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Development And Research Of Surface Cleaning Technology Of Solar Photoelectric Panels

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ABSTRACT: in the article, the dependence of the efficiency of 15 kW solar photovoltaic panels located in the city of Karshi, the southern region of Uzbekistan, on the amount of dust and energy-efficient cleaning technology are proposed. In a 15 kW solar power plant, when the solar radiation is 650 W/m2 and the amount of dust on the surface of solar photovoltaic panels is 15, 20, 25 g/m^2, the output power reduction efficiency is 38, 50, 54%, 750 W/m^2 and solar photovoltaic panels respectively. The reduction efficiency of the output power when the amount of dust on the surface is 15, 20, 25 g/m^2 is 22, 40, 47%, 850 W/m^2 and the output power when the amount of dust on the surface of solar photovoltaic panels is 15, 20, 25 g/m^2 reduction efficiency was estimated to be 20, 35, 40%, respectively. By using the developed technology, the possibility of additional production of electricity up to 30% per year, saving 12574.11 kWh of electricity and saving 850 $ in a 15 kW solar power plant was studied.

KEYWORDS: solar radiation, solar photovoltaic panel, efficiency, dust content, cleaning technology.

I. INTRODUCTION

The development and research of surface cleaning technology of solar photovoltaic panels is of great importance in increasing the efficiency of solar power plants in the world. The production of electricity using solar photovoltaic panels depends on solar radiation, external temperature, wind speed, humidity and sunlight angles, and any impurities such as dust and bird droppings can affect the efficiency of solar panels [1]. It is important to regularly clean the surface of solar photovoltaic panels. The duration of cleaning the surface of solar photovoltaic panels and the technologies used depend on the geographical coordinates and climate characteristics of the solar panels. For example, in areas with high rainfall, cleaning of solar panels is not necessary as often, and any technology can work here depending on cost effectiveness. However, in arid areas with low rainfall, as well as in areas with high solar energy availability, solar photovoltaic panels require frequent surface cleaning. At the same time, these areas are prone to drought and water resources are scarce, so the use of non-aqueous solutions and water recycling technologies can be a practical solution here.

The procedure and technique for cleaning the surface of solar photovoltaic panels is determined by the proximity of the solar project to large industrial facilities or thermal power plants, as well as their location on roofs, on the ground, or in water bodies. For example, in very remote locations, routine manual maintenance may not be possible due to security reasons and lack of manpower, and therefore automated solutions are more suitable for such project areas. Figure 1 shows the methods of cleaning the surface of solar photovoltaic panels. In this case, technologies for cleaning the surface of solar photovoltaic panels are proposed depending on the climatic conditions of the area where solar photovoltaic panels will be installed, water resources, economic efficiency in use and how far they will be installed from residential areas.

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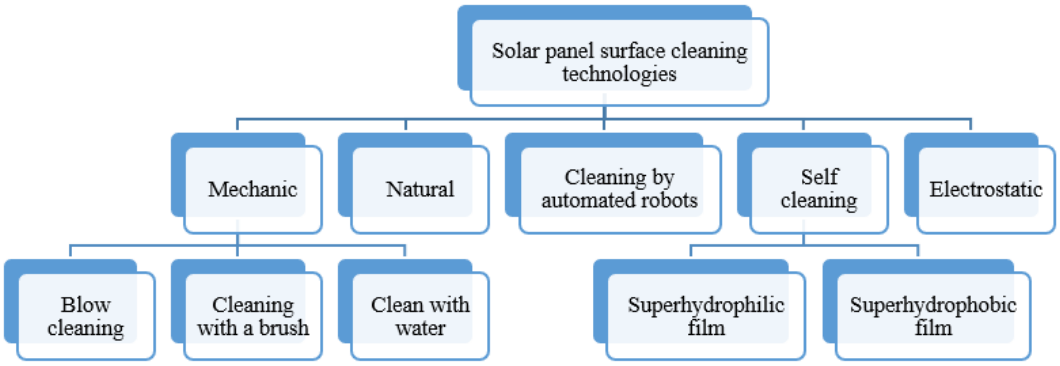

