CALCULATION OF PARAMETERS AND MAIN CHARACTERISTICS OF A SOLAR PANEL WITH A CLEANING SYSTEM

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Abstract. *This article provides the volt-ampere and volt watt characteristics of a solar panel that has a cleaning system and also calculates and analyzes its parameters. When calculating, it turned out that the largest difference in panel power P was 33.30 %, which is a significant indicator. The efficiency PR of the cleaned solar panel was on average 13.02 % higher than the efficiency of the uncleaned panel. The volt-ampere and volt watt characteristics of the solar panel, which has a cleaning system, where higher than the characteristics of the panel that does not have a cleaning system. Therefore, for solar panels the use of a cleaning system, which allows increasing not only efficiency, but level of ease use, service life, is extremely important and necessary.*

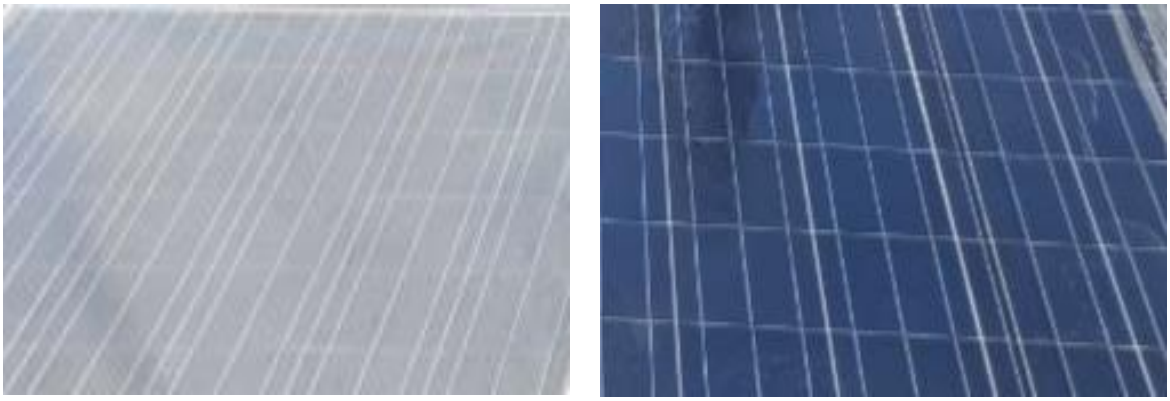
Keywords: *renewable energy sources, a solar panel, volt-ampere and volt-watt characteristics, efficiency, power, short circuit current, solar radiation flux density, dust, a cleaning system.*

It is known that the universe consists of matter in various forms, all forms of matter in turn contain energy, which is defined as the ability to do work, therefore it is and remains the main factor in the functioning of almost all types of living organisms on the planet [9]. There are such types of energy as electric, thermal, solar, wind etc. Among the listed types of energies electrical energy is both reliable and universal, that is it can be easily converted and obtained into other types of energy, such as thermal energy. Therefore, the demand for electrical energy is growing steadily day after day in many countries, including Uzbekistan.

The Sun produces energy over several years in an hour it emits a large amount of energy, which is sufficient to satisfy the energy demand throughout the year. The technical potential of Uzbekistan for renewable energy sources is117984 million toe, in particular the technical potential for solar energy is 177 million toe, which proves that our country has enormous solar resources potential [1,2]. Therefore, in recent years our country has paid special attention to solar energy, which is becoming increasingly relevant and a number of legislative acts have been adopted. For example, on February 16 2023 Resolution of the President of the Republic of Uzbekistan No. PP 57 “On measures to accelerate the implementation of renewable energy sources and energy-saving technologies in 2023” was adopted, which became the stimulus and next impetus for the development and widespread introduction of renewable energy sources.

According to the Decree large solar and wind power stations with a total capacity of 2100 MW, small photovoltaic stations with a capacity of 550 MW will be commissioned in the country, as well as solar panels with a total capacity of 1200 MW will be installed in households, social facilities and various buildings, as a result natural gas will be saved in a significant amount, the reserves of which are running out [3].

