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Amorphous and monocrystalline PV degradation investigations by the seaward PV200 solar PV tester

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ABSTRACT

This study, it is aimed to evaluate the degradation of two different types of photovoltaic (PV) technology; a 10 W Monocrystalline PV module and a 7 W Amorphous Silicon PV module. The electrical key parameters; open circuit voltage, short circuit current, maximum power point, current and voltage at maximum power point (MPP), fill factor of 10 W Monocrystalline PV module and MPP, current and voltage at MPP of 7 W Amorphous Silicon PV module. Five years later, key points of 10 W Monocrystalline and 7 W Amorphous Silicon PV modules are gathered via outdoor experiments conducted via the Solar Survey 200R and Seaward PV200 solar PV test devices. The solar radiation and temperature data is gathered via a 200R device, meanwhile, electric data result from the conversion of solar radiation via the PV module received via the Seaward PV200 Solar PV Test Device. The results illustrated that the open circuit voltage increased over time because of the degradation of the modules which also result in changes in almost all key parameters. For the amorphous panel, the study concluded with the voltage distortion rate at the MPP of 7.05% and the annual distortion rate at the MPP of the voltage at 1.41% between the 2016 and 2021 years. On the other hand, the decrease rate of the circuit voltage is -19.05; the annual deterioration rate was determined as -3.81%. For the monocrystalline panel, the voltage at the MPP is -16.67% and the annual voltage reduction rates from -3.33% are also the results of this study.

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1. INTRODUCTION

Monocrystalline and amorphous silicon PV modules have behavioural differences under solar radiation conditions. Monocrystalline silicon panels offer higher efficiency and better performance characteristics. These panels are made of single-crystal silicon and generally have a longer lifespan. They perform better at higher temperatures and need less sunlight. Monocrystalline silicon panels come at a higher cost. Amorphous silicon panels offer lower efficiency and less performance characteristics. These panels are made of polycrystalline silicon and are generally less expensive. They perform better at lower temperatures and need more sunlight. But the lower efficiency of amorphous silicon panels means more space is needed. Therefore, monocrystalline silicon panels are generally preferred because of their higher solar efficiency and longer lifetime, while amorphous silicon panels are more cost-effective and perform better in low-temperature conditions. In other words, monocrystalline silicon panels are less sensitive and more durable. Since the structures of these panels are made of single-crystal silicon, they are less sensitive to the effects of environmental factors such as temperature and humidity changes or mechanical stresses. Therefore, monocrystalline silicon panels have a longer life and require less maintenance. Amorphous silicon panels, on the other hand, are more sensitive and tend to be brittle. Due to their polycrystalline silicon structure, they are more sensitive to environmental factors and can be damaged more easily. Also, amorphous silicon panels have a higher risk of cracking or splintering at low temperatures. However, these differences may vary depending on the usage areas and conditions of the panels [1-4].

Amorphous Silicon 7 W panel can be used for mobile phones, tablets, and other small electronic devices. For amorphous Si 7 W and monocrystalline 10 W panels, street lamps, and other lighting systems; can be used as a power source for agriculture and irrigation systems [1-3].

The materials of PVs, which are generally designed to have a lifespan of about 25 years, temperature, humidity, UV radiation,

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rain, snow, hail, wind, sand, etc. deterioration or different effects are possible [4-16]. The PV degradation rates are reviewed by Jordan and Kurtz and published by NREL (National Renewable Energy Laboratory) [17]. The results of several studies consisting of different PV technologies such as amorphous silicon, cadmium telluride, copper indium gallium selenide, monocrystalline silicon, and multi-crystalline silicon are examined under module and system consideration. The studies are examined under two different periods which are before and after the year 2000. The summary of those studies is listed according to several data points, exposure time in years and degradation percentage by year.

The degradation analysis of a PV system under outdoor conditions via electrical parameters is done by Dhoke and Mengede [18]. The experiments are conducted at The University of Queensland, Australia. The degradation evaluation is done by the module degradation factor stated in the study which varies according to open circuit voltage and short circuit current. They stated that the change in the open circuit voltage is negligible. So, they examined the short circuit current. The degradation is seen as the series resistance is increased and caused a decrease in short circuit current. At last, they stated that an increase in degradation in other words decrease in current causes power generation and it also increases degradation with more speed [19-22].

