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# Simulation of Natural Dust on Solar Tree and Implementation of Robot Cleaning for Maximum Output Power

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***Abstract*—The deposition of dust on the surface of solar panels reduces the amount of sunlight reaching the solar cells beneath, reducing the efficiency of the solar panel. To fully utilize their designed capacity, they must be cleaned on a regular basis. Cleaning becomes difficult and costly in some areas due to water scarcity. The solar photovoltaic conversion technique is widely used as a pioneering and efficient method of converting solar energy. The concept of a solar tree is capable of effectively and elegantly addressing these issues. In this paper, we present a solar tree plant with spiraling phyllataxy and for automatic wiper for dust cleaning, which will improve the plant's efficiency and results in more power generation.**

***Index Terms*— Solar Tree, Spiralling phyllataxy, Renewable En- ergy, solar cell, Solar Energy.**

## I. INTRODUCTION

The major issue that all nations of the world are currently facing in the twenty-first century is how to meet their constantly increasing electricity requirements. One of the most widely used methods of generating electricity, particularly in developing countries such as India, is to capture thermal energy produced by the combustion of fossil fuels. These conventional energy resources, on the other hand, are finite natural resources that contribute to widespread environmental pollution. Similarly, the production of electricity from hydro- energy causes significant environmental degradation in the vicinity of the power plant. Nuclear energy is also becoming a popular way to generate electricity in developed and developing countries, but it carries the serious risk of a mass disaster. Because of these constraints, researchers have focused their efforts on harnessing solar energy to generate electricity. Solar energy is a clean, abundant, and inexhaustible source of energy. Though solar energy currently accounts for only 0.05 percent of total primary energy supply, efforts are being made to maximize its utilization and increase conversion efficiency [1]. In fact, the capacity of solar energy has increased threefold in the last four years. Photovoltaic cells, solar heaters, solar thermal energy (STE), solar architecture, and artificial photo- synthesis can all be used to harness it. Photovoltaic systems are by far the most common technique for generating power[2,3]. The Indian government has embarked on a long-term ambitious plan to expand the country's solar energy capacity.

The Ministry of New and Renewable Energy established the National Solar Mission, which aims to achieve 20,000 MW of installed solar power generation capacity by 2020 which will be increased to 100,000 MW by

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2030 and 200,000 MW by 2050. By 2030, it aims to match coal-based thermal power generation. India's goal of tripling the share of renewable energy by 2030 will not only have a significant positive effect on its energy supply, but will also strengthen the country's efforts to combat climate change.[4,5,6] The Ministry of New and Renewable Energy (MNRE) is implementing a number of schemes for promoting the adoption of renewable sources of energy for generation of electricity. These schemes include setting up of Solar parks, rooftop solar, solar street light etc. Govt of India gives 40% of the project cost for rooftop solar plant upto 3kw capacity and 20% of the cost for capacity above 3kw and upto 10kw is available under scheme.

The literature survey [7-11] shows that the accumulation of dust on the solar panel considerably affects the performance of solar PV panels. The study of different city data shows that the amount of reduction in power varies from some 22 to 51%. So the cleaning of PV panels is one of the necessary steps improving the efficiency of the panel. However, market available and general cleaning techniques are used but each of it having some limitations along with its uniqueness too. All these techniques have one common goal that is to improve the efficiency of PV panel. The main issue that reduces the efficiency of solar panels is soiling. Many factors influence the efficiency of solar photovoltaic energy conversions [12], including solar intensity, module area, semiconductor, tracking mechanisms, dust, and dirt, among others. Dust and dirt, among these factors, have recently become important for research because they have a significant effect on conversion efficiency. Using Robotic cleaning mechanisms it will result in a 25% increase in output energy or a 15% to 20% increase in conversion efficiency. As a result, a thorough examination of the SPVC automated cleaning mechanism is essential.

In this paper, we present a novel method for efficiently generating power by solar tree[13]. As per details given in section II & III the model is prepared. The model was built and tested. In this research an ECU program is an efficient cleaning method to make the system fully automated without any human interface except for initial activation and maintenance issues. The system is successful in removing dust and bird droppings on the PV panels which led the PV to have better output.

