DOI: https://doi.org/10.24113/ijoscience.v7i4.375

Experimental Analysis of Solar PV Module by Cleaning & Cooling for Optimizing Efficiency

Utpal Srivastava
M. Tech scholar
Truba Institute of Engineering & Information Technology
Bhopal, M.P, India
utpal.srivastava@gmail.com

Dr Rajeev Arya
Director
Truba Institute of Engineering & Information Technology
Bhopal, M.P, India

Shravan Vishwakarma
Assistant professor
Truba Institute of Engineering & Information Technology
Bhopal, M.P, India

Abstract: **Sun-oriented energy is a resource of energy on earth. Sun-based energy can be gotten as warmth to create power or it is additionally conceivable to change over sun-based energy straightforwardly into power. The main objective of this project is to catch maximum solar radiation from the sun and increase the overall efficiency of solar panels. To design a cleaning mechanism that runs across the length of the panel. To avoid dust-associated problems on the solar panels. The temperature in case of water cooling system was lowered down to 410C from the ambient temperature 440C at 14:00 in the morning of 21/09/2020. The power output was 4.789W and in case of set up having dust on the surface of the solar panel the temperature rose to 490C with power reduced to 4.00185W. The temperature in case of water cooling system was lowered down to 400C from the ambient temperature 430C at 14:00 in the morning of 22/09/2020. The power output was 4.89W and in case of set up having dust on the surface of the solar panel the temperature rose to 490C with power reduced to 4.00185W. The outcomes for day 3 of the experimentation were also recorded on 23/09/2020 and the setup with a cooling system produces a maximum power of 5.20 W by lowering the temperature to 370C from the maximum ambient temperature of the day 410C.**

Keywords: Sun, Temperature, Solar Panel, Solar Energy.

I. INTRODUCTION

Sun oriented energy is a resource of energy on earth. Sun based energy can be gotten as warmth to create power or it is additionally conceivable to change over sun based energy straightforwardly into power (photovoltaic module). Sun based energy is an essentially sans carbon sustainable asset. Creating power with sun based boards is the awesome most encouraging other option. Sun based force age, particularly in distant territories, is a promising and feasible answer for giving clean energy. Sunlight based energy can be utilized to handle the worldwide energy emergency. Albeit sun based force is promptly accessible, numerous components, for example, dust gathering or the foundation and temperature ascent of the phones, influence its utilization with a sunlight based board. Collection of residue or contamination is a main consideration influencing the presentation of sunlight based boards in the Middle East and Africa. Residue can be delegated particles under 500 microns in width. The decrease in the exhibition of the sun oriented module isn't uniform, as the amassing of residue isn't uniform and is exceptionally reliant on the states of the geological area. Reports have been distributed showing that the deficiency of energy creation because of contamination issues happens primarily in universes like PV or CSP (Concentrated Solar Energy) frameworks.

II. LITERATURE REVIEW

NasibKhadka et al. [1] This article presents the exhibition and outline of the utilization of sun oriented cells. Th module establishment area for the yield boundaries of sun based cells was researched. Trial Results Displays the measure of variety in the sunlight based cell yield boundaries like greatest yield power, open circuit voltage, impede and fill factor as a component of temperature and light forcee part of different working conditions like temperature, daylight power and sunlight based.

K. Mondal et al. [2] This article gives an exhaustive outline of the residue issue and ongoing improvements in computerized cleaning frameworks for sunlight based photovoltaic modules, giving a short outline of methods like electrical, mechanical, substance and electrostatic cycles. The primary goal of the investigation is to audit the writing on computerized cleaning procedures for sunlight based PV modules to recognize research holes in mechanized cleaning frameworks.

LaythMohsin et al. [3] The objective of this investigation was to create and assemble a shrewd framework for programmed cleaning and cooling of photovoltaic modules that would initiate dependent on execution debasement because of residue gathering and high temperature conditions. The principal module was outfitted with the model cleaning framework, while the second was viewed as standard.

D. M. Tobnaghi et al. [4] This article presents the exhibition and outline of the utilization of sun oriented cells. The part of different working conditions like temperature, daylight power and sunlight based module establishment area for the yield boundaries of sun based cells was researched. Trial Results Displays the measure of variety in the sunlight based cell yield boundaries like greatest yield power, open circuit voltage, impede and fill factor as a component of temperature and light force.

III. OBJECTIVE

- The main objective of this project is to catch maximum solar radiation from the sun, and increase the overall efficiency of solar panel.
- To design a cleaning mechanism that runs across the length of the panel.
- To avoid dust associated problems on the solar panels.

IV. METHODOLOGY

A. *Surface coatings*

Surface coatings treat the outside of the glass front of SPV boards and keep dust from sticking to the surface. Contingent upon the principle vulnerability to assault and the sort of residue, various kinds of surfaces and coatings valuable for the boards are accessible: (I) hydrophobic sort, which has a lower partiality for ionic species (ii) low energy type surface, which diminishes the surface compound response; (iii) synthetic sort which responds with tacky powder and (iv) oil coatings. The hydrophobic coatings make a high contact point between the outside of the SPV and the water drops, which permits the drops to roll openly over the outside of the SPV, subsequently eliminating dust. The compound replacement of the particle of gathering I with bunches II or III makes an answer of a water-safe or hydrophilic nature. The hydrophilic arrangements are intended to oppose dust gathering and the water layer considers successful cleaning of the SPV surface. Various sorts of covering blends are presently being contemplated. Notwithstanding, these are not industrially effective as drawn out UV openness forever harms coatings and bargains their strength as wind and sand can cause disintegration.

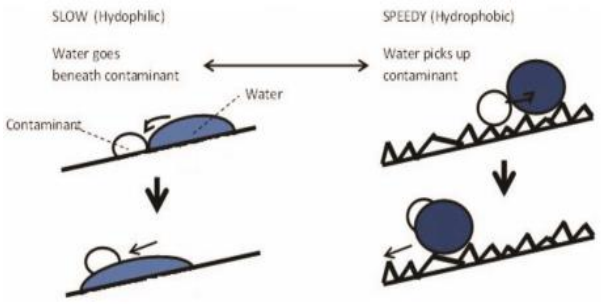

Fig. 1. Hydrophilic and hydrophobic surface cleaning processes.