Distortion/degradation analyzes are important to improve the quality and performance of PV panels. These analyzes are often part of the design and manufacturing processes of the panels and are important to ensure that the panels operate reliably and for a long time. For amorphous Si and monocrystalline silicon panels, these analyzes may differ according to the material properties and structure of the panels. For example, amorphous silicon panels have a higher risk of cracking or splintering at low temperatures, so the influence of these factors is also tested. For monocrystalline silicon panels, the influence of these factors can also be tested due to higher temperature and humidity tolerances [1-4, 23-31].

As can be seen from the literature studies, outdoor testing plays a vital role in measuring the long-term behaviour and lifetime of a PV panel or module. The reliability and lifetime of PV modules are highly dependent on the module construction and the climate in which it is installed. The information gained during this study, order to provide an examination of the main PV durability and reliability [5].

Issues that contribute to power loss at both the array level and the module level are investigated. Namely:

- Calculating the degradation rates of modules and arrays
- Obtaining evidence confirming the absence/presence of potentially induced
- Emphasize durability and reliability specific to the "hot-dry" climate
- Investigating the effects of solar radiation power and temperature on performance degradation

If the PV modules are removed from the field (or replaced) before the end of the warranty period due to any type of failure, including power outage beyond the warranty limit, these failures are classified as severe failures and this is called reliability. On the other hand, if the performance of the PV modules degrades but still meets the warranty requirements, these losses can be classified as soft losses or dissipative losses and are called reliability. Typically, product failures are categorized as infant failures, midlife failures, and wear-out failures [8].

Tests and investigations are carried out to determine the performance of monocrystalline and amorphous silicon photovoltaic modules with equipment such as Seaward PV200 Solar PV Test Equipment, Seaward Solar Survey 200R and Fluke Ti90_9Hz Thermal Imager. In this way, product failures and losses are classified, providing basic data for reliability analysis. In this study, using these test devices, experiments were carried out on outdoor solar radiation for amorphous and crystalline PV panels, as described in the following sections, and the results were examined. Thus, this study is aimed to examine the issues that while the V_{OC} value may increase due to the ageing of the panel or the changes in environmental conditions, the Isc value may decrease at the same time and therefore the performance of the panel may decrease.

2. EXPERIMENT and METHODOLOGY

The performance of two modules that are 10 W monocrystalline and 7 W amorphous silicon photovoltaic modules within the Zuhal ER's opportunities in ITU are conducted via Seaward PV200 Solar PV Test Equipment, Seaward Solar Survey 200R, and Fluke Ti90_9Hz Thermal Imager. The performance and degradation analysis for both modules examined key parameters *Isc*, *Voc*, *Vmp*, *Imp*, and *FF* meanwhile evaluation of other characteristic parameters like photocurrent, series, and shunt resistances are subject to other studies conducted in Table 1. But both panels are five years old, the main difference between amorphous silicon 7 W and monocrystalline 10 W PV panels is in efficiency and cost. Which panels to choose may vary depending on factors such as application and budget. This study, it is aimed to analyze the degradation of these panels, knowing that the efficiency of two panels, which are different due to their structural features, can be used in small applications, such as street lamps, and by using our current facilities. The two PV modules amorphous silicon and monocrystalline silicon PV's specifications are listed in the table below.

Table 1. Monocrystalline Silicon & Amorphous Silicon PV module characteristics.

Monocrystalline 10W		*Amorphous Silicon 7W*	
Property	*Quantity*	*Property*	*Quantity*
P_{mp}	10 W	P_{mp}	7 W
V_{mp}	16.8 V	V_{mp}	15.6 V
I_{mp}	0.60 A	I_{mp}	0.46 A
$V_{OC,\ STC}$	21 V	$V_{DC,\ STC}$	N/A
$I_{SC,\ STC}$	0.66 A	$I_{SC,\ STC}$	N/A
Width	N/A	Width	0.315 m
Length	N/A	Length	0.40 m

The electrical specifications of Seaward PV200 Solar PV Test Equipment are given above via Table 2 and Seaward Solar Survey 200R are given in below via Table 3.

Table 2. Electrical specifications of PV200 PV test equipment [19, 20].