Fig.1. Methods of cleaning the surface of solar panels

The scientific research conducted on the development of technologies for cleaning the surface of solar photovoltaic panels was analyzed. British scientist Dacheng Lee conducted theoretical and practical research on cleaning and cooling the surface of solar panels using compressed air [2]. An experimental setup for monocrystalline solar modules operating in arid climates has been developed to demonstrate the proposed modeling and system performance. Through cleaning and power, the existence of a solar photovoltaic panel has been determined. From the nozzle structure, the clearance can be increased to 86.4%, and the R-squared factor for the temperature modeling tool was 0.978. According to the test results, the design and control of the regulation system for solar panels (12 panels) operating in the arid region of northwest India is studied. When the blowing time is set to 10, 15, 20 s, the power output of the solar panels increased from 567.4 W to 30.7, 33.6, and 36.1%, respectively. China's Sunray Technology Co., Ltd. produces a two-axis rotating solar panel surface cleaning brush [3]. The proposed two-axis cleaning system is manual and consists of three lengths of telescopic booms, 3.6m, 5.4m and 7.2m. The main advantage is that the device is lightweight, easy to carry, low noise, and easy to use. The cleaning width is up to 60 cm, one person can clean 500-750 square meters per hour, 3500-5000 square meters with 8 working hours per day. Water consumption per square meter is about 1.5-3 liters and water consumption per megawatt is about 9-15 tons. One person can clean 1 MW per day, which is more efficient than similar devices. K.A. A group of scientists led by Moharram researched the possibilities of using water and chemical liquids to clean the surface of solar panels [4]. The goal of this research is to clean the dust accumulated on the solar panels using the minimum amount of water and energy. The solar panels in question are part of a 14kW solar power plant installed at a German university in Egypt. The efficiency of the solar panels decreased by 50% after 45 days of cleaning with depressurized water, while the efficiency remained constant when a mixture of anionic and cationic surfactants was used for cleaning. B. Parrott conducted experimental research on automated, robotic chemical cleaning of solar panels using a silicone rubber brush in Tuwal, Saudi Arabia [5]. According to research results, automated robotic cleaning systems using silicone rubber foam brushes have been used for waterless dust removal. Comparing the performance of robotically cleaned panels and manually cleaned panels, 1 week of no cleaning resulted in an expected performance difference of approximately 1.5%, and 2 weeks resulted in a greater than 3% drop in performance. The developed robotic system is one of the main advantages of being an inexpensive, easy to automate, simple and reliable method of cleaning solar panels at high frequencies. A.S. The effect of electrostatic cleaning on the efficiency of solar power plants installed in the Al-Salaymeh region of Jordan was studied. The results of the proposed cleaning method were compared with the results of three different conventional solar panel surface cleaning methods [6]. After two weeks of exposure to natural dust without cleaning or rain, the energy loss due to dust accumulation on the surface of the solar panels was 5.93% for the naturally cleaned module. Electrostatic neutralization treatment reduced energy loss to 4.56% and nano-coating reduced energy loss to 2.33%. Research has been conducted to achieve a 1.37% increase in energy savings using electrostatic neutralization. A group of scientists led by Ping Wang conducted research on superhydrophobic film and self-cleaning of solar modules [7]. The preparation of the superhydrophobic film combined a low surface energy layer and an anti-reflection layer, which enhanced the adhesion between the superhydrophobic film and the glass substrate by forming stable covalent bonds. After coating the surface of the solar panels with a superhydrophobic film, it was found that the output power increased by 15.7%.

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Despite the progress made, there have not been enough studies on cleaning the surface of solar panels from various contaminations using innovative energy-efficient methods. In this case, for regions with water resources, it is important to conduct research on the treatment of water used for cleaning the surface of solar photovoltaic panels and improving the output indicators of solar panels at high temperatures.

The purpose of the research is to develop and research the technology of cleaning the surface of automated solar photovoltaic panels.

II. METHODOLOGY AND DISCUSSION

The possibilities of using 15 kW solar photovoltaic panels in the electric energy supply system of the two-slope construction autonomous greenhouse with a crop area of 50 m^2, located in the landfill of alternative energy sources, Faculty of Engineering and Economics, Karshi Institute of Economics, were studied. 30 GS-540 S6 solar panels with a capacity of 540 W (77.5 m^2) were installed in this test site. Maximum output voltage 600 V (DC), voltage variation limit 90-520 V (DC), maximum output current 2x11 A (DC), mains voltage and frequency 220-230 V, 50/60 Hz (AC), output 3 Solish-1P5K-4G brand inverters with a capacity of 5 kW were used. Table 1 shows the passport parameters of the GS-540 S6 solar panel with a power of 540 W.