B. *Removal of Dust and Dirt*

The amassing of residue in the dusty climate on the sunlight based modules prompts a decline in the porousness of the module. Sun based desalination plants in some Middle Eastern nations, for example, the Abu Dhabi sun powered desalination plant experience the ill effects of residue development on their sun based boards. The impact of amassed dust is diminished as the point of tendency increments, since the point of tendency additionally influences the hour of openness to daylight. The most ideal approach to dispose of the effect of amassed dust on the sun based modules is to clean the modules. Cleaning sun based boards is generally done by washing, which is drawn-out and bulky, yet in addition exorbitant as far as work and time. By and by, the cleaning of sun based boards should be done every now and again. The strategy for cleaning reduces to characteristic methods, mechanical methods.

C. *Block Diagram*

The block diagram mainly consists of

• AVR Micro-controller, Solar panel, Light Dependent resister, Motor, Brush

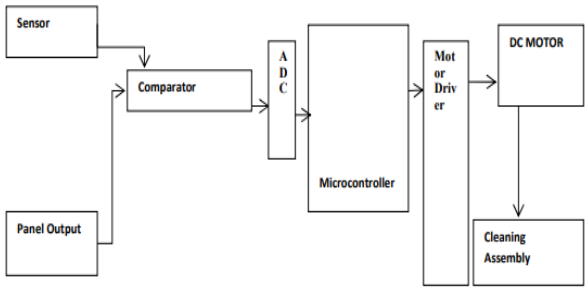

Fig. 2 Solar panel dust cleaning system

Fig. 2 shows the square diagram of the customized dust combination structure for the daylight based modules. This sensor recognizes the power of the air and its yield is given to the comparator. The comparator gets two signs, I. H. Board yield and sensor yield. Right when the sensor yield is high and the board yield is low stood out from the standard rating, the buildup assembled on the daylight based board and comparator offers the positive hint for cleaning. If the sensor yield is low and the board yield is furthermore low diverged from the standard rating, I. H. Night or turbulent season, no buildup on the sun situated board, so the comparator doesn't offer a positive hint for cleaning.

The comparator yield is passed to the ADC for change to a DC signal. The ADC yield is passed to the microcontroller to play out the accompanying cooperation. Dependent upon the comparator yield, the microcontroller offers rules to cleaning. The motor control IC is used to drive the motor to move and clean the social occasion.

D. Mechanical removal of dusts

Mechanical techniques eliminate dust by brushing, blowing, vibrating and ultrasonic directing. Brushing techniques clean the sun oriented cell with something like the brush or brush, fueled by the vehicle which was assembled very much like a windshield wiper. Notwithstanding, most importantly, the cleaning cycle is wasteful because of the little size and solid grip of the powder. Also, the terrible work space of the sun based cell makes machine support troublesome.

The cleaning machine is consequently incredible because of the huge estimated estimation of the sun oriented cell generator. At long last, the surfaces of the sun based cell may have been harmed by the brush during its cleaning. The blowing cycle for cleaning the sun oriented cell by wind energy is a productive cleaning measure, aside from the low proficiency, high energy utilization and unsuitable support of the fan. Vibration and ultrasonic residue expulsion is likewise a decent mechanical cleaning technique. The way in to this technique is the drive strategy, recurrence and a bundancy of the sunlight based cell.

E. Techniques to Improve/Maintain Solar PV Efficiency

Loss of brightening assumes a significant part in sun based energy creation. This can be brought about by factors that are important for the incorporated framework or an individual from the climate. Moreover, this outcomes in a decrease in the proficiency of the framework.

A portion of the issues influencing board execution require thought of the need to present another material that can be maximally used. Be that as it may, issues accordingly, including the impacts of residue and dampness, can be limited and the effectiveness of sun powered boards can be improved by cleaning the modules. Different techniques have been presented, with their own benefits and hindrances, the sole reason for which is to improve productivity through cleaning.

The cleaning of the sun powered modules should be possible both consequently and physically. Manual cleaning takes a ton of work. Likewise, manual cleaning can be helpful for families with few sunlight based boards. For huge scope projects, inclination is given to a robotized automated cleaning framework which would now be able to procure information continuously by noticing amassed dust, power produced and cleaning from now into the foreseeable future.

The many robotized frameworks fabricated today rely upon the scene where the sun oriented boards are found. They additionally rely upon the design of the boards. In light of these components, numerous advances have arisen that advance the exhibition of sun based boards through cleaning.

F. Main Components Required

Frame: It's gentle steel. All parts are mounted on this casing structure with the right format. Boring to the size of the direction and open openings is done in one go to appropriately adjust the orientation during reassembly. Care is taken to cover the orientation with oil.

Battery: A fixed lead-corrosive battery with a voltage of 12 V and an ostensible limit of 7 amperes is utilized for energy stockpiling. Battery utilization and upkeep are free. The battery is utilized during the day within the sight of the sun, ie H. Sun powered energy, charged and utilized when required. The glue can be utilized consistently for up to 5-6 hours subsequent to charging.

Fig. 3 Battery

Solar Panel: 10 watt solar panel with a power of 16.85 volts and 0.59 amps. Photovoltaic solar modules absorb sunlight as an energy source to generate electricity.

Fig. 4 solar panel

DC Motor: The motor is utilized to drive the cleaning unit, 12 V 1.2 Ampere DC engine. This single-stage engine works as indicated by the Fleming hand rule and creates power. This electric flow is changed over into mechanical work to turn the sharp edge and cut the brush.

Fig. 5 DC motor

Pump: Pump is used to supply water required for cleaning. Capacity of pump is 12V and 5 Amps.

Fig. 6 pump

G. Working

The cleaning unit comes and goes on the solar panel. The cylindrical brush mounted on the cleaning unit rotates clockwise.

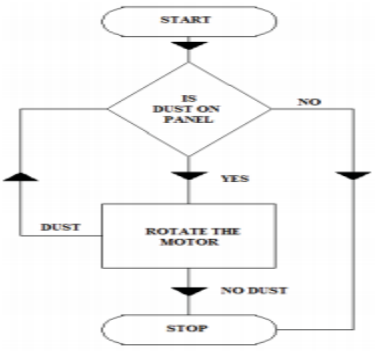

Fig. 7 Working Flowchart

H. Experimental Setup

The experimental setup shown in Figures 4.8 to 4.10 consists the following:

1. Solar panel of 10 watt
2. Submersible pump of 9 volt
3. DC motor of 12 volt (30 rpm)

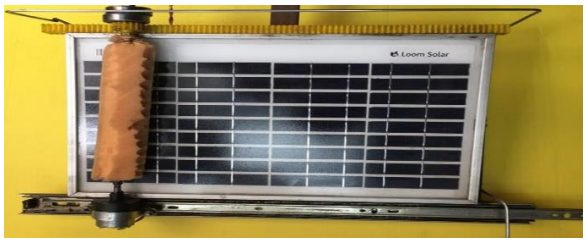

Fig. 8 Experimental setup

The solar panel cleaning mechanism is controlled by an integrated system that uses a microcontroller that drives the DC motor and also controls the spray of water on the cleaning foam.