Open Circuit Voltage Measurement	
Measuring range	5.0VDC – 1000VDC
Resolution	0.1VDC maximum
Accuracy	± (0.5 % + 2digits)
Short Circuit Current Measurement	
Measuring range	0.50ADC–15.000ADC
Resolution	0.01 ADC Maximum
Accuracy	± (1% + 2digits)
Operating Current	
Current measuring range	0.1A – 40.0 A DC 0.1A – 40.0 A AC 50-60Hz
Resolution	0.1A
Accuracy	± (5% + 2digits)
DC Operating Power	
Measuring range	0.50 kW – 40.0 kW
Resolution	0.01 kW
Accuracy	± (5% + 5digits)
I-V Curve	
Voltage measurement range	5.0V-1000V
Voltage measurement accuracy	±(0.5%+2digits)
Current measurement range	0.5A-15.0A
Current measurement accuracy	1%
Power measurement range	5W-15kW
Power measurement accuracy	2%

Table 3. Electrical specifications of Solar Survey 200R [21].

Irradiance	W/m^2
Display range	100 – 1500
Measurement range	100 – 1250
Resolution	1
Temperature	°C
Display range	from -30°C to +125°C
Measurement range	from -30°C to +125°C
Resolution	1°C

The Seaward PV200 Solar PV test equipment is used to define the current-voltage curve, open circuit voltage, short circuit current, current and voltage at the maximum power point, and fill factor of the module. The resolution and the measurement range of each parameter are given in Table 3. Besides, Seaward Solar Survey 200Ris used to define the solar radiation in which the measurement can be conducted with 1 W/m^2 resolution and measurement range of 100 W/m^2 to 1250 W/m^2, and the temperature of ambient and surface of PV module in which the measurement can be conducted with 1° resolution and measurement range of -30°C to +125°C.

Both devices are connected via a wireless connection so the temperature and solar radiation data are stored within the same store which is the PV200 SD card. The experimental setup, measurement devices, and 26°inc lined PV modules are given in Figure 1.

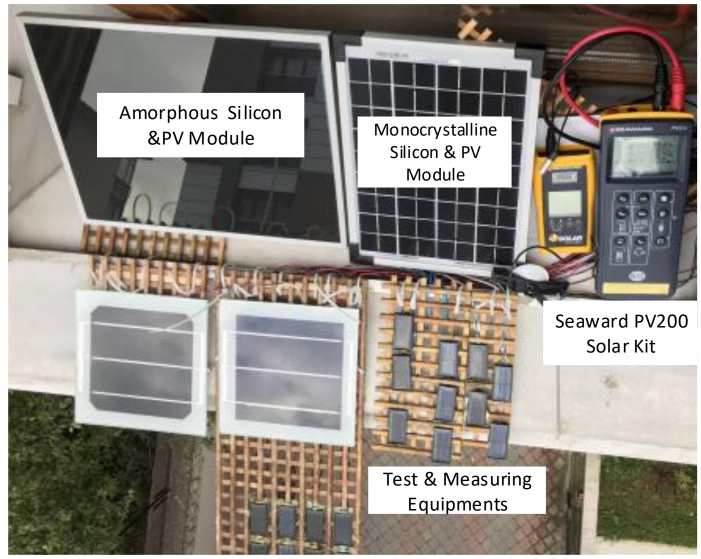

Fig. 1. Seaward PV200 Solar PV test equipment kit and experimental setup.

3. EXPERIMENTAL RESULTS

Warranty periods may vary depending on the quality of the materials used in the production of the panels, the production process, the design, and other factors. Many manufacturers specify the warranty period of monocrystalline panels as 25 years. Some manufacturers offer a similar warranty period for amorphous Si panels. However, the warranty period of amorphous Si panels can often be shorter than monocrystalline panels. Warranty periods are determined by the results of manufacturers' performance tests and the rate of decrease in power generation of the panels. Generally, panels are required to provide a certain minimum power output during their warranty period. This is important to guarantee the performance of the panels and to provide users with a safe application.

The performance and degradation experiments are conducted via PV200 PV Test Equipment and Seaward Solar Survey 200R in the Bostanci district in Istanbul, Turkey during the time of the pandemic. Each experiment was done during the sunshine duration to examine the daily performances of each panel. However, the same tests were repeated on other days and average results were given. Solar intensities are between 678,30 W/m^2 and 845.02 W/m^2, 362.84W/m^2 and 858.30 W/m^2 as given in Table 4 and Table 5 in Appendix A and B, respectively.

For both modules, the electric results are as expected regarding the average solar radiation data. The experiments were done for both the 10 W monocrystalline silicon PV module and the 7 W amorphous silicon PV module. The current-voltage data was measured via PV200 device and the average solar radiation, ambient, and PV surface temperature data was obtained via Solar Survey 200R. The graphs for the amorphous module and monocrystalline modules are given in Figure 2 and Figure 3, respectively.

