Automatic Cleaning System for Solar Panel

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Abstract: *Generally, the solar panels are installed in the dusty areas. Because of excessive dust accumulation and bird droppings the facility generation efficiency of solar panels is affected. Cleaning the solar array manually is tedious and cumbersome. In this paper we propose a programmable system to scrub solar panels using water and wiper. In this project we are using the technology i.e. Internet of Things (IOT). The Microcontroller and various sensors will be controlled by the system. The system can be controlled by using an android device. The system notifies the user about the varied operations performed through text message. The system could also be converted to portable in order that it are often utilized in various locations.*

Key Words: *SPV panel, Motors, Microcontroller, IOT, Sensors.*

INTRODUCTION:

The sun may be a excellent energy source, so there's many solar power available in nature. If all solar energy could be made available for utilization, supplying the world's energy demand would be more sufficient. However, due to the surrounding environmental conditions, this is not possible. Solar energy are often converted via solar array into more usable sorts of energy. Renewable energy, especially solar power, which provides electricity without causing any impact on gas emissions, is of wide interest. Many alternatives have considered the photovoltaic method of extracting electricity from solar energy. It promises to satisfy the ever increasing energy demand. Due to weather, the efficiency of the solar array is restricted, so parameters like dust, moisture and temperature are extremely important. In this respect, the efficiency study of the solar array was administered with and without dust accumulation. In this project we are going to use the automatic dust cleaning system design and implementation. The main aim of the project is to supply an automatic cleaning mechanism for dust from the solar array. Most of the factors affect the efficiency of Photovoltaic (PV) power, like snow, high temperatures, pollen, dust and dirt. The main factor affecting the efficiency of PV panels is dust, which, depending on the environment, can reduce its efficiency by up to 50 percent. Cleaning has traditionally been done manually. Manual cleaning has disadvantages like accident and panel damage, movement problems, poor maintenance, etc. The automatic dust cleaning system of solar panels has resolved the issues of conventional cleaning and also creates effective cleaning and revents inconsistencies in efficiency thanks to the deposition of dust. Studies conducted to assess the efficiency of the solar array for at some point, one week and one month of dust collected thereon. The efficiency of the solar array was also calculated at some point, one week and one month after cleaning the surface. And finally, it's proven that the efficiency of the solar array increases significantly by comparing both efficiencies. The developed model improves the performance of the solar array .

LITERATURE SURVEY:

Below are the surveys and therefore the study reports done by various differing types of Universities, Firms, Companies and therefore the Farms for the solar array cleaning system.

A) The Boston University Study reported the costs and benefits of three current methods of cleaning solar panels. These methods include natural cleaning through rain and snowfall, manual cleaning, and cleaning by an electrodynamics system (EDS). An emerging technology, called an EDS, consists of interdigitated Electrodes (made of indium oxide) within the transparent dielectric film. The cleaning process is orchestrated by low power, three phase pulsed voltages (from 5 to twenty Hz). An electro-dynamic screen (EDS) or multi-phase electric curtain-based system requires a high- voltage external power source for its operation, but the EDS are often made self-sustainable with the power output from the PV cell itself. It incorporates a transparent EDS with a PV array as its power source to form itself sustainable. This process led to a reflectivity restoration of 90% after only a couple of minutes.
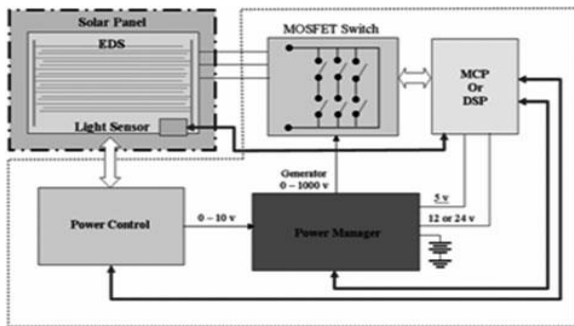
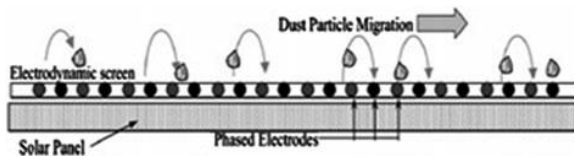**Fig. 2.1 - Block diagram of EDS/PV array system**

Fig. 2.2 - Surface electrodes energized by phased voltages produce an electrostatic traveling wave for lifting and transporting dust particles

B) Manual cleaning technically isn't a robot but as this is often often often one among the foremost used ways of cleaning residential solar panels today it, therefore, important to say also. Standing on ladders or climbing on roofs, this is often often often employment for knowledgeable because it's risky and requires the right material. However, this method may need little or no influence on the yearly yield unless it gets done regularly. Especially if the work is completed by a contractor this could be a really bad investment where the labor costs will exceed the profitable return.

