# DEVELOPMENT OF PHOTOVOLTAIC SOLAR PANEL CLEANING MECHANISM

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## ABSTRACT

*Growing interest in renewable energy has led the solar photovoltaic industry to expand notably in the last decade. However a big issue that is often overlooked too easily, is keeping the panels clean. Panels are often difficult and dangerous to reach and not worth the risk cleaning them. The implementation of a PV system has shown that their reliability and efficiency depend upon many factors.The output of solar PV system is mainly affected by different environmental factors like dust, color, irradiance, shading, etc. Dust is also an important factor that degrades the panel rating. The temperature effect on the current and thus the power rating of the panel is also considered in this paper. Furthermore, autonomous cleaning robots are often only economical on a larger scale due to both installation costs and the fact that custom-made parts are needed to fit the plant. However, dust particles tend to gradually accumulate on the PV surface making the cleaning task more difficult. The accumulated dust reduces the overall PV panel efficiency due to the combined effect of shading and heating.This paper's focus is on solar panels cleaning mechanism which is more economical to small scale photovoltaic panels. This paper mainly focusing on cleaning solar panels up to 4KW rating which is for small rating. This paper briefly discusses the type of dust and other deposits on solar panel surface but eventually the paper shall focus on atmospheric dust and bird shit as these are most common in the present scenario.The solar panel cleaning device clean the solar panel weekly. Cleaning device increase efficiency and life of solar panel.However, dust particles tend to gradually accumulate on the PV surface making the cleaning task more difficult. The accumulated dust reduces the overall PV panel efficiency due to the combined effect of shading and heating.*

**Keyword: -** *Solar, Photovoltaic, Panel, Cleaning, Mechanism*

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## 1. INTRODUCTION

Solar power has become central to the quest for clean, renewable energy. The use of photovoltaic panels and photo-thermal collectors is expanding rapidly as the world embraces a new era of "green" power. Widespread, efficient solar collection could have a significant impact in reducing greenhouse gas emissions, enhancing energy security, and creating jobs in countries that have abundant sunlight. At the present time, less than 0.04% of global energy is derived from the sun. [1].

Environmental degradation affects performance and durability of solar optics and decreases optical efficiency of photovoltaic (PV) modules. Energy-yield losses caused by the deposition of atmospheric dust often range from 5 to 30% annually. The environmental degradation of PV modules includes [2] loss of optical efficiency by soiling, [3] UV radiation damage the polymer films used at the back and front surfaces, [4] delamination of the module, [5] moisture penetration and damp heat related component failures, [6] corrosion of metal contacts and interconnections, [7] mechanical damage, and [8] cell failures caused by other problems such as hot spot formation by shading losses [2]–[8]

Growing interest in renewable energy has led the solar photovoltaic (PV) Industry to expand notably in the last decade. In the year 2013 a staggering 80 terawatt-hours of electricity [1] was produced in the European Union hence covering 3 percent of the total electricity demand. Because photovoltaic energy is an accessible technology it has become a popular investment for companies as well as for residential users. Consequently, this demand has stimulated the research for increasing the overall output power of PV systems causing laboratories all over the globe to work hard on making the technology both more efficient and cost effective. Regardless of the effort of the industry to shorten the payback time, a preventable loss namely soiling is often overlooked. As a result a layer of dirt piles up on top of the glass reducing its transmittance and therefore decreasing the power output of the entire system. The rate at which the power reduces over time is rather unpredictable as it depends on various environmental factors such as the type of soil, agricultural activity, precipitation, wind, bird droppings. Common order of magnitude for losses due to soiling can be estimated between 3-8% but can go up to 30-40% in dry and sandy climates. Seeing that precipitation plays a considerable role in the cleaning capability it must be said that rainfall often does not suffice because some types of soil cement and stick. The same counts for bird droppings which don’t flush away either.

However cleaning solar panels is not always as straightforward. To begin with, there is the issue of accessibility. Due to the fact that PV panels often are situated on dangerous and difficult to reach places, it might be hard to clean them manually and it takes time to do it safely. Secondly, cleaning a panel only once a year might not have a significant impact on the yearly energy yield for the simple reason that dirt stacks up again in a short period of time making the difference negligible. Especially if you need to contract someone to clean the panel for you, it might just not be economical. However, leaving panels uncleaned might not be wise either since soiling can lead to permanent damage of the glass limiting the lifespan of the installation. Lastly, because cleaning the glass only seldom pays off and plants might be unreachable to clean, the logical solution is to clean them automatically and autonomously. Sadly, there isn’t an abundance of such products available and therefore often built to purpose robots do the job. As a result cleaning robots are only cost-effective on vast plants.

Therefore this paper is aiming at working out a concept design for an autonomous cleaning robot that is both flexible as it is cost-effective in order to be economical at smaller scales. The way to do this is by focusing on the most costly features of installing a robot to an array of panels. The biggest factor that makes up the cost of a cleaning robot is the drive system. Cleaning robots are most commonly installed on rails along the panels. These make the installation relatively expensive for two reason. The first reason is the obvious fact that more material costs more money. All parts are machined and often are built to purpose, in order to fit a specific plant. The second reason is the labour costs for installing the track system to the installation. Apart from rail based robots, there are other solutions for cleaning panels like sprinkler systems or robots driving on caterpillar tracks made from suction cups. However, these solutions lack both flexibility and cost effectiveness to be applied on a smaller scale. The logical next step is to look for a more adaptable and economical drive principle for the robot to translate itself over the panels. A concept then has to be investigated on the different design criteria that come along with building such a robot. The robot has to be able to handle all the forces involved with moving it and this for the different angles at which solar panels can be installed. The driving principle has to be modelled in order to make sure the demanded criteria are met and to simulate its behavior on a commonly sized installation. Later on, a physical proof of concept is made in order to validate the model and to grasp of how it would work in real life.