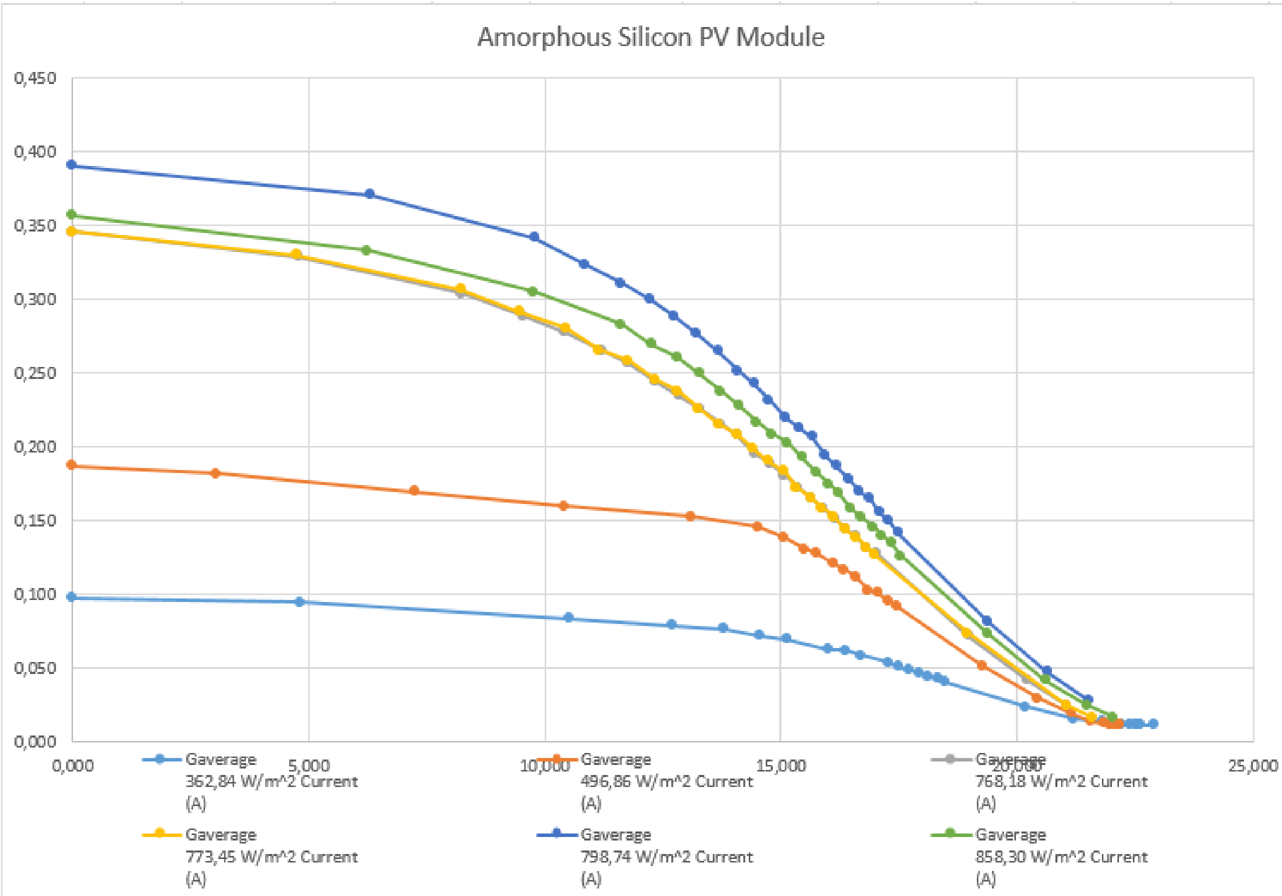

Fig. 2. I-V Characteristics of Amorphous Silicon PV Module.

