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Design, Development and Performance Evaluation of Solar Panel Cleaning Kit for Street Lights and Ground Mounted Systems

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ABSTRACT: *Solar Photovoltaic (PV) is one of the key renewable energy sources and is the base to fulfill future world's energy demand. Solar PV power has been adopted on large scale as well as on domestic scale. The main reason behind it's successful utility as a power source is due to its less maintenance and increasing efficiency with decreased per Watt cost. Now several GW of solar installation have been done all around the world whereas more is planned to be installed in future. One of the major advantages of solar PV panels is its installation in places where conventional grid is not accessible. Maintenance of solar energy is relativity low as compared to other power generating sources. Although less maintenance is required but still significant factor that reduces its generation is dust accumulation on solar PV modules. Dust accumulation effectively decreases the solar panel energy yield. The paper deals with indigenously designed automatic cleaning mechanism for solar PV modules. The designed mechanism comprise of an electronic solar kit that automatically cleans the solar modules at desired Rate without requirement of Water for solar module cleaning. This cleaning mechanism is also suitable for pole mounted street lighting systems where daily manual cleaning is not possible. The cleaning kit was indigenously designed and tested under areas of Karachi Pakistan.*

Keywords: Solar Cleaning, Electronic Kit, Dust, Brush

1. INTRODUCTION

Solar Energy is one of the important renewable sources of power generation for future. Since World's fossil fuels are decreasing and in near-term conventional power generation will not be able to fulfill world energy demand. To prepare for the upcoming and unstoppable fossil fuel depletion disaster, the only and reliable sources of energy would be renewable energy. In 2013, 37,007 MW of solar PV power has been installed worldwide whereas world solar PV power capacity has been increased to 35% i.e. 136,697 MW [1].

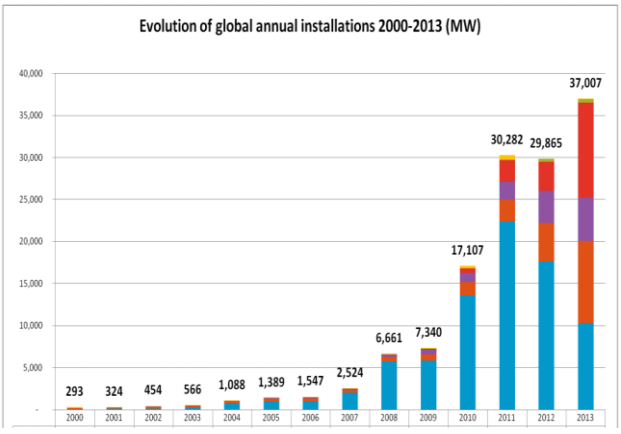

Figure 1: Evolution of global annual installations (MW)

Technological advancements in solar energy make it a viable power generation source for future. Solar energy has an efficiency of 19.41%, the efficiency was independently confirmed by the National Center of Supervision and Inspection on Solar Photovoltaic Product Quality (CPVT) in Wuxi, China [2]. The cost of per watt is also decreasing from 2009 to 2015. Figure 2 shows the cost of solar module decreased from $1.29/W to $0.42/W $/W over the worldwide.

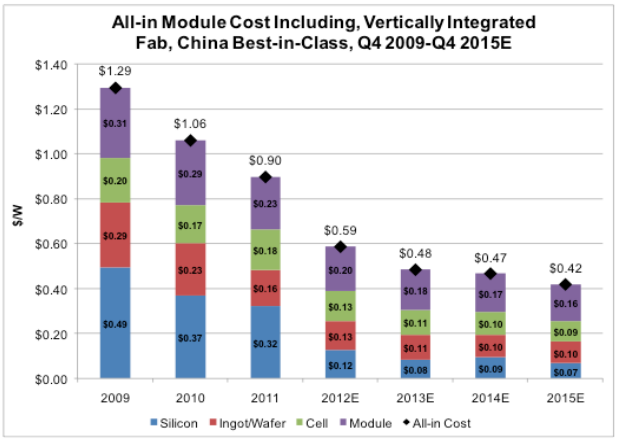

Figure 1: The $/W cost decrement worldwide [3].

Technological maturity and economic viability of solar PV power shows its prominence as a perfect replacement for the fossil fuels. Since solar PV does not have any moving part and requires less maintenance, but still it requires regular cleaning in order to generate maximum power. Solar PV modules are installed on roof tops and in large grounds; dust is accumulated on solar panel, which significantly reduces the power yield. Power loss can reach up to 1.35% due to dust accumulation on solar PV module. Figure 3 shows the percentage of energy yield loss in different areas of the world.

