

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF SURFACE CONTAMINATION ON POWER OUTPUT IN PHOTOVOLTAIC PANELS

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Abstract

It is known that as the demand for energy increases, fossil resources are decreasing day by day and current electricity prices are increasing. For this reason, renewable energy installations are gaining importance day by day. On the other hand, interest in electricity generation from wind and solar, among renewable energies, is also increasing. However, the fact that solar radiation does not remain constant during the day and that the intensity of solar radiation varies according to seasons negatively affects electricity production. To benefit from solar energy with maximum efficiency, operating conditions in photovoltaic panel conversion systems must be correct. An important reason for the decrease in conversion efficiency in solar panels is the effect of dust and pollution on the surfaces of photovoltaic cells. In this study, The effect of photovoltaic panel cell surface pollution on electricity production was examined experimentally in a solar energy conversion system established on the campus of Trakya University Faculty of Engineering. After the installation was completed, only one of the photovoltaic panels was cleaned regularly with glass cleaner every Monday. Data was received and recorded through the system for 3 months. Based on the results of the study, it was observed that the photovoltaic panel that was cleaned only once a week produced approximately 4% more electrical energy after 3 months than the one that was not cleaned.

Keywords: Photovoltaic panel, energy, data recording, surface pollution.

INTRODUCTION

With the increase in the world population, many problems arise with the difficulties in meeting the energy demand and global warming due to excessive fossil fuel consumption. Especially in developed countries, solving these problems in meeting energy demand is becoming the main agenda item. If measures are not taken to reduce the use of fossil energy-based oil, coal and natural gas reserves, it is estimated that these resources will be depleted within the next century [1-2]. Recently, the most up-to-date studies among renewable energy sources are being carried out in the field of electricity production from solar energy. Certain stages have been reached in studies on converting the energy coming from the Earth's constant exposure to sunlight into electrical energy.

The amount of electrical energy obtained from photovoltaic panels varies depending on the project components and operating conditions of the system. In addition, the conversion efficiency of solar radiation into electrical energy varies depending on the material properties and production technology used in photovoltaic panel cell construction. An important factor affecting the conversion efficiency of solar energy is the surface cleaning of photovoltaic panels. On the other hand, the efficiency and lifespan of photovoltaic panels that are not cleaned regularly decreases. Although solar energy radiation intensity varies according to climatic conditions, the photovoltaic panel efficiency used today is around 20% under normal conditions. It is known that substances such as dust, dirt, sand, and algae accumulated on the surface of photovoltaic panels have a significant

impact on system efficiency. The accumulation of these contaminants on the surface significantly reduces the efficiency of the system. The resulting dirt and dust greatly reduce the photovoltaic performance. For this reason, it has been revealed that photovoltaic panels should be cleaned periodically [3-4]. It should be known that dust on the surface of photovoltaic panels negatively affects solar radiation transmittance. It has been observed that the accumulation of a small amount of dust particles on the photovoltaic panel reduces the radiation transmittance by 11% [5]. In addition to all these, it is stated that even if there is low dust accumulation on the panel surface ($\approx 1\text{g/m}^2$), there may be a loss of 40 €/kWp on an annual basis [6-7].

When the studies in the literature on the effects of pollution and dust on the surface of photovoltaic panels are examined; In the eastern region of Saudi Arabia, a power decrease of up to 50% was observed in photovoltaic panels exposed to intense dust for a period of six months [8]. In a study describing the significant impact of dust accumulation on photovoltaic modules on permeability, temperature and roughness, some existing cleaning methods were summarized, and self-cleaning coating materials were proposed to prevent dust accumulation. It has also been explained that dusting varies depending on the particle diameter, the installation angle of the photovoltaic modules and the wind speed [9]. To examine the effect of dust on the performance of photovoltaic modules, a 200 W solar panel was modeled and analyzed in five locations in Iran. Considering the dust accumulation, it was found that the south of Tehran provides better conditions for the installation of solar modules than other places [10]. A study conducted in Cairo. In the study, the effect of cleaning frequency of photovoltaic panels on energy conversion efficiency was examined. It was observed that higher energy was obtained when cleaning was done more frequently for different types of photovoltaic panels. It has been found that

energy production decreases by approximately 16% when cleaning frequency is reduced from one week to three weeks. Similarly, when cleaning was done every eight weeks, the amount of energy obtained from photovoltaic panels decreased by 24%. Therefore, more frequent cleaning has been recommended to prevent energy loss in photovoltaic panels [11]. Dust accumulated on solar modules prevents solar radiation from entering the cell. It has been observed that photovoltaic panel output power decreases by up to 60% due to module pollution. In order to prevent this situation, it has been stated that certain photovoltaic panel surfaces should be cleaned periodically, such as automatic cleaning, robotic cleaning, mechanical cleaning and manual cleaning [12]. In addition to all these, natural contamination, and shadowing over time, which affects the efficiency of photovoltaic panels, should be prevented.

