International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 04 Apr. 2024, pp: 354-359 www.ijaem.net ISSN: 2395-5252

# Determination of Yearly Degradation Rate of Electrical Parameters of Polycrystalline Silicon (p Si) Photovoltaic Module in Minna. Nigeria

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Date of Submission: 05-04-2024 Date of Acceptance: 14-04-2024

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**ABSTRACT**
The need for accurate knowledge of degradation rate and lifespan of photovoltaic (PV) module in every location for an effective solar PV power system is paramount. Outdoor degradation analysis was carried out on polycrystalline silicon PV module rated 10w using CR1000 software base Data acquisition system (DAS). The PV module under test and meteorological sensors were installed on a metal support structure at the same test plane in the laboratory guarding of Federal University of Technology,MinnaThe data monitoring was from 09:00amto 06:00pm hours each day continuously for a period of four years, from December 2014 to November 2018. Annual yearly averages of the pserformance variables were carried out to ascertain the degradation rate and lifespan of the module. It was observed that open circuit voltage (Voc), short circuit current (Isc),Power(W),Maximum current(Imax) A,and Maximum power(W) has average yearly degradation of 0.286V, 0.004A, 0.024W, 0.276$V_{max}$, 0.0042$I_{,max}$, 0.0343$W_{max}$

## I. INTRODUCTION

Photovoltaic solar energy is a form of renewable energy; it can generate electricity by converting the solar radiation and by using the photovoltaic effect. The installation of photovoltaic systems is mainly dictated for optical performance by its geographical context as the location and conception of the sun expose by several factors such as solar irradiation, ambient temperature, humidity, wind, shading and dust accumulation; these factors can accelerate the degradation rate. There is need for accurate knowledge of degradation rate and lifespan of photovoltaic (PV) module in every location for an effective solar PV cells and module due to their exposure to atmospheric parameters such as solar irradiance temperature wind speed relative humidity which depreciate the electrical parameter of the limited lifetime is as a result of several factor that are in play simultaneously, The performance of PV module has been observed to gradually decrease with operation time (Dunlop and Halton, 2006) long time performance of PV module is vital if they have to pay back to the consumer. It is important to investigate the performance parameters of modules With rapid economic growth and important in living standard, there has been a marked increase in energy consumption in many third world countries. Most countries use fossil fuel. Hydroelectric power and nuclear power as a source of energy, Nuclear and fossil fuehave adverse effect on the environment such as large amount of greenhouse gases emission and pollution from the burning of fossil fuel (Rene, 2005, Azhar and Abdul, 2012)

Since fossil fuel and nuclear power of energy are not renewable, it is necessary to explore other sources of energy that are cost effective especially in the developing countries that rely heavily on imported fossil fuel, Renewable energy such as sunlight. Wind tides and wave can be particularly suitable for developing countries especially in rural and remote areas where transmission and distribution of energy generated from fossil fuel can be difficult and expensive Producing renewable energy locally can offer a viable alternative.

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Technology advances are opening up a huge new market for solar power, Even though they are typically poor, use inefficient energy system like kerosene lamp and stoves. Power cost half as such as lighting with kerosene, (Dnke et al, 2010)

The energy conversion efficiency of a PV module or array as a group of electrically connected PV module in the same plane is defined as the ratio between electrical power conducted away from the module and the incidence power of the sun (Rakovect et al 2011)

This conversion efficiency of photovoltaic (PV)module by manufactures is done under standard Test condition (STC) The standard Test conditions are module temperature of 25c Irradiance of 1000W/m2 and Air mass of 1.5.Different PV module technologies now exist in the market theseIncludes crystalline module such as mono crystalline, polycrystalline and amorphous modules. The moduleavailable are rated by manufacture depending on their power output such as 5watt, 10watt, 15watts The choice of the module to use depend on the power output needed by the consumer and its efficiency photovoltaic {PV} modules are often considered as themost reliable elements in PV system . However, photovoltaic module reliability data are not shows on commercial data sheets in the same way as it is with other product such as electronics devices and electronics power supplies Conversely, the high reliability associated with PV module are indirectly reflected in the output power warrantiesusually provided in the industry, which range from 25- 30 years As a matter of fact, PV module have a low return time .the exception being the catastrophic failures. The performance of PV modules decreases when deployed outdoors over time. After several years of operation, this decrease will affect PV module reliability (manuel and ignacio, 2008) degradation rate of electrical parameters of polycrystalline silicon PV module and the finding can be used to fairly design an effective PV modules.