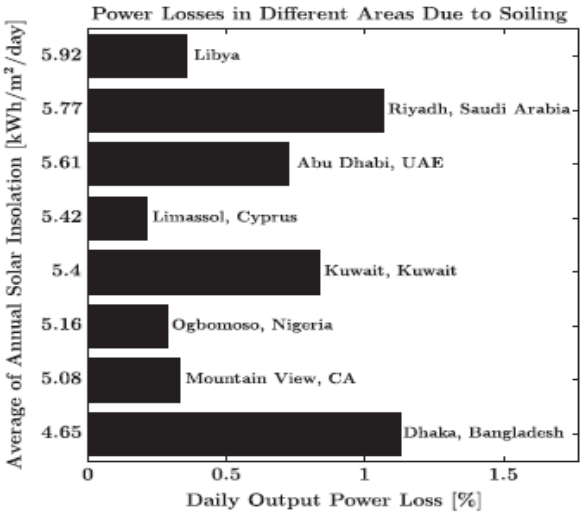

Figure 2: Daily Output Power Loss (%) [3]

On the other hand, factors like bird droppings, contamination etc. make this mandatory to clean the solar modules on regular basis. This increase the maintenance cost and also seems to be a hectic job since a person is required for passive cleaning of the solar farm or pole mounted street lights every day. Nevertheless several techniques have been adopted to clean the solar PV modules with less cost. Author discusses a solar cleaning system with solar tracker in [4] to maximize the solar PV power yield. The system comprises of a tracker, brush and a servo motor. The tracker tracks the sun movement around the day and microcontroller controls the operation of servo motor. The brushes are coupled with motor to clean the solar panel twice a day. Solar PV module cleaning mechanism is developed in United Arab Emirates to clean solar module using PLC and microcontroller [5]. The main purpose was to clean the solar panel from bird droppings since on sky scrapers bird's droppings are the causes of power loss. Microcontroller has been utilized to spray the sea water available in a tank on solar module whereas PLC based programmed brushes used to clean a solar panel for twice a day. Author developed a cleaning mechanism for small scale solar PV plants in [6]. This mechanism comprise of a nozzles placed at the top the solar array. Upon the command/signal from microcontroller, these nozzles spray cleaning solution on solar array. Author in [7] discussed the few concerns of [6] that need to be rectified includes unequal water flows at the end of the solar array, utility of large amount of water for large scale of PV power plants, high temperatures and water evaporation etc. So, the author in [7] uses the same technique but with water recycle tank. Motor and brush cleaning mechanism was tested at mono crystalline solar module. Author uses two solar modules, one equipped with the cleaning mechanism and other remained unequipped. Results found from both solar modules clearly indicate that the solar module having cleaning mechanism has better performance. Technique adopted in this paper also comprise of a roller brush with aurdino based commanding system, however the dominant aspect of this proposed system is that it does not require water for cleansing. This mechanism is based on number of cleaning cycles/day. The cleaning cycle/day can be increased through electronic controllers of like microcontroller, PLCS, Aurdino etc. In higher dusty environments, controller can be programmed for every hour cleaning which will prevent the dust accumulation.

2. DESIGN AND OPERATION

The proposed solar cleaning kit mechanism works on 2 DC motors with a roller brush. The roller brush is made up of Teflon material that rolls on the solar panel.. Battery will be charged using solar power. In this

scheme, water has not been utilized for cleaning purpose. An electronic controller programmed for multiple cleaning cycles is deployed which resists dust accumulation.

2.1 Mechanical Design

Mechanical design consists of a steel structure for the solar panel. This structure also holds the electronic part of proposed kit and actuators (DC motors) connected to the brush. Two steels rods have been placed as a base for the solar panel. Another rod with a screw has been used which will turn the roller brush up and down on the solar array, this rod is connected with the motor as the motor rotates so the rod rotates which in turns rotates the screw, on rotation of the screw, the screw moves down from one end of the rod to downwards at the other end of the rod. This screw is connected to roller brush and in this way roller moves down and upward at the solar array. Another motor rolls the brush which cleans the dust while moving up and down. Mechanical design of the solar panel and structure is show n in the Figure. 4

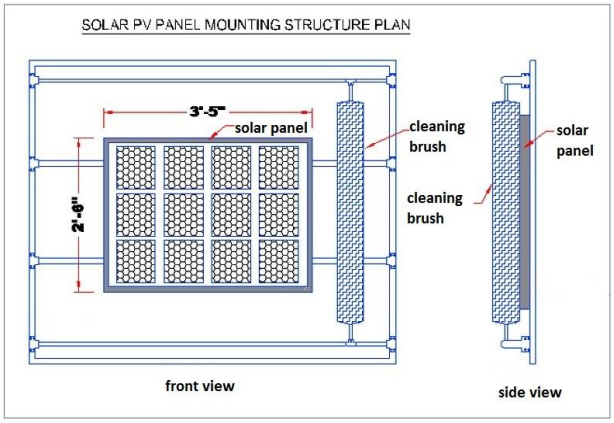

Figure.4: Mechanical structure of designed kit

2.2 Electronics Design

Electronic part consists of an arudino controller which controls the movement of brush by controlling the actuators. Relays have been used to start the working of actuators. The working of the roller brush is based on the climatic conditions. The timer circuit can be settled according to the desired operation of the roller brush. For normal climate condition, timer is used after every eight hours. This not only reduces the power consumption of the actuators but also gives sufficient time for the battery to get fully charged. On the other hand accumulated dust on solar panel between eight hours can be cleaned easily by the brush. Figure 5 shows the circuit diagram of proposed system.

