Effect of Colour Spectrum and Plastic on the Performance of PV Solar System

Bhabani Patnaik, Sarat Ch. Swain, Ullash Ku. Rout

Abstract: Solar irradiation is the primary input for the solar PV module. Different types of PV module are used to get high efficiency such as polycrystalline, monocrystalline and amorphous PV module. Among all module polycrystalline PV cell is the most reliable one. Two valuable inputs of a solar PV cell are solar irradiation and temperature. For temperature, solar PV material is very sensitive. However, solar irradiation has many types of wavelengths, and each wavelength has a different effect on solar cell because each wavelength has different energy frequency. Energy frequency is the primary term which affects the output of PV panel. So in this paper two types of experimental analysis has done to know the effect of the colour spectrum, and another experiment has done to know the effect of different types of plastic on PV panel. The experimental data used to verify the efficiency and output power of the system. The results show how the output power and efficiency of PV affected by these two factors.

Keywords: Colour spectrum, Solar PV panel, Thickness of plastic, Temperature, Wavelength

I. INTRODUCTION

India is a country where 21.9% proportion of the population living below the poverty line and 84.5% proportion of the population have access to electricity, whereas 34.0% have the renewable energy share in the total final energy consumption[1]. India is prone to be affected by cyclical storms disrupting electricity supply which takes a pretty long time to restore. The consumption of conventional energy sources as evident has a severe effect on the environment, causing a rise in temperature[2]. It is also predicted that some of the coastal prosperous cities may be submerged owing to global warming and the increase of carbon dioxide and monoxide proportion will result in the extinction of a variety of animals and plants. From the above, it can be observed that solar energy is the only solution to the above problem which not only increase the standard of living of the people of the country but also have a high impact on correcting the environment [3,4]. Nowadays, the demand for solar system especially solar photovoltaic system is of prime importance owing to its cost-effective nature and effortless installation [5]. The basic principle of a solar PV cell is to convert the solar irradiation into electricity, semiconductor of cell absorb solar irradiation. Spectral irradiance is the power radiation obtained from each wavelength by unit area [5]. These spectral irradiances influence the atmosphere by its path length and optical transmittance properties, whereas the attenuation of the spectral irradiance is the exponential function of the distance that the radiation travels. The Air Mass (AM) is the ratio of the actual distance travelled to that of the path of shortest distance [6].

II. EXPERIMENTAL ANALYSIS

The experimental work is divided into two sections in which the first section includes the effect of the colour spectrum and the second section includes the thickness of plastic on solar PV performance. To verify this two experiment, a polycrystalline PV module was taken. The specification of this PV module is given in Table I.

Table- I: Solar PV panel specification

|            |               |
|------------|---------------|
| Max power  | 10 watt        |
| dimension  | 30cm×20cm      |
| Open circuit voltage | 18.7 volt   |
| Short circuit current  | 0.8 amp     |
| Maximum voltage  | 16 volt       |
| Maximum current  | 0.5 amp      |

III. EFFECT OF COLOUR SPECTRUM ON SOLAR PV PERFORMANCE.

The solar radiation absorbs by the ground is divided from different energy content which is called wavelength. There are three types of wavelength such as ultraviolet which is less than 400nm with an energy content 5 to 10% from the total energy level. The second one is visible light which is 400 to 700nm, and it covers 40% total energy, and the last one is infra-red, which is above 700nm, and it contains 50% of total energy content. As we know that ultraviolet ray can't enter to the earth atmosphere due to the presence of the ozone layer. So 90% of solar irradiation which includes visible and infra-red ray only absorbed by the earth surface[7,8]. Visible ray has different ranges of the colour spectrum, which starts from violet to red. As per the energy equation E=hf, where E is defined as the energy of the photon, h is the Planck's constant and f is the frequency of light.
So the colour spectrum has a significant effect on the photovoltaic cell. In this experimental work, some colour filters were taken to verify the effect of these wavelengths on solar PV module.

The wavelength of various colour spectrums which are used in this experiment given in table II.

**Table-II: Different colour spectrum with a respective wavelength**

| Colour | Wavelength(nm) |
|--------|----------------|
| Red    | 622-780        |
| Yellow | 577-597        |
| Green  | 492-577        |
| Blue   | 455-492        |
| White  | 400-750        |

**A. Experimental Set-up**

The experiment was conducted at KIIT, BBSR, INDIA in April 2019. To get accuracy, the same experiments have done repeatedly for three days. The results are discussed in the result and discussion part of the paper.

