyranometers. In general, for a given solar radiation, when the cell temperature increases, the open circuit voltage Voc, drops slightly, while the short circuit current increases[4,5,6].

v. FILL FACTOR (FF)

The FF is defined as the maximum power from actual solar cell to the maximum power from ideal solar cell. As time goes the PV curve degrades. It is essential to check quality of cell periodically. Quality of cell is determined by fill factor. Graphically, fill-factor is a measure of the squareness of the PV cell and is also the area of the largest rectangle which will fit in the I-V curve. A good quality PV module is expected to have fill-factor above 70%[7].

III. METHODOLOGY

A photovoltaic cell consists of a single diode connected in parallel with a light generated current source, Iph, and Series and parallel resistor as presented in Figure 1. The characteristics equations were presented in equation 1 to 5.

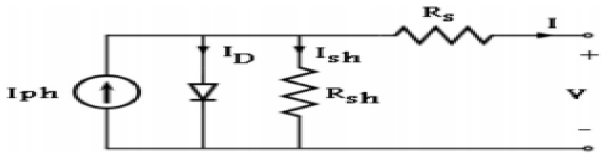


Figure 1: PV Cell Circuit

$$I_{rs} = \frac{Isc}{Exp\left(\frac{q.voc}{n.Ns.K.T}\right)-1} \quad (1)$$

$$I_o = I_{rs}.\left(\frac{T}{Tn}\right)^3.\exp\left[\frac{q.Ego\left(\frac{1}{Tn}-\frac{1}{T}\right)}{n.k}\right] \quad (2)$$

$$I_{sh} = \left(\frac{V+I.Rs}{Rsh}\right) \quad (3)$$

$$I_{Ph} = [I_{sc} + K_i.(T-298)].\frac{G}{1000} \quad (4)$$

$$I = I_{ph} - I_0.\left[\exp\left(\frac{q.(V+I.Rs)}{n.k.N_s.T}\right) - 1\right] - Ish \quad (5)$$

Where I_{rs} the reverse saturation current, I_0 is the saturation current, I_{ph} is the photo current, I_{sh} is the current through shunt resistor, I is the output current. I_{sc} is the short circuit current, q is the charge, Voc is the open circuit voltage, n is the ideality Factor, k is the Boltzmann's, constant (J/K), Ego is the energy band gap of semiconductor, N_s is the number of cells connected in series, N_p is the number of PV modules connected in parallel, R_s is series resistance, R_{sh} is the shunt resistance and V_t diode thermal voltage.

Parameters of the PV module

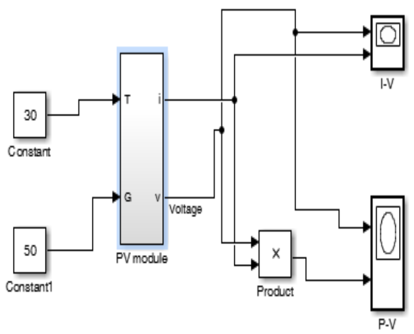
Parameters	Values
Rated power	200W
Voltage at maximum power	26.4V
Current at maximum current	7.58
Open circuit current	32.9
Short Circuit voltage	8.21
Total Number of Cells in Series	54
Total Number of Cells in Parallel	1

From the solar irradiation data from NIMET in Abuja in the average solar radiation varies from 27.69 to 763.10. This research considered irradiance values of 50, 100, 200, 400 and 800

W/h/m2. While the temperature considered 25 ^{o} C, 30 ^{o} C, 50 ^{o} C and 75^o C.

4. Result and Analysis

The result of the simulation were presented in figure 1 to 18 at different temperature and different solar irradiance value.