C) Sprinkler systems are often utilized in dry areas to stay panels clean. It the same cleaning effect as rainfall and may clean panels at a relatively low cost. Like most systems, the one found on the web site of Heliotex, exists out of a water filtration system and soap dispensing system. They also mention that water hardness has got to be tested and optionally a water treatment is suggested for locations with water. Although this is often a comparatively good working system, there are a few of drawbacks thereto. This technique is suitable for very dry sandy areas where sand stacks up in no time but won't clean as thoroughly as a brush system.

D) An Italian company called 'Wash Panel' produces robots 'solar panel cleaning robots' that clean arrays of PV panels by moving a vertical brush horizontally over a row of panels. Having a length of 1 to 16 meters and containing a 12V battery it are often deployed automatically. Also, a water hose is attached for wetting the panels while

cleaning. Wash panel's system is fully autonomous, it's a double programmable functioning through a rain sensor and by use of water jets. It provides a continuing and uniform cleaning. This technique is modular, with possible supervision and management from a foreign site. It doesn't require any extra frame, support and extra guides. It are often installed on ground systems, buildings, peaked roofs or shed roofs. For continuous monitoring, it sends text messages to mobiles, allowing command control from remote sites as shown in Fig. 2.3
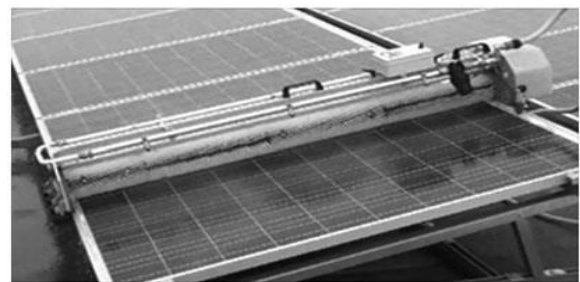

Fig. 2.3 - Wash panel cleaning over SPV

E) Additionally, robotic cleaning mechanisms like 'Gekko Solar' and 'Gekko Solar Farm' from Sabot Swiss Innovations developed for mobile deployment onto SPV panels as shown in Figure 2.3. Gekko solar features a cleaning capacity of up to $400m^2$ per hour. Its cleaning is thru a rotating brush and demineralized water. It's supported by a mobile lifting platform. The operator controls the robot by use of a joystick. It's supplied from a support trolley over a 50m long supply hose. Its movement is predicated on feet, with vacuum technology, which is rotating on two trapezoid-shaped geared belt drives, enabling the robot to astonishing flexible movement in every chosen direction. It are often radio controlled with a joystick.
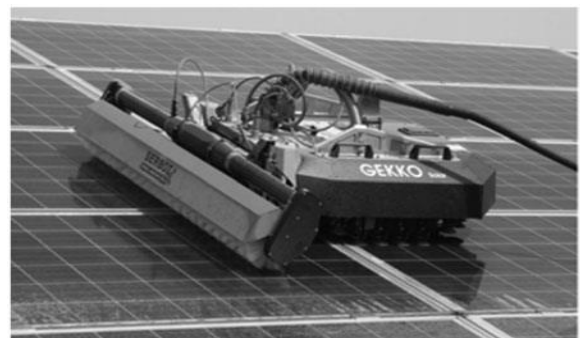
**Fig. 2.4 - Cleaning using Gekko solar and Gekko solar farm**

F) The GEKKO Solar Farm was developed specifically for the cleaning of huge free-field solar parks. The challenge lies within the dimensions. The rows of panels are miles long, which makes an efficient use of cleaning tools a requirement. With a cleaning capacity of up to 2000 m² per hour, GEKKO Solar Farm fulfills this requirement. The GEKKO Solar Farm are often spent to an incline of 30° and may traverse gaps of up to 60 cm. The operator controls the robot over radio control employing a joystick. This is often supported by an integrated crane arm.