**IV. EFFECT OF THICKNESS OF PLASTIC ON SOLAR PV PERFORMANCE**

Today researches are doing various experiments to increase the efficiency of solar PV module [9]. As per the effect of different environmental condition, the efficiency of the PV module is vary because the output of PV system depends on PV materials also [10,11]. To know the different thickness of plastic effect to the PV performance, Here slide calipers was taken to measure the thickness of plastics and three different thickness of plastic (0.002cm, 0.005cm and 0.008cm) was kept on solar PV module. The temperature is measured both above and below the plastic. This experiment was conducted at the same place in May 2019. The results of this experiment has shown in result and discussion part of this paper.

**V. RESULT AND DISCUSSION.**

A. Results of the different colour spectrum.

The output power and efficiency of the above experimental analysis was compared with clean panel and with different colour filter .which is shown in Table-1V and Table –V.

---

**Retrieval Number:** D4373118419/2019©BEIESP

**DOI:** 10.35940/ijrte.D6745.118419

**Published By:** Blue Eyes Intelligence Engineering & Sciences Publication
Table- IV: Average outcomes of PV panel with colour spectrum

| Different colour spectrum | Current Isc (amp) | Voltage Voc (volt) | Power Pm (watt) | Efficiency |
|---------------------------|------------------|-------------------|----------------|------------|
| Clean                     | 0.36             | 18.4              | 2.997          | 4.88       |
| White                     | 0.35             | 18.3              | 2.668          | 4.44       |
| Red                       | 0.36             | 18.2              | 2.619          | 4.365      |
| Yellow                    | 0.33             | 18.1              | 2.484          | 4.14       |
| Green                     | 0.32             | 17.8              | 1.892          | 3.15       |
| Blue                      | 0.32             | 17.8              | 1.856          | 3.1        |

From above reading it shows that the efficiency of the clean panel gives better efficiency then other filters as per result the short circuit current of red is higher as compare to other colour filters due to its longer wavelength. From five colour spectrum it shows that the white colour gives more output in compare with other colour filter. After white colour filter, red colour filter gives more output then other three and blue colour gives minimum output as compare to other due to shorter wavelength. So from above result shorter the wavelength the output power and efficiency is decreasing accordingly.

![Fig. 3. Effect of power on the different colour spectrum](image)

The above graph shows the output power of different colour spectrum after clean panel, the white colour gives the maximum power than other colour spectrum.

Table- V: Average outcomes of Pv panel with different plastic

| Thickness of plastic | Voltage Voc (volt) | Current Isc (amp) | Temp(un)°C | Power Pm (watt) | Efficiency |
|----------------------|--------------------|-------------------|------------|----------------|------------|
| w.o.p               | 18.4               | 0.36              | 50.2       | 2.997          | 4.88       |
| 0.002               | 18.1               | 0.36              | 50.8/52.4  | 2.716          | 4.52       |
| 0.005               | 18                 | 0.37              | 51.4/53.6  | 2.632          | 4.37       |
| 0.008               | 17.3               | 0.375             | 51.4/54.2  | 2.52           | 4.2        |

From the above reading (Table-V) shows that clean panel gives more output power than other plastic. The effect of temperature is the leading region of this experimental analysis. With increase of temperature the output power of the module is decreasing. So, it is essential to maintain the less temperature to get maximum output power.

![Fig-5 Above and below the temperature of various plastic](image)

From the above graph shows that more thickness of plastic give less output due to an increase in temperature and vice versa. With increase in temperature the output power and efficiency is decreased. For every solar module, there is a standard temperature which is called standard test condition temperature (STC). And on this standard test condition PV module gives maximum output. So to maintain the standard temperature it is necessary to clean the module as a various procedure like water spray, wind spray or auto cleaning mechanisms.
VI. CONCLUSION
Experimental analysis has given a brief idea about the effect of a various factors on solar PV output. Till date the efficiency of solar PV panel is 15 to 20% but the demand of PV energy is increasing day by day so it is the time to give more concentration on PV system that can give more efficiency for coming decades. Coming to above experimental analysis it conclude that longer wavelength spectrums are more efficient with photovoltaic cells than shorter. In general, to get more efficiency, the high solar radiation intensity is needed without colored filters. From the effect of plastic analysis shows that solar PV is very sensitive to temperature. Very less increase of temperature also effect more to solar PV output, so to ensure better efficiency it is essential to keep the module temperature less.

ACKNOWLEDGMENT
Authors like to thanks School of Electrical Engineering, KIIT Deemed to be University, Bhubaneswar, Odisha for providing necessary equipment for these experiments and constant encouragement to do this work.