However, there are also a number of problems in solar energy, primarily these problems are related to the operation of solar panel. It is known that solar panels depend on the flux density of solar radiation, so they are installed in open areas where the temperature sometimes exceeds normal and there also different dust concentrations that lead to reduction in parameters, efficiency and performance degradation [4]. Therefore, today maintaining the efficiency and performance of solar panels throughout the entire daylight period is one of the main tasks of solar energy and to solve it depending on the structural and mechanical part of solar panels it is necessary to develop and apply systems such as a sun trucking system, a cooling system and an active cleaning system [5,6,7]. In this work we will consider the characteristics of a solar panel equipped with a cleaning system, which was developed by author, and also calculate its parameters. The illustration below shows a panel surface that has been cleaned by the cleaning system and a surface that has not been cleaned.



a) b)

Figure.1. Surface of solar panels: a) uncleaned; b) cleaned.

From above the pictures you can see that the surface of the panels is so much different. The surface of the panel, equipped with a cleaning system, has been cleaned of dust and the surface of the panel, which does not have a cleaning system, has accumulated dust, which negatively affects the performance, resulting in the parameters of the panel being significantly reduced. Table 1 shows the following electrical parameters of solar panels: short circuit current, open circuit voltage, current and voltage at the maximum power point, as well as solar radiation flux density, which were obtained as a result of scientific experiments.

Table No. 1

Solar panel parameters

Cleaned solar panel						Uncleaned solar panel			
№	E, W/m^2	Isc, A	Uoc, V	Impp, A	Umpp, V	Isc, A	Uoc, V	Impp, A	Umpp, V
1	623	6,70	33,2	6,50	25,5	6,43	33,4	6,04	25,6
2	521	6,73	33,0	6,50	25,3	6,34	33,1	5,90	25,8
3	584	6,17	33,0	5,90	25,6	5,75	33,0	5,31	25,9
4	518	5,88	34,3	5,50	27,0	5,27	33,5	4,94	26,6
5	546	5,63	33,4	5,26	26,2	5,03	33,1	4,71	26,3
6	541	5,45	33,1	5,09	25,9	4,84	32,9	4,58	25,9
7	533	5,3	33,3	4,93	26,3	4,67	33,1	4,41	26,4
8	491	4,72	33,2	4,43	26,4	4,27	33,1	3,94	26,7
9	340	4,01	33,02	3,87	27,1	3,17	33,0	2,79	28,2

From the parameters it is clear that the parameters of a solar panel with a cleaning system are significantly greater than the parameters of a solar panel, which does not have a cleaning system. For example, the maximum short circuit current value of a cleaned panel is 6.73 A, which is 4.6 % greater than the maximum short circuit current value of an uncleaned panel.

It is known that the coefficient of performance (efficiency) is a physical quantity that shows the proportion that useful work makes up of the total work produced. Using this value, we can evaluate the efficiency of a solar panel (or any other element or system). Below is the formula for determining the solar panel output power and efficiency respectively [8,10]:

$$\boldsymbol{Pout = Impp * Umpp} \quad (1)$$

where, Pout is output power of the solar panel, Impp and Umpp are current and voltage at the maximum power point.

$$\boldsymbol{PR = \frac{Pmp/Pmax}{E/1000}} \quad (2)$$

where, PR is the performance coefficient of the solar panel, Pmp is measured power, Pmax is the maximum power of the solar panel, E is the solar radiation flux density measured on the solar panel surface.

Now, using the formula (1) and electrical parameters indicated in the table No. 1, we will determine the output power of a solar panel with and without cleaning system respectively:

