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Standards and Testing Experiments for a Photovoltaic Module

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Abstract

This study examines the effect of irradiance and temperature on the performance of a PV panel. Additionally this study was focused on two main multi-disciplinary topics. Firstly, the standards and testing for solar modules with main focus being on TS EN 61215 related criteria which has regional nonconformities such as Standard Test Condition with respect to the 250C and testing is examined. This scrutinize will also give insight on selecting to examine this particular standard over many other standards related to solar modules with Natural Test Condition (NTC). Secondly, the knowledge of standards is applied to a real life experiment for a photovoltaic module. Voltage values, current values and temperature values were taken and graphs were singled out in this paper. Consequently, the panel which was deemed unfit to meet the standards was subjected to testing in this study. An average cell temperature higher than NOCT value is observed. Higher temperatures in solar modules decreases open circuit voltage, causing the panel to enter the breakdown region where current drops earlier. Thus, due to this aberration we were able to observe the breakdown region for the tested panel.

Keywords: Photovoltaic, Solar panel test, Solar panel standards, Solar panel efficiency, Solar panel performance, I-V graphs of PV panel

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1. INTRODUCTION

Energy consumption of the world is increasing rapidly over centuries due to the growth of technology [1,2,3]. However, even with all of its advantages, with enormous amount of manufacturers all around the globe, standards for PV panels must guarantee cost effectiveness for investors. Standards ensure the products are safe, reliable and of good quality. International standards also give confidence to the customers that the products will do the job they were intended for and they can buy and use a product manufactured anywhere, even in another country safely. They help to bridge the gap between research and marketable services or products. They are also proven to boost productivity and help economy [http1]. This study is set on the several main topics such as that the theory working principles of solar cells and also standards and testing for solar modules with main focus being on TS EN 61215 related criteria and testing. Therefore, the evaluations will also give insight on selecting to examine this particular standard over many other standards related to solar modules. In this respect, the knowledge has been applied to a real life experiment. The experimental study shows what kind of conditions affect the efficiency of a PV panel. Evaluation of the results of the PV panel efficiency in the system. Thereby, these experimental studies has made withtogether the focusing on standards and testing of photovoltaic modules.

1.1. TESTING AND STANDARDS FOR PV PANEL

New electrical standards projects are jointly planned between European Committee for Electrotechnical Standardization(CENELEC) and International Electrotechnical Commission (IEC), and where possible most are carried out at international level. After 20 years of partnership CENELEC and IEC have reconfirmed their longstanding cooperation on 17 October 2016, by signing the Frankfurt Agreement [http2].

These agreements allowed mutual code numbers for standards. IEC standards are also found preceded by EN to indicate that the IEC standard is also adopted by CENELEC as a European standard (e.g. IEC 61215 is also available as EN 61215).

Also worth mentioning; International Organization for Standardization (ISO) is a sister organization to IEC and the European Committee for Standardization (CEN) is a sister organization to CENELEC. CEN and CENELEC are the regional mirror bodies to their international counterparts, IEC and ISO[http3]. National standards for Turkey about PV modules are prepared by Turkish Standards Institution (TSE) and they are a projection of both global standard of ISO and European standards (EN). TSE become a full member of ISO and IEC by 1956, and a full member of CEN and CENELEC by 2012 [http4, http5, http6, http7, http8]. The main standards related to PV modules by TSE are;

•TS EN 61215: Terrestrial photovoltaic (PV) modules - Design qualification and type approval

•TS EN 61646: Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval

•TS EN 61730-1: Photovoltaic (PV) module safety qualification- Requirements for construction

•TS EN 61730-2: Photovoltaic (PV) module safety qualification- Requirements for testing

•TS EN 61345: UV test of photovoltaic (PV) modules

• TS EN 62716: Photovoltaic (PV) modules Ammonia corrosion testing

•TS EN 61701: Salt mist corrosion testing of photovoltaic (PV) modules

For a PV module to be approved (branded) by TSE, it should pass all the related standard testing.This study is focused on TS EN 61215 as it is the main standard for crystalline photovoltaic modules, which is most commonly used. Therefore, in this study, the experimental setup consisted of the solar module which is made by Siemens with product type of SP75 as shown in the Figure 1.

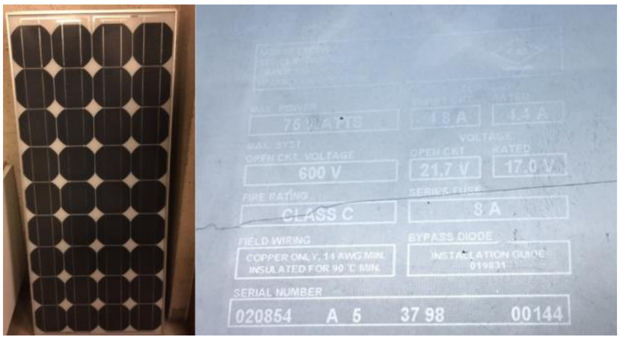

Figure 1. Solar module used in the experiments and technical parameters from the documentation of the panel on the name plate (These values are tested in Standard Test Conditions (STC), which is; 1000W/m² Irradiance, 25 ºC Cell Temperature and Air Mass: 1.5).

