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Review Article

Implementation Guidelines for an Automated Solar Panel Cleaning System

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Abstract

Using solar panels is one of the best methods for absorbing solar energy. PV panels, like any other electrical equipment, require regular maintenance to stay in working order. Over time, the effectiveness of the modules is decreased by the accumulation of dust layers on their surfaces. Water is not necessary for dry or automated cleaning of solar modules. Dry brushes and air pressure are used by solar panel cleaning robots to remove dirt from the panels' surface. In general, dry cleaning is less successful than moist cleaning. This is as a result of the water's role as a conduit for the discharge of dust particles during wet cleaning. However, not all places have easy access to water, which makes cleaning the modules difficult. Dry cleaning can be an excellent alternative in this regard. Moreover, regular wet cleaning of PV modules seems to be a challenging task (because to the significant water, labor, and financial costs involved). This study covers the steps and procedures needed in implementing an automatic solar panel cleaner.

Keywords: *Procedures, Automatic Panels Cleaning, Photovoltaics (PV) Panels, Sun, Energy Generation, Dusts Cleaning.*

I. INTRODUCTION

Since climate change and global warming pose a threat to the future of our planet, it is more important than ever to find environmentally beneficial alternatives to meet our energy needs. The generation of power from solar energy is one of the most effective clean, renewable energy sources. sun panels use sun energy to generate electricity. Solar panels are among the most inexpensive and low-maintenance ways to produce electricity because they don't have any moving parts. Reference [4] conducted research on solar panel efficiency, which quantifies how much power a solar panel generates in respect to its theoretical maximum efficiency. The study tested a solar panel's cleanliness and tracking mechanisms in a variety of settings, including fixed and clean, filthy and fixed, dirty and tracking, and clean and tracking. It has been demonstrated that dust collection on the solar panels' surfaces lowers their efficiency, even with integrated sun-tracking. The increased rate of light transmission boosts the efficiency of the cleaned solar panel [5]. Compared to keeping the solar panel stationary and clean, tracking it can cause an efficiency loss of up to 50%. Large-scale power plants lose megawatts more frequently due to dust buildup on solar panels [6]. A 1% decline in proficiency may have a considerable impact on the Internal Rate of Return (IRR). In contrast, low-level dust buildup might not have a negative effect on small solar plants [7]. In the energy industry, photovoltaics (PV) is a new technology that converts solar irradiance—the radiant energy from the sun—directly into electricity. Here, the photovoltaic cells take the energy contained in the photons emitted by the sun and transform it into usable energy. The energy industry has seen a radical transformation because to PV technology, which has made it possible for the globe to move toward more sustainable energy practices [1, 2]. This opened the door for the photovoltaic sector to make tremendous industrial progress in earlier times, and it continues to do so as technology advances. One can observe a significant advancement in technology if they follow the development of laboratory scale models, experimental scale models, and current real-time running power plants in the PV business. In order to solve the issues with energy demand at the load centers themselves and minimize the need for lengthy