Pout for the solar panel with a cleaning system	Pout for the solar panel without a cleaning system
$Pout1 = 6.50 * 25.5 = 165.75$	$Pout1 = 6.04 * 25.6 = 154.62$
$Pout2 = 6.50 * 25.3 = 164.45$	$Pout2 = 5.90 * 25.8 = 152.22$
$Pout3 = 5.90 * 25.6 = 151.04$	$Pout3 = 5.31 * 25.9 = 137.52$
$Pout4 = 5.50 * 27.0 = 148.5$	$Pout4 = 4.94 * 26.6 = 131.40$
$Pout5 = 5.26 * 26.2 = 137.81$	$Pout5 = 4.71 * 26.3 = 123.87$
$Pout6 = 5.09 * 25.9 = 131.83$	$Pout6 = 4.58 * 25.9 = 118.62$
$Pout7 = 4.93 * 26.3 = 129.65$	$Pout7 = 4.41 * 26.4 = 116.42$
$Pout8 = 4.43 * 26.4 = 116.95$	$Pout8 = 3.94 * 26.7 = 105.19$
$Pout9 = 3.87 * 27.1 = 104.87$	$Pout9 = 2.79 * 28.2 = 78.67$

As can be seen from above calculated values, the output power of a solar panel with a cleaning system significantly exceeds the power of solar panel that does not have a cleaning system. For example, in the first calculation, the output power of the panel with a cleaning system was equal to 165.75 W, which is 11.13 W more than the power the output power of the panel without a cleaning system, and in percentage terms this is a difference of 7.19 %. At the last calculation, the power difference was 26.2 W, in percentage terms this difference is 33.30 %. Therefore, the use of a cleaning system for solar panels is very appropriate and acceptable.

And now, using formula (2), we determine the efficiency of the solar panels with and without cleaning system respectively:

$$PR1 = \frac{165.75/250}{623/1000} = 10.64 \qquad PR1 = \frac{154.62/250}{623/1000} = 9.92$$
$$PR2 = \frac{164.45/250}{521/1000} = 12.62 \qquad PR2 = \frac{152.22/250}{521/1000} = 11.68$$
$$PR3 = \frac{151.04/250}{584/1000} = 10.34 \qquad PR3 = \frac{137.52/250}{584/1000} = 9.41$$
$$PR4 = \frac{148.5/250}{518/1000} = 11.46 \qquad PR4 = \frac{131.40/250}{518/1000} = 10.14$$
$$PR5 = \frac{137.81/250}{546/1000} = 10.09 \qquad PR5 = \frac{123.87/250}{546/1000} = 9.07$$
$$PR6 = \frac{131.83/250}{541/1000} = 9.74 \qquad PR6 = \frac{118.62/250}{541/1000} = 8.77$$
$$PR7 = \frac{129.65/250}{533/1000} = 9.72 \qquad PR7 = \frac{116.42/250}{533/1000} = 8.66$$
$$PR8 = \frac{116.95/250}{491/1000} = 9.52 \qquad PR8 = \frac{105.19/250}{491/1000} = 8.56$$
$$PR9 = \frac{104.87/250}{340/1000} = 12.33 \qquad PR9 = \frac{78.67/250}{340/1000} = 9.25$$

From the calculation it is clear that the efficiency of a solar panel that has a cleaning system was always higher than the efficiency of a solar panel, which does not have a cleaning system. For example, in the first calculation, the efficiency value of the cleaned panel was 10.64 and uncleaned panel was 9.92, if compared, the difference is 7.25 %. At the 5th and 9th calculations, the difference in efficiency was 11.24 % and 33.29 % respectively. On average, the efficiency of the cleaned panel was 13.02 higher than the efficiency of the uncleaned panel. This differences once again confirms that it is necessary to clean the surface of the panel in order to maintain their effectiveness during daylight hour.

It is known from science that the current-voltage characteristics of a solar panel is an important parameter that is associated with efficiency and shows how the current that passes through the circuit changes depending on the voltage that is applied to it [11].

Below are the volt-ampere and volt-watt characteristics of solar panels with and without cleaning system.