Fig. 9 Setup showing solar panel and cleaning foam

The cleaning froth is wrapped on a shaft associated with the DC engine which pivots on the sun powered board at a speed of 30 RPM to clean it. The subsequent objective, to keep the temperature of the sun powered module at an ideal level, is to splash water on the froth. Along these lines, the froth fills two needs: to clean the soleplate and to keep an ideal temperature range.

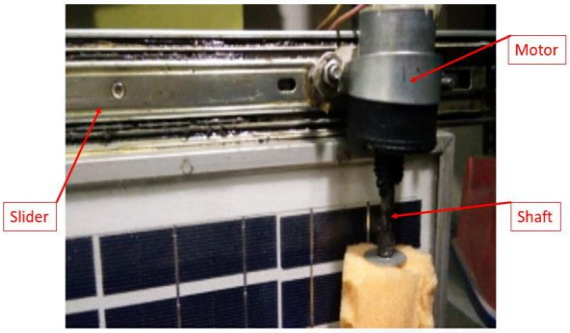

Fig. 10 Setup showing slider, shaft and motor

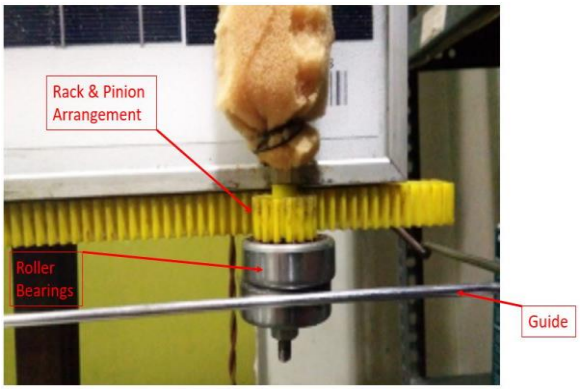

Fig. 11 Setup showing rack and pinion arrangement, roller bearing and guide

The examinations were directed to look at the exhibition of the sunlight based board under three unique conditions: (a) with dust on the board, (b) without dust on the board, and (c) with cooling the board with water.

Readings were made with halogen radiation. Two 100 watt incandescent lights were utilized. The investigations were performed utilizing two incandescent lights so the impact of temperature could be inspected and a temperature range that starts when the productivity of the board starts to diminish. A halogen was at first lit, its temperature bit by bit expanded,

and once the main halogen arrived at its most extreme temperature, the subsequent halogen was lit with the goal that the board temperature kept on rising.

V. RESULTS AND DISCUSSION

The analyses were led on three unique days so a normal worth could be determined to arrive at a complete resolution.

The accompanying measures were taken on 21 September 2020 from 9:00 to 17:00 for sun oriented modules without dust collection.

The charts beneath show the variety of the yield voltage and current as an element of temperature for different courses of action made on 21 September 2020. The charts likewise show the variety of the deliberate valid and ideal voltage versus temperature for various plans and the variety of execution in when the temperature changes on 09/21/2020.

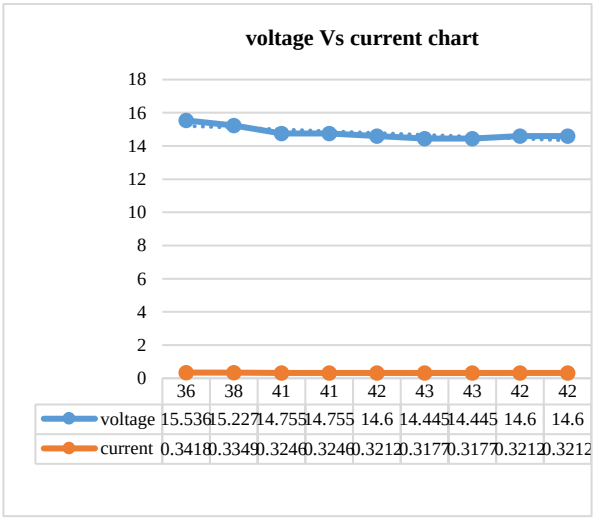

Fig. 12 Current and voltage variation with temperature on 21/09/2020 having solar panel without dust arrangement

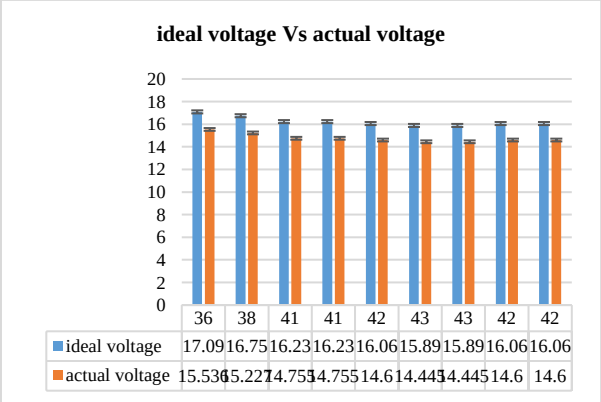

Fig. 13 Ideal voltage v/s actual voltage in solar panel without dust setup on 21/09/2020

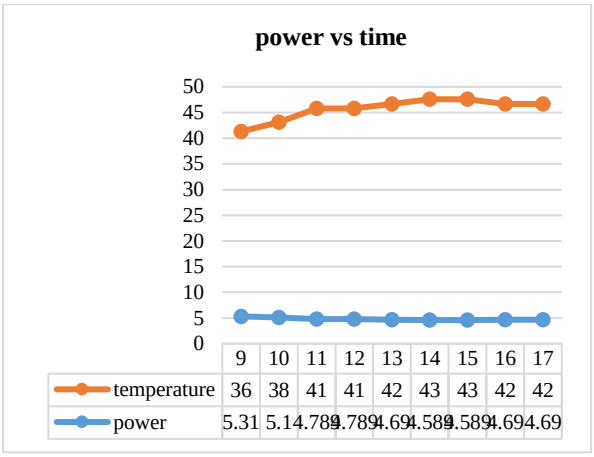

Fig. 14 Variation of power output with time as the changes in temperature is observed in without dust setup on 21/09/2020