Unlike the literature, in this study, the effect of manual cleaning of the photovoltaic panel surface on the power output in a solar energy system installed at Edirne Trakya University Faculty of Engineering Campus was examined. One of the photovoltaic panels was manually cleaned once a week, while the other panel was not cleaned for 3 months. Energy production values obtained from photovoltaic panels were recorded for 3 months and compared at the end of the study.

MATERIAL METHOD

The experimental system shown in Figure 1 was established to compare the electricity production from photovoltaic panels due to dust and pollution. The experiments were fixed with an inclination angle of 20, considering the house roof systems in the geographical conditions of Edirne province. The data logger system that measures the electrical energy current and voltage values produced simultaneously through the installed solar panels and records them on the memory card, sensors, batteries, 3 polycrystalline 260-watt power units. It consists of

photovoltaic panels and connection cables. There are 3 photovoltaic panels on the energy conversion system, as seen in Figure 1. One of them was cleaned manually with (Glass cleaning liquid) once a week for three months. The second PV panel has not been cleaned for 3 months. The third PV panel produces the electrical energy required for the operation of all electronic components and the datalogger on the installed system. Since the third PV panel is used to provide the required electrical energy to the system, its power output is not measured. After the installation was completed, the electrical energy values obtained from both panels were recorded for 3 months, from the beginning of May to the end of July. At the end of the experimental study, monthly graphs were drawn according to the amount of electrical energy produced in the cleaned and uncleaned panel.



Fig. 1. Solar energy system installation

The pollution formation on the photovoltaic panel during the experimental study process is shown in Figure 2. Figure 2 shows that the PV panel, which is cleaned once a week, has a cleaner surface.



Fig. 2. Pollution formation on the uncleaned photovoltaic panel surface

The electronic circuit components and datalogger used to receive data through the installed solar energy conversion system are shown in Figure 3.

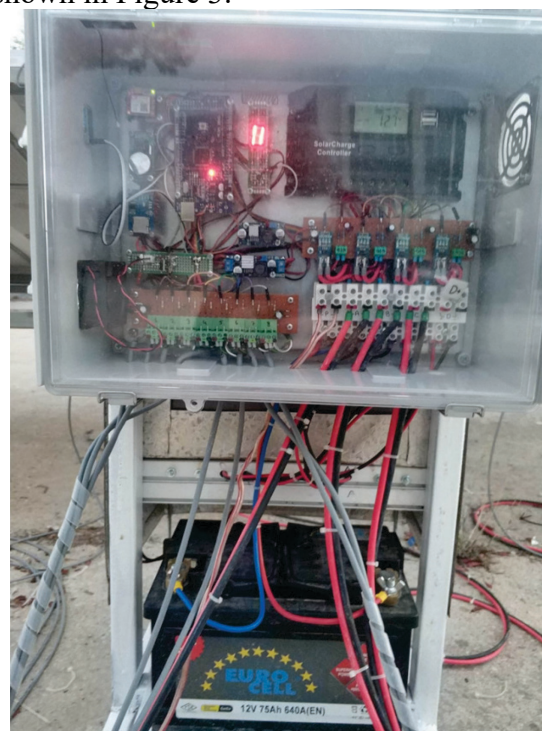


Fig. 3. Datalogger and electronic system components

RESULTS AND DISCUSSION

May 25, 2022 was chosen as a random day during the time period when the experiments were carried out, and the energy change for this day is shown in Figure 4. At the end of this selected day, 756.25Wh of energy was obtained from the cleaned PV panel and 708.81Wh of energy was obtained from the uncleaned PV panel.