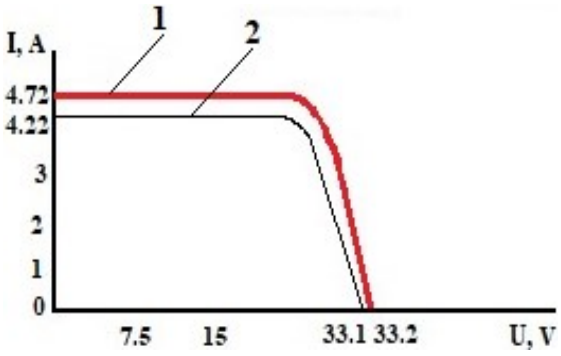


Figure.1. Volt-ampere characteristics

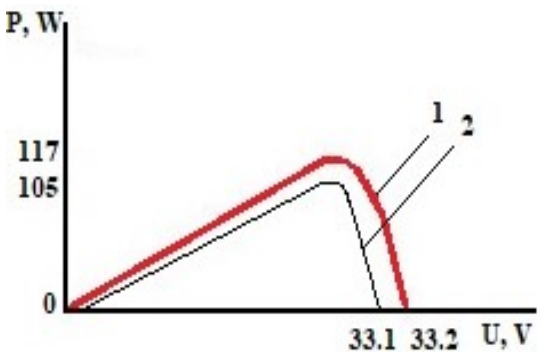


Figure.2. Volt-watt characteristics

It is known that the higher the volt-ampere and volt-watt characteristics of a solar panel, the better its performance. From volt-ampere characteristic it is clear that the characteristic of a cleaned panel is higher than that of an uncleaned panel, therefore the parameters are also higher. The short circuit current of the panels is 4.72 A and 4.22 A respectively, if we compare, the difference is 11.84 %. As can be seen from the volt-watt characteristic, the maximum power value of the panels is 117 W and 105 W, which differ by 12 W, and in percentage terms by 11.42 %. This difference in electrical parameters once again confirms the need use a cleaning system for solar panels, which not only improves the parameters, but also increases the service life, the level of ease of use, efficiency and also reduces the payback period.

Thus, from the above we can conclude that the following:

1. Dust on the surface of the solar panel leads to a decrease in parameters and cleaning system allows to prevent a decrease in parameters, increase service life, the level of ease of use, efficiency and also reduces the payback period;

2. The largest power difference when calculated was 33.30 %, which is a significant and very acceptable value;

3. On average, the efficiency of a solar panel equipped with a cleaning system was 13.02 % higher than the efficiency of a panel without a cleaning system;

4. The short circuit current of the panels in the volt-ampere characteristic was equal to 4.72 A and 4.22 A, which differ by 11.84 %;

5. This differences in electrical parameters once again confirms the need to use a cleaning system for solar panels.

REFERENCES

1. Antonova E., Goryachev S. Improving the energy efficiency of solar batteries of new generation through the use of new materials and their hybridization // Bulletin of the North Caucasus Federal University. – 2019. № 1 (70).
2. Allayev K.R. Modern energy and prospects for its development. – Tashkent. 2021. -952 p.
3. Decree No. PF-57 of the President of the Republic of Uzbekistan dated February 16, 2023 "On measures to accelerate the implementation of renewable energy sources and energy saving technologies in 2023" / Legal documents National database of information, 17.02.2023, No. 07/23/57/0093.
4. Shoguchkarov S.Q., Kamolov T.R., Boliyev A.M. Study of the influence of various dust concentration on the current-voltage characteristics of a photovoltaic battery // Universum: Technical sciences. – 2019. № 4 (61)
5. Sitdikov R.A., Radionova O.V. Ensuring stable energy efficiency of photovoltaic installation. // Current problems of power supply systems. –Tashkent. -2023. – 286-289 pp.
6. Zikrillayev Kh.F, Sodiqov T.B. Study of the structural and mechanical part of the HANWHA solar panel. // Scientific-technical journal FerPI. -2023. – V.27. № 5.
7. Kovshik V.V., Krasovsky V.I. Overview of photovoltaic solar module cleaning device. Belarusian state university. https://doi.org/10.46646/SAKH-2020-2-376-379
8. Tursunov M.N., Sabirov X., Eshmatov M.M., Kholov U.R. Effect of environmental parameters on the efficiency photoelectric batteries and photo thermal batteries. // Technical science and innovation. – 2023. –V.17. № 17.
9. https://www.jove.com

10. https://www.webmath.ru
11. https://solar.kiev.ua