CHARACTERIZATION OF THE PERFORMANCE OF THE PHOTOVOLTAIC MODULES MEASURED OUTDOORS

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1. Introduction

Among the various types of renewable energy, solar energy has been widely promoted throughout the world in recent years. The reliability of photovoltaic modules is essential for the acceptance of the market. The photovoltaic modules are devices within the system, which are responsible for converting sunlight directly into electricity. Since modules are typically deployed as components in systems, therefore the module degradation and failure may not be immediately recognized. Although the photovoltaic modules are a source of reliable electricity, their study and analysis within the field indicate that they can have a remarkable degradation or a slight failure. In this paper, we study those losses with the modules that have been exposed outdoors for a long time.

2. Methodology

To study the degradation of the photovoltaic modules required a thorough analysis over time. These results can be seen with a slight loss of power in the module production. It is therefore essential to conduct a thorough analysis of the power loss of this device for measuring the IV curve. To this end an IV curve tracer was used. Curves were captured every 10 seconds in sequence every day.

Figure 1: Outdoor PV facility installed in the University Carlos III de Madrid for testing the PV modules used in the study

The characteristics of I-V parameters of all modules tested in the same way, as well as other parameters, are taken to supplement the results obtained with the obtained data. These measurements were performed using an I-V curve tracer. 7 This succeeds in obtaining the following parameters: open circuit voltage, short circuit current, maximum power point. The data were normalized to standard conditions: 1000 W/m2 and 25 °C. 8 A change in the obtained values at different times is an indicator of the degradation of photovoltaic modules. Analysis of these data taken over a period of time is a valid technique to estimate the progression of degradation. The analysis of this process can determine which parameters are degrading, and what causes the degradation of photovoltaic modules.

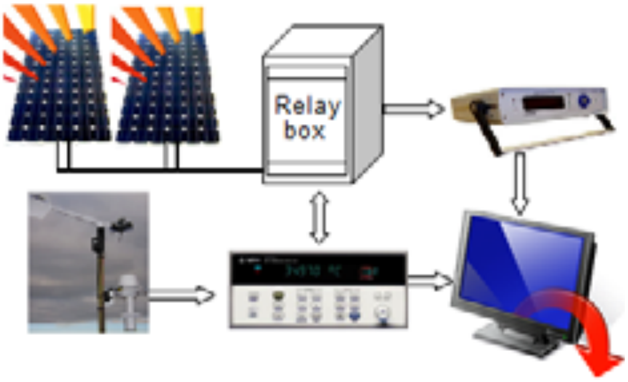

Figure 2: Capture Diagram

In the diagram shown in Figure 2 shows the procedure for capturing data from the solar panels, this diagram consists of the following components: solar panels, a relay box, weather station, an IV curve tracer, a datalogger and a computer. For viewing a program was constructed as shown in Figure 3, this shows all the parameters measured in this system.