Figiure 2: The model of PV Array

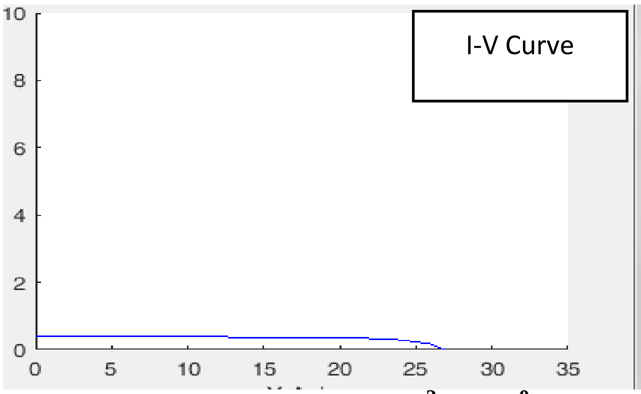


Figure 3: I-V Curve At 50W/m^2 at 25 ^{0}C

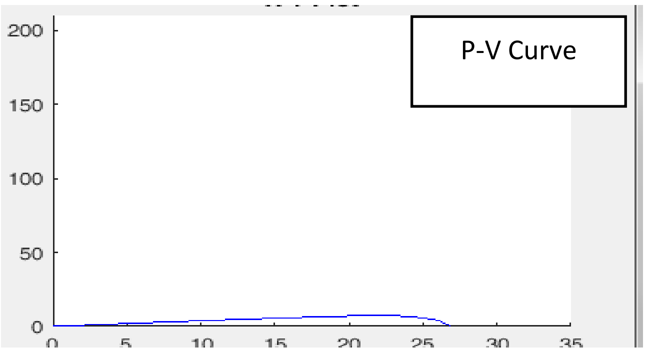


Figure 4: P-V Curve at 50W/ m^2 at 25 ^{0}C

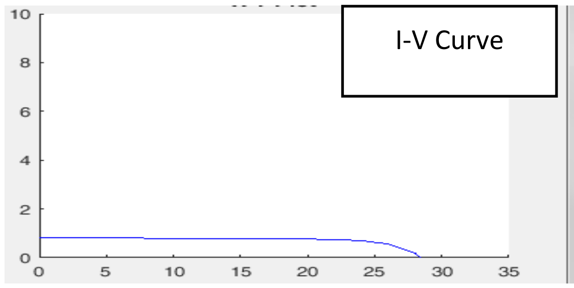


Figure 5: I-V Curve At 100W/m^2 at 25^{0}C

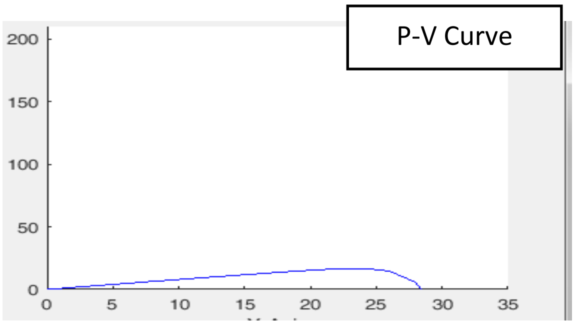


Figure 6: P-V Curve at 100 W/m^2 at 25^{o}C

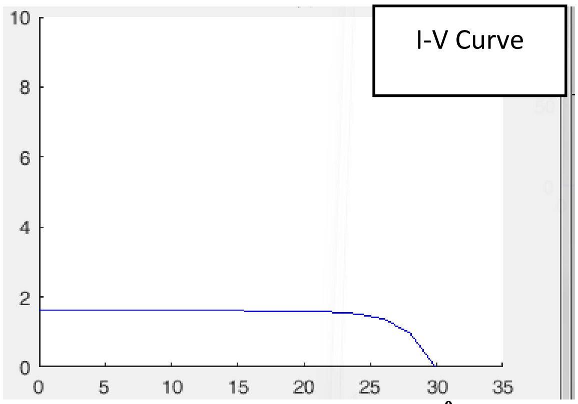


Figure 7: I-V Curve at 200W/m at 25 ^{0}C

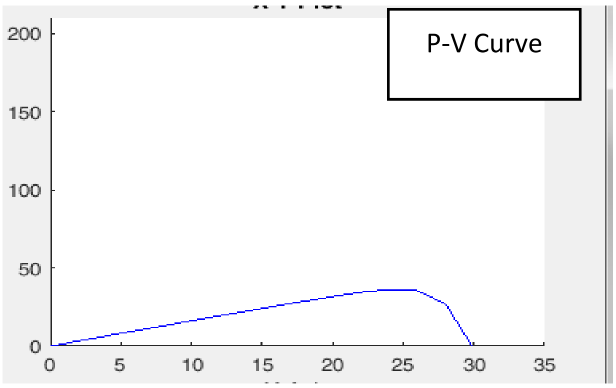


Figure 8: P-V Curve at 200 W/m at 25 ^{0}C

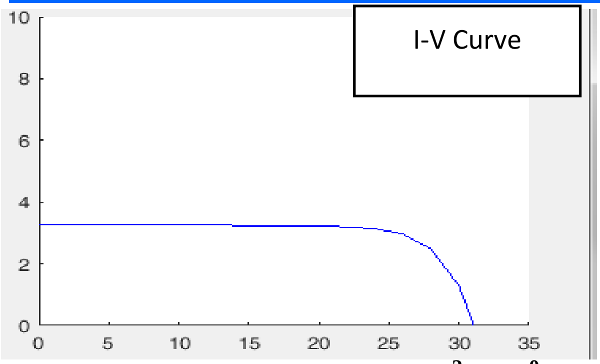


Figure 9: I-V Curve At 400W/m^{2}at 25^{0}C

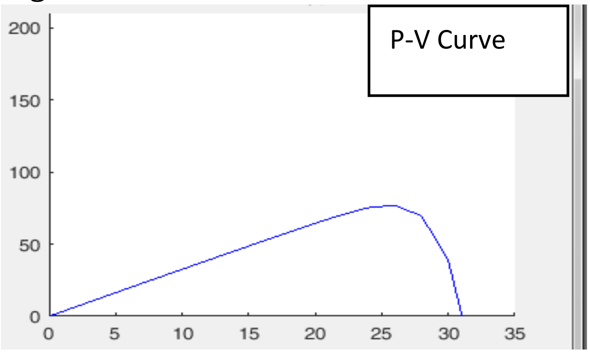


Figure 10: P-V Curve at 400 W/m^2 at 25 ^{0}C

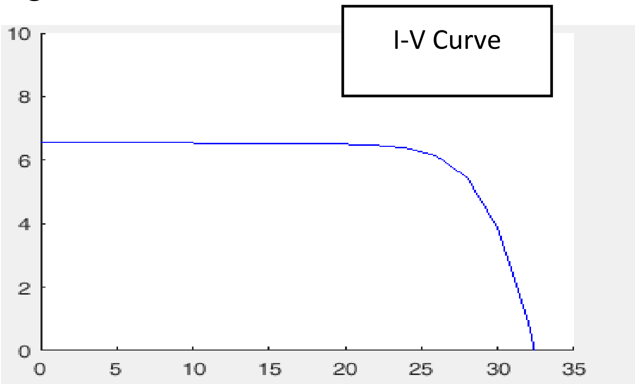


Figure 11: I-V Curve at 800W/m, 25 ^{0}C

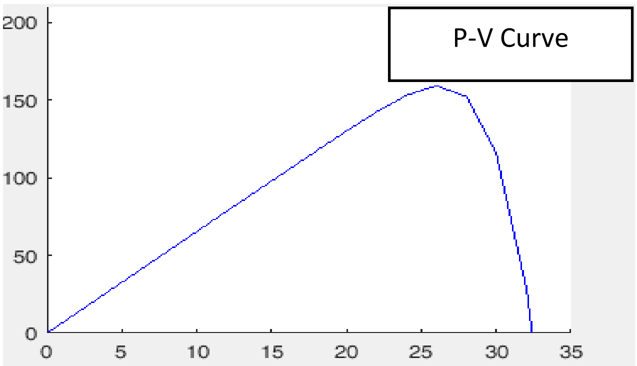


Figure 12: P-V Curve at 800 W/m, 25 ^{0}C

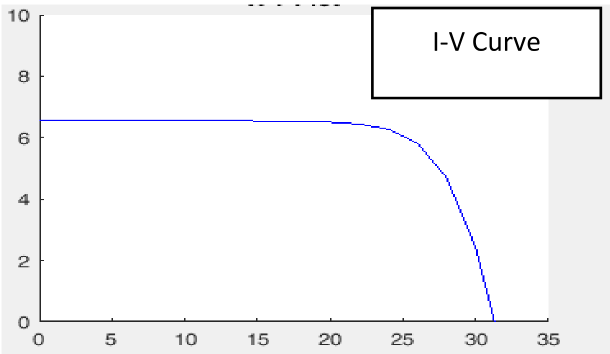


Figure 13: I-V Curve at 800W/m^2, 30^{0}C