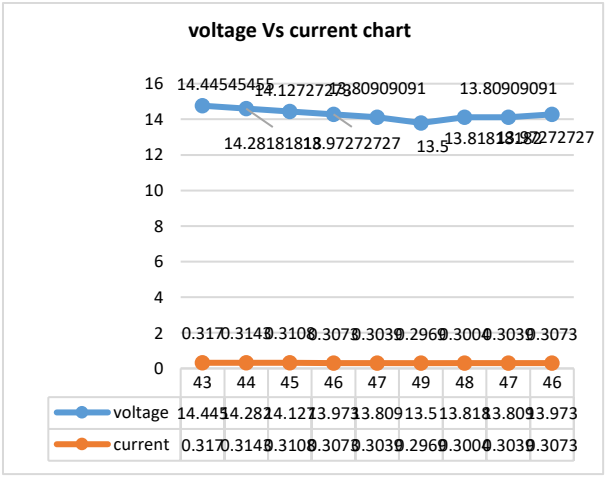

Fig. 15 Current and voltage variation with temperature on 21/09/2020 having solar panel with dust arrangement

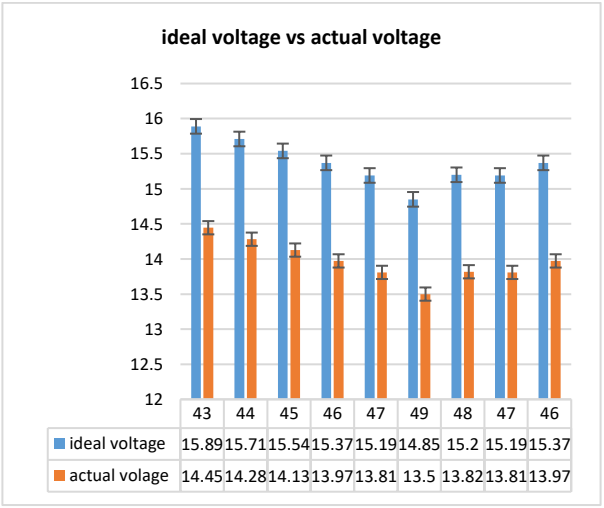

Fig. 16 Ideal voltage v/s actual voltage in solar panel with dust setup on 21/09/2020

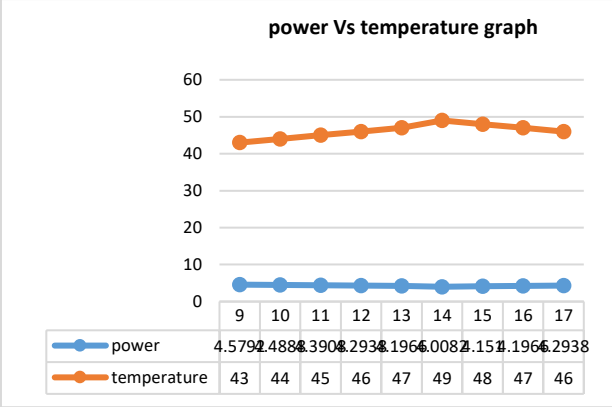

Fig. 17 Variation of power output with time as the changes in temperature is observed in with dust setup on 21/09/2020

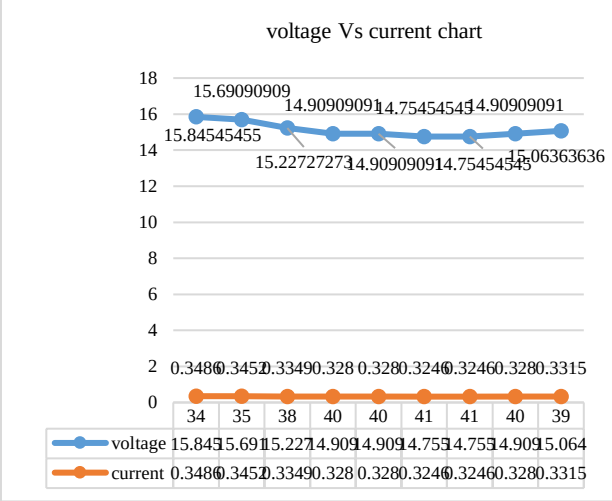

Fig. 18 Current and voltage variation with temperature on 21/09/2020 having solar panel cooling arrangement

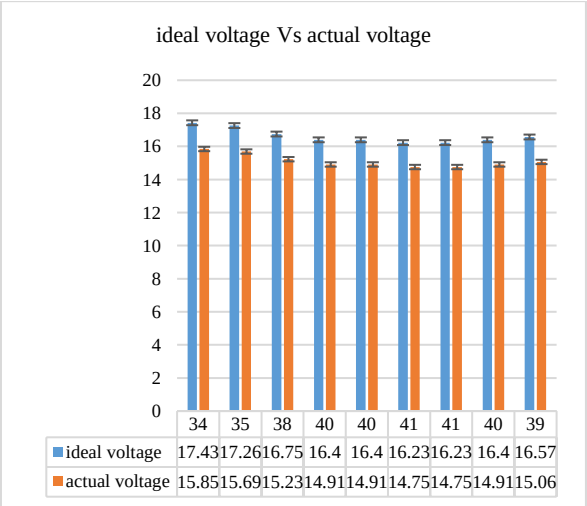

Fig. 19 Ideal voltage v/s actual voltage in solar panel having water cooling setup on 21/09/2020

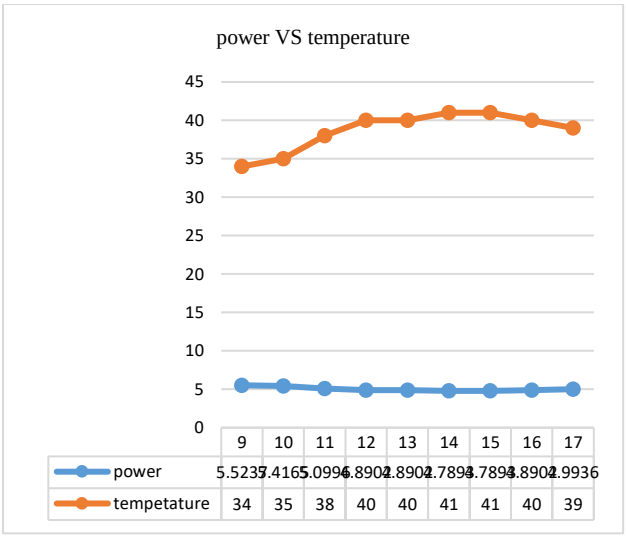

Fig. 20 Variation of power output with time as the changes in temperature is observed in water cooling setup on 21/09/2020

The following readings were taken for solar panel without dust setup on 22nd day of September 2020 from 9 am to 5 pm.