transmission and distribution, these PV technologies have arisen and become a crucial component of many other sectors. Commercial PV technology development led to the creation of big utilities or multi-megawatt power facilities. Utility solar power plants are currently being developed in large and broad numbers on open spaces, rural and urban structures, and water surfaces. Building integrated photovoltaics (BIPV) and building applied photovoltaics (BAPV), a new type of PV technology, have been developed in recent years in response to improvements in PV technologies pertaining to contemporary infrastructure [3]. A study on various dust-removal methods has been conducted. For instance, [15, 16] suggested using a nylon brush with an automated robotic system to remove dust particles from the surface of solar PV panels, while [17] discussed the energy losses brought on by the deposition of dust particles on solar panels. The research conducted by prior researchers revealed a sizable level of power loss [18]. The intensity of power loss worsens when PV based power generation is used on a big scale. Here, a low-power wide-area network (LPWAN) based on a network of ESP8266 node MCUs associated with a set of sensors in various configurations was attempted to be used to develop an automated cleaning system. The results of the experiment were successful enough to be implemented in large industrial scale solar PV power plants. After a year of solar system installation, the solar PV panel's efficiency has dropped to 40% [19]. High temperature, panel pitch and orientation [20], deposition of dust, snow, sea salt, and bird droppings [21], among other factors, are blamed. Among these, the buildup of dust and other debris on solar PV panels causes a 50% reduction in system efficiency [22]. By offering a suitable cleaning method, these particles can also be removed from the panel's surface. A number of research projects were conducted to implement various software-based prototype cleaning techniques. The production was raised by around 35% by using arm controllers [51–55, 57–58, 60] and gear motor-based cleaning techniques. A microcontroller-based automatic dust cleaning system was created to clean the panel every two hours, increasing efficiency by roughly 1.6% to 2.2% [23– 29]. The operational cost is decreased and total efficiency can be raised by supplying a self-cleaning mechanism using software and hardware [30-41]. The cleaning mechanism works more efficiently when the accumulated dust on the panel can be identified and fed to it from the simulation. The performance of the PV panel was improved by a dust cleaning mechanism with a panel cooling system [42–45]. The overall system efficiency of solar street light panels with an automatic dust cleaning system that ran during the day and shut off at night was increased [46–49]. The majority of the established or proposed automated cleaning systems were found to be implemented with dry cleaning mechanisms to prevent short circuits and were permitted to run while dust built on the panels in the research investigations previously mentioned. Despite all of the benefits of solar panels, if impurities like dust, dirt, and dirt are allowed to accumulate, the efficiency of the panels could deteriorate. For solar panels to continue producing power at their peak efficiency, regular cleaning is necessary. Solar panel cleaning by hand is time-consuming and dangerous, though. Therefore, by guaranteeing that the solar panels are kept clean without endangering people, an autonomously operated solar panel cleaning robot could play a significant role in maintaining the effectiveness of solar power production. The cleaning robot contributes to improving the effectiveness of solar panels in a variety of applications, including solar panels in homes and other industries, particularly in harsh areas like Iraq. In this work, a small mobile solar panel cleaner robot is created with the intention of being used in Iraq's small and medium solar panel plants. The components used in the suggested design are readily available. This robot uses two different types of brushes and DC motors to move. One that is hard for tough dirt and one that is moist and gentle for dusting and polishing. We'll be using a water tank, a pump, sensors, and high-friction tank track wheels. Its whole construction will consist of a controller circuit incorporated within a metal chassis. The mobile robot will be wirelessly controlled and observed via a smartphone application. The controller, an Arduino Mega, will behave in accordance with the information received and transmitted [8]. Ski lancer Solar Cleaning created a water-free Solar Cleaning Robot in 2017 to do away with the cost of water and the accompanying infrastructure, including tanker trucks, storage bins, hoses, and pipelines [52, 54]. Every day, it eliminates 99% of soiling. Three components are combined to ensure soiling is moved downward and off panel rows: controlled airflow over the panel surface, a specific microfiber that removes soiling gently, and gravity [9]. The Solar Clean robot, created in 2017, also ensured a secure and eco-friendly solar panel cleaning environment. It can also be used to clean solar panels in desert regions with intense temperatures right after sandstorms. The solar plant personnel may remotely check on the robot's cleaning and operation status via dedicated web and mobile apps [10]. HELIOS, a drone-mounted [50] autonomous cleaning robot service that performs fully automated solar panel cleaning, will be unveiled by clean-tech startup ART Robotics in 2022. A brush and vacuum are used to clean a small, light robot that navigates on its own utilizing edge detection and accurate location estimate. Additionally, the cleaning robots from the solar panels are both deployed and collected by the Helios Drone [11]. Cleaning the floating solar panels, where hand cleaning is practically impossible, is an essential function of the automatic robotic cleaner. The gear motors and motor driver power the robot, and it also has another motor with a cleaning membrane attached to it so that it can be washed with water. The camera records footage of the solar panels and transmits it to the cloud for storage and use in damage and cleaning analysis [12-13]. The majority of places where solar panels are deployed are dusty. The panel's surface is covered in dust, which has gathered and blocked the sun's light. The panel's ability to generate electricity is reduced. In this case, cleaning solar panels on a regular basis is necessary to maximize solar energy. In this study, a cleaning robot is created to regularly remove dust particles from solar panels. A rotary brush and water spray are being used by the robot to clean a solar panel. Additionally added to increase the panel's efficiency is sun tracking [56, 59]. This study proposes a potential method for reducing the impact of dust on a solar PV panel's surface. In largescale solar PV power generation, where many solar panels are connected in the form of arrays and each array requires a robot to

carry out effective cleaning within the allotted time, a decrease in power output has been identified with an increase in particle deposition. An effective cleaning system in large-scale solar power plants requires autonomous automatic cleaning operation, self-control and monitoring of accumulated dust, as well as good coordination through networking between robots. In order to do the same thing, it is required to pick the appropriate communication technology for real-time wireless networking of solar cleaning robots that function over a broad area while consuming little electricity. Here, a low-power wide-area network (LPWAN) based on a network of ESP 8266 Node MCUs associated with a set of sensors was attempted to implement an automated robot cleaning system. The results of this attempt showed promise for implementation in large-scale industrial solar PV power plants [14].