Certifications and qualifications of the panel are;

• IEC 61215 • UL-Listing 1703 • TÜV safety class II

• JPL Specification No. 5101-161 • CE mark • FM Certification

The technical data of the panel is as Max Power is 75 Watts, Open Circuit Voltage is 21.7 V

Fire Rating is Class C, and For Current; Short Circuit is 4.8 A, Rated: 4.4 A, For Voltage; Open Circuit is 21.7 V , Rated is 17.0 V and also NOCT (Nominal Operating Cell Temperature) 45±2 ºC . The experiments in this study was conducted in Göztepe/ Istanbul-Turkey that the coordinates are 40º 58' 47.06'N and 29º 3' 36.35'' E as shown in the Figure2.

Figure2. Location of the experiment via the computer calculation program that is combined by the Google Maps JavaScript API

2. RESULTS AND DISCUSSION

The real life experiments support the understanding on what kind of conditions affect the efficiency of a photovoltaic module. Voltage, current and temperature values were taken and graphs were singled out in this paper to understand the efficiency of module as shown in the Figure 3 and Table 1.

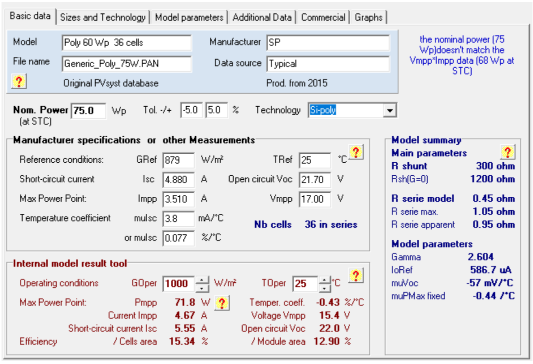

Figure 3. Definition of PV module parameters via computer program

The results are also checked with respect to the TS EN 61215 [4,5]. The standard explains the requirements ofname plate, documentation accompanying to the module and pass criteria thoroughly.As it can be observed in *Figure 1,* the name plate is not complexly readable. As an example according to TS EN 61215-1 section 5.1 each module should include clear and indelible markings of (section 5.1, clause a) "name, registered trade name or registered trade mark of the manufacturer" [4]. Thus, if this module was a test sample for TS EN 61215-1in the state it is in when the experiment was conducted, this flaw alone would cause this module to be deemed not to have met the qualification requirements.

Table 1. The open circuit values of the experiment in 1st of June

Time	Degree	Temperature	V_oc (V)	I_sc (A)	P_sc (W)	T_1sc (°C)	T_2sc (°C)	T_3sc (°C)	T_4sc (°C)	T_sc_abs (°C)
14:34	0°	24°C	18,56	3,86	71,6416	65,9	68,4	68,5	67	67,45
14:42	10°	24°C	18,7	4,02	75,174	60,8	63,8	65,6	65,3	63,875
14:51	20°	24°C	18,9	3,91	73,899	59,1	61,1	61,3	61,7	60,8
15:02	30°	24°C	18,9	3,75	70,875	56,1	56,8	57,1	55,1	56,275
15:11	40°	23°C	18,92	3,38	63,9496	52,9	51,6	53,1	52,8	52,6
15:19	50°	23°C	18,95	3,17	60,0715	52,6	56,5	56,4	52,9	54,6
15:30	60°	23°C	18,95	2,85	54,0075	53,9	54,1	52,9	53	53,475
15:38	70°	23°C	18,92	2,41	45,5972	51,6	53,3	55,2	52,1	53,05

Testing was conducted in different times of the day for multiple days; both for open circuit system and closed circuit system. Experimental results for 1st June 2017 are given by the Table 1 and their evaluations are illustrated by the Figure 4 and Figure 6.

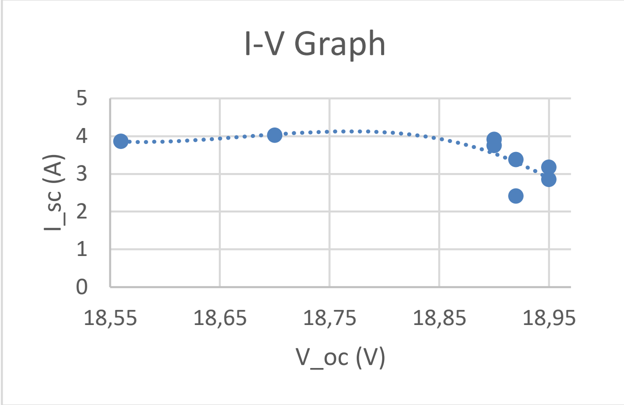

Figure4. The I-V graph of the experiment in 1st of June in the open circuit arrangement

The computed results are also analyzed and compared with the graph of datasheet calculated. These computer evaluations are illustrated on the Figure 5 and Figure 7. Solar radiation power per unit area on the horizontal surface is calculated using by average values of the results in this study. This calculation is given by the Equation 1.