The following graphs show the variation of voltage and current output against temperature for different arrangements done on the 22nd day of September 2020. Also graphs show the variation in actual and ideal voltage measured against temperature for different arrangements and power deviation with the time as the temperature changes on the 22/09/2020.

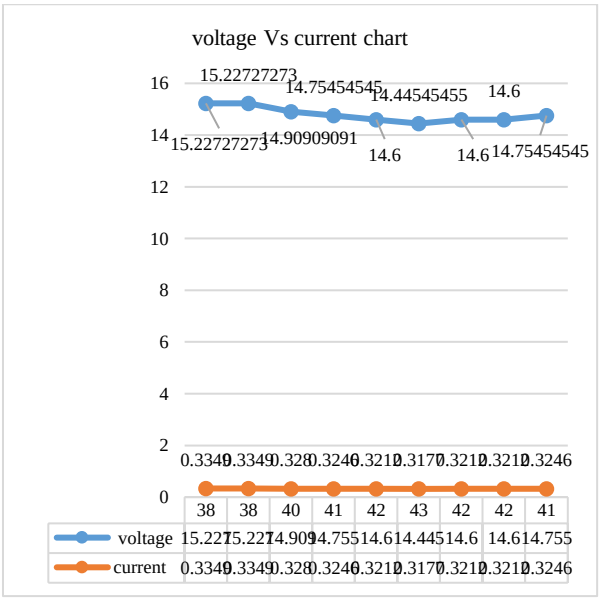

Fig. 21 Current and voltage variation with temperature on 22/09/2020 having without dust arrangement

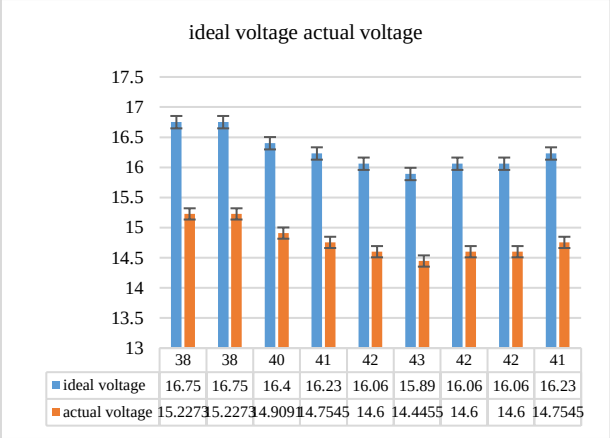

Fig. 22 Ideal voltage v/s actual voltage in solar panel having without dust setup on 22/09/2020

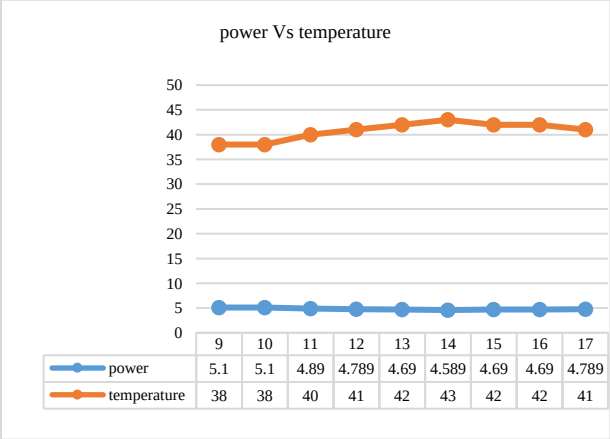

Fig. 23 Variation of power output with time as the changes in temperature is observed in without dust setup on 22/09/2020

The following readings were taken for solar panel with dust setup on 22nd day of September 2020 from 9 am to 5 pm.

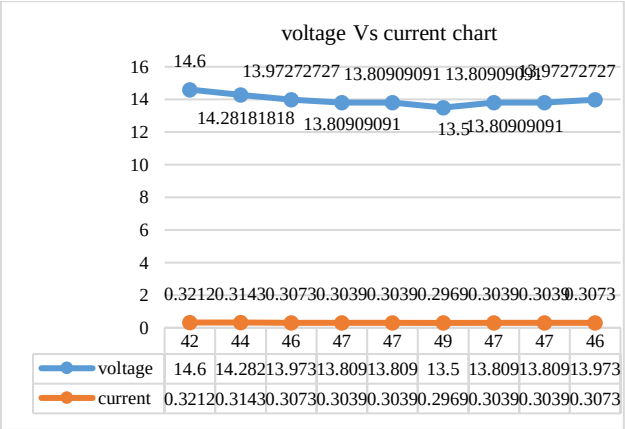

Fig. 24 Current and voltage variation with temperature on 22/09/2020 having without dust arrangement

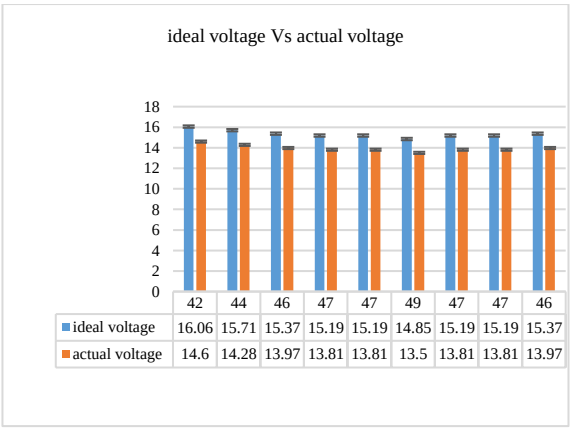

Fig. 25 Ideal voltage v/s actual voltage in solar panel having with dust setup on 22/09/2020