REFERENCES
1. https://powermin.nic.in Government of India ministry of power.
2. Qdah, Khaleed & Abdulqadir, Saleh & Harbi, Nawaf & Soggyah, Abdullah & Isb, Kamal & Alharbi, Mohammed & Binsaad, Nassir. (2019). Design and Performance of PV Dust Cleaning System in Medina Region. Journal of Power and Energy Engineering. 07. 1-14. 10.4236/jpee.2019.711001.
3. Alonso-Abella, M., Chenlo, F., Nofuentes, G., & Torres-Ramírez, M. (2014). Analysis of spectral effects on the energy yield of different PV (photovoltaic) technologies: the case of four specific sites. Energy, 67, 435-443.
4. Patnaik, B., Swain S.C., Rout U.K. (2020) Modelling and Performance of Solar PV Panel with Different Parameters. Applications of Robotics in Industry Using Advanced Mechanisms, ARIAM 2019. Learning and Analytics in Intelligent Systems, vol 5. Springer, Cham.
5. DeJarnette, D., Tunkara, E., Brekke, N., Otniarczuk, T., Roberts, K., Gao, B., & Saunders, A. E. (2016). Nanoparticle enhanced spectral filtration of insolation from trough concentrators. Solar Energy Materials & Solar Cells, 149, 145-153.
6. Chauchan, M. T., & Kazem, H. A. (2016). Experimental analysis of solar intensity on photovoltaic in hot and humid weather conditions. International Journal of Scientific & Engineering Research, 7(3), 91-96.
7. Rawat, Pratish. (2017). Performance Analysis of 300W Solar Photovoltaic Module under Varying Wavelength of Solar Radiation. International Journal for Research in Applied Science and Engineering Technology, V. 2476-2482. 10.22214/ijraset.2017.11346.
8. K. Sudhakar, N. Jain and S. Bagna, "Effect of a colour filter on the performance of solar photovoltaic module." 2013 International Conference on Power, Energy and Control (ICPEC), Sri Rangalatirtha Dindigul, 2013, pp. 35-38. doi: 10.1109/ICPEC.2013.6527620.
9. Kumar MN, Saini HS, Anjaneeyulu KSR, Singh K. Solar Power Analysis Based on Light Intensity. The International Journal Of Engineering And Science (IIES), 2014:1-5.
10. Sarkar, M.N.I. Effect of various model parameters on solar photovoltaic cell simulation: a SPICE analysis. Renewables 3, 13 (2016) DOI:10.1186/s40807-016-0035-3
11. Didier Beloin-Saint-Pierre, Isabelle Blanc, Jérôme Payet, Philippe Jacquen, Nadine Adra, et al. En-virionmental Impact of PV Systems; Effects of Energy Sources Used in Production of Solar Panels.24th European Photovoltaic Solar Energy Conference, Sep 2009, Hamburg, Germany. pp.4517-4520 -ISBN 3-936338-25-6, 10.4229/24thEUPVSEC2009-6DV.3.71. hal-00487349

AUTHORS PROFILE
Bhabani Patnaik obtained her B.Tech in Electrical Engineering, 2010 from Synergy Institute Of Engineering and Technology, Dhenkanal and M.Tech. in Power System, 2012 from CVRCE, Bhubaneswar, BPUT. She is currently pursuing her PhD in Electrical Engineering from KIIT Deemed to be University, Bhubaneswar. Her area of interest are Power System, Renewable Energy source and published good conference papers and journal papers.

Dr. Sarat Ch. Swain, Ph.D. in Electrical Engineering, Professor School of Electrical Engineering, KIIT Deemed to be University, has 23 years of experience in teaching and published around 100 nos. of research papers in reputed International Journals and IEEE Conferences. He has research experience in Application of A.I. Techniques to Power System Problem, Soft Computing, FACTS Controllers, Power System Stability Improvement, PV Modeling Grid Interconnection of Photovoltaic Solar System and guided 38 M.Tech. Thesis and 4 Ph.D. Scholars.

Dr. Ullash Kumar Rout, is currently working in the post of Associate Professor in Electrical Engineering, Department College Of Engineering and Technology, Bhubaneswar. He received his B. Tech. in Electrical Engineering from Utkal University, M. Tech. in Power System from IIT Kanpur, and Ph.D. in Energy System from University of Stuttgart, Germany. He has around 11 years research experience in energy system modelling and 7 years in teaching. His research interest includes energy system and power system. And has published many research papers in journal and conference. He guided 3 Ph.D. scholars.