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Effect of Dust on PV Performance in Samsun

Vedat Keskin[1*], Musab Kurşun [1]

[1]Renewable Energy/science Institute,Ondokuz Mayis University, Samsun, Turkey
[*]Corresponding author: vedatkeskin@omu.edu.tr
[+]Speaker: vedatkeskin@omu.edu.tr
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Abstract – Here we discussed the electrical performance of Photovoltaic (PV) panels of natural dust accumulation by wind, bird droppings etc., over time which is of great importance especially for the areas where the rain density are high [1, 2]. In this study, the effect of the pollution on the solar power plant panels of 114 kW belonging to Teknopark located in the campus of Ondokuz Mayis University, Samsun, is analyzed.
The values of the panels exposed to radiation depending on the three different fall angles of the sun three times in a day were read and interpreted. In order to measure the energy loss due to pollution, the values of 4 inverters, have been examined. A comparison was made between the values of cleaned panel array connected to the inverter 1 and of the not cleaned panel array connected to the inverter 2.

Module readings(power, current, volt) will decrease as they accumulate over time. The angle of inclination of the PV modules was investigated on a single angle because the panels of the plant we measured were stationary. The effect of pollution on the efficiency was examined by cleaning the panels at specific periods; once every three weeks and once a month [3]. In the readings, efficiency losses were observed as 3% weekly for 2 weeks and 5.5% for 4.5 weeks.

In this study two important parameters were clarified. First, the uncertainties related to dust for a long period of time and evaluated the results. Second, the frequency of cleaning according to the optimized time schedule and acceptable efficiency loss limits over time.

Keywords – Dust effect, Pv module, Pollution, radiation, efficiency

I. Introduction

The world population is increasing and the need for increased energy needs to be met. The fact that fossil fuels bring environmental pollution and are consumed, that is non-renewable, has led experts to find different alternatives that can meet their energy needs. New energy sources are the most important features of being friendly to the environment, being renewable and meeting the needs to some extend. Without any doubt, the sun is at the forefront of energy resources that are most suitable for this purpose.

Solar energy has different uses. However, conversion to electric energy through photovoltaic modules is the most common application. PV modules are influenced by environmental factors such as temperature, slope angle, pollution, radiation, and geographical factors (longitude, latitude and solar intensity) during energy conversion.. In recent years, the energy converted by the panel has been found to have significant effects on the energy efficiency of the modules, [4]. Similarly, the maximum output power for the PV system was reduced by 13% after one month of open work in the Abu Dhabi town of Arab Emirates, [5]. In addition, the output of PV modules has been found to decrease by at least 5.8% in only 20 days in Hermosillo, Mexico [6].

This data shows that PV efficiency is significantly reduced particularly in deserts and dusty areas. So dust cleaning is important and necessary in order to increase energy efficiency in these areas. In addition, intensive dust exposure of PV modules has been found to be significantly related to installation and slope angle [7].

When considering the importance of cleaning dirty panels in deserts where water shortage is a problem, one should reduce the water use to a reasonable level. This study on the cleaning frequency of PV modules has been carried out for the first time in Samsun, comparing two different module series, one being dirty and the other being clean.

As a result of this work can help enterpreneur to determine the cleaning frequency based on two or three parameters. More importantly, if the efficiencies of Solar panels are kept constant, the need to fossil fuels will decrease which is problematic to the country's economy and environment. Thus eliminating the effect of pollution can make operation of PV modules more efficient.

II. Materials and Method

Environmental conditions

The climate data of the place where the experiment was carried out were obtained from the records of the General Directorate of Meteorology and the Samsun.

Meteorology Regional Directorate. Table 1 givess the average of long-term climate data, [8].

The climatic characteristics of the province of Samsun reflect the temperate and climate characteristics of the Black Sea Region of Turkey. According to averages for many years, most of the rain falls in winter and autumn, but in summers and springs rainfall are comparably less. When the data were analyzed, it was seen that in the period experiment was conducted, there was no significant difference during first year on the average.

Long term montly average temperatures are 6.6 °C in February and 20.1 °C in June. These values were seen in June, 2018, as 20.5 and in February, 2017, as 5.8 °C, and 9.0 °C and February, 2018, respectively. In Samsun province, a total of 564.8 mm rainfall has been measured as averages for many years. The highest monthly rainfall averages are, October,85.6 mm and the lowest total rainfall average is in June with 47.8 mm. The lowest total rainfall in the years 2017-2018, when the experiment was conducted, was in June with 35.8 and 8.2 mm respectively, while the highest total rainfall occurred in October with 96.5 mm and November and 128.8 mm respectively.