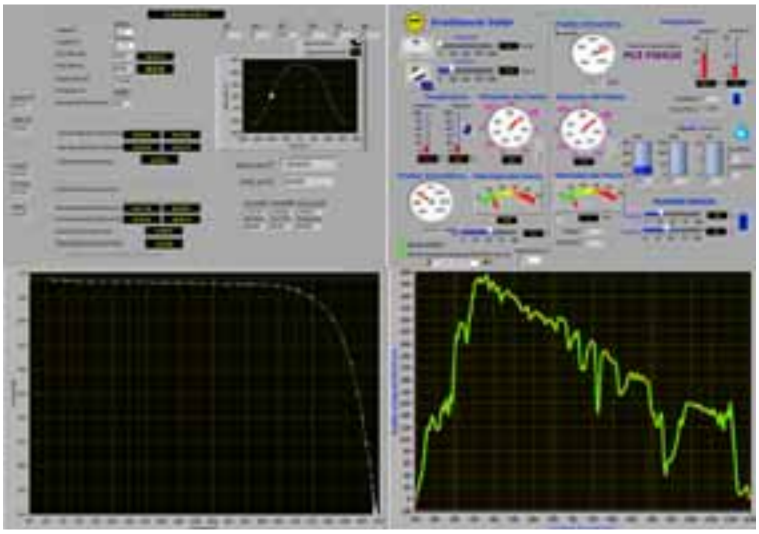

Figure 3: Display diagram

3. Degradation and Analysis

In order to make the analysis of the degradation of photovoltaic modules, a set of evaluation methods was carried out, which contained several pieces of equipment and data visualization, which allowed a comprehensive study of the various parameters of the modules, such as: I-V curve, short circuit current, open circuit voltage, maximum power, irradiance (global, diffuse and direct), room temperature, module temperature, wind speed and direction, relative humidity. This system was installed at the University Carlos III of Madrid, Leganés Madrid, in collaboration with CIEMAT. Table I summarizes some experimental results obtained.

TABLE I

Modules Used Also Listed are the Modules Specified and measured, PR and Powers and the Aperture Efficiencies.

Module	Specified (W)	Measured (W)	Corrected (W)	η (%)	PR
A	70	61.4	62.4	8.4	0.87
B	60	59.7	62.02	6.18	95.0
C	121	117.7	119.27	7.54	0.92
D	80	68.4	76.4	8.47	0.91
E	160	147.1	145.6	10.84	0.88

The design power, performance and efficiency are calculated as expressed in equation 1, 2, 3.

$$Pcorreg = \frac{P\max \cdot 1000 \cdot (1 - \gamma * \Delta T)}{G} \quad (1)$$

$$\eta = \frac{Pcorreg}{A \cdot G} \quad (2)$$

$$PR = \frac{P\max / Pnom}{G / 1000} \quad (3)$$

Pnom = Nominal Power
Pmax = Power Measured
G = Irradiance Measurement
γ = 0.005 for Si crystal
γ = 0.0035 for Si amorphous
A = area of the module

The PV modules are divided in five sets; modules in each set are connected to an I-V curve register.

TABLE II

The Temperature Coefficients for I_{sc} (α), V_{oc} (β) and P_{max} (γ) of the Modules Used.

Module	A	B	C	D	E
α (mA/°C)	0.0017	0.0029	0.0037	0.003	0.0093
β (mV/°C)	-0.1694	-0.2561	-0.1191	-0.1429	-0.1375
γ (mW/°C)	-0.2514	-0.0176	-0.1729	-0.2447	-0.4583

The temperature coefficients for I_{sc} (α), V_{oc} (β) y P_{max} (γ) and are listed in Table 2.

3.1 The temperature coefficients for the module A

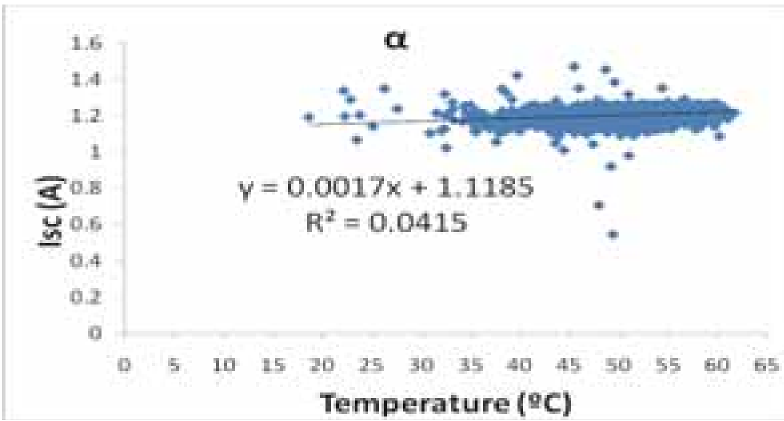

Figure 4: trend of parameter alpha for the A module.