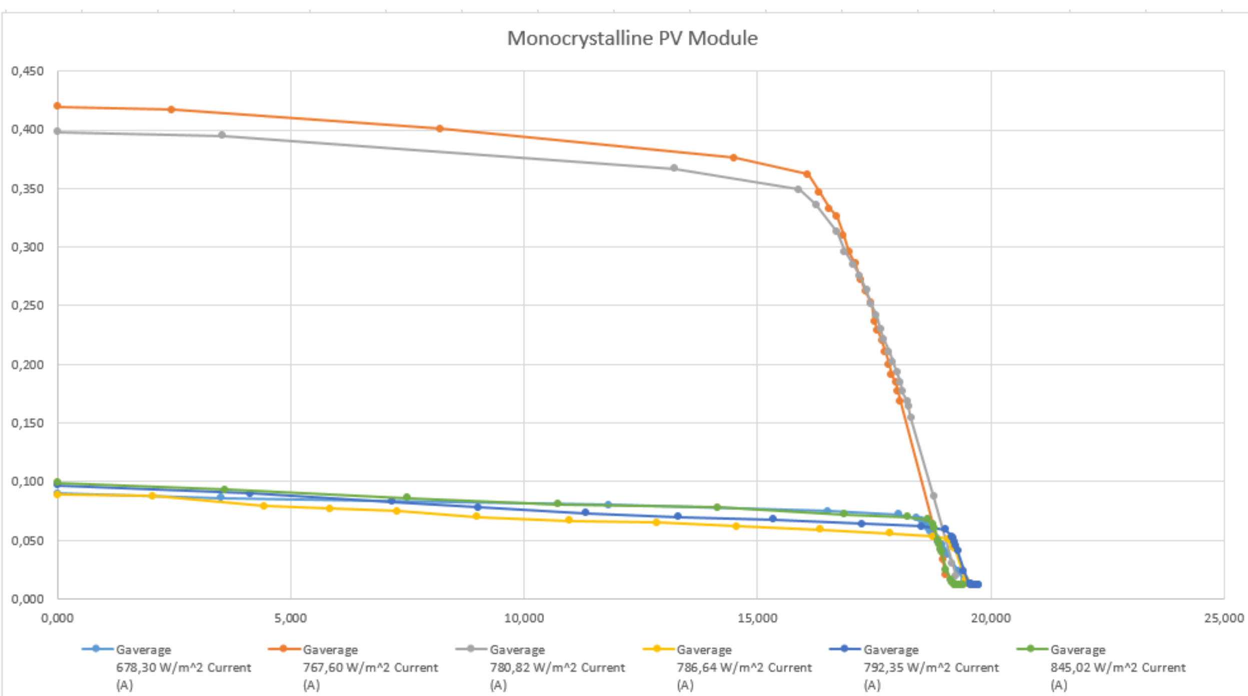

Fig. 3. I-V Characteristics of Monocrystalline PV module.

It is known that the current-voltage data is not only related to solar radiation. Therefore, the effect of ambient temperature so the module temperature efficiency is also examined by considering data such as open circuit voltage, short circuit current, and fill factor. The data in question were drawn in graphs, processed and visualized for evaluation. As a result of these investigations, it was observed that the irradiance changes have little or no effect on the V_{OC} differences. On the contrary, it was determined that for each radiation data set, the *c-Si* panel short-circuit current started to increase relative to the *a-Si* panel short-circuit current.

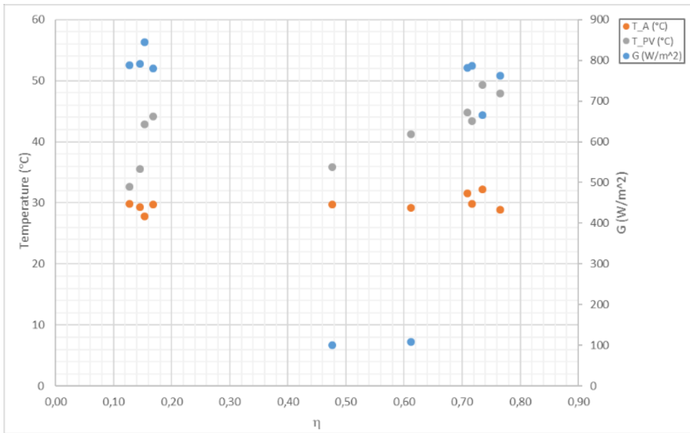

Fig. 4. Temperature correlations for monocrystalline PV module.

As shown in Figure 4 the association with the ambient temperature was observed to be in the narrow band range of 27.78^0C to 32.21^0C while the 10 W Monocrystalline PV module temperature showed variability. A major reason for this is that the radiation is not in the narrow band range but within a rather variable range of 108.70 W/m^2 to 844.10 W/m^2. In addition, the effect of the factors affecting the change in panel temperature is shown in Figure 4. The highest efficiency is 0.77 where solar radiation is 761.7 W/m^2; module and ambient temperature are 47.88^0C and 28.91^0C respectively. For both modules, it can be seen that changes in solar radiation and the ambient temperature affect the module temperature and so the efficiency of the PV device by affecting the module key parameters. Figure 4 and Figure 5 show that even though there is a slight change in ambient temperature the PV module temperature changes.