With better design and increasing the number of solar panels along with some advanced technology it is Possible to implement in this paper on a large scale[14-15]. It would not only solve the Problem of energy crisis to a great extent but would also give a landscapic view to the city.

## II. Specification of Proposed Solar Tree

| Cost for 1 KW Solar Tree (approx.) | | | | | |
|---|---|---|---|---|---|
| Item | Specification | Make | Qty | Base Price in Rs. | Total in Rs |
| Solar Panel | 335W, 24 Volt, 8.5-10.5 Amp (Max output current) | Goldi | 3 | 12300 | 36900 |
| Battery | 150 Ah, 24V | Eastman | 1 | 15300 | 15300 |
| Invertor | 24V, 2000VA | Eastman | 1 | 14000 | 14000 |
| 12V DC motor | 12V, 30 RPM, 254 N-cm, 29×37 (LxW) mm | Johnson Geared DC Motor | 1 | 476 | 476 |
| DC motor driver | DC-DC 12v to 3.5v 5v 12V | Johnson | 1 | 99 | 99 |
| Electronic Control unit | NodeMcu ESP8266 V3 Lua CH340 Wifi Dev. Board | | 1 | 339 | 339 |
| Wiper | | | 1 | 1500 | 1500 |
| Other accessories as required | | | | | 2000 |
| Fabrication material & other charges | | | | | 22000 |
| Grand Total | | | | | 92614 |

## III. Proposed Work

The proposed block diagram is depicted in figure 1.

### *A. Solar Panel*

We can use solar panels to generate electricity. A 335W, 24V solar panel is connected to an inverter. The system derive power from photovoltaic cell. Hence it does not depend on electricity.

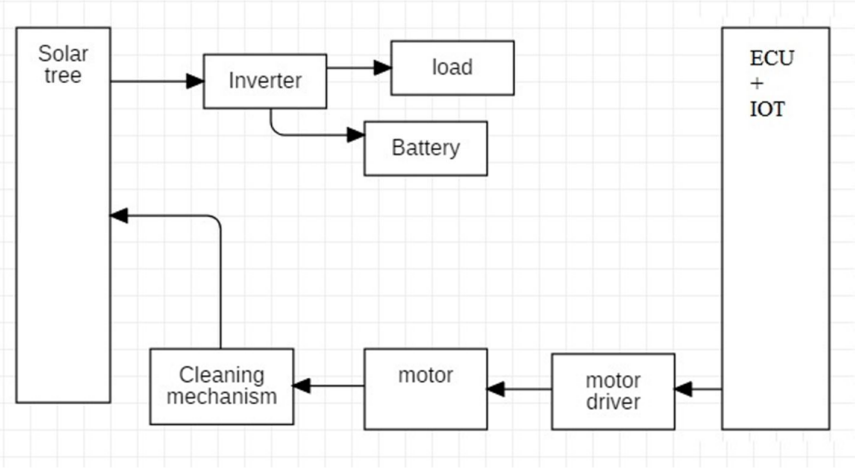


Figure. 1. Block diagram of proposed work with robot cleaning

*B. Inverter*

The main uses of inverter are to convert the direct current to alternating current of the solar panel. It efficiency also matters most for power optimization.

Figure. 2. Installation of 1kw Solar Tree

*C. Battery*

Battery which will store the power, The project aims at finding a system that can charge a battery using economic and non-conventional way. Hence we have used a 24 V battery for the charging purpose as a normal lighting load can be connected to a 12 V battery. we can use a battery with higher rating as the output of the generator That can reach upto 50 V Battery bank with multiple units can be installed if the rating of the generator is increased.

*D. DC Motor*

A motor is any an rotary electrical motors that converts direct current electrical energy into mechanical energy. Here 12 V DC motor is used for movement of wiper for cleaning purpose.

*E. Motor Driver*

Motor drivers acts as an interface between the motors and the control circuits. Motor require high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

*F. Electronic Control Unit*

The Electronic control unit (ECU) based automatic cleaning device is used 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 an ECU which has the ability of program upgrading and low power consumption.

