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DESIGN OF SOLAR PANEL MONITORING MECHATRON MODULE

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Abstract
The development of solar panel power generation control technology has proven to be crucial to increase reliability and reduce costs. As a renewable energy source, solar panels do not emit any pollution while producing electricity. However, solar panels are negatively affected by pollution, which is a major environmental factor affecting energy production. The intensity of the light falling on the solar panel is reduced when dirt accumulates on the surface. This, in turn, reduces the output of electricity produced by the solar panel. Since solar panel cleaning is important, constant monitoring and evaluation of these processes is necessary to optimize them. This highlights the importance of using smart systems to de-dirt and clean solar panels to improve their performance [1]. The article attempts to verify the existence and level of research interest in this topic and evaluates the impact of intelligent systems for detecting pollution conditions and cleaning solar panels in comparison with autonomous and manual technologies.

Keywords: Photovoltaic panel; remote solar plant; automatic cleaning; status monitoring; Internet of Things; solar panels dirt; detection of dirt; accumulation and removal of dirt; device management; real-time monitoring and cleaning.

Introduction

In many industrialized countries, electricity generation is still dependent on fossil fuels. Although these fuels are very efficient in terms of energy quality, they are not suitable for long-term use as the source of fossil fuels will eventually run out. In addition, fossil fuels seriously threaten the ecological balance and cause many environmental problems such as global warming. Therefore, the use of renewable resources should be adopted as soon as possible. An important feature of renewable electricity generation is the unlimited supply. Compared to traditional fossil fuel technologies, renewable electricity sources have a negligible impact on the environment in terms of cleanliness. Solar panel technology is gaining popularity as a renewable electricity generator due to the increasing demand for renewable energy [2]. By the end of this decade, China's solar capacity is expected to reach 400 GW. Total installed solar capacity in megawatts between 2012 and 2021 is shown in Figure 1, based on data provided by IRENA, the International Renewable Energy Agency.