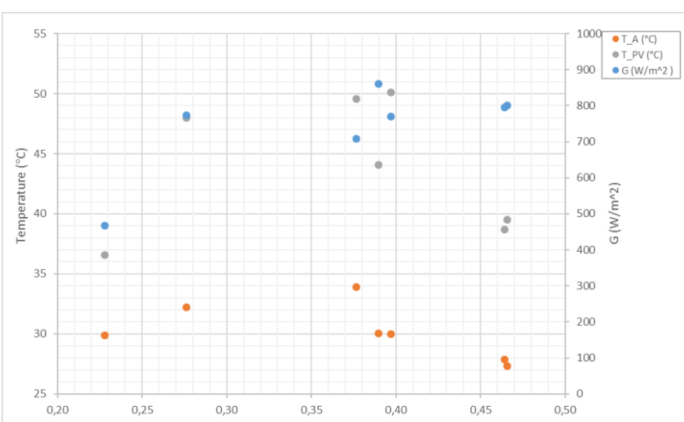

Fig. 5. Temperature correlations for amorphous silicon PV module.

The association with the ambient temperature was observed to be in the narrow band range of 27.34^0C to 33.93^0C, while the 7 W Amorphous Silicon PV module temperature showed variability. A major reason for this is that the radiation is not in the narrow band range but within a rather variable range of 466.90 W/m^2 to 860.40 W/m^2. In addition, the effect of the factors affecting the change in panel temperature is shown in the graph. The highest efficiency is 0.47, where solar radiation is 800W/m^2, and module and ambient temperature are 39.49^0C, and 27.34^0C respectively.

On the other hand, the degradation rate of parameters for five years period of the Monocrystalline and amorphous Silicon PV module according to the degradation rate of parameters equation and yearly degradation rate of parameters equation. Both modules have data sets from 2016 manufacturer datasheet values, 2021 when the experiments were conducted via PV200. Both key parameters are considered under standard test conditions which are 1000W/m^2 insulation and 25^0C of temperature.

Table 6. Monocrystalline silicon PV module degradation.

Property	*New product 2016*	*Measured via PV200 2021*	*Degradation Rate (%)*	*Yearly Degradation Rate (%)*
I_sc (A)	0.66	0.49	25.76	5.15
V_oc (V)	21.00	25	-19.05	-3.81
V_mp (V)	16.80	19.6	-16.67	-3.33
I_mp (A)	0.60	0.43	28.33	5.67
P_mp (W)	10.08	8.43	16.39	3.28
FF	0.73	0.69	5.40	1.08

The decrease in the values of parameters is caused by the degradation of the electric characteristics of the module over time. Due to Table 6, the evaluation resulted in negative values of the degradation rate of open circuit voltage of -19.05% between 2016 and 2021 and also the yearly degradation rate of open circuit voltage of -3.81% between 2016 and 2021. Also, evaluation results in negative values of the degradation rate of voltage at a maximum power point of -16.67% between 2016 and 2021 and also the yearly degradation rate of voltage at MPP of -3.33% between 2016 and 2021. These results are because the open circuit voltage value increased over time caused by the degradation of the hotspot on the PV module. This is the negative value we have determined, negative is referred to as value. This means declining performance over time.

Table 7. Amorphous silicon PV module degradation.

Property	*New product 2016*	*Measured via PV200 2021*	*Degradation Rate (%)*	*Yearly Degradation Rate (%)*
I_sc (A)	N/A	0.36	N/A	N/A
V_oc (V)	N/A	27.2	N/A	N/A
V_mp (V)	15.60	14.5	7.05	1.41
I_mp (A)	0.46	0.27	41.30	8.26
P_mp (W)	7.18	3.92	45.44	9.09
FF	N/A	0.40	N/A	N/A

The initial value of short circuit current and open circuit voltage is not available for amorphous silicon PV modules. Due to Table 7, the decrease in the values of parameters is caused by the degradation of the electric characteristics of the module over time. Evaluations result in values of the degradation rate of voltage at a maximum power point of 7.05% between 2016 and 2021, and also the yearly degradation rate of voltage at MPP of 1.41% between 2016 and 2021. As the current at the maximum power point does not change over time the maximum power also results in negative values so the fill factor.

