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# A Review of Solar Panel Cleaning Systems

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***Abstract*—** solar energy is a renewable source of energy, which has a great prospective and it is emitted by the sun. The effectiveness of solar photovoltaic model is determined by the existing Sun's irradiance along with various ecological factor like moisture, temperature, dirt, slush, bird excrement etc. These ecological factor decreases the performance of the p-v modules. The power output decreases as much as by 50% if the module is not washed for a month. This paper covers the problem associated with solar cleaning system and also discusses techniques used for solar panel cleaning.

***Keywords-*** *Solar P-V, Cleaning of P-V Panel techniques.*

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## I. INTRODUCTION

Global Energy demand is hypothetical to be improved by more than 50% on 2030's. Many governments in the world have dedicated to implement renewable energy source to cope energy demand in transportation, heating as well as in power sector industry. The sun produces energy at very large rate hence there is abundant accessibility of solar energy in the nature. Solar photovoltaic being one of the renewable energies is making a lead in global market for past few years. The 15-18% of solar radiation is used to produce electricity. This efficiency changes due to several factors like: lower irradiance; higher AM; higher temperature; regardless of this solar radiation is failed to be harnessed due to accumulation of foreign particles like dust, bird excrement, snow, and many other [1]. Solar PV panel cleaning has been a challenge in renewable energy segment to achieve supreme efficiency possible. Different cleaning systems have been designed to handle up reduction of efficiency and studies have been made to show the usefulness of cleaning system.

## II. SOLAR PANEL EFFICIENCY

Solar panel efficiency is a quantity of how much of the sun's energy assured panel can convert into usable electricity. This is done by taking the electrical current made when sunshine interacts with silicon or thin film cells inside a solar panel. If a solar panel has 20 % efficiency that means it's capable of converting 20 % of the sunlight hitting it into electricity. The highest efficiency solar p-v panels can reach almost 23 % efficiency. But the average efficiency of solar p-v panels falls between the 15 to 18 % efficiency ranges. Mathematically, efficiency of solar panel is [3]

$$Efficiency = \frac{Voc * Isc * FF}{Pin}$$

## III. EFFICIENCY CONSTRAINTS IN P-V SYSTEM

### A. *Material*

Three main semiconductor ingredients namely Silicon, Cadmium Sulphide and Gallium Arsenide have been successfully used for operation of thin film PV cells. Other widely used materials are Arsenic, Indium, Phosphorus, Sulphur, Tellurium, Zinc and Aluminum. Moreover, these materials are expensive, exotic and fragile. Processing and reprocessing of the materials can lead to toxic pollution of the environment. In addition the storing batteries used for PV systems are more often accountable to environmental pollution as they use some toxic materials like Lead, Nickel, Cadmium, Acids etc.

### B. *Cost*

The most costly part of a p-v energy system is the power storage. It needs very costly storage devices like batteries to provide power in the night.

### C. ***F****abrication*

The fabrication process of p-v cells are quite difficult. To make p-v cells we need pure slicon which is relatively difficult to make. It also needs Indium which is very rare. We also need large amount of heat energy (around 900ºC) and a very clean environment to make solar cell.

### D. *Environmental Constraints*

Different Ecological factors such as: temperature, humidity, solar irradiance effect on efficiency of solar panel. Cell temperature affects the output of solar panel, as the temperature of solar cell rises, band gap decreases following the decrease in solar short circuit voltage which finally results in decrease of output power. Short circuit current of solar panel is directly proportional to incident light intensity

ISSN: 2454 - 4248
84 – 86

whereas open circuit voltage increases logarithmically with incident light intensity [3].

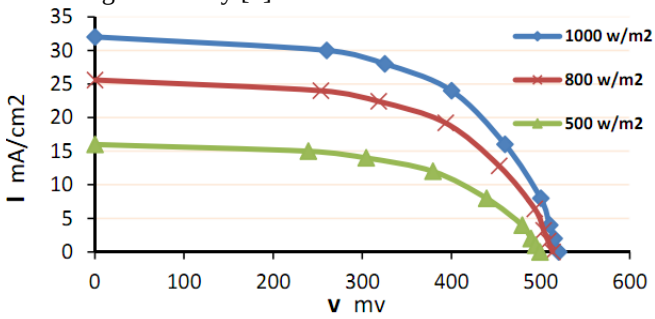


Figure 1. V-I characteristics for different irradiance

## IV. TECHNIQUES TO IMPROVE/MAINTAIN SOLAR PV EFFICIENCY

The loss of illumination plays a vital role in producing solar energy. This can be began by factors that is a part of the combined system or a member of the atmosphere. Furthermore, this leads to the lowering of efficiency in the system. Some of the difficulties that drags the output of the panels require into contemplation that a different material needs to be hosted that can be utilized to its maximum potential. However, problems as such including effect of dirt, effect of humidity can be minimalized and the efficiency of solar panels can be improved by cleaning of the panels. Various methods have been introduced whose sole purpose lies on improving the efficiency through cleaning.