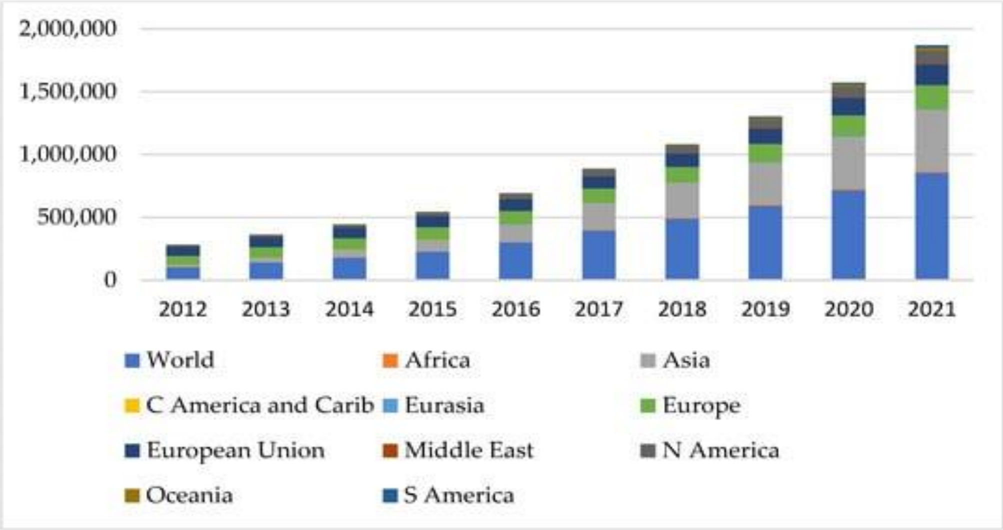

Figure-1. Collected solar power from 2012 to 2021

It is very important to properly manage solar power plants, optimize their performance and reliability for their continuous use. The efficiency and stability of solar panels can be increased, while the costs can be reduced. Irradiance and temperature are the main environmental factors that determine the capacity of a solar panel module. A decrease in the amount of radiation and an increase in temperature will reduce the efficiency of the solar panel module. Solar panels convert solar radiation into direct current electricity; should always be exposed to the maximum amount of sunlight to improve electrical performance. Nevertheless, the reduction of irradiance caused by shading due to the accumulation of dirt on the surface of the solar panel can be well controlled. This happens repeatedly and reduces the amount of sunlight reaching the panels. Dirt that accumulates on solar panels can include dust, snow, ice, and other organic debris [3]. Fine dust particles settle deeper into the surface of solar panel modules and affect their output performance more than coarse dust particles. A controlled experiment using fluorescent lights to simulate solar radiation found that external radiation resistance can reduce photovoltaic performance by up to 85%. Rain can naturally wash away dust and sand, but moss requires proper cleaning. Solar panel cleaning is one of the main challenges for solar energy developers, because solar panel surface cleaning requires careful planning and resources (time, materials, and labor) and leads to increased production costs. However, cleaning solar panels is a critical task to ensure the long-term operational and financial success of a solar power plant. Solar panel cleaning is essential as it ensures proper maintenance of the solar panel surfaces to ensure efficient energy production. It also prevents damage caused by rapid aging or corrosion due to weather conditions such as heavy rain, snow, hail or high humidity [4].

The performance of a solar panel is mainly measured by its efficiency, which indicates how much electricity the panel produces compared to its maximum theoretical efficiency. For example, a solar panel with 20% efficiency means it produces 20% more electricity than if left uncovered. Performed by experiment on cleanliness and tracking mechanism for different conditions of solar panel [5]. The conditions considered are fixed and clean panel, dirty and fixed panel, dirty and tracking panel, and clean and tracking panel. Dust build-up on the surface of solar panels will reduce efficiency, even when solar tracking is installed. The high transmittance of light in a refined solar panel leads to an increase in efficiency. Monitoring a solar panel without cleaning is more effective than keeping the solar panel tight and clean, reducing efficiency by up to 50%[6]. The accumulation of dust on solar panels represents more losses in large-scale power plants in megawatts. A 1% reduction in qualification can have a significant impact on the internal rate of return (IRR). In comparison, low levels of dust accumulation may not significantly affect the output of small-scale solar plants[7].

Methods

The brush cleaning method combines mechanical and electronic components to control the movement of the brush, as shown in Figure 2, to clean the solar panel with or without water. The on and off process is automated by sensing the current dust accumulation on the solar panels and comparing it to a reference set by the program. The electronic component signals the engine to actuate the cleaning system. The system must be robust to a wide variety of complex procedures to be performed with greater accuracy, flexibility, and control than conventional methods. In addition, the developed system improves the efficiency and output power of the solar panels as a result of improved performance[8].

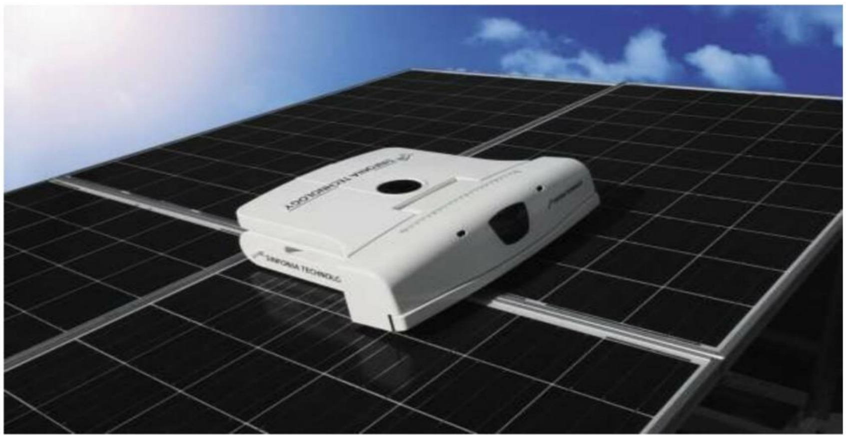

Figure-2. Cleaning solar panels with a robotic brush.