## II. MATERIALS AND METHOD

### 2.1 Method of Data acquisition

The degradation rate of the polycrystalline silicon PV module to ambient weather parameters; temperature, wind speed and relative humidity, irradiance was monitored in Minna environment, with the help of CR1000 software-based data logging system with computer interface. The PV modules under test, and meteorological sensors, were installed on support structure at the same test plane at about three meters of height, so as to able or ensure adequate exposure to insolation and enough wind speed, since wind speed is proportion to height. Also the PV was elevated above the ground to ensure that it is free from any shading from shruds and also protect from damage or interference by intruders and the entire system is secured. The modules are titled at approximately $10^0$ (since Minna is on latitude $09^0$37N) to horizontal and south-facing to ensure maximum insolation (Strong and Scheller, 1991; Ugwuoke et al., 2005. Ezenwora, 2016). The data monitoring was from 9:00am to 6:00pm local time, each day continuously for a period of four years spanning from December 2014 to November, 2019.

Data acquired in the past five years was used to validate the data to support analysis. The experiment was carried out near Physics Department, Federal University of Technology, Minna (Latitude $09^0$37’N), longitude $06^0$32E and 249 meters above sea level. The sensor are connected directly to CR1000 Campbell Scientific data, while the modulesare connected to the logger via electronic loads. The logger was programmed to scan the load current from 0 to 1 A at intervals of 50mA every 5 minute and average value of short circuit current $I_{ce}$, open-circuit voltage $V_{oc}$ current at maximum power, $I_{max}$, voltage at maximum power, $V_{max}$, power and maximum power obtained from the modules together with the ambient parameters are recorded and logged. Data download at the data acquisition site was performed every 7 days to ensure effective and close monitoring of the data acquisition system (DAS). At the end of each month and where necessary, hourly. Daily and monthly averages of each of the parameters-solar irradiance, solar insolation, wind speed, ambient and module temperature, and the output response variables (open-circuit voltage, $V_{oc}$, short-circuit current, $I_{sc}$, voltage at maximum power, $V_{max}$, current at maximum power, $I_{max}$, efficiency, Eff, and fill factor, FF) of the photovoltaic modules were obtained. The global solar radiation was monitored using Li-200SA M200 Pyranometer, manufactured by LI-COR Inc. USA, with calibration of 94.62 microamperes per 1000W/$m^2$. The ambient temperature and relative humidity was monitored using HC2S3-L Rotronic HygraClip2 temperature/relative humidity probe, manufactured in Switzerland. Wind speed was monitored using 03002-L RM Young Wind Sentry Set. And module temperature was monitored using 110PV-L Surface-Mount Temperature probe: All sensors are installed in the CR1000 Campbell Scientific data logger with measurement and control module.