Solar panel cleaning can be both automatic and physical. Physical washing demands extensive labor. Moreover, physical cleaning maybe practical to households with a few solar panels. For large scale projects the situation favors an unmanned automated cleaning system that can take in the real time data with survey to the dust accumulated, power generated and clean henceforth. The many automatic systems made as of today are needy on the landscape of the place where the solar panels are located. Depending on these issues, many tools have come to surface that optimizes the performance of solar panels by cleaning them.

### *A. Linear Piezoelctric System*

A linear piezoelectric system contains two heavy feet integrated face to face onto a guide which is operated at the same operating frequency to form two symmetric oval trajectories at two driving tips [7].

### *B. Gekko Solar and Gekko Solar Farm*

The cleaning is done by a revolving brush and demineralized water. Its movement is based on feet, with vacuum technology, which are rotating on two trapezoid-shaped geared belt drives. This enables the robot to move on every desired direction. The robot is designed for places that are difficult to access. For larger application, 'Gekko Solar Farm' has been used. The GEKKO Solar Farm robot is designed for utility scale solar farms. With an efficiency of up to 2000 $m_2$ per hour the robot is very powerful [8].

### *C. Fuzzy Logic Control based Solar Panel Cleaning*

Fuzzification of sunlight sensor output and cell output current is done and defuzzification of input variables decides whether to clean solar panel or not. Motor driver for cleaning action is dependent of fuzzy logic. Cleaning action is decided by the fuzzy logic of two input variables irradiance and output current [9].

### *D. HECTOR*

HECTOR is a automated washing system, which can be used for Solar PV panel cleaning. It is wireless, rechargeable and carries water solution tank with itself. It requires no external power or water supply for its operation; it carries its own batteries and water tank. HECTOR is designed for night and day operation. Its performance is very slow and the weight of HECTOR is over the panel [10].

### *E. Solar Brush*

Solar Brush is a robotic cleaning system for SPV panels. The robot 'solar brush' walks over the solar PV panel. It is wireless and rechargeable. It is having a cleaning brush which swipes the dust. Solar brush is light weight of 2.5kg.

### *F. Greenbotic's robotic cleaning system*

'GB1' from Greenbotic's is a robotic cleaning system for SPV panels. It is wireless and rechargeable. It includes rotating cleaning brushes vertical to the axis of panel and a wiper system, such that not only does it clean the panel, but also clear the dirty water [11].

### *G. PLC based cleaning system*

This is an example of cleaning system that lifts the output power performance of P-V compromised by the effect of shadowing and shading. The main component of this system is the PLC which controls and powers both the mechanical and electrical parts of the design. The system is successful in removing dust and bird droppings on the PV panels which led the PV to have better output hence, more efficient and more reliable for offshore application

### *H. Automatic Solar Panel Cleaning System*

It automatically wash-downs and rinses the solar panels. It attaches nozzles to the solar panels. It comprises a reservoir for soap concentrate. There is also a deposit filter that contains water softener media. It also has an anti-siphon valve to prevent backwashing into the system. System consists of a controller which automatically provides wash and rinse cycles, the controller programming can be changed as per seasonal requirements [12].

### *I. Electrostatic Charge System for cleaning*

Places with very rare source of water such as deserts, thirsty areas like Saudi Arabia or even places with no water like Mars use electrostatic techniques for cleaning. Electrostatic charge concept for lifting and transporting charged particles of insulating materials has been used for providing standing wave-type electric curtain.

## V. DISCUSSION AND CONCLUSION

Environmental factors like humidity, temperature, solar irradiance affect efficiency of solar p-v panel. Atmospheric dust and dust deposition on solar panel both decrease efficiency of solar panel. Experimentally it is seen that efficiency of the solar panel reduces by 30-40% for indoor set up with constant illumination whereas there is loss of 4-5% for

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84 – 86

outdoor set up with natural lightening condition. Most of the cleaning system require human interface to clean efficiently, and uses high pressure water to spray on surface thus requiring high power to operate.For automatic and uninterruptible cleaning PLC based cleaning system is finest but requires heavy gears that add load in the surface of the panels.

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