Analyzing the Performance of Polycrystalline Solar Panel under Different Temperature using Color Filters

Anshu Khokhar[1] Vijay Nandal[2]
[1]PG Student [2]Assistant Professor
[1,2]ECE Department
[1,2]Matu Ram Institute of Engineering. & Management, Rohtak

Abstract— *An attempt is made to evaluate the effect of colors of light on the performance of polycrystalline photovoltaic module .A case study is conducted to experimentally verify the effect of various color filters on the performance of solar panel. Based on the surface temperature, solar irradiance the power output of photovoltaic system have been evaluated. The main factors affecting the solar energy system that came in our concern was temperature and illumination. Depending on these two factors we saw how it affects the cell performance and output. The aim of the present study is to find out the variation of efficiency of solar photovoltaic module with ambient temperature corresponding to the use of filters and to calculate the cell output under different environmental conditions. The model is used to calculate the cell output power for over a period of six months. An analytical model based on physical parameters is also developed to evaluate the efficiency of solar panel. The results show that the present day PV technology is influenced by the red color of light.*

Keywords— solar cell, polycrystalline photovoltaic panel, colored filters, multimeter, power output, temperature.

I. Introduction

It Nowadays we get most of our energy from non-renewable energy sources eg. fossil fuels but we cannot depend upon them forever as the resources are limited, our dependence on fossil is close to its end. And on the other hand the energy requirement of the world is ever increasing . The increasing energy demands put a lot of pressure on the conventional energy sources. Therefore , there is a need for alternative energy sources which can provide us energy in a sustainable manner. The obvious choice of a clean energy source, which is abundant and could provide security for the future development and growth, is the sun's energy[1]. Solar radiations can be converted to electric energy by using Photovoltaic process.

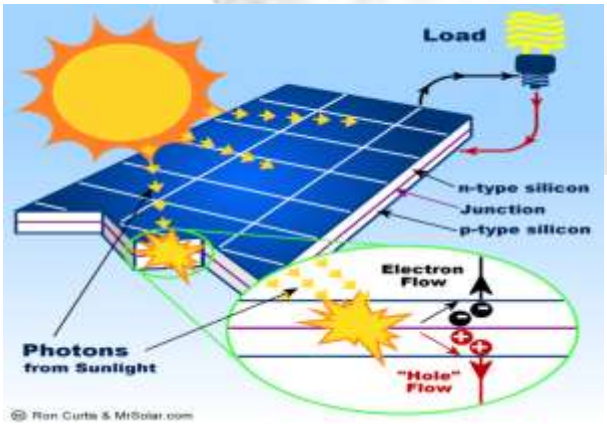


Fig. 1: Working of solar cell[2]

The development of affordable, inexhaustible and clean solar energy technologies will have huge and longer-term benefits[3]. Photovoltaic systems have been installed to provide electricity to the billions of people that do not have access to mains electricity. Power supply to remoter houses or villages, irrigation and water supply are important application of photovoltaics for many years to come[4]. Since the photovoltaic cells uses a part of the solar energy spectrum which is determined by the band gap of a semiconductor. The photons which have a power greater or lower than the band gap generate heat that can be dissipated by the transmission loss. These heat generations called thermalization process where the photons are absorbed with less energy than the solar cells band gap energy. This thermalization process is the dominant loss that limits the conversion performance of solar cell[5]. As discussed above , the spectrum of the solar energy is not fullt utilized in photovoltaic cells. Studies have been done towards the next advancement for increased output and efficiency. The color of light is determined by its wavelength and dictated in the color spectrum[6].

Colour	Approximate Wavelength (nm)
White	390-780
Violet	390-455
Blue	455-495
Green	495-575
Yellow	575-600
Orange	600-625
Red	625-780

Fig. 2: sunlight color wavelength table[7]

The aim of this study is to investigate the effect of different color filters on the power output of polycrystalline silicon panel at different temperature under different climatic conditions.

II. Literature Review

A. *Quarry Muck*

Quarry Our work starts with analyzing the performance of polycrystalline solar panel by calculating the output power due to the effect of color filters. From several research papers, and works done up to date, we found that, temperature and illuminance are the key factors that heavily influence the output output power of polycrystalline panel. So many researchers suggested that other applications can provide an effective way and an alternative to the use of solar radiations[8]. C.O. Osueke(2011)[9] aims to maximize the capacity of the panel by introducing a system of convex lens and color filter. Sudhakar K(2013) [10]this study is done to determine the wavelength and the effect of color

filters on the performance of monocrystalline solar panel. D.M. Tobnaghi(2013)[11] study proposed that the performance of solar cells is independent on environmental conditions and their output parameters

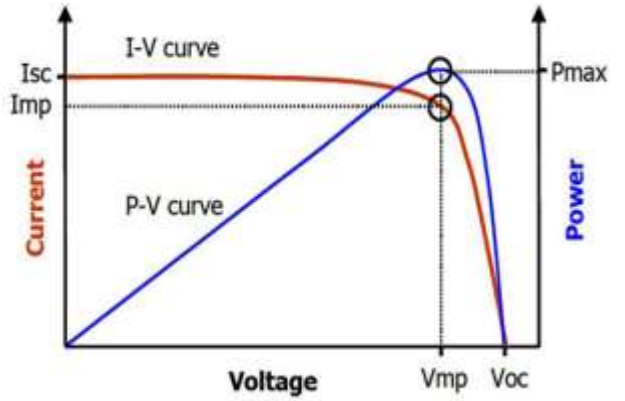


Fig. 3: I-V curve of solar cell[12]

like maximum output power, open circuit voltage, short circuit current, and fill factor vary by temperature.