The effect of open-circuit voltage on performance and degradation analysis can be expressed along with other parameters. An increase in the V_{OC} parameter does not always mean an increase in performance, and a decrease in current does not always indicate an increase in performance. The series resistance of the cell gives information about performance and degradation which is related to open circuit voltage. An increase in the series resistance causes a reduction of the output current of the PV cell which is a sign of the degradation of the PV cell and so the PV module. Also in 2017, Dhoke and Mengede shared module degradation factor correlation which is calculated regarding the short circuit current and open circuit voltage at standard test conditions and operational conditions. The open circuit voltage gives information about the performance and degradation of the PV module [18]. The increase or decrease of *Voc* is not states directly the performance rise. An increase in *Voc* and current may result in a performance rise. These results are because the open circuit voltage value increased over time caused by the degradation of the hotspot on the PV module. For the two modules in this study, individual IV curves were modelled, and radiation and temperature considerations were made. Both modules showed deterioration of < 0.5 %/year, and we can say that this deterioration is mostly related to decreases in short-circuit current.

4. CONCLUSION

In this study, the degradation of 10 W monocrystalline and 7 W amorphous Silicon PV modules are evaluated experimentally as well via Seaward PV200 solar PV test equipment, Seaward Solar Survey 200R. The degradation rate and yearly degradation rate are deduced for both modules and between the years 2016-2021 for key parameters such as short circuit current, open circuit voltage, current and voltage at the maximum power point, maximum power, and fill factor. It is seen that the decrease in the values of parameters is caused by the degradation of the electric characteristics of the module over time. We think that the crystal will suffer much more from long-term degradation than any modern thin film and that in hot weather, thin-film degradation will be relatively small. Poly-Si modules show a wider range of degradation rates than other modules; this may be an artefact due to most modules from weak manufacturer parameters. However, the open circuit voltage value increased over time caused by the degradation of hotspots on the PV module.

Consequently, investigating the degradation mechanisms of amorphous and mono PV panels in more detail can help you better understand how degradation occurs. This can help develop more effective degradation prevention strategies. In addition, the effects (such as hot points) observed at the end of the study were also reflected in the PV panel performance considerations. With these aspects, the work contains originality.

Appendix

A. Current-voltage data of Monocrystalline Silicon PV module.

Monocrystalline PV Module											
Gaverage 678.30 W/m²		*Gaverage 767.60 W/m²*		*Gaverage 780.82 W/m²*		*Gaverage 786.64 W/m²*		*Gaverage 792.35 W/m2*		*Gaverage 845.02 W/m²*	
V (V)	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*
0	0.09	0	0.42	0	0.4	0	0.09	0	0.1	0	0.1
3.52	0.09	2.45	0.42	3.55	0.4	2.03	0.09	4.14	0.09	3.6	0.09
11.81	0.08	8.2	0.4	13.22	0.37	4.43	0.08	7.17	0.08	7.49	0.09
16.52	0.08	14.51	0.38	15.89	0.35	5.83	0.08	9.01	0.08	10.73	0.08
18.02	0.07	16.09	0.36	16.26	0.34	7.28	0.08	11.32	0.07	14.14	0.08
18.42	0.07	16.33	0.35	16.71	0.31	9	0.07	13.31	0.07	16.85	0.07
18.51	0.07	16.54	0.33	16.87	0.3	10.97	0.07	15.34	0.07	18.21	0.07
18.59	0.06	16.7	0.33	17.05	0.29	12.84	0.07	17.24	0.06	18.64	0.07
18.66	0.06	16.85	0.31	17.19	0.28	14.57	0.06	18.52	0.06	18.76	0.06
18.72	0.06	16.97	0.3	17.34	0.26	16.36	0.06	19.03	0.06	18.79	0.06
18.76	0.06	17.1	0.29	17.43	0.25	17.84	0.06	19.17	0.05	18.87	0.05
18.85	0.05	17.22	0.27	17.55	0.24	18.76	0.05	19.2	0.05	18.89	0.05
18.87	0.05	17.32	0.26	17.64	0.23	19.08	0.05	19.21	0.05	18.91	0.05
18.92	0.05	17.44	0.25	17.7	0.22	19.16	0.05	19.26	0.05	18.92	0.04
18.96	0.05	17.51	0.24	17.82	0.21	19.21	0.04	19.3	0.04	18.94	0.04
18.96	0.04	17.58	0.23	17.89	0.2	19.23	0.04	19.43	0.02	19.05	0.03
18.99	0.04	17.67	0.22	17.99	0.19	19.46	0.02	19.55	0.01	19.15	0.02
19.03	0.04	17.74	0.21	18.07	0.19	19.52	0.01	19.58	0.01	19.18	0.01
19.07	0.04	17.82	0.2	18.1	0.18	19.54	0.01	19.58	0.01	19.21	0.01
19.29	0.02	17.87	0.19	18.21	0.17	19.59	0.01	19.63	0.01	19.22	0.01
19.44	0.02	17.96	0.19	18.24	0.16	19.59	0.01	19.67	0.01	19.24	0.01
19.52	0.01	18.01	0.18	18.29	0.15	19.62	0.01	19.7	0.01	19.31	0.01
19.6	0.01	18.06	0.17	18.78	0.09	19.63	0.01	19.72	0.01	19.32	0.01
19.62	0.01	18.97	0.03	19.17	0.03	19.66	0.01	19.74	0.01	19.37	0.01
19.63	0.01	19.04	0.02	19.25	0.02	19.71	0.01	19.74	0.01	19.4	0.01
19.26	0	19.3	0	19.54	0	19.7	0	19.71	0	19.39	0