G) Module cleaning devices have long consisted of telescopic rods with cleaning brushes affixed to the highest . The PvSpin is a consistently effective and easy-to-handle module cleaning system powered by water pressure. PvSpin works on the thought of two durable rubber brushes rotating in opposite directions, removing dirt and other contaminants from the module surface. Lightweight and straightforward to handle, it are often guided from the ridge of the roof and safely operated by one person. Bird droppings, tough dirt, and other debris are easily removed by the rotation of the durable rubber brushes and filtered water.

Fig. 2.5 - Pv- Spin Module cleaning device

H) Sinfonia's robot Resola features a distinction in being "autonomous" therein, instead of tethered to rails, the robot is in a position to maneuver from panel to panel, to tackle the panels' dirt and debris. The robot is given scrub brush , wiper, and detergent and also sprinkles water stored in its tank. The robot can add the dark. it's LEDs, having wavelengths within the infrared range Fig 2.6.
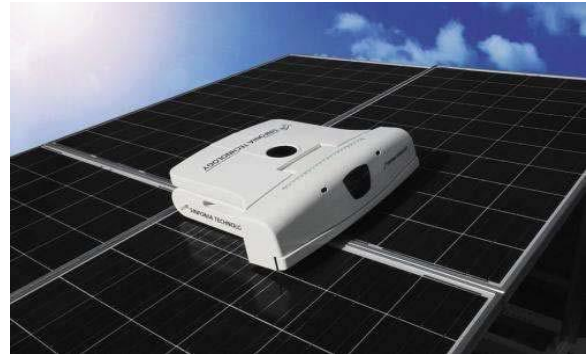
Fig. 2.6 – Sinfonia Robot

I) 'HECTOR' is also one of the robotic cleaning system for Heliostat, which can be used for Solar PV panel cleaning also, as shown in Figure 11. It wireless, rechargeable and carries a water solution tank with itself. HECTOR robots only require an operator's intervention for refilling its cistern, changing the battery and distributing it within the plant Fig 2.6. It's fused with various sensors which enable it to navigate autonomously with none human supervision. It requires no external power or water system for its operation; it carries its own batteries and cistern. HECTOR is supposed for night and day operation. Its performance is extremely slow and thus the load of HECTOR is over the panel. HECTOR performs a radical, uniform, brush cleaning action.

Fig.2.7 – Hector Robot

J) The Ecoppia E4 could also be a totally autonomous robot that uses microfiber brushes to comb the dust off of panels. It's designed for giant rows of panels situated in dry and sandy environments. The brushes move downwards spinning, creating an airflow by making use of gravity that helps to detach the dust. The robot makes use of an onboard solar array and battery to store energy that permits the robot for cleaning in the dark. Another interesting feature is that the positioning of the solar array on rock bottom of the rail, allowing it to be cleaned by the brushes also. Both horizontal and vertical translation happens employing a guide rail and wheels. The E4 cleaning solution removes 99% of dust daily and keeps solar panels at top production levels and use even within

the harshest desert conditions. Eliminating manual labour and water waste, a fleet of E4 cleaning robots is remotely managed from a dashboard or mobile app. By using the self-cleaning mechanism, the water-free E4 robots cleans the PV modules during and after cleaning routines. It's an Eco-hybrid system which helps significantly extend battery life time.

Fig. 2.8 – Ecoppia E4 robot

K) The Solarbrush may be a light-weight, autonomous robot for cleaning solar panels or glass dry environments. Using tracks made up of suction cups, it moves over the panels making it possible to cross gaps up to 30mm and dealing on surfaces tilted up to 35 degrees. Different sorts of brushes are often attached to the front of the robot so as to brush away dust, sand, and dirt. Power comes from a chargeable battery. It's wireless and rechargeable. It's a cleaning brush which swipes the dust. Solarbrush is light weight of 2.5 kg.

Fig.2.9 - Solarbrush robot for solar panel cleaning

L) Miraikikai Inc. designs lightweight, battery powered robots which can autonomously clean large-scale solar arrays. By using rotating brushes to flick away dust and sand, a robot cleaner with small wheels that utilize state of the art sensor technology to deftly navigate entire solar arrays. The smaller prototype SMR640AD model, weighing just 17kg, runs on a Liion battery cartridge that provides approximately 1.5 hours of usable time per 3hour battery charge. The robot changes direction to maneuver to subsequent line of modules when it reaches the sting of the solar PV array and signals the very best of cleaning when it arrives at the "goal" point. Onsite engineers need only replace batteries and monitor the progress of the robot

because it cleans. As compare with the manual cleaning, these robots reduce cleaning costs by 80 percent. These robots would be used solely in countries with high amounts of sunlight and low rainfall.