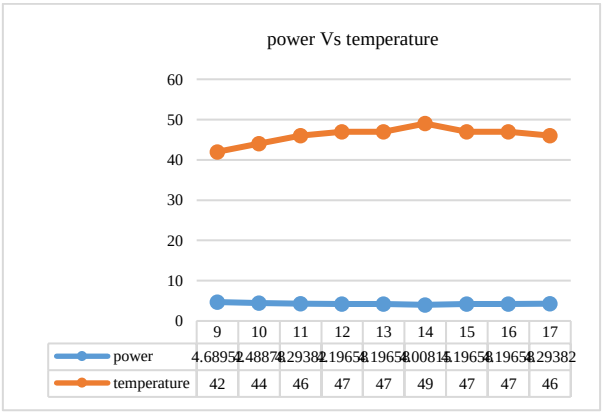

Fig. 26 Variation of power output with time as the changes in temperature is observed in with dust setup on 22/09/2020

The following readings were taken for solar panel with water cooling setup on 22nd day of September 2020 from 9 am to 5 pm.

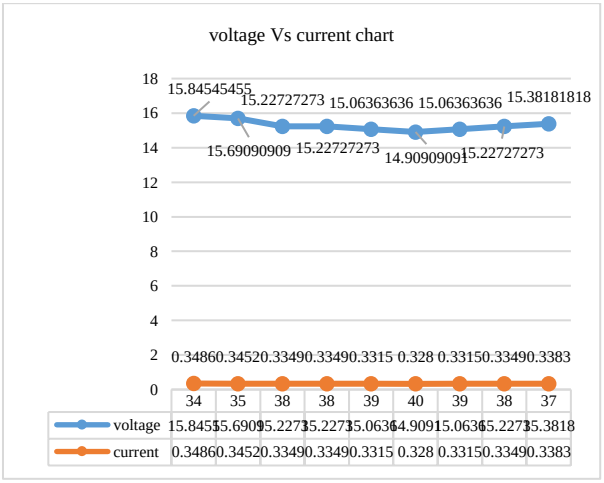

Fig. 27 Current and voltage variation with temperature on 22/09/2020 having solar panel cooling arrangement

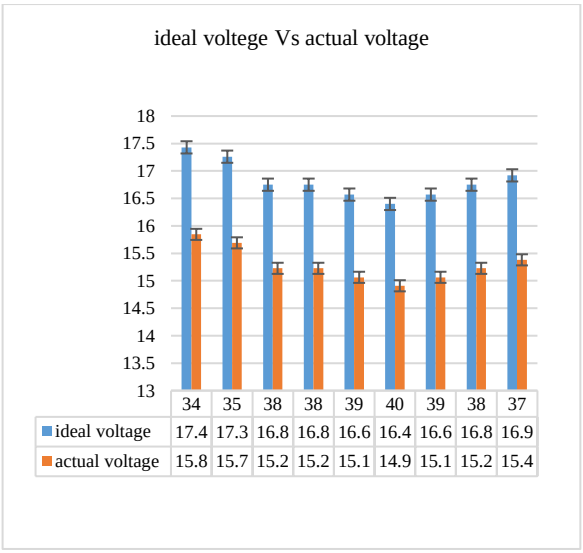

Fig. 28 Ideal voltage v/s actual voltage in solar panel having water cooling setup on 22/09/2020

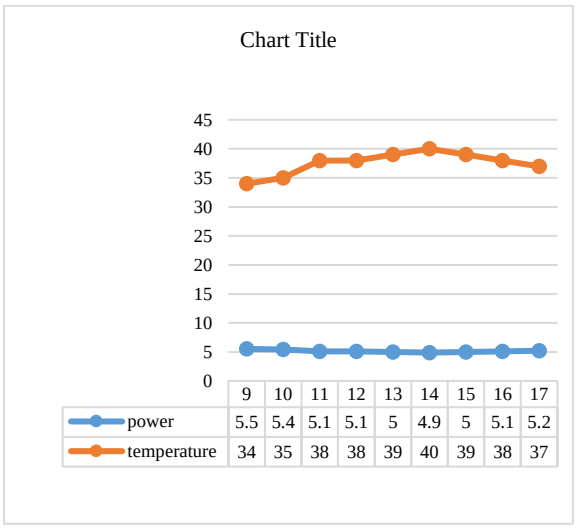

Fig. 29 Variation of power output with time as the changes in temperature is observed in water cooling setup on 22/09/2020

The following readings were taken for solar panel without dust setup on 23rd day of September 2020 from 9 am to 5 pm.

The following graphs show the variation of voltage and current output against temperature for different arrangements done on the 23nd day of September 2020. Also graphs show the variation in actual and ideal voltage measured against temperature for different arrangements and power deviation with the time as the temperature changes on the 23/09/2020.

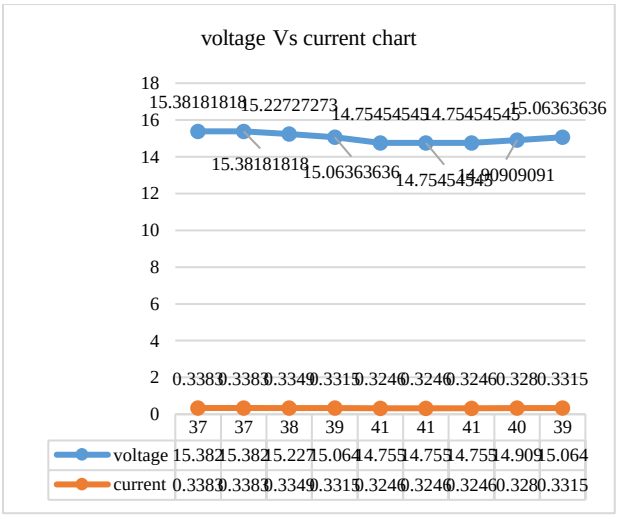

Fig. 30 Current and voltage variation with temperature on 23/09/2020 having with dust arrangement