Heliotex cleaning

Heliotex cleaning involves spraying water onto solar surfaces. If necessary, the cleaning system can be programmed based on the environment. If it is blocked by sand and cleaner filling, no additional maintenance is required, except for the occasional replacement of the water filter[9]. Pumps are connected to the reservoir through pipes, installed on nozzles on the surface of the sun. The system is highly efficient and is recommended for areas where there is no water shortage due to the large amount of water used for cleaning. Figure 3 shows the heliotex cleaning method. This system is not suitable for all situations[10].

Figure-3. Demonstration of the heliotex method of cleaning solar panels.

Design of Mechatronic System:

Electrostatic cleaning. Another method of dust removal is electrostatic dusting, which is used on dry and dusty solar panels, as shown in Figure 4. In electrostatic precipitation (ESP), small dust particles on the surface of a solar panel can be removed by induced electrostatic charges. Solar panels are covered with transparent plastic or glass plates of electrostatically charged material; when a high AC voltage is applied to the electrostatic material, the force acts on the dust near it and causes the storage motion of the dust particles to shake them off the surface of the solar panel. The system can clean 90% of collected dust in less than two minutes[11] . An important concern limiting the use of this method is safety. This would be dangerous because the solar panel will always remain charged even in rainy weather. However, the dynamic motion of all particles cannot be conveyed by rigid wire electrodes as experimented in[12].

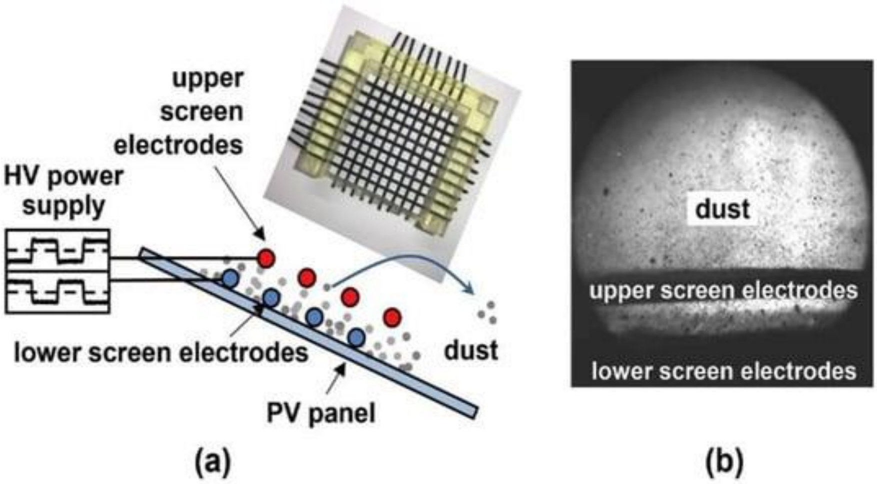

Figure-4. Electrostatic cleaning procedure. Some dust particles pass through the hole in the upper screen electrode due to the inertial force, and the changing electrostatic field near the electrodes excites the dust particles, and a high-speed microscope camera was used. results as shown in (a) and (b), respectively[13].

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Monitoring and Maintenance:

A forced air cleaning system for solar panels helps keep them clean and free of debris. In addition to improving the efficiency and performance of residential and commercial solar panels, these types of systems use a blower to force air through the panels to help remove dirt, dust, and other debris[14]. However, this method is only effective for cleaning air-blown dust from solar panels. Water is not consumed and does not come into direct contact with the turbulent air flow produced by the compressed air[15]. These results were used to build a pilot cleaning and cooling system using a compressed air unit consisting of a compressor, an air tank, an air flow control valve and nozzles with a thickness of 5 mm, see Figure 5