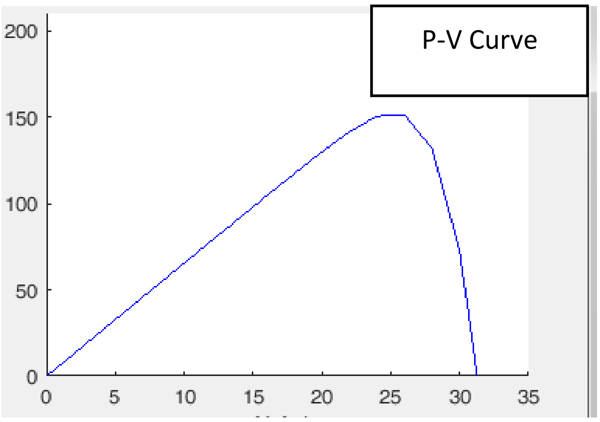


Figure 14: P-V Curve at 800 W/m^2, 30^{0}C

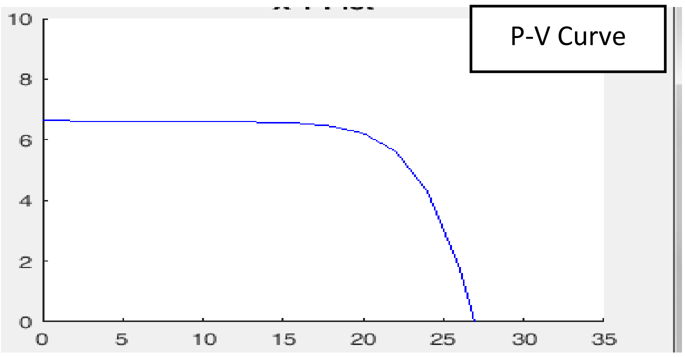


Figure 15: I-V Curve at 800W/m^2, 50^{0}C

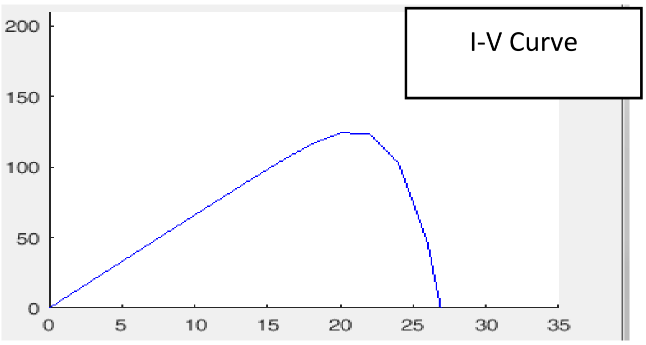


Figure 16: P-V Curve at 800 W/m^2, 50^{0}C

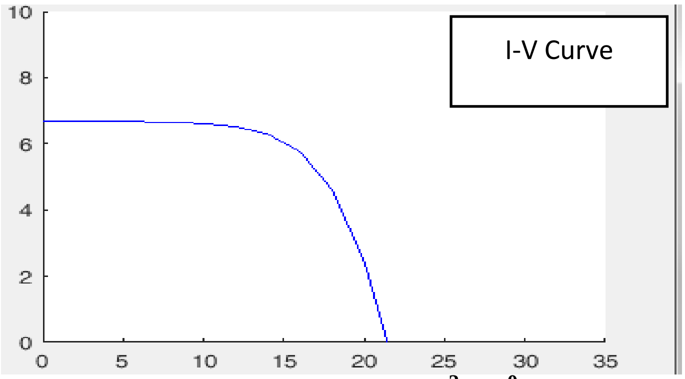


Figure 17: I-V Curve at 800W/m^2, 75^{0}C

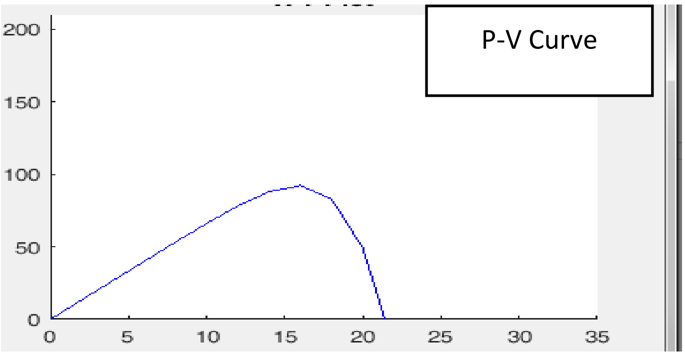


Figure 18: P-V Curve at 800 W/m^2, 75^{0}C

From Figure 3 to 12 the I-V curve and P-V curve of the PV module at different irradiance of 50, 100, 200, 400 and 800 respectively at constant temperature of 25^{0}C there is a significant increase in the P-V and I-V curve Output as the irradiance increases. The current and the voltage increases, also the power and the voltage also increases. However, with increase in temperature there is a decrease in the I-V and the P-V curve and the power, current and temperature decreases as the temperature increases. Also, with the highest value of irradiance in the study area, the output of the PV module is not as maximum. Therefore, it is necessary to monitor the irradiance and temperature of the location where the PV curve will be installed as this will allow effective optimization of PV module that will be used in the study Area.

Conclusions

The study shown the variation in the P-V curve of a solar panel with variation in irradiance and temperature. The following conclusions are made:

i. The PV curve of solar panel depend on the solar irradiance

ii. The higher the temperature of the environment the lower the PV curve output

iii. The maximum output of the solar panel can be achieve at the highest irradiance with lowest temperature.

Recommendations

This research recommends that in using of PV module for a given area, the simulation of the panel output should be done based on the average irradiance of the area in order to optimized the PV output. This will also reduce cost of procurement of the PV module.

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