Table 1. Passport parameters of the solar panel

Model type	GS-540 S6	Open circuit voltage, (Uoc), [V]	52,2
Maximum power, (Pmax), [W]	540	Short circuit current, (Isc), [A]	13,6
Voltage at maximum power, (Ump), [V]	42,75	Temperature coefficient, (Isc)	+0.046%℃
Current at maximum power, (Imp), [A]	12,63	Temperature coefficient, (Uoc)	-0.276%℃
STC	1000W/m² 25℃ AM1.5	Temperature coefficient, (Pmax)	-0.35%℃

The following technical problems should be solved when installing the surface cleaning technology of solar photovoltaic panels:
- development of a technology that ensures the reliable cleaning efficiency of the surface of solar panels with the possibility of providing high-speed water supply with pulsating pressure;
- improvement of the system of processing and collection of dirty water or rainwater generated after cleaning the surface of solar panels;
- development of an automated system for cleaning the surface of solar panels 2-3 times a month;
- reduce costs and increase the reliability of cleaning.

An innovative method for cleaning the surface of 15 kW solar panels from various contaminations was proposed. In this case, the technology of cleaning the surface of solar panels with water every 10-15 days and processing used or rainwater was developed (Fig. 2). As a result of cleaning the surface of solar panels with water, the temperature on the surface of the panel can also be reduced. Here are the devices and equipment used in the cleaning technology: 500 W pressure water pump, two-stage dirty water purification filter, plastic water pipe with a cross section of 20 mm and a total length of 40 m, 30 water sprayers, It consists of a semi-cylindrical water tank with a diameter of 100 mm and a length of 30 m, a water tank with a volume of 500 l, a control and management system, and additional briquetting elements. This system can be used in other months except winter months.

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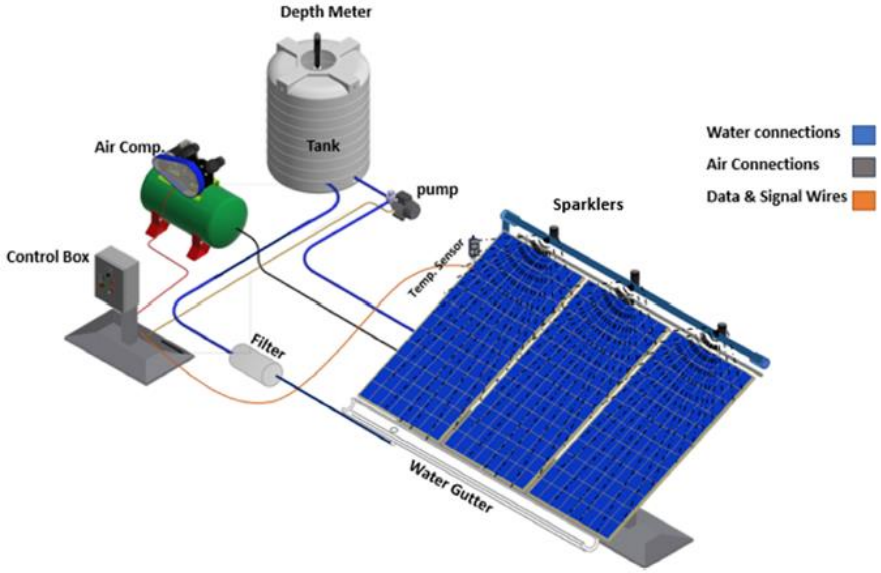

Fig. 2. Solar panel surface cleaning technology [8]

The technology of cleaning the surface of solar panels works in the following order: first clean water from a water tank with a volume of 500 l is directed by a pumping device to a water pipe with a cross-sectional area of 20 mm installed on the solar panels with pressure, from this water pipe, each solar the water placed on the panel is transferred to the sprinklers, the sprinklers use the pressurized water flow on the entire surface of the solar panel from top to bottom for 3 minutes (in the case of one panel), this process is carried out 2 or 3 times a month, depending on the pollination, after cleaning, the dirty water flows into the tray installed at an angle of 10^{o} below the solar panel, the dirty water in the tray is transferred to the two-stage water purification filter, the purified water from the filters is directed to the water tank, 80% of the total used water is recycled and collected in the water tank the remaining 20% evaporates into the atmosphere, in addition, we can also collect rainwater by processing it into a water tank through solar panels, the process can be operated by an automatic control system or by phone. Table 2 shows the prices of cleaning technology devices and materials.