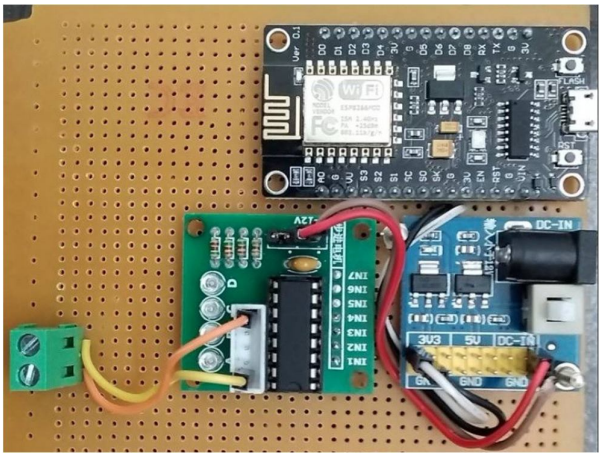


Figure 3. ECU + IOT unit

## IV. RESULTS

As our proposed solar tree has various applications like it can be applicable in following fields, Street Light, New housing estates , Recreational parks , and city parks , Golf courses and resorts, Mountains regions, Airports, Highways, Private gardens. To test the efficiency of the system we have received simulation results as well as actual results from installation site.

TABLE I. RESULT FROM SIMULATION

| Solar Irradiation ($W/m^2$) | Output power without dust (W) | With dust | | |
|---|---|---|---|---|
| | | Dust weight (gm) | % loss | Power after loss (W) |
| 200 | 93.05 | 10 | 24.12 | 70.61 |
| | | 15 | 31.37 | 63.86 |
| | | 20 | 34.87 | 60.61 |
| | | 25 | 42.04 | 53.92 |
| 500 | 373.55 | 10 | 24.12 | 283.45 |
| | | 15 | 31.37 | 256.37 |
| | | 20 | 34.87 | 243.3 |
| | | 25 | 42.04 | 216.47 |
| 650 | 513.8 | 10 | 24.12 | 389.87 |
| | | 15 | 31.37 | 352.62 |
| | | 20 | 34.87 | 334.64 |
| | | 25 | 42.04 | 297.75 |
| 800 | 654.05 | 10 | 24.12 | 496.3 |
| | | 15 | 31.37 | 448.88 |
| | | 20 | 34.87 | 425.99 |
| | | 25 | 42.05 | 379.02 |


Figure. 4. Simulation Inputs

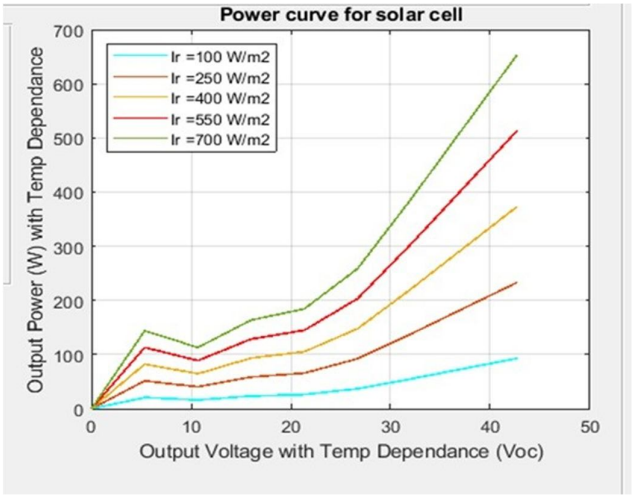


Figure. 5. Simulation Results without dust

TABLE II. AVERAGE POWER GENERATED IN A DAY

| Sr.No. | Date | Reading without dust | | | Date | Reading with dust | | | % loss due to dust |
|---|---|---|---|---|---|---|---|---|---|
| | | Voltage (V) | Current (A) | Power ($W/m^2$) | | Voltage (V) | Current (A) | Power ($W/m^2$) | |
| 1 | 15.01.2022 | 29.9 | 22.1 | 660.79 | 20.01.2022 | 26.7 | 14.6 | 389.82 | 41.01 |
| 2 | 21.01.2022 | 29.8 | 22.7 | 676.46 | 26.01.2022 | 27.6 | 14.8 | 408.48 | 39.62 |
| 3 | 27.01.2022 | 27.5 | 24.7 | 679.25 | 02.02.2022 | 26.1 | 13.8 | 360.18 | 46.97 |
| 4 | 03.02.2022 | 28.2 | 22.5 | 634.5 | 08.02.2022 | 27.1 | 13.5 | 365.85 | 42.34 |
| 5 | 09.02.2022 | 29.4 | 21.2 | 623.28 | 14.02.2022 | 26.5 | 14.1 | 373.65 | 40.05 |