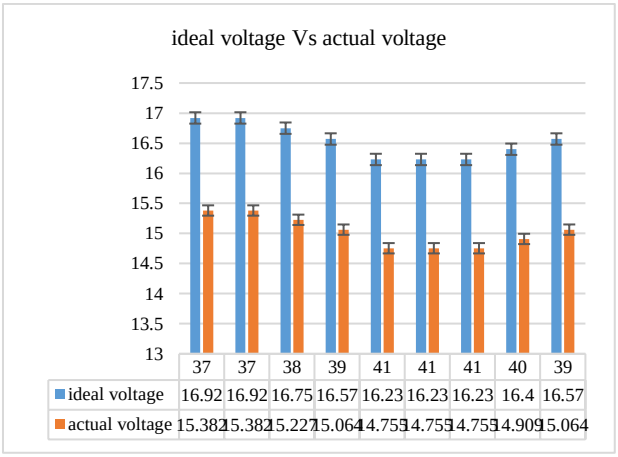

Fig. 31 Ideal voltage v/s actual voltage in solar panel having with dust setup on 23/09/2020

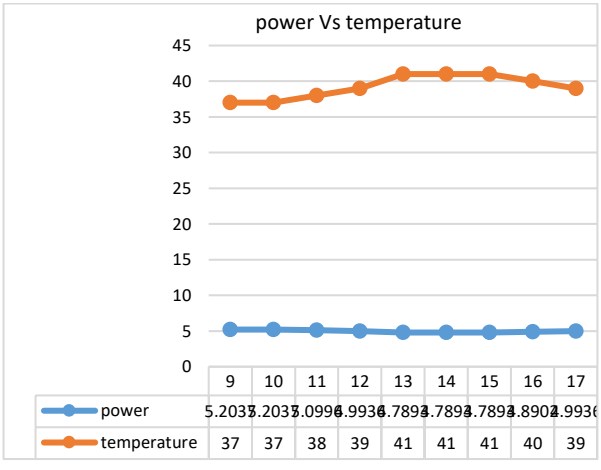

Fig. 32 Variation of power output with time as the changes in temperature is observed in without dust setup on 23/09/2020

The following readings were taken for solar panel with dust setup on 23rd day of September 2020 from 9 am to 5 pm.

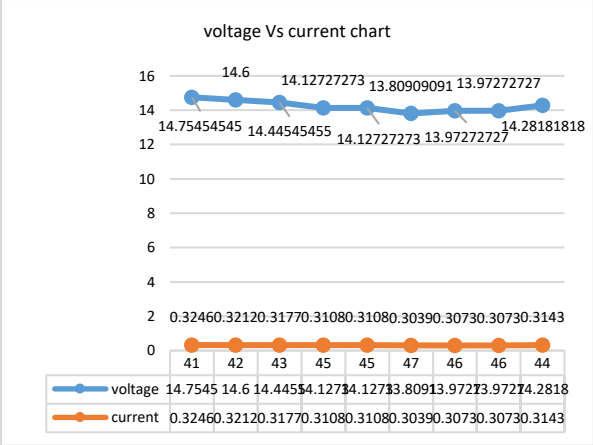

Fig. 33 Current and voltage variation with temperature on 23/09/2020 having without dust arrangement

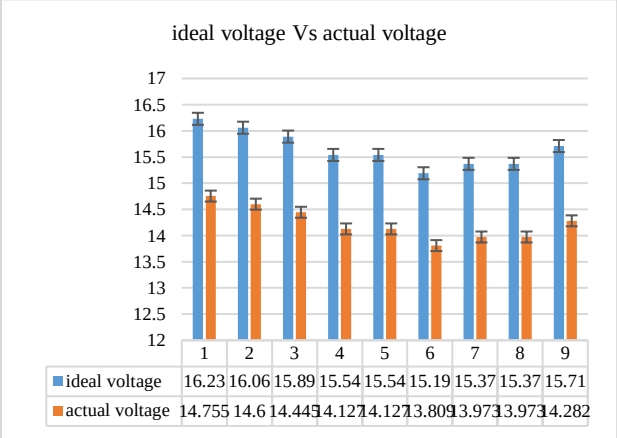

Fig. 34 Ideal voltage v/s actual voltage in solar panel having without dust setup on 23/09/2020

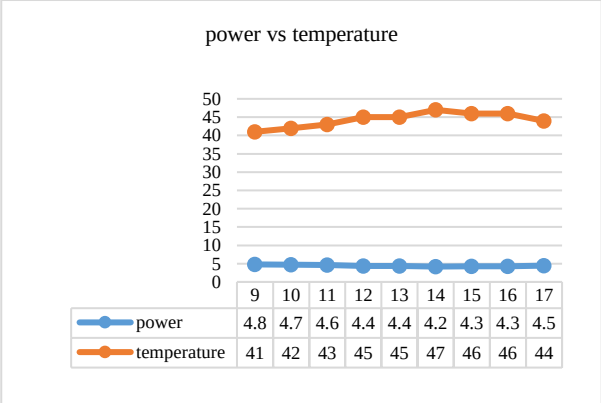

Fig. 35 Variation of power output with time as the changes in temperature is observed in with dust setup on 23/09/2020

The following readings were taken for solar panel with water cooling setup on 23rd day of September 2020 from 9 am to 5 pm.

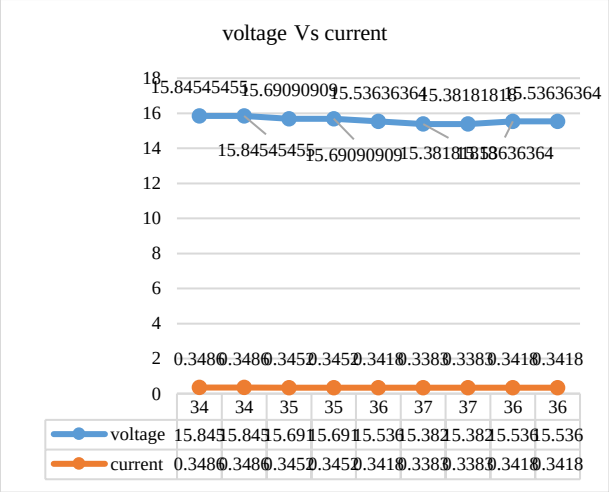

Fig. 36 Current and voltage variation with temperature on 23/09/2020 having water cooling arrangement