## 2. LITERATURE SURVEY

In Saudi Arabia, the accumulation of dust on the surface of photovoltaic arrays decreases the power production by up to 50% for a duration of one year and up to 32% for a duration of 32%. While in Egypt the effect of dust on photovoltaic solar panels is reduction in power generation by 65.8% for a duration of 6 months, while in Thailand 11% reduction in transmittance was reported in a one month study[9].

Research done by engineering students in Baghdad in 2010 found that the transmittance decreases over a month period by approximately 50% on average due to the natural deposition of dust on photovoltaic panel. Cleaning is dependent up on the environment, which is evident by a claim of a New Zealand company that solar panels there should be cleaned only once or twice in a year specifically due to the environment there[9].

Electrostatic cleaning is a tested method and provided most effective cleaning with minimum moving parts leading to better reliability; however the cost of this cleaning system is a factor of concern. Electrostatic cleaning is effective only at dry and dusty area, as if it was designed specifically for photovoltaic panels located on Mars. Two minutes of cleaning cycle can remove up to 90% dust from surface of the panels. This cleaning methodology requires small amount of electricity, so it provides a power efficient system, yet at present the application of this system is only at 4%[9].

## 3. CONCEPT OF CLEANING MECHANISM

As mentioned earlier, cleaning of bird shit, besides cleaning dust from the solar panel is one of our main concerns. Bird shit, if left unattended, can seriously damage the solar panel glass due to its acidic nature. Thus we explored cleaning solutions accordingly. We found that there are basically three resources for cleaning the solar panels, pressurized air, water and use of brushes. We then did a few basic experiments on the possible application of these resources for our purpose. We found that neither of the three resources, if used individually, can efficiently clean both bird shit and dust off the solar panel surface. However when used in combination, use of water and brushes provided for the most economical and yet sufficiently efficient cleaning prospect.

### 3.1 Components

To develop an efficient solar panel cleaning mechanism we have thought of a design with following components

- Brushes
- Two dc motor
- Power screw
- Two guide ways
- Watering mechanism
- Drying mechanism

### 3.2 Construction

The power screw shall form the basis of linear motion. A high torque, medium speed ( approximately 400 rpm ) motor shall transfer rotational power to the power screw, which shall convert this rotational energy to linear motion. An assembly of spiral & cylindrical brushes shall form our cleaning workhorse. The brushes should be of sufficient height and softness to accommodate for cleaning at the solar panel boundary as well. This shall form our cleaning arm. The cleaning arm shall be coupled to another motor of high speed and low torque such that the dust particle are efficiently cleaned in even the first cycle itself. This cleaning arm along with its motor coupled to it at one end, shall be mounted on the power screw which will allow for the linear motion of cleaning arm throughout the solar panel surface. Power screw along with its motor shall be placed in the middle of our solar panel array, the cleaning arm shall be placed on top of the power screw but placed perpendicular to it. The cleaning arm should be provided with guide-way at both right and left extreme ends. A watering and drying mechanism should be provided for as well, since without watering the solar panel it would be difficult to completely wash away bird shit; also without proper drying of water once the cleaning cycle is completed, the dust from atmosphere shall accumulate back on the solar panel negating the efforts taken in cleaning. Considering the cost of components and the bending moment, we intend to place the power screw(the costliest component) along the shorter side thus by reducing the length of the power screw we can improve it bending moment and lower the cost of system; this would allow for cleaning along the longer side.

### 3.3 Working

From our initial experiments on cleaning of bird shit, our observations were that if bird shit is made wet and allowed to stay like that for a few minutes, then with even a few strokes of brushing it is easily and completely removed from the solar panel surface. Thus for our cleaning mechanism we intend to water our solar panel first. With this watering the bird shit can be soften also more importantly most of the loosely placed dust particles shall wash down along with the water making the cleaning process easier. Next after a few minutes, both motors should start, thus the brushes on the cleaning arm are now rotating along their shaft, also this cleaning arm is linearly transiting through the power screw. When the cleaning arm reaches at extreme of the opposite side, the polarity of motor coupled to the power screw should be reversed which will allow for reversal of path of the cleaning arm. A to and fro movement of the cleaning arm will form one cleaning cycle. We hope to size the motors and brushes such that we achieve efficient cleaning of the solar panel surface within maximum two cleaning cycles, thus limiting our energy consumption for cleaning process. At the end of two cleaning cycles, drying of the solar panel surface is important otherwise dust from the atmosphere shall stick back on the recently cleaned but wet surface, thus negating all the efforts taken in the cleaning process. This entire cleaning process shall be undertaken in evening time so that the power generation from solar panels is not disrupted in any way.

### 3.3 Expected Result

With such an arrangement for cleaning, we expect to achieve a clean and dry solar panel surface at the end of two cleaning cycles. There shall be no mark left of even a week old bird shit on the panel surface. We also expect to accommodate for a cleaning frequency of once in 15 days by providing thorough cleaning each time. Thus we can successfully limit our energy consumption and provide for more energy production by the cleaned solar panel surface than the energy consumption in cleaning the solar panels.

## 4. CONCLUSION

This project highlights the effect of dust, dirt and bird droppings on the PV system's efficiency. However, the development of the cleaning mechanism can help solve those problems. This development is divided into two parts; mechanical (stability and cleaning mechanism) and the electrical specifications. The cleaning time has been reduced to two minutes by setting a path for the system on the surface of the PV panel. From this project we learned about he field of mechanical designing. Also learned how to lead and manage a project in the future.

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