Note : Data is collected from actual installation of site( Solapur District). It is located on south east edge of the Maharashtra state of India. The Solapur district falls under category of dry climate with no moisture. The Irradiations are between 750 to 850W/m2 and temperature is 28 to 34°C. Type of dust found is sandy.

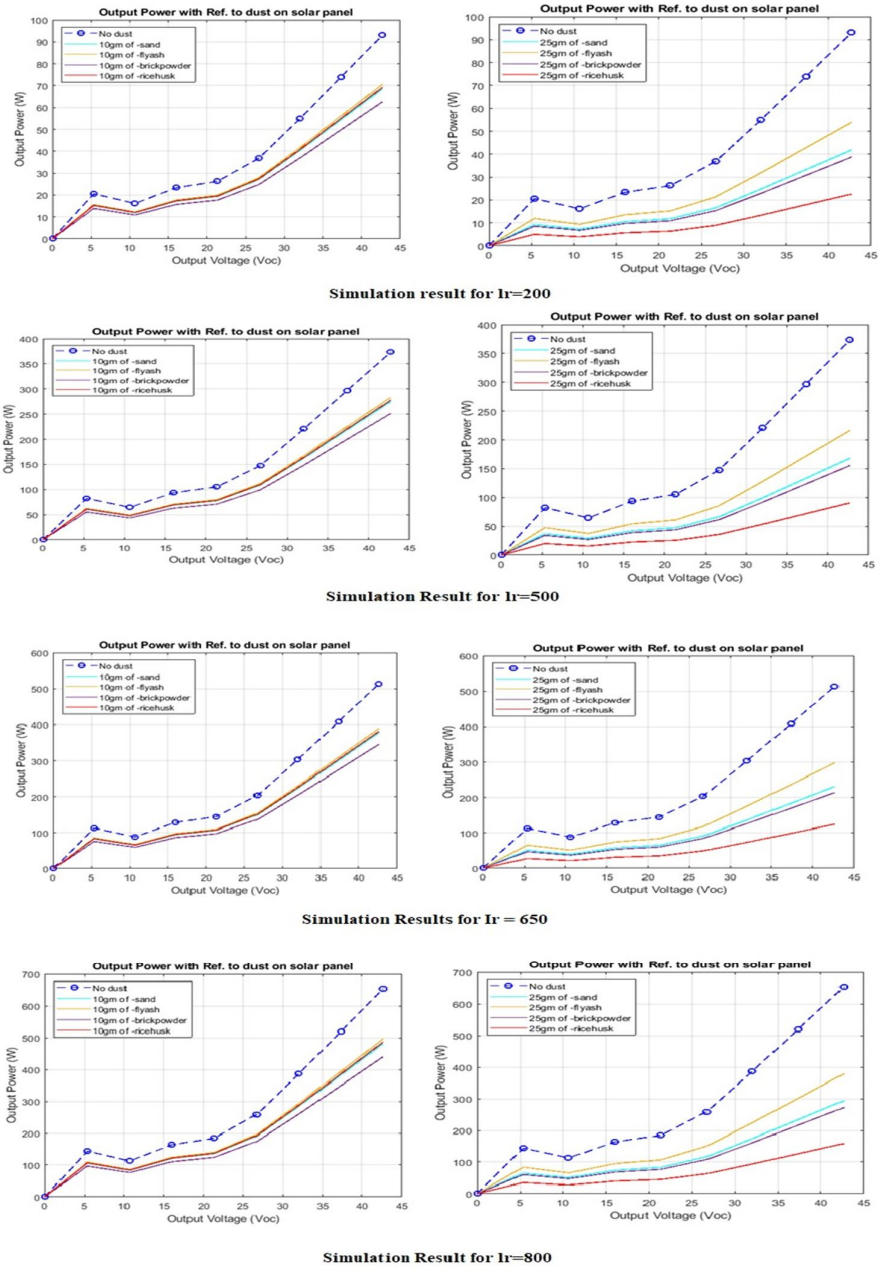


Figure. 6. Simulation results with IR=200,500,650,800 w/m2

*Area utilized and cost comparison*

To compare the area of solar panel, the size of a solar panel is about 65X39 inch2 = 2535 inch2 and also 2535 inch2 = 17.61 Sq. Ft. and the amount of area required by the solar tree is 4 square feet. Let us take 25 number of module which are arrange in a particular way of 5 5 matrix in a linear way on the land so total area occupy by the 25 module is 440.25 square feet. On comparing the area (fig 7) of both solar tree and solar PV system on total area occupied by the solar PV system is 99.14% more than the solar tree. Also fig 8 depicts the cost comparison of our proposed solar tree with traditional rooftop and from the fig it is found that solar tree is less costly.

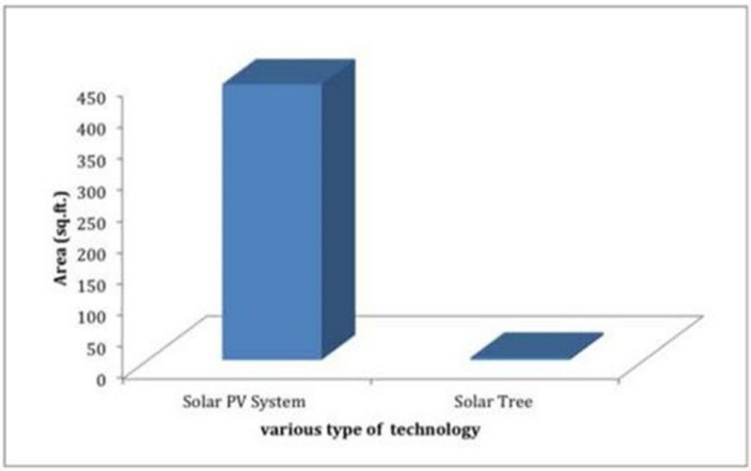


Figure. 7. Comparative analysis of area utilization

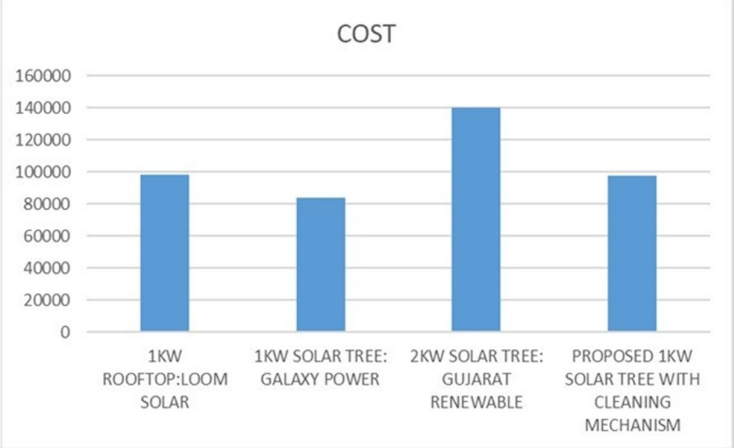


Figure. 8. Cost analysis

## V. Conclusion

In this paper we present simulation of natural dust on solar tree with robotic cleaning, it produces more energy than solar PV system at fixed angle of inclination as can be seen from above result. Here 4 types of dust are considered: sand, flyash, brickpowder, ricehusk. As these 4 types of dust are found in INDIA mostly. As we have seen the increase in amount of dust i.e. the weight of dust, the solar panel efficiency decreases with a greater extent with only 25gm of dust the power output is decreased by 42% that is half of the power generated, this is not economical for us to waste half the power generated. According all above facts we can say that the solar trees are need of the future because these are renewable sources of energy and in coming time these will become very popular because the requirement of land is less and sun light available till the future. In India there is too much population and the land is less and the requirement of energy is high so the solar trees are as an alternative solution of these problems. By further increasing the height and the number of solar panels, it is possible to Light up an entire building with the help of the solar panels.

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