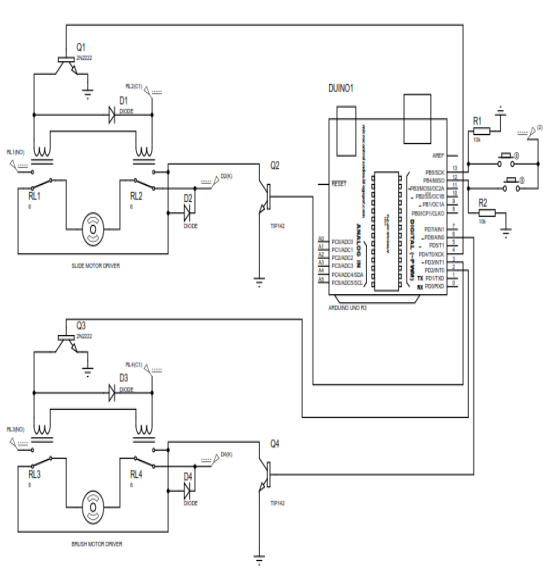

Figure 3: Circuit diagram of proposed kit

2.3 Application

The designed solar cleaning kit can be installed on ground mounted system where regular cleaning is not possible i.e. villages isolated large areas, roof tops of high rise buildings etc. It can also be utilized on domestic scale like solar panels mounted on house roof top. Besides this, the solar cleaning mechanism kit can also be installed on street lights. Since solar street lights cannot be cleaned on daily basis due to its placement on tall poles. To clean these panels that are often seen full of dirt can be cleaned automatically.

Figure 6: Complete Structure of Designed System

3. TESTING AND RESULTS

A 30 Watts PV mono-crystalline panel having short circuit current of 2 Amp and open circuit voltage (VOC) 21.6 Volts was selected for the test at village area of Hamdard University Karachi. The site was selected on the basis of high dust rates as compared to the other parts of the city. The test was conducted with two panels of same ratings with and without equipped with cleaning kit. Both of the panels were kept under natural conditions on 30° tilt and were tested for 8 days. VOC and short circuit current (ISC) were recorded for both of the panels. The results are shown in Figure.7a and 7b. The graphs are plotted between VOC and ISC verses days respectively. The result shows difference between the two panels in eighth day. On testing for longer period it is expected that test will provide much better results.

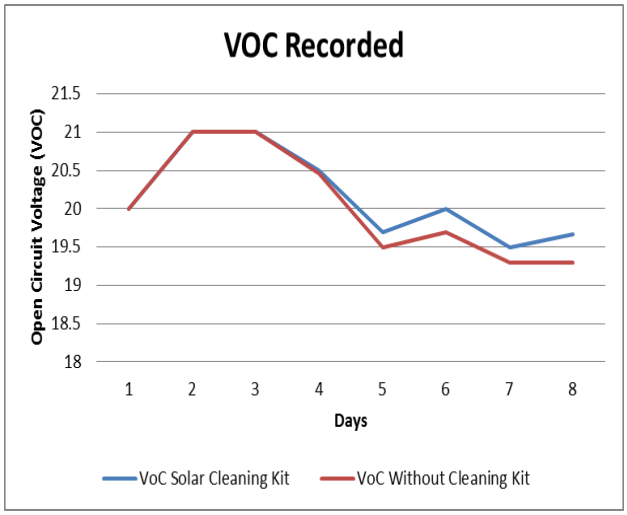

Figure 7a: VOC for solar module with and without cleaning kit

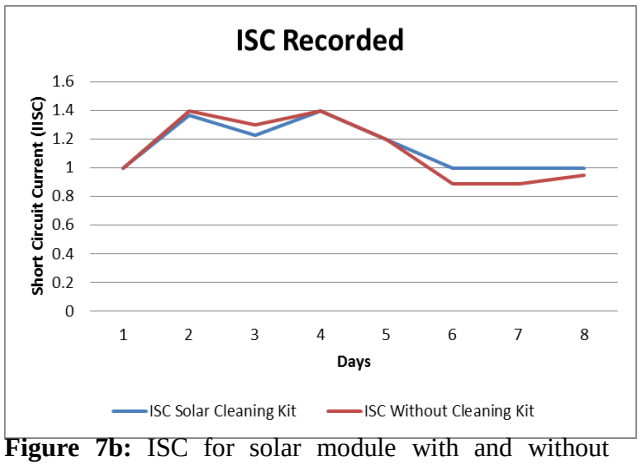

Figure 7b: ISC for solar module with and without cleaning kit

4. CONCLUSION

To improve the efficiency of solar PV, the accumulated dust on the panel must be removed on regular basis. To clean the panels, human effort is not possible for large scale and tall pole mounted systems. Based on the indigenous design and encouraging results of 8 days test. It is expected that this cleaning kit will be helpful to clean solar PV modules on high rise buildings, ground mounted systems and for street lights. On the other hand main advantage of this kit is that it does not require water for cleaning. This technology is good for small PV systems and street lights however on further modifications in the design will make this concept useful for larger solar power plants like Quaid-e-Azam solar power plant at Bahawalpur, Pakistan.

5. REFERENCES

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