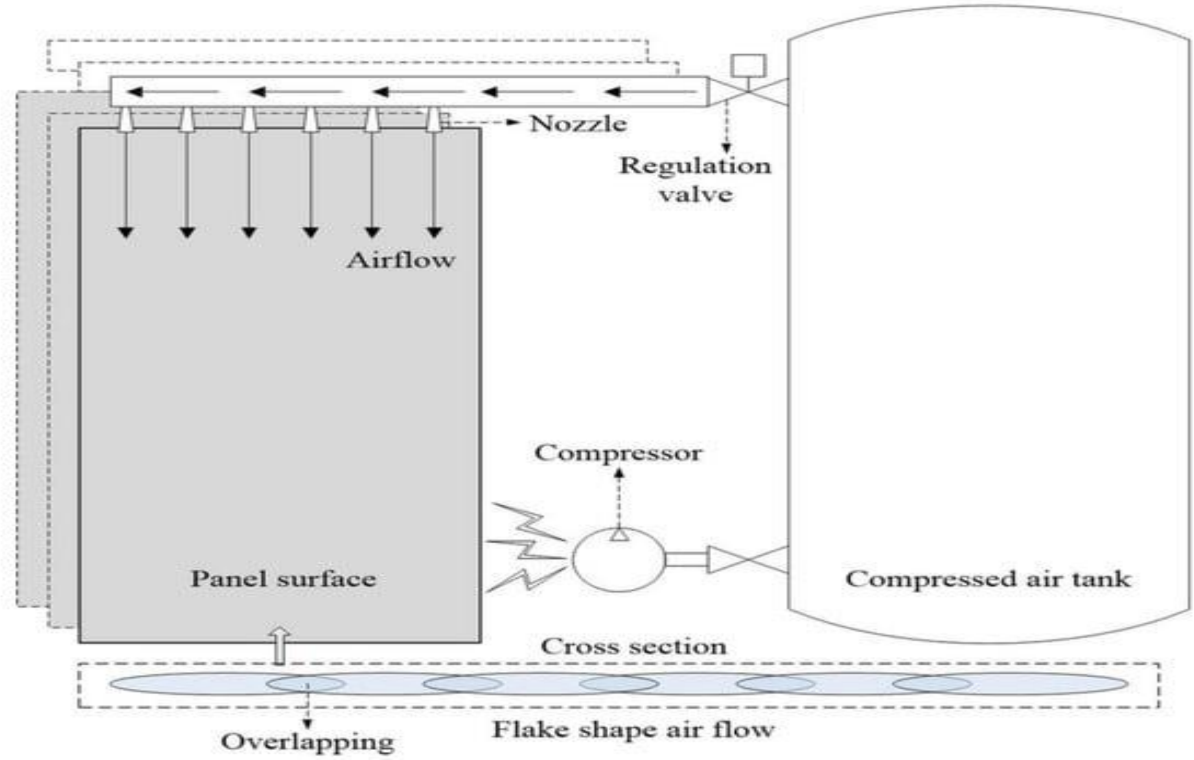

Figure 5. Regulation mechanism for solar PV panel arrays using compressed air.

Results

Compared to other reviews on solar panel tracking and cleaning (e.g., the current review) presents a relatively short bibliometric analysis. was then conducted and only work with those in. Due to the lack of research on the implementation of the Internet of Things in improving the performance of solar panels, the number of articles was significantly reduced during the filtering process[16].

Conclusion:

Well-conducted studies in a systematic review have shown improvements in solar panel cleaning and monitoring by incorporating smart system integration. The results of other reviews of smart systems for solar panels are consistent with the observation that smart systems for solar panel monitoring and maintenance are effective. The solar panel's ability to visualize contamination conditions can play an important role in optimizing cleaning time and performance. Our research identified four areas of intervention: dirt detection, cleaning methods, wireless communication technologies for data collection, and cloud platforms for IoT implementation. There is currently sufficient evidence, but more research is needed to fill the identified knowledge gaps. Smart systems for solar panels have the potential to improve lifetime performance, reduce maintenance costs, reduce human intervention, and increase energy production. Ultimately, the optimal frequency and cost of cleaning must be determined by observed data, but the evidence reviewed here may be useful for practice, policy, and future research.

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