Fig 2.10- Jetro robot solar cleaning system

M) The NOMADD (NO Water Mechanical Automated Dusting Device) could also be a desert solar battery cleaning system, which embodies the last word combination of solutions to the desert cleaning challenge. The device has eight patents pending that relate to the unique mechanical actions of the system, that allow it to possess just three moving parts while removing 99.6% of dust with a price effective daily clean. The NOMADD achieves its fully automated status, by deploying one dedicated system per row of panels, with onboard power and system . Each row are often up to 200m long, and 5m wide, with plans to expand to 300m because the merchandise develops to satisfy customer needs. The unique and price effective guiding rail system is cost-effective, and ensures that no pressure is applied to panel surfaces which the system translates smoothly across the array for the lifetime of the array. Maintenance are often performed by unskilled labor, by removing the duvet and replacing cheap, simple parts on a two and five yearly maintenance cycle, in under 20 minutes per machine, with one tool.


Fig. 2.11 – Nomadd solar cleaning robot

N) Automated microcontroller PIC based cleaning system helps to reduce the effect of shading on the output power of the PV panels. This design was built and tested for a quick period of some time. Because of the system's location, the research had to need into consideration several constraints like lack of power supply, availability of water, maintenance and available space. Microcontroller technology was used because the electrical basis for the design because of its many advantages especially thanks to its low power consumption. Power losses were calculated and located to be minimal thanks to the implementation of the microcontroller technology during this design.


Fig. 2.12 - The cleaning process where the wiper is pulled upwards by two motors attached to the rails. It also shows the electric circuit designed to power and control the mechanical section

O) The PLC microcontroller based automatic cleaning device wont to enhance the output power of PV modules especially for offshore applications where efficiency and reliability are critical issues. The system is powered and controlled by means of a programmable logic controller (PLC) which has the facility of program upgrading and low power consumption. The model was built and tested. the foremost component of this system is that the PLC which controls and powers both the mechanical and electrical parts of the design . PLC program is an efficient method to make the system fully automated with none human interface aside from initial activation and maintenance issues. The system is successful removing the dust and the bird droppings on the PV panels which helps the PV to possess better output hence, more efficient and more reliable for offshore application.
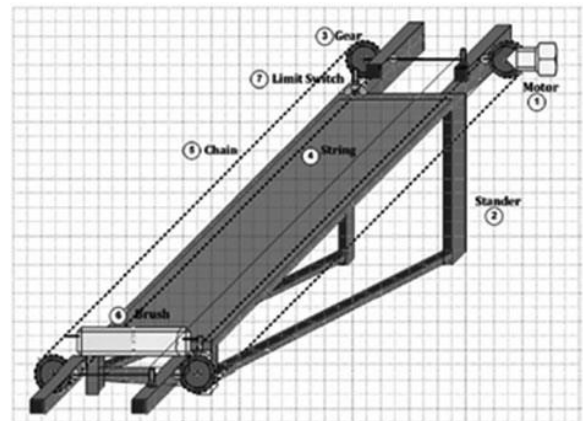
Fig. 2.13 – PLC based mechanical design for cleaning

P) a totally unique four-stage automated 'dry cleaning' method is reported for solar panels. The proposed cleaning process is run in four stages with no involvement of liquids. The cleaning process involves gas spray, followed by cleaning through a foam roller and a poly wool synthetic duster. An electronically controlled mechanical assembly holds the rollers and guides them along the solar panels. The system is extremely useful for small and massive installations alike, especially in dry areas where there's little or no rain throughout the year. The system consists of the onboard compressor which sprays jet air on the panel. it's followed by a panel cleaning employing a spinning foam roller and artificial duster roller. The system is controlled by an on-board microcontroller and really low electrical power requirements are often met directly using the panel itself. Since it involves no supply of liquids within the least , it's extremely cost effective and efficient for the dry and hot environmental conditions as those of Saudi Arabia , Qatar and thus the center East countries. The detachable rollers and readily available components, which make the maintenance easy and really cheap. of those features make this system user-friendly. it's to not be confined to large industrial plants, and should equally be used at the small scale for home and buildings PVs and solar panels.
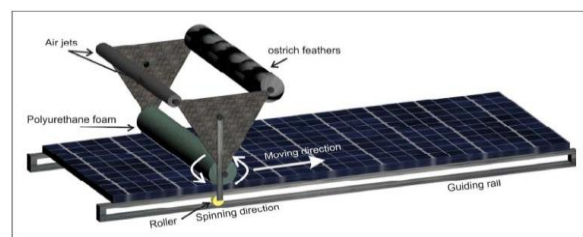
Fig. 2.14 – Novel dry cleaning assembly for cleaning