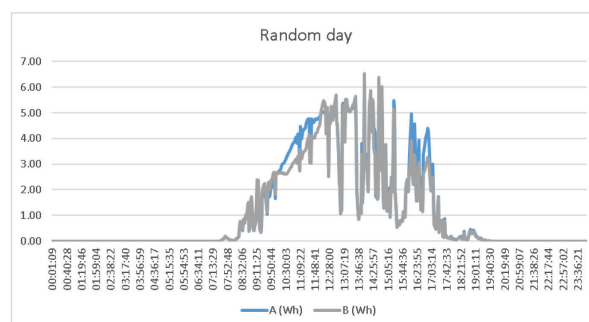


Fig. 4. Amounts of energy obtained from cleaned and uncleaned PV panels on a randomly selected day

When the data obtained between 01.05.2022 and 01.08.2022, when the study was carried out, was analyzed, the highest energy was produced in the cleaned PV panel on 17.06.2022 as 1109.50Wh. On this date, 1077.36 Wh energy was obtained from the uncleaned panel. The best day obtained from the PV panels belongs to The energy change graph is seen in figure 5.

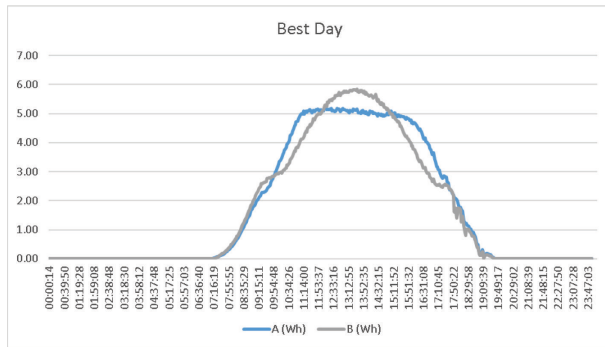


Fig. 5. The amount of energy obtained from PV panels on the day when the best conditions are provided

During the period of the study, the day with the least energy production was determined as 10.05.2022. On this date, 94.68Wh of energy was obtained from the PV panel that was cleaned, while 92.89Wh of energy was produced from the PV panel that was never cleaned. The energy change in the PV panels is seen in Figure 6.

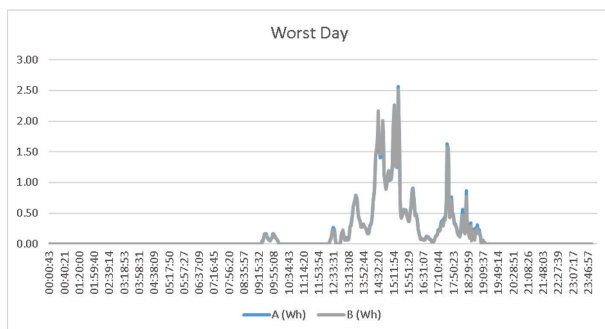


Fig. 6. Amounts of energy obtained from PV panels on the day when the worst conditions were met

Depending on the experimental data, the total amount of energy obtained from the system at the end of 3 months is given in Table 1. It can be seen in Table 1 that more energy was obtained from the PV panel that was cleaned on all selected dates. Logs

were saved every 120 sec (2 min) by averaging 12 samples collected at 10 sec intervals. Number of Records is 55587.

Table 1: Total amounts of energy obtained from PV panels at the end of the study

| Total Produced Energy | Date Range | Panel A (Wh) | Panel B (Wh) |
|-----------------------|---------------------|--------------|--------------|
| Overall | 1.05.2022-1.08.2022 | 63.830.07 | 61.215.65 |
| Best Day | 17.06.2022 | 1.109.50 | 1.077.36 |
| Worst Day | 10.06.2022 | 94.68 | 92.89 |
| A Random Day | 29.05.2022 | 756.25 | 706.81 |

CONCLUSION

In this study, the effect of dusting and pollution on the photovoltaic panel surface on the amount of energy produced was examined. As a result of manual cleaning of the photovoltaic panel surface on the installed solar energy system once a week, an increase in power output was achieved. When the data received from the system was analyzed, cleaning was done within a 3-month period. 2615Wh more energy was obtained from just 1 photovoltaic panel. When we consider the number of photovoltaic panels used in both roof installations and solar power plants, it is understood that much more energy will be obtained with the increase in power obtained. As a result; As a result of manual cleaning of the photovoltaic panel surface only once a week, a 4-5% increase in efficiency was achieved. It is understood that in the future, energy efficiency will increase if research is carried out on the cleaning frequency and automatic cleaning methods of photovoltaic panel surfaces by using different cleaning agents.

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