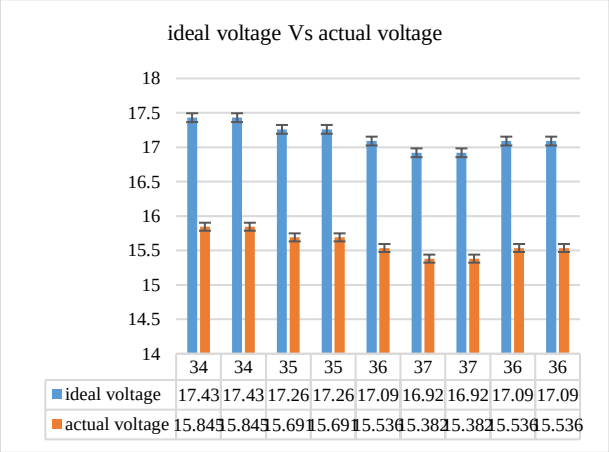

Fig. 37 Ideal voltage v/s actual voltage in solar panel having water cooling setup on 23/09/2020

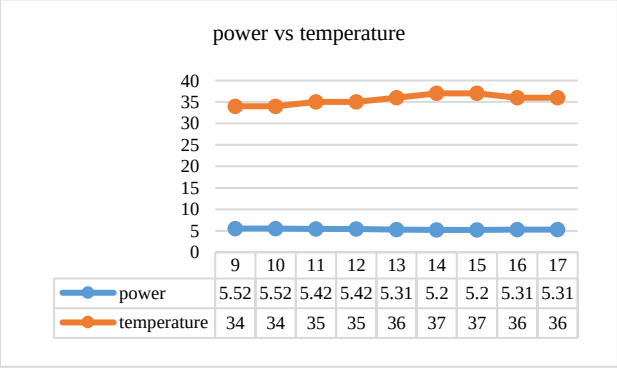

Fig. 38 Variation of power output with time as the changes in temperature is observed in water cooling setup on 23/09/2020

VI. CONCLUSION

This experiment produced the following results:

- The temperature in case of water cooling system was lowered down to 41^0C from the ambient temperature 44^0C at 14:00 in the morning of 21/09/2020. The power output

was 4.789W and in case of set up having dust on the surface of the solar panel the temperature rose to 49^{0}C with power reduced to 4.00185W.

- The temperature in case of water cooling system was lowered down to 40^{0}C from the ambient temperature 43^{0}C at 14:00 in the morning of 22/09/2020. The power output was 4.89W and in case of set up having dust on the surface of the solar panel the temperature rose to 49^{0}C with power reduced to 4.00185W.
- The outcomes for the day 3 of the experimentation was also recorded on 23/09/2020 and the setup with cooling system produces maximum power of 5.20 W by lowering the temperature to 37^{0}C from the maximum ambient temperature of the day 41^{0}C.

The comparative graphs are being drawn for the ambient temperature at 14:00 for three days where the ambient temperature was found to be maximum that any time of the day. The ambient temperature recorded was 44^{0}C, 43^{0}C, 42^{0}C for day 1, day 2 and day 3 respectively.

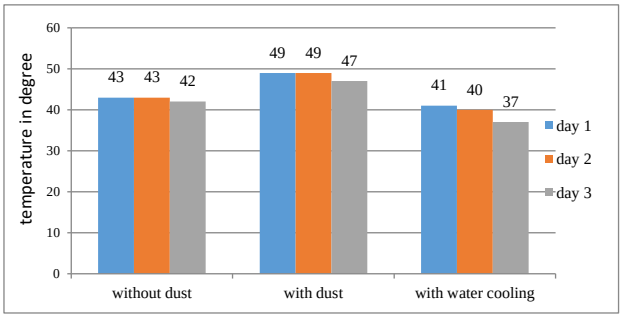

Fig. 39 Comparison of temperature of solar panel with different setups

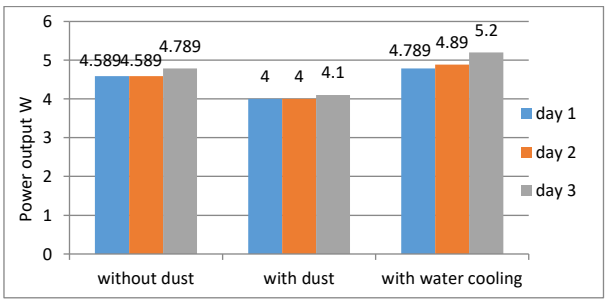

Fig. 40 Comparison of power outputs from solar panel with different setups

REFERENCES

[1] NasibKhadka , BinamraAdhikari “Solar Panel Cleaner Technology: A Review” 5th International Conference on Developments in Renewable Energy Technology (ICDRET'18), At KathmanduApril 2018

[2] A. K. Mondal and K. Bansal, "A brief history and future aspects in automatic cleaning systems for solar photovoltaic panels,” Advanced Robotics, vol. 29, no. 8, pp. 515-524, 2015.

[3] LaythMohsin , Ahmad Sakhrieh “Optimized cleaning and cooling for photovoltaic modules based on the output performance” DOI: 10.2298/TSCI151004145M January 2016

[4] D. M. Tobnaghi and D. Naderi, "The Effect of Solar Radiation and Temperature on Solar cells Performance,” Extensive Journal of Applied Sciences (EJAS), vol. 3, no. 2, pp. 39-43, 2015.

[5] M. K. Panjwani and G. B. Narejo, "Effect of Humidity on the Efficiency of Solar Cell (photovoltaic)," International Journal of Engineering Research and General Science, vol. 2, no. 4, pp. 499-503, 2014.

[6] Í. P. dos Santos and R. Rüther, "Limitations in solar module azimuth and tilt angles in building integrated photovoltaics at low latitude tropical sites in Brazil," Renewable Energy, vol. 63, pp. 116-124, 2014.

[7] B. Parida, S. Iniyan, and R. Goic, "A review of solar photovoltaic technologies," renewable and sustainable energy reviews, vol. 15, no. 3, pp. 1625-1636, 2011.

[8] F. Dinçer and M. E. Meral, "Critical factors that affecting efficiency of solar cells," Smart Grid and Renewable Energy, vol. 1, no. 01, p. 47, 2010.

[9] L. Dorobantu, M. Popescu, and C. Popescu, "Yield loss of photovoltaic panels caused by depositions," in Advanced Topics in Electrical Engineering (ATEE), 2011 7th International Symposium on, 2011, pp. 1-4: IEEE.

[10] A. Rao, R. Pillai, M. Mani, and P. Ramamurthy, "Influence of dust deposition on photovoltaic panel performance," Energy Procedia, vol. 54, pp. 690-700, 2014.