II. BENEFITS OF AUTOMATIC SOLAR PANEL CLEANING

1. Increased Energy Production People frequently consider the money we save by using the sun as a renewable energy source, as well as how solar panels can help the environment by lowering greenhouse gas emissions, when they think of solar panels. The majority of us are unaware that unclean solar panels can't produce as much energy as they could. An automatic solar panel cleaning system safeguards your investment by ensuring that the solar panels are always clean, which can enhance energy production by up to 30%. 2. Minimal Maintenance There is no further work needed after the RST Night Wash automated solar cleaning system is installed on a residential or commercial property. Our systems are constructed to order to meet the precise specifications of a specific residential or commercial solar array and to account for seasonal changes. Additionally, because there are no moving parts, it is simple for residential and business owners to benefit from consistently clean panels without worrying about having to fix or replace system components. 3. Protect Panel Warranty Unfortunately, some conventional techniques for cleaning solar panels can actually cause more harm than good. While maintaining solar panels clean is crucial for maximizing production, doing so incorrectly might result in damaged panels and voiding warranty coverage. RST Night Wash, on the other hand, was created in accordance with all standards and specifications set forth by solar panel manufacturers. Our method employs soft, filtered water to remove limescale buildup and cleans at night to reduce heat stress. 4. No Personal Injury Risk Working on roofs and climbing up there can be risky for both humans and panels. A robotic solar panel cleaning system, such as RST Night Wash, eliminates the need for roof access for cleaners to your home or business. This greatly lowers your responsibility as a property owner. 5. Completely Green A solar panel automation system that is entirely green is called RST Night Wash. We only utilize soft, filtered water instead of any chemicals or their byproducts. Additionally, it uses water very effectively, preventing any unneeded waste [61].

III. THE ADVANTAGES OR BENEFITS OF CLEVER WASTE MANAGEMENT INCLUDE THE FOLLOWING

1. Using intelligent garbage collection bins and systems with fill level sensors saves time and money. Only the filled bins or containers are visited by smart transport vehicles. Up to 30% less money is spent on operations, maintenance, and infrastructure.
2. Because there are fewer waste collection vehicles on the road, there is less air pollution, which reduces traffic flow and noise. Two-way communication between smart dustbins and service providers has made this feasible.
3. It highlights a healthy atmosphere, maintains our surrounds green and clean, eliminates the stench of waste, and makes cities look better.
4. It also lowers the amount of labor needed to manage the garbage collection process.
5. By optimizing management, resources, and costs through the application of smart waste management techniques, the city becomes a "smart city."
6. It assists the administration in bringing in additional funds by running smart device adverts [31].

IV. DRAWBACKS OF ROBOTIC CLEANING OR DRY CLEANING ROBOTS

1. When compared to water-based cleaning, dry cleaning is less efficient. This is because dust particles are more able to be transported away from the modules by fluids like water. 2. These kinds of robotic devices have a significant upfront cost. Consequently, it is not the ideal option for a home system. 3. The operation of these robotic cleaners requires electricity. The additional expense of this electricity mounts up. 4. Since robotics technology is relatively new, there is still a great deal of research and development (R&D) to be done in this field. Artificial intelligence and other sophisticated technologies are still needed for these machines [64].

V. AUTOMATIC SOLAR PANEL CLEANER STAGES AND PROCESSES INVOLVED IN THE IMPLEMENTATION

Solar panels represent a sustainable power source in the field of renewable energy. But environmental elements, like as dust and dirt, greatly reduce their effectiveness, necessitating routine maintenance. Our research presents a novel solution—an autonomous solar panel cleaning machine—in response to the labor-intensive and expensive nature of manual cleaning.

1. Pump Wiring: Because the pump runs on 12V, its wiring is rather straightforward. The pump will initiate the flow as soon as it is linked to a 12V battery. If the pump is linked to a breadboard, it can be operated via a switch or a push button.
2. Pump Connection: To make the pump connection, cut a 20" piece of vinyl tubing in half so that you have two 10" pieces of tube. Next, attach the tube to both ends of the water pump, making sure the tube is tight at both ends with hose clamps. The identification of the pump's inlet and outflow is a crucial component. If you examine closely, you will notice an arrow indicating the direction in which the water will flow.
3. PVC Pipe Assembly: In order to complete this step, first attach the PVC endcap to one end of the PVC pipe and then the PVC adapter to the other end. To connect everything as a single unit, gently press each component onto the PVC pipe.
4. Slip Adapter to Swivel Insert Assembly: This step is to place the female swivel insert onto the slip adaptor. The female end threads onto the male end until fastened together tightly.
5. Hose to Swivel Insert Connection: In this phase, the vinyl tubing is connected to the female swivel insert, and a hose clamp is used to secure the two components together. To guarantee a secure connection, the hose can be slid over the insert until it reaches the base, at which point the hose clamp can be tightened.
6. PVC Pipe to Solar Panel Connection: Mounting the PVC pipe to the solar panel is the next step. Strong sticky tape with two sides can be used for this. The best approach to finish this step is to press on the PVC pipe after applying tape to the solar panel.
7. System Finalization: The last stage involves attaching the PVC pipe tubing to the water pump and securing it with a hose clamp. The connection between the water tank and the pump requires an additional length of vinyl tubing, which is secured using hose clamps. In order to power the pump, the positive and negative wires from the pump must lastly be linked to the positive and negative terminals on the battery. After completing each step above, the system is prepared for operation. Just turn on the pump and let water enter the dispensing unit to start spraying water onto the solar panel.

VI. CONCLUSION

For this study, a large number of articles on robotic solar panel cleaners and solar tracking systems have been reviewed [62]. There has been notice taken of their development and the caliber of their panel cleansing. The advantages of automatically cleaning solar panels are also covered [63]. There is additional discussion of the drawbacks of robotic dry solar cleaning [65].

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