For the long-term average, the annual relative humidity average was 73.6%, compared to 70.5% in 2017-18 [9].

Table 1*: Long-term average climate data for Samsun.*

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
Avg. Temperature (°C)	6.6	7.1	8.1	11.5	15.2	19.5	22.3	22.4	19.6	15.8
Min. Temperature (°C)	3.3	3.6	4.4	7.8	11.7	15.7	18.6	18.7	15.8	11.9
Max. Temperature (°C)	10	10.7	11.9	15.3	18.7	23.3	26	26.2	23.4	19.7
Avg. Temperature (°F)	43.9	44.8	46.6	52.7	59.4	67.1	72.1	72.3	67.3	60.4
Min. Temperature (°F)	37.9	38.5	39.9	46.0	53.1	60.3	65.5	65.7	60.4	53.4
Max. Temperature (°F)	50.0	51.3	53.4	59.5	65.7	73.9	78.8	79.2	74.1	67.5
Precipitation / Rainfall (mm)	71	59	62	58	48	46	32	35	51	81

Module Properties

The array consisted of 132 crystalline silicon wafer-based photovoltaic modules that were exposed to a long-term continuous exposure for 3 years without cleaning. The system as a whole, was produced by a single manufacturer, but were mounted at different times..

Polycrystalline pillars, electrical, optical and structural features are the same as monocrystalline pillars. The sizes of the veins are directly proportional to the quality of the crystals. The discontinuity between the veins plays an important role, especially in transferring electrical charge carriers.

MODULE TYPE	Polycrystalline 260 Wp PV Module
Total number of modules	440 units
Module dimension (LxWxH)	1650 mm x990 mm x40 mm
Weight	18.5 kg
Number of drain holes	24
Cable	2 pieces of solar cable 4mm²
Plug-in connection	MC4
MODULE ELECTRİCAL VALUES	
Panel maximum power – Pmax	260 Wp
Power tolerance	0 - +6 Wp
Nominal power voltage – Vmp	30,3 V
Nominal power current – Imp	8,59 A
Cell operating temperature range	-40 - +85 ºC
Maximum system voltage	1000 V
Temperature coefficient [V] [I] [P]	-0,32% ºC/ 0,05% ºC / -0,42% ºC
Maximum series fuse ratio	15 A

Table 2: Technical specifications and schematic view of module type.

The electrical properties of multicrystalline material are degraded in proportion to the size of the reduced vessel; resulting in a small efficiency when compared to monocrystalline. However, multi-crystalline silicon production technologies are easier and costly. Since the cost is low, it is found more in the market and it is preferred by investors. Pouring method is used when producing polycrystalline silicon material. In the production phase, most of the processes performed with the single-crystalline silicon are applied exactly the same. Molten semiconducting silicon is poured into molds and expected to cool. The blocks obtained from the molds are cut in a square shape. The cost of solar cells obtained from the materials produced by this method is less and efficiency is low between 14% and 16, [10].

Cleaning Process

Modules were installed ın 2015 and were not cleaned until June 2018. Values were read from 4 different inverters every 2-3 days for about one month before cleaning. Total 132 panels were cleaned in order to read and compare two inverter values that the triplet array. Dust on PV modules were removed by hand using microfiber cloth, chlorine-free water, soft-tipped brush and sponge, [11].

Fig. 1: an image before and after cleaning.

Fig.2: Visual comparison of the cleaned area to the contaminated area.

Specifications and location

Fig.3: Satellite picture of the area where the plant is located.

Table 3: Technical specifications of GES belonging to Samsun Technopark

Project owner company	Name	Samsun Technology Development Zone Manager Joint Stock Company		
	Address	OMU Atakum Campus		
The project	Name	SAMSUN TEKNOPARK GES		
	Land Address	OMU Atakum Campust Atakum/Samsun		
	Sheet no	–	Parcel No	–
PAFTA NAME	PLANT GENERAL LAYOUT PLAN-1			
PAFTA NO	TKNPRK_1	SCALE	1/100	
DESIGNER	SELMAN AKAY	DATE	09.03.2015	
MODULE NUMBER AND POWER	İNVERTER NUMBER AND POWER	DC POWER	AC POWER	
440 x 260 kWp	2 x 27.6 kWp 2 x 20.0 kwe	114,4 kWp	95,2 kWe	
Elektric branch engineer	Signature and confirmation		Sheet no: 1/6	
NAME	SELMAN AKAY		E	
CERTİFİCATE NO	1503020012			
ROOM REGİSTİRATİON NO	61722			