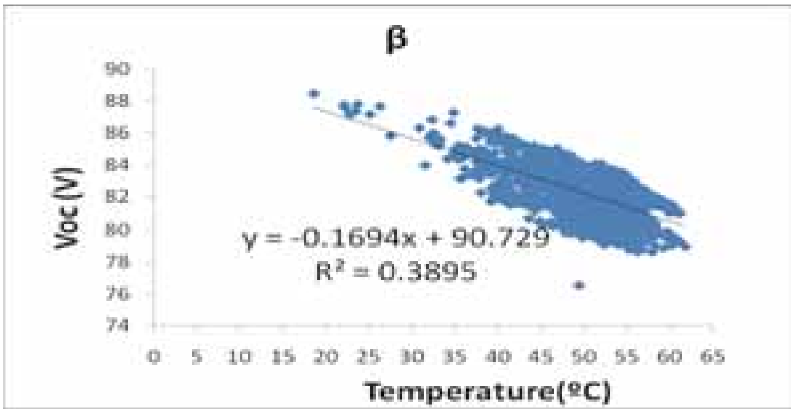

Figure 5: trend of parameter beta for the A module.

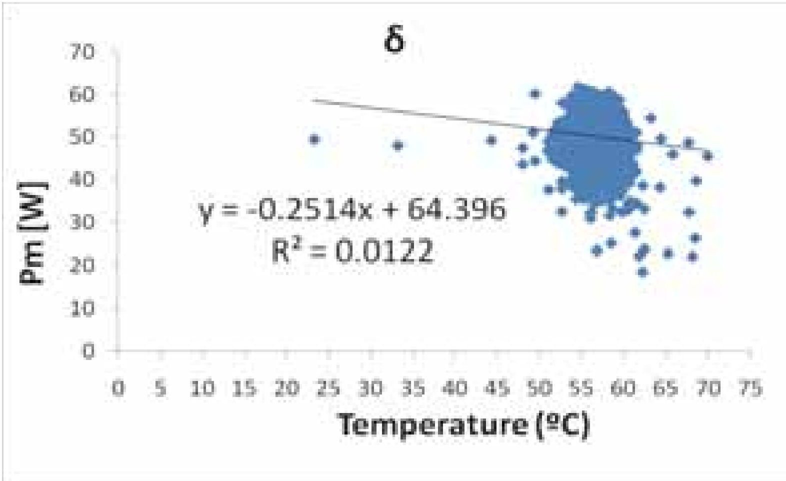

Figure 6: trend of parameter gamma for the A module

Figures 3,4 and 5 show the temperature coefficients alfa, beta and gamma of the module in question. For obtaining values, the system measures the short circuit current, open circuit voltage and power panel, measured from January 2010 to July 2011 and filter measurements where only using the values of irradiance in a range between 950 and 1050 W/m^2. in the figures mentioned above, can be seen hanging on every factor, but the worth of these results are the same as those specified by the manufacturers. The reliability of the results obtained is based on the amount of samples analyzed and the different temperature ranges were subjected to the modules under test.