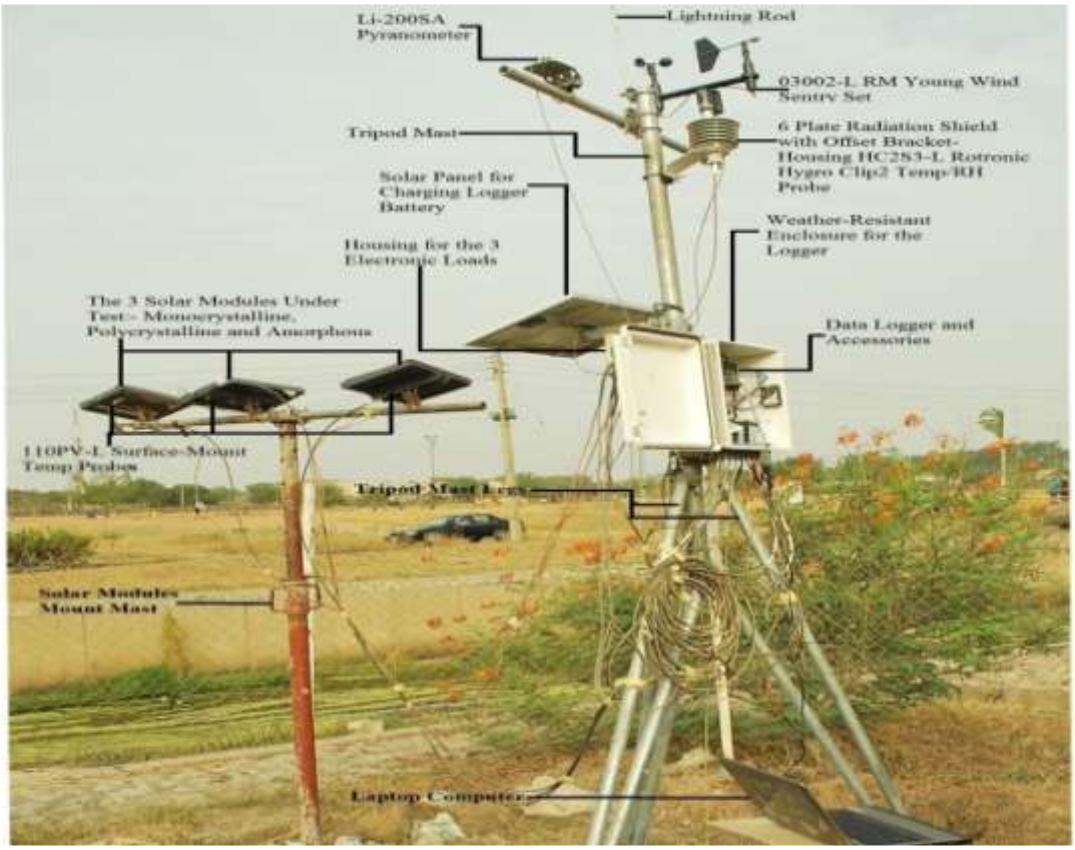


Plate 1: The experimental set up (Near physics Department, FUT Minna).

**2.2 Method of Data Analysis**

The situation responses of the polycrystalline module to ambient weather considering some parameters was analyzed in terms of Isc short-circuit current,Voc, open-circuit voltage, voltage at maximum power, V max, Imax , efficiency, Eff and fill factor, FF current at maximum power,.

FF, Efficiency, Eff, Fill Factor, and Module Performance Ratio (MPR) were evaluated using the following expressions (Ugwuoke, 2005. Ezenwora, 2016).

Ll Factor, FF $=I_{max}\ V_{max}/I_{sc}V_{oc}$1

Efficiency, Eff $=I_{max}\ V_{max}/P_{in}= I_{sc}V_{oc}FF/P_{in} = I_{sc}V_{oc}FF/AE_e$2

TheI-V curve were achieved by plotting current against voltage produced by the logger in scanning the electronic load current from 0 to 1 A at intervals of 50 mA. The maximum power point, $P_{max}$, that is the operating point of the module, was also note down by the logger. This maximum power point also corresponds to the largest area of the rectangle that fits into the curve. The current and voltage at this point are $I_{max}$ and $V_{max}$.

Table 1: Annual Average of ambient parameters and Performance Variables for the Polycrystalline Silicon Module

| T(Years) | WS(m/s) | Ta($^{0C}$) | RH(%) | Tmod($^{0C}$) | Hg(W/m2) | Voc (v) | Isc(A) | P(W) | $V_{max}$ (V) | Imax(A) | $P_{max}$ | FF | Eff(%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YEAR 1 (2015) | 1.65 | 25.5 | 48.3 | 36.4 | 507 | 5.66 | 0.045 | 0.693 | 5.66 | 0.145 | 0.977 | 3.213 | 0.06 |
| YEAR 2 (2016) | 1.57 | 31.4 | 49.7 | 36.7 | 520 | 5.46 | 0.040 | 0.658 | 5.47 | 0.136 | 0.911 | 3.388 | 0.05 |
| YEAR 3 (2017) | 1.34 | 32.3 | 47.1 | 37.5 | 502 | 5.88 | 0.046 | 0.636 | 5.88 | 0.135 | 0.891 | 2.926 | 0.05 |
| YEAR 4 (2018) | 1.03 | 32.7 | 53.1 | 37.5 | 485 | 5.64 | 0.044 | 0.621 | 5.65 | 0.132 | 0.874 | 2.986 | 0.05 |
| AVG | 1.40 | 30.5 | 49.6 | 37.0 | 504 | 5.66 | 0.044 | 0.652 | 5.66 | 0.137 | 0.913 | 3.128 | 0.05 |