B. Current-voltage data of Amorphous Silicon PV module.

Amorphous Silicon PV Module											
Gaverage 362.84 W/m²		Gaverage 496.86 W/m²		Gaverage 768.18 W/m²		Gaverage 773.45 W/m²		Gaverage 798.74 W/m²		Gaverage 858.30 W/m²	
V (V)	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*	*V (V)*	*I (A)*
0	0.1	0	0.19	0	0.35	0	0.35	0	0.39	0	0.36
4.8	0.1	3.04	0.18	4.78	0.33	4.74	0.33	6.32	0.37	6.25	0.33
10.54	0.08	7.25	0.17	8.25	0.3	8.22	0.31	9.78	0.34	9.77	0.31
12.69	0.08	10.4	0.16	9.54	0.29	9.47	0.29	10.84	0.32	11.63	0.28
13.8	0.08	13.09	0.15	10.42	0.28	10.43	0.28	11.61	0.31	12.26	0.27
14.56	0.07	14.51	0.15	11.21	0.27	11.15	0.27	12.23	0.3	12.8	0.26
15.13	0.07	15.06	0.14	11.77	0.26	11.77	0.26	12.73	0.29	13.28	0.25
16.02	0.06	15.5	0.13	12.33	0.25	12.33	0.25	13.22	0.28	13.72	0.24
16.37	0.06	15.76	0.13	12.84	0.24	12.81	0.24	13.68	0.27	14.12	0.23
16.71	0.06	16.13	0.12	13.28	0.23	13.25	0.23	14.08	0.25	14.5	0.22
17.26	0.05	16.33	0.12	13.73	0.22	13.67	0.22	14.43	0.24	14.82	0.21
17.49	0.05	16.58	0.11	14.08	0.21	14.06	0.21	14.74	0.23	15.15	0.2
17.71	0.05	16.86	0.1	14.43	0.2	14.41	0.2	15.1	0.22	15.45	0.19
17.92	0.05	17.05	0.1	14.76	0.19	14.73	0.19	15.39	0.21	15.74	0.18
18.12	0.04	17.28	0.1	15.08	0.18	15.07	0.18	15.67	0.21	16.01	0.18
18.33	0.04	17.47	0.09	15.36	0.17	15.33	0.17	15.94	0.19	16.22	0.17
18.48	0.04	19.27	0.05	15.63	0.17	15.63	0.17	16.17	0.19	16.47	0.16
20.19	0.02	20.44	0.03	15.91	0.16	15.86	0.16	16.44	0.18	16.69	0.15
21.2	0.02	21.15	0.02	16.14	0.15	16.12	0.15	16.68	0.17	16.95	0.15
21.83	0.01	21.58	0.01	16.38	0.14	16.37	0.14	16.88	0.17	17.13	0.14
22.2	0.01	21.85	0.01	16.58	0.14	16.6	0.14	17.09	0.16	17.34	0.14
22.39	0.01	21.97	0.01	16.79	0.13	16.81	0.13	17.28	0.15	17.54	0.13
22.5	0.01	22.05	0.01	17.04	0.13	16.99	0.13	17.48	0.14	19.38	0.07
22.56	0.01	22.1	0.01	18.97	0.07	18.95	0.07	19.38	0.08	20.61	0.04
22.6	0.01	22.12	0.01	20.22	0.04	21.04	0.03	20.64	0.05	21.48	0.03
22.90	0.01	22.17	0,01	21.04	0.03	21.58	0.02	21.53	0,03	22.03	0.02

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