$$E_{inc} = \frac{1000\frac{W}{m^2} * I_{sc(avg)}}{I_{sc(stc)}} = 712{,}240\,\frac{W}{m^2} \qquad (1)$$

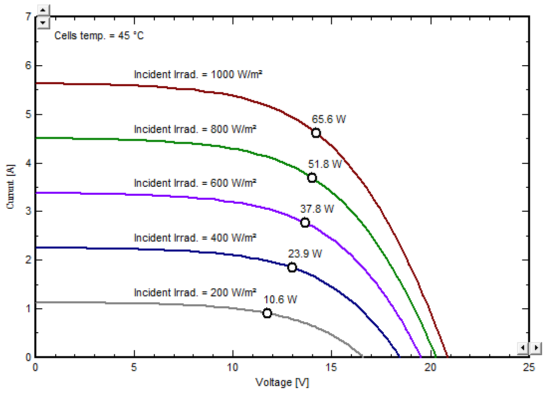

Figure 5. Module behavior according to the incident irradiation (W/m2)

The Figure 5 represents the current-voltage evaluation with respect to incident radiance which is solar power per unit area. The green line in the Figure 5 is compatible with our calculation.

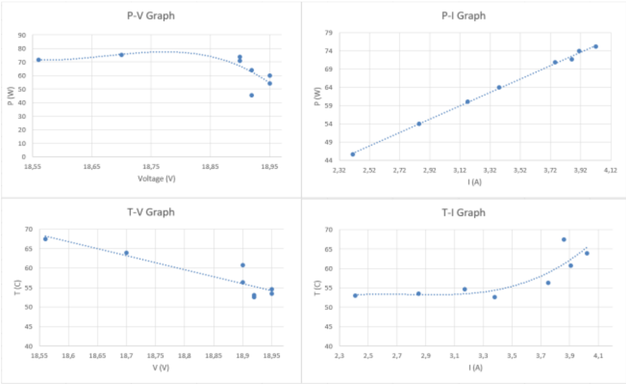

Figure 6. Other graphics for the open circuit arrangement for 1st of June

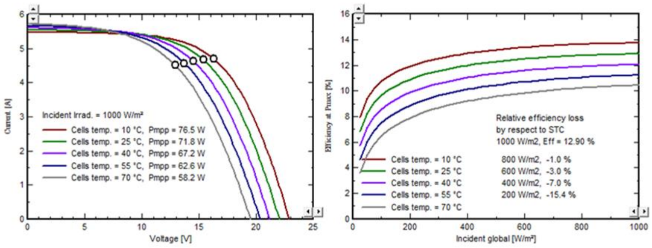

Figure7.Temperature dependency of I-V characteristics (left-hand side) and efficiency (right-hand side) of the module

The performance of the panel was unsatisfactory. Cell temperatures were ranging between 47,33ºC to 67,45ºC, indicating the module was not working properly, as the NOCT of the module is 45ºC. This value is valid under 1000 W/m^2 and wind speed of maximum 1 m/s.

$$T_{leftstring(avg)} = 56{,}525 \text{ °C}$$

$$T_{rightstring(avg)} = 57{,}225 \text{ °C}$$

Moreover, because the panel is time-worn, there is a defect in a cell as it can be observed in *Figure 8.*.As it is dictated in TS EN 61215section 8, clause h; if there are voids or corrosion in any cell, defective area should not exceed 10% of that cells total area. Which in this case it does. Thus this also would cause this module to fail to meet qualification requirements.

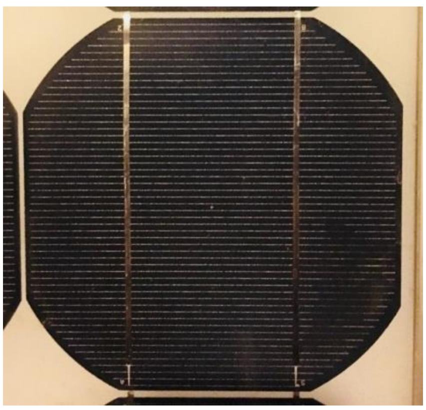

Figure 8. Defective Cell

3. CONCLUSIONS

A degraded panel which was deemed unfit to meet the standards (by visual inspection) was subjected to testing in this study. During the experiment the irradiance was lower and wind speed was higher. Thus an average cell temperature lower then NOCT value should be possible.

Nevertheless, the damaged cell was the reason behind elevated cell temperatures. The main reason for the defect was the EVA (ethylene vinyl acetate), that is a layer which lies under the upper part of the cell. EVA layer helps the cell to resist impacts but if there is a problem with this layer; it is easier for the cell to be oxidized. The damaged part of the cell cannot produce electricity thus it acts as a load, increasing the temperature of itself and the string of the cells it is in; which decreases the performance. Higher temperatures in solar modules decreases open circuit voltage, causing the panel to enter the breakdown region earlier, which results in an earlier current drop. Thus, due to this aberration we were able to observe the breakdown region without a solar simulator as the panel should be designed to not to enter this region under normal outdoor conditions.

Ultimately, the visual inspection, as it was imposed by the standards predicted an unsatisfactory outcome. All of the experimentation done subsequently approves validity of TS EN 61215.

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