Results and discussion

A typical module with a flat lid glass is shown in Figure 4 before cleaning, (it was very dirty), and after manual cleaning. Low voltage and current values indicate that their values are falling due to cloudiness, [12]. After manual cleaning, short current I_{sc} and power output Wp cautiously increased the power and nominal I - V curve shape was recorded. In some previous studies it has been shown that cleaning with a high-pressure water spray system does not provide an additional improvement to flat glass modules. [13]. However, it was seen that small changes were observed ın textured modules, [14]. It seems that ın measurıng the pollution effect on flat glass PV panels, manuel cleaning is the right choice. In our work, pollution effect on the yield of solar panels is very low compared to the area exposed to desert effect. Therefore, the decrease in efficiency loss does not meet the cleaning cost offered by cleanıng firms.

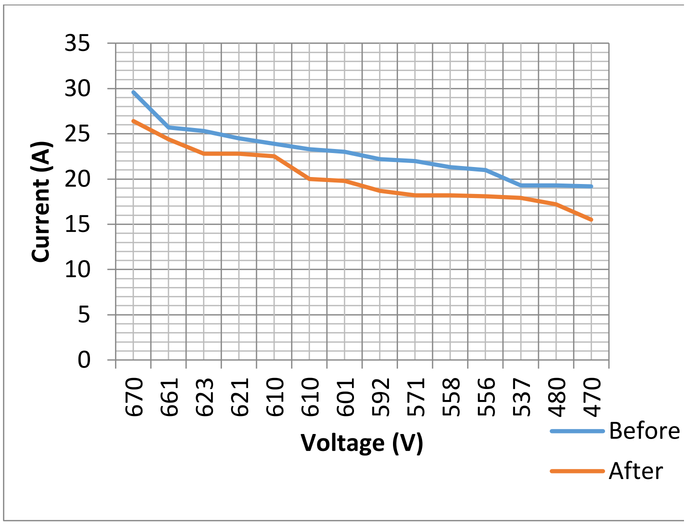

Fig.4: current voltage change

$$P_{max,loss} = \frac{(P_{clean} - P_{dirty})}{P_{clean}} \times 100$$

where P_{clean} are the maximum power of each private units and P_{dirty} is the maximum power of the entire dirty module.

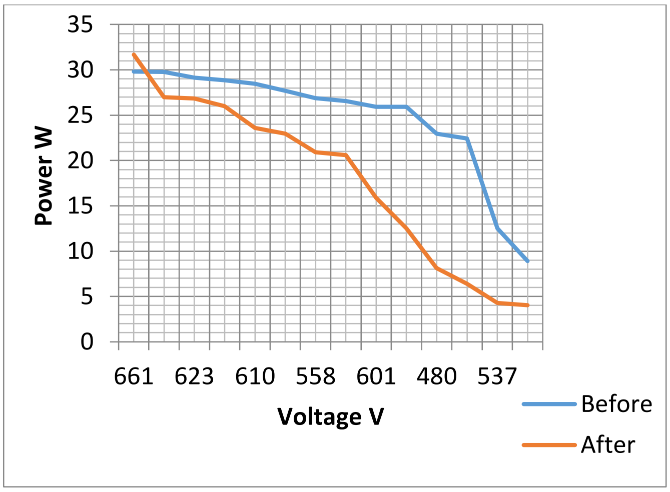

Fig.5: Current power change

The current-voltage and power-voltage curves of a 260-watt polycrystalline panel and the temperature-dependent P (power), current (I) and voltage (V) variations are shown below. [15].

IV. CONCLUSION

The effects of long-term dust on the performance of 132 exposed silicon-based PV modules exposed for more than 3 years in a temperate and rainy climate have been investigated. Manual cleaning is preferred because different cleaning methods will be more expensive and there is no difference in efficiency. Since the modules are flat glass, they do not need any extra treatment. Readings were made before any treatment. It was then cleaned with a period of three