Q) Mechatronics drive system for cleaning machines is that the structure of the cleaning machine, hydraulic scheme and thus the mechatronic system supported a unit with a microcontroller. The cleaning machine combines a washing system with low- pressure water jet (~2 bars) with brushing the photovoltaic panel. The mechanics and kinematics of the machine were developed by the R&D institute ICTCM Bucharest. It is a Hydraulic tank of 100 litres with return filter and oil cooling system. Automating of the installation is based on a microcontroller unit that receives information from sensors, from contacts limiter, thermostat and thus the pressure switches and provides commands to the valve coils for creating various movements. Electrical commands are given through high side switches IC's. The project is extremely complex and requires design in terms of kinematics, hydraulics, and mechatronic systems. The washer for solar photovoltaic panels is that the primary of its kind being developed within the country and is within the prototype stage.
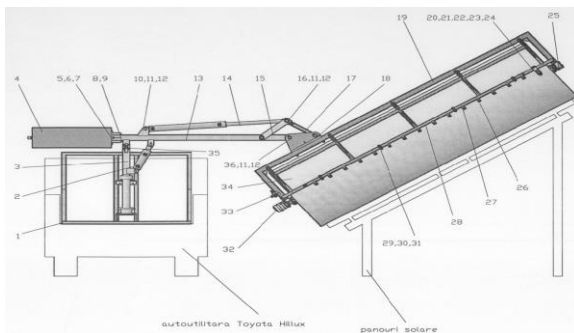

Fig. 2.15 – Mechatronics drive system for cleaning

METHODOLOGY:

Dust deposition on the solar array can reduce the extent of performance of the solar array and reduce the productivity of solar cells and, if the panel isn't cleaned, the efficiency is approximately 50 percent over 6 months. This leads to significant annual monetary losses. We proposed a cleaning mechanism during this paper to wash the accumulated dust on the solar array. This proposed system is totally automatic and doesn't require any human intervention, but the system are often initiated / triggered via the android device if the automated system sometimes does not respond. Regardless of their size, the system are often attached to any solar array. The system operates by the microcontroller which is fixed to the frame and it will move using the stepper motors with the wheels. The power is supplied to the whole system via batteries or solar panels. The cleaning wiper is triggered by the initiation of the water spray mechanism as soon because the dust sensor detects dust. There will be no dust

notifications about the cleaning operation will be sent to the user after the dust sensor senses.

The methodology involves the following steps:

1. Details on the effect of accumulation of dust on the solar array on the efficiency of power generation.

2. Designing an automatic cleaning system model.

3. to stay the value minimum and produce an efficient system, select the microcontroller, sensors, water nozzles and other components for the system.

4. Design of an effective communication system for communication between user and microcontroller.

ANALYSIS OF DUST ON PANEL:

The accumulation of dust on the solar array surface reduces radiation to the filament and causes voltage and power loss. Dust not only reduces radiation within the photovoltaic cell , but also changes the reliance on the angle of incidence of radiation . Research shows that the daily energy loss due to the dust deposited on the surface of the PV module is around 4.4% over a year. Daily energy losses can be higher than 20% during a longer period of time without rain. Moreover, the loss of radiation isn't perpetual during the day and immensely depends on the angle of sunlight and therefore the ratio of attenuation to direct radiation. The loss of solar output is symmetrical at noon when studied according to the position of the sun, where the minimum value is reached. Different pollutants were tested for the performance of the PV module. Depending on the quantity and type of contaminant accumulated, a decrease within the voltage and output power of the PV module is observed when particles of dust are stashed in the Solar module. In addition, there's a greater reduction within the temperature of the PV module. The PV modules are clean and funky, also as efficient system performance. The generation of electricity within the solar array is calculated scientifically with dust and without dust with different load resistance.
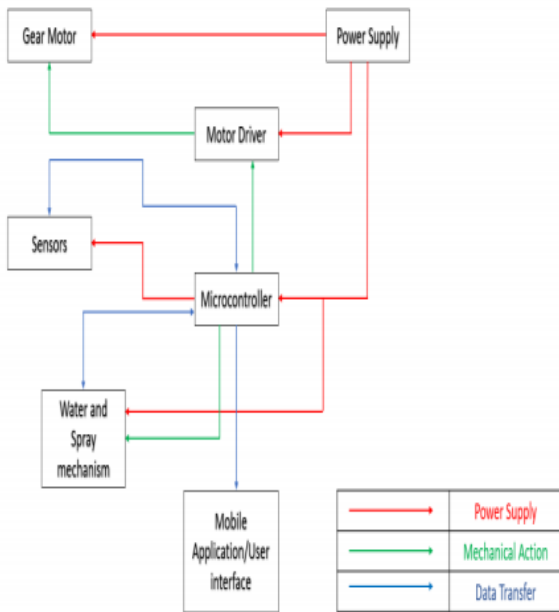
Fig.1 Flow Diagram of Cleaning System
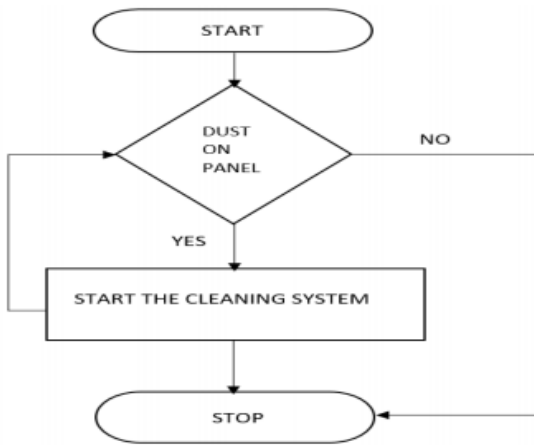

Fig.2 Automated Solar panel cleaning Algorithm

This project consists of 4 modules:

1. Sensor module

2. Motor module

3. Cleaning module

4. User Interface

1. Sensor Module

The dust sensor detects dust on the solar array . If there's dust the sensor gives a positive value and if there's no dust

the worth is negative. The microcontroller, on the idea of knowledge, communicates with the opposite modules to initiate cleaning or not.

2. Motor Module

The motor module deals with the movement of the cleaning device. When dust is accumulated on the panel, the dust sensor sends a positive value to the microcontroller, which then initiates the motor driver to activate the cleaning device.

3. Cleaning Module

The cleaning module deals with the cleaning of the panel. As the motor driver gets initiated, the microcontroller then asks the wiper to start out out out the clean operation and also activates the spray mechanism. The cleaning operation is performed till the dust sensor gives a negative value.

4. User Interface

The interface enables the communication between the user and therefore the device. The device sends text messages to the user through IFTTT to inform him about every operation that's being performed. Also, during this module the user can initiate to wash his solar array own through the mobile application.

APPLICATION:

In the 21st century, the utilization of non-conventional energy resources for electricity generation increased. More and more people install solar panels on their home's roofs to get electricity. However, when dust is accumulated on the solar array , the flow is reduced and fewer electricity is produced. Therefore, cleaning the panel as soon because the dust is accumulated is extremely important for the right power generation. But it's a really tedious task to wash the panel, requiring human effort and time that the majority people don't have. The elderly cannot clean the panel even regularly. The solar array cleaning device therefore helps the user solve all the issues mentioned above. It automatically cleans the panel employing a dust sensor, cleaners and communicates with the microcontroller. The device also allows you to speak in order that the user also can start cleaning whenever the user wants.

ADVANTAGES:

1. System has to be installed only once.

2. Low operation and maintenance costs.

3. Easily replaceable components.

4. Easy installation.

5. Low production cost.

6. Highly safe cleaning system with no threat to humans.

7. Easy to operate and maintain.

8. No heavy machinery is required.

9. Working in a system is very easy.

DISADVANTAGES:

1. Microcontrollers may get damaged due to irregular voltage supply.

2. Wiper must be changed when wiped out.

CONCLUSION:

Existing automated cleaning systems focus totally on large solar energy plants and aren't generally useful for installation on smaller solar panels on dwelling roofs. This means that only a smaller solar array must be installed for those with space constraints, which is why this project offers these smaller solar panels an enormous advantage. The system are often installed on the highest of the roof for solar panels.

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