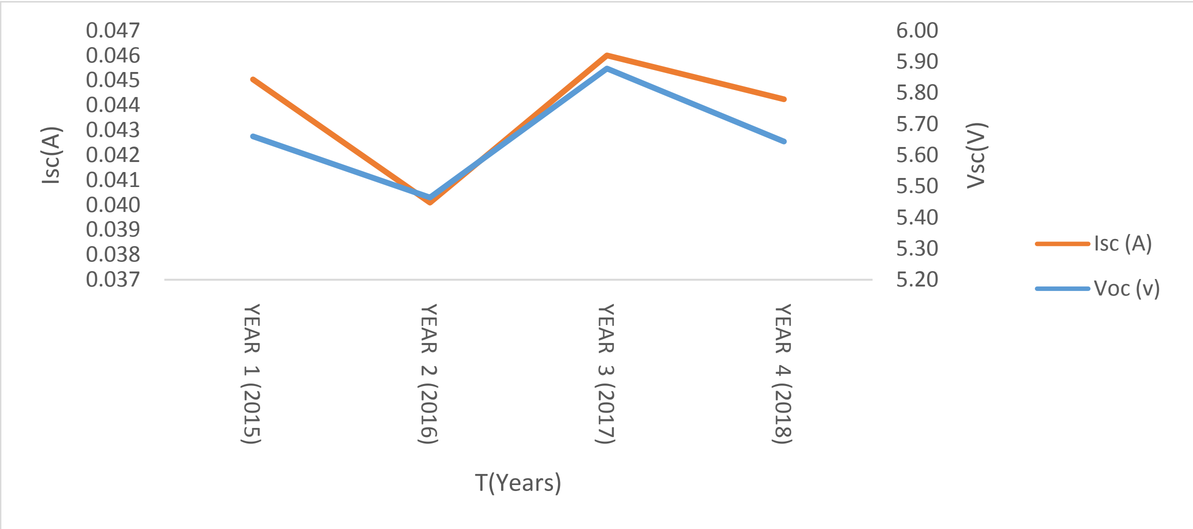


Figure 1: Variation of short circuit current and open circuit voltage as a function of years

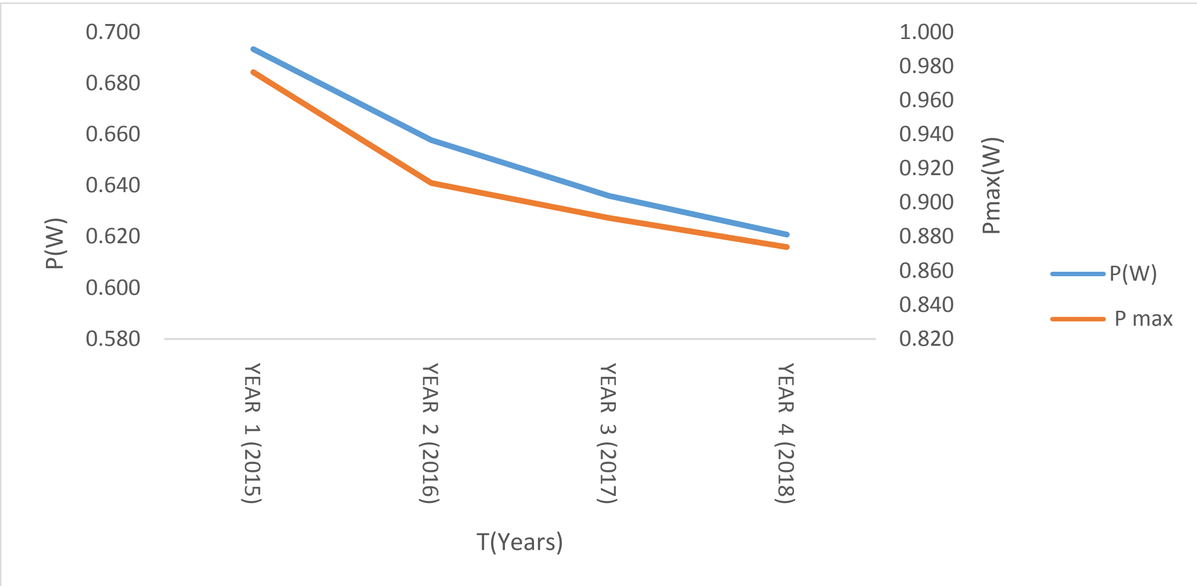


Figure 2:variation 0f power and maximum power as a function of years

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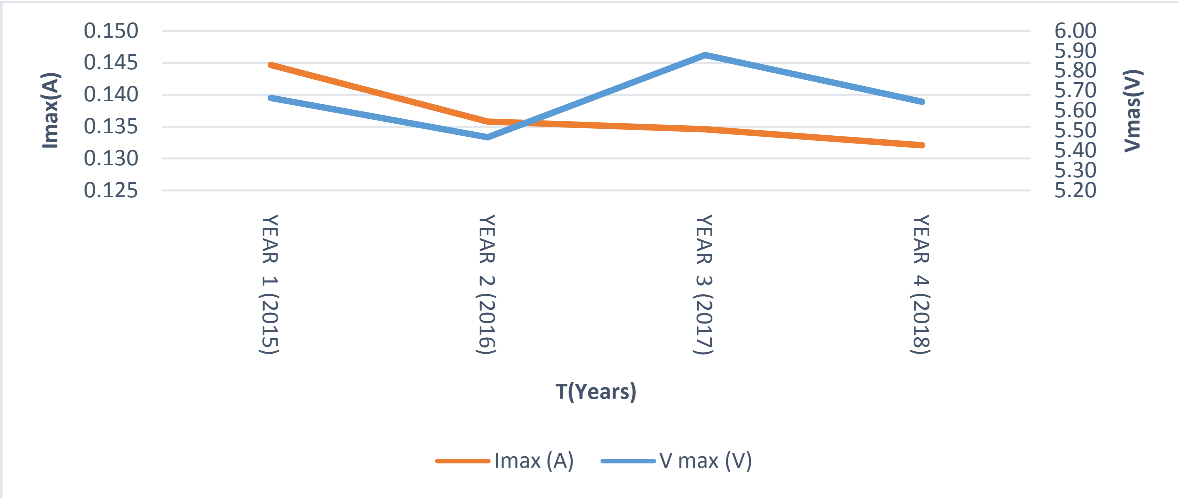