Table 4: Current, Voltage, power and healing values

day	Current (A)			Voltage (V)		Power (kWh)	P (imp)			
	I clean	I Dirty	Imp x4	V clean	V dirty	Vmp	P dirty	P clean	P max	P_l
1. day	29.6	26.4	8.59	661	670	30.3*22	31.67	29.79	34.32	5.93
2. day	25.7	24.4	8.59	670	660	30.3	29.77	26.98	34.32	9.37
3. day	25.3	22.8	8.59	621	607	30.3	29.13	26.85	34.32	7.82
4. day	24.5	22.8	8.59	610	606	30.3	28.86	25.99	34.32	9.94
5. day	23.9	22.5	8.59	558	595	30.3	28.45	25.59	34.32	10.3
6. day	23.3	20	8.59	592	594	30.3	27.7	24.95	34.32	10.10

weeks and values were read. Comparisons were made between the readıngs before and after cleaning. After cleaning, the overall healing of P_{max} ranged from 5.9% to %10.10 on average (shown above), which meant a mean contamination rate of 0.32% at P_{max} and 0.25% at Isc. This relatively low value can be explained by the fact that rain in this area above the average annual rainfall of 733 mm are not considered to be a moderate rain or wind effect which usually prevents large dirt accumulation on the modules. Therefore, the average losses from pollution calculated in this long-term (> 3 years) are lower than those calculated from studies carried out for shorter periods and for high dust or sand content in selected geographical areas. Two independent systems with the same characteristics were observed, leaving one as clean as the other, and the difference between the two sequences was observed.The yield results are lower than desired. It was predicted that since the study area is 267 meters above the sea level with the presence of trees and steeps on the front side, pollution must be due to only wind-borne dust.

REFERENCES

[1] M.R. Maghmi, H. Hizam, C.Gomes, M.A. Radzi, M.I.Rezadad, S. Hajighhorbani, Power loss due to soiling on solar panel: A review, Solar Energy. 59 (2016) 1307–1316.

[2] H. M. Ali, M. A. Zafar, M. A. Bashir, M. A. Nasır, M. Ali, and A. M. Sıddıqui, Effect of dust deposition on the performance of photovoltaic modules in city of Taxila, Pakistan, Thermal Science, 21, 2 (2017) 915-923.

[3] Y. Jiang, L. Lu, and H. Lu, A novel model to estimate the cleaning frequency for dirty solar photovoltaic (PV) modules in desert environment, Solar Energy. 140 (2016) 236–240.

[4] Rehman, S., El-Amin, I., Performance evaluation of an off-grid photovoltaic system in Saudi Arabia. Energy 46 (2012) 451–458.

[5] Al Hanai, T., Hashim, R.B., El Chaar, L., Lamont, L.A.,. Environmental effects on a grid connected 900W photovoltaic thin-film amorphous silicon system. Renew. Energy 36, (2011) 2615–2622.

[6] Cabanillas, R.E., Munguía, H., Dust accumulation effect on efficiency of Si photovoltaic modules. J. Renew. Sustain. Energy 3 (2011) 043114.

[7] Hegazy, A.A.,. Effect of dust accumulation on solar transmittance through glass covers of plate-type collectors. Renew. Energy 22, (2001) 525–540.

[8]https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=SAMSUN (28.06.2018)

[9] (Sirat, A., Sezer, İ., samsun ekolojik koşullarında bazı iki sıralı arpa (Hordeum vulgare convdistichon) çeşitlerinin verim unsurları ile kalite özelliklerinin incelenmesi. Akademik ziraat Dergisi 6 (1) : (2017) 23-24

[10] Boz O., Günümüzün alternatif enerji kaynağı güneş pilleri, Yüksek Lisans Tezi, Balıkesir Üniversitesi Fen Bilimleri Enstitüsü, Balıkesir. (2011).

[11] Appels, R., Lefevre, B., Herteleer, B., Goverde, H., Beerten, A., Paesen, R., De Medts, K., Driesen, J., Poortmans, J.,. Effect of soiling on photovoltaic modules. Sol. Energy 96 (2013) 283–291.

[12] Schill, C., Brachmann, S., Koehl, M.,. Impact of soiling on IV-curves and efficiency of PV-modules. Sol. Energy 112 (2015) 259–262.

[13] J. Lopez-Garcia et al.Long-term soiling of silicon PV modules in a moderate subtropical climate / Solar Energy 130 (2016) 175.

[14] John, J.J., Tatapudi, S., Tamizhmani, G.,. Influence of soiling layer on quantum efficiency and spectral reflectance on crystalline silicon PV modules. In: 40th IEEE Photovoltaic Specialist Conference, 8–13 June, Denver, USA, pp. (2014) 2595–2599.

[15] https://www.jinkosolar.com/ftp/EN-JKM265P-60(4BB)-tr.pdf