Table 2. Cleaning technology elements and prices

Devices and materials of cleaning technology	Image	Price
EPA EVN-A600-2 brand water pump, nominal power 600 W, head 40 m, working capacity 50 l/min.		120 $
Plastic water pipes, 20 mm, (40 m)		20 $
Water sprinklers (30 units)		45 $

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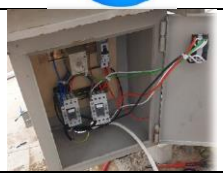
Water filter		40 $
Water collection tank, 500 l		45 $
Control system and shit		25 $
Additional costs		20 $
Total:		**315 $**

III. EXPERIMENTAL RESULTS

Figure 3 shows the solar panel surface dusting (a) and cleaning technology. Measurement experiments were conducted from June 1 to July 1, 2023. Researches were conducted for two 5 kW solar power plants with cleaned and untreated surfaces. The output parameters of solar panels, voltage, current, power and dynamics of changes in electricity were evaluated.

a) b)

Fig. 3. Surface dusting of solar panels (a) and cleaning technology (b)

Figure 4 shows the theoretically calculated indicators of electricity generated by a 15 kW solar power plant (2023, 38.87° N, 65.80° W). In this case, the solar panels are installed at an angle of 39° relative to the horizontal surface. The annual average and total annual electricity produced were 114.89 kWh/day and 41913.7 kWh, respectively (cleaned). The output power reduction efficiency is 38, 50, 54% when the solar radiation is 650 W/m^2 and the dust content on the solar panel surface is 15, 20, 25 g/m^2, 750 W/m^2 and the dust content on the solar panel surface is 15, 20, 25 g/m^2 the output power reduction efficiency is 22, 40, 47% when g/m^2, 850 W/m^2 and the output power reduction efficiency is 20, 35, 40% when the solar panel surface dust content is 15, 20, 25 g/m^2 was found to be equal to due to dusting of the surface of solar panels, it was estimated that the annual average of 30% reduction in electricity production.

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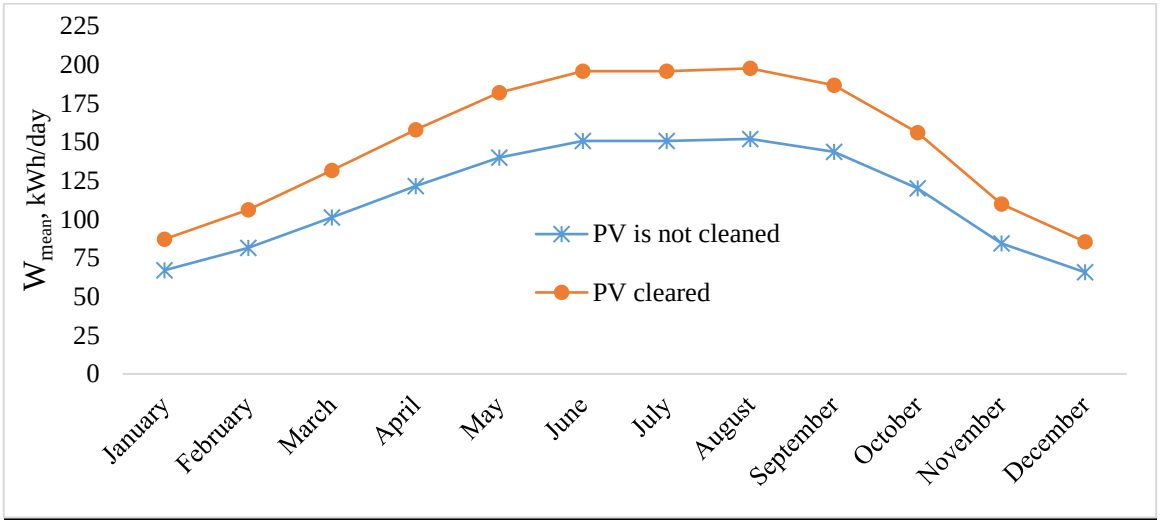

Fig. 4. Electricity indicators produced by a 15 kW solar power plant (2023, 38.87º N, 65.80º W)

Along with the development of the use of solar energy, increasing the use of wind and water energy is becoming important [9-15].

IV. CONCLUSION

Based on the anti-climatic characteristics, the dependence of the efficiency of solar photovoltaic devices on the amount of dust formed on the surface was studied. In 15 kW solar power plants, when the solar radiation is 650 W/m^2 and the amount of dust on the surface of solar photovoltaic panels is 15, 20, 25 g/m^2, the efficiency of output power reduction is 38, 50, 54%, 750 W/m^2 and solar photovoltaic panels respectively. 22, 40, 47%, 850 W/m^2, and 15, 20, 25 g/m^2 dust content on the surface of solar photovoltaic panels. efficiency was estimated to be equal to 20, 35, 40%. By using the developed technology, the possibility of additional production of electricity up to 30% per year, saving 12574.11 kWh of electricity and saving 850 $ in a 15 kW solar power plant was studied.

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