Figure 3: variation of maximum current and maximum voltage as a function of years

## III. RESULT AND DISCUSSION

In fig 1: it was discover that $I_{sc}$ degradation steadily throughout fours the years but for $V_{oc}$ that increased between 2016 and 2017 and this increase was due to the decrease observed in the solar irradiance for 2016 and 2017 which is in consouad with Ezenwaro,el at.,2018.

From fig 2:it was discover that both the power and power maximum degrades steadilythroughoutfour the years From fig 3:it was observed that $I_{max}$ degraded steadily though out the four years but for $V_{max}$ thatincreased between 2016 and 2017 and this was due to the decrease insolar irradiance seen from the for the year 2016 and 2017

From table 1 it was observed that $V_{oc}$and $I_{sc}$ has a yearly decrease of 0.286Vand 0.004A after difference of four years with averaging and divided by 3 from 2017 and 2018 are slight increase throughout fours the years and increase was due to the decrease observed in solar irradiance,for P(w) and P($w_{max)}$ has observed that is degrades steadily throughout four the years by 0.024W and 0.0343$W_{max}$ However from 2015 to 2016 $v_{max}$ is decreased and from 2017 to 2018 is slight increase by 0.276$V_{Max}$and $I_{max}$ degrades throughout four the years by 0.0042$I_{max}$ Annual average of ambient parameter and performance variables for the polycrystalline silicon module.

## IV. CONCLUSION

It is conclude that the yearly determination of degradation rate of polycrystalline photovoltaic modules in Minna local environment reveals that all the performance variables of the modules degraded significantly from year to year for the four years of study. It was observed that the Electrical parameters of the module has an average degradation rate of $V_{oc}$ 0.286v for $I_{sc}$ 0.004A for P 0.024W for $P_{max}$ 0.0343$W_{max}$ for $I_{max}$ 0.0042$A_{max}$for $V_{mxa}$ 0.276$V_{max}$From

It was observed that electrical parameters of the module has an average degradation rate of $V_{oc}$= 5.66$v_{1,}$ for $I_{sc}$ = 0.044$I_{sc}$, for P (W) 0.652W, For $V_{max}$. 5.66$V_{max}$ , For $1_{max}$ 0.137$A_{max.}$ for P($W_{max}$) 0.913$W_{max.}$ for the four years of study. It was also observed from the table that $V_{oc}$ and $I_{sc.}$ Has a yearly decrease rate of 0.286V and 0.004A from year 2017 to 2018 and a slight increase of 0.24V show that there is increase in solar irradiance and $I_{sc}$ steadily decrease throughout the four years. By 0.004A, it was observed that P (w) and P ($W_{max)}$ are degrade throughout the four years. By 0.0241W and 0.0343$W_{max.}$ from the 2015 to 2016 $V_{max}$ decrease steadily by 0.2$V_{max,}$ but from 2017 to 2018 it shows that there is a increment in solar irradiance and there is slight increment by 0.23$V_{max}$ showing that there is increase in solar irradianee $I_{max}$ was observed that is degrades throughout the four years. By 0.042$I_{max}$ it has observed that $P_{max}$ was degrades throughout the four years by 0.0343$P_{max.}$ (Ezenwora et:al, 2018).

It is recommended that outdoor, yearly degradation studies should be carried out on all commercially available PV modules in every location of developing countries where this is lacking. Results will furnish policy makers, designers PV power system installers the vital information on the degradation rate or lifespan of all commercially available PV modules for effective and reliable PV power system.

**Acknowledgement**
It is my appreciation to acknowledge and thank Joel A. Ezenwora's Photovoltaic Lab for the data used for this research work.

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