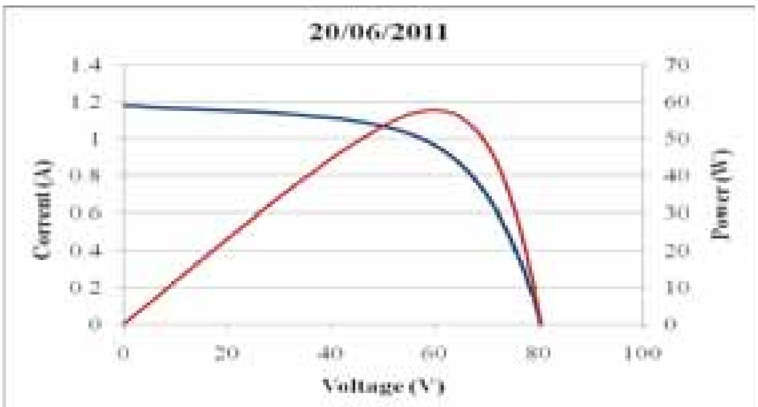

Figure 7: Characteristic curves of photovoltaic module B

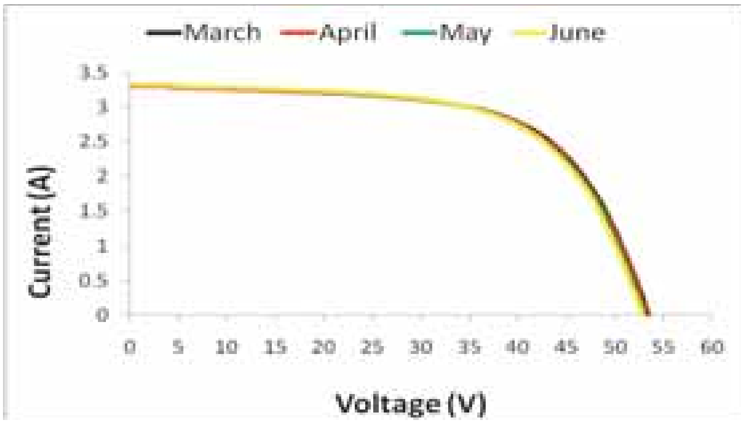

Figure 8: Current-voltage curve for technology D measured in different Month

Figure 7 presents the power losses in module D monthly period, it is obvious that the photovoltaic modules have a slight loss of potency over time, but you cannot determine how much power can lose a photovoltaic module that has not been subjected to all possible weather conditions of operation. This module has been exposed to temperature ranges within those specified by the manufacturer.

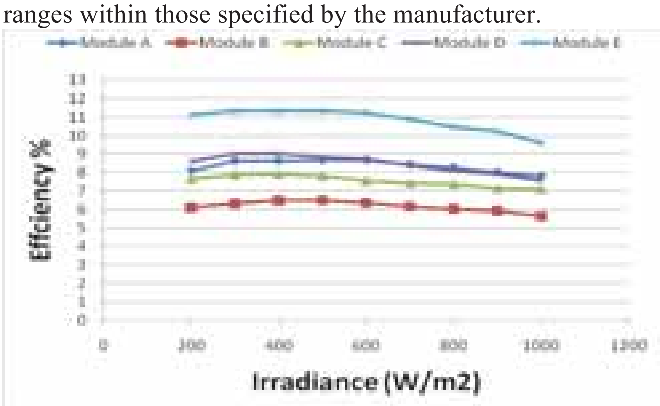

Figure 9: Aperture area efficiency of the five modules as a function of irradiance

Figure 8 shows the comparison of different technologies and the variation of its efficiency in connection with irradiance. We can see that some of those technologies undergo a positive effect while some others has the opposite effect, i.e. their efficiency decreases as the irradiance is increased.

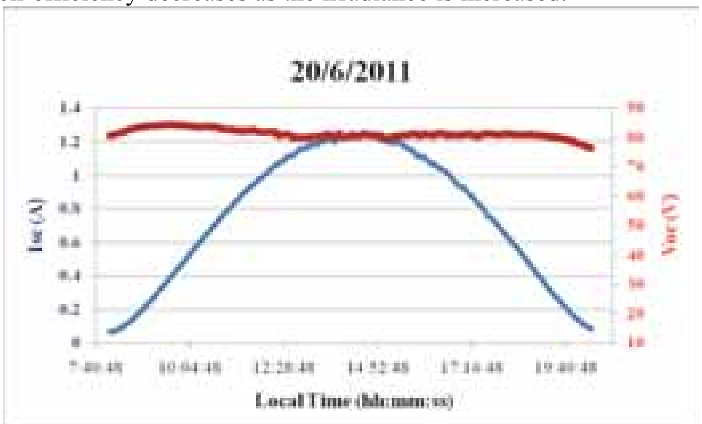

Figure 10: I_{sc} and V_{oc} of the B module measured on June 20, 2011.

4. Measured I_{sc} and V_{oc}

It can be seen that the short circuit current and the open circuit voltage in a whole day. 6 The open circuit voltage changes slightly throughout the day while the short circuit current follows the path of the irradiance. 2

5. Conclusions

We can conclude: First, the modules for determining the rate of degradation should be made of performance data for periods of at least six months. Conclusions will be presented from all measured as a function of irradiance and temperature. Second, the modules periodically degrade over time.

6. Acknowledgements

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