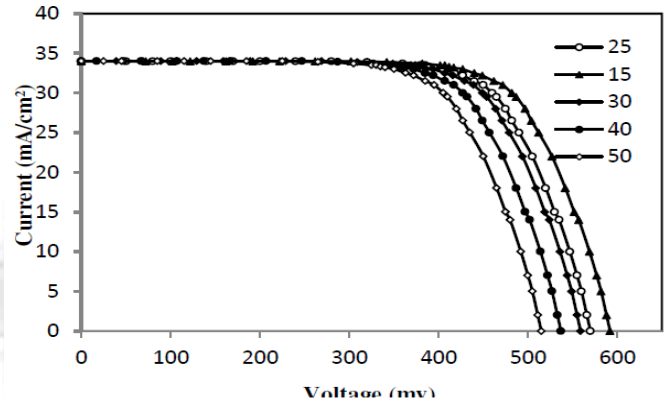


Fig.3 V-I characteristics of solar cell under different temperature

Fig. 4: V-I curve of solar cell under different temperature[13]

R. Siddiqui(2014)[14] summarizes the electrical characterstics of two polycrystalline silicon photovoltaic module under the influence of indoor and outdoor conditions. Tanima Bhattacharya(2014)[15] the research work the effects of temperature on photovoltaic module output performance were investigated.

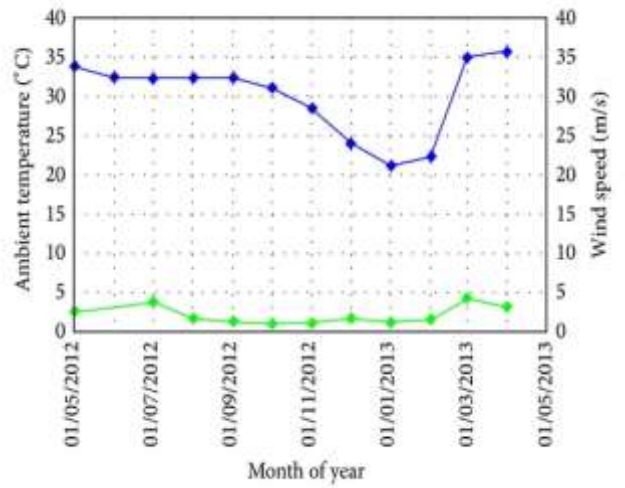


Fig. 5: solar cell ambient temperature and wind speed graph[16]

A statistical analysis has been done which shows that the correlation between the efficiency and ambient temperature is very good as compared to the correlation between efficiency and wind speed. A.M. Muzathik(2014)[17] proposed a simple formula to derive the photovoltaic cell temperature from the environmental variables such as ambient temperature, irradiance and wind speed also the total percentage error of the expected temperature would be less than 3% in this study. Sayran A. Abdulgafar(2014)[18] this study is to optimize the efficiency of solar panel by submerged it in distilled water at different depths. Dr. M. Narendra Kumar(2014)[19] as the solar power is based on the intensity and wavelength of sun rays, so this paper analysis the performance of panels due to the effect of temperature and the intensity of rays and proved that solar system maximum efficiency can be obtained if the sun rays wavelength is more and the temperature on panel surface is less. Indra Bahadur Karki(2015)[20] discuss about the effect of the light intensity and temperature on the output performance on the solar module. Study shows that short circuit current and maximum current are increase linearly with increasing light intensity and open circuit voltage and maximum voltage are decrease with increasing temperature module.

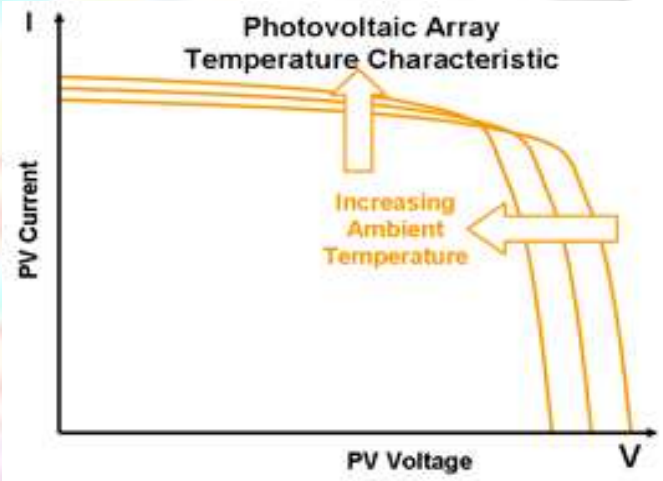


Fig. 6: temperature characterstic of solar cell[21]

B. V. Chikata(2015)[22] a multicrystalline solar panel is used, where its performance is improved with the use of mirrors and by the rate of thermal degradation. Hussein A. Kazem(2016)[23] monocrystalline solar panel has been taken and determines that different wavelength can influence the solar cell in a different how way. But the tests were conducted on days where the outside temperature did not exceed 25 degree celsius. Adnan Ahmed Siddique(2016)[24] this research aims in calculating output power and to compare and understand the behaviour of temperature and sunlight on 3 panels namely monocrystalline, polycrystalline and amorphous and result shows that photovoltaic cell performance is very much sensitive to cell surface temperature and this temperature is influenced by weather parameters like ambient temperature, wind velocity, humidity, solar irradiance, cell structure and material.

III. MATERIALS & METHODS

The materials needed to perform this experiment are stated as follows:

1. Solar Panel:
A poly-crystalline solar panel was used. Its maximum rating was found to be: 5watts; 9V; 0.55A. its size was also found to be 0.9m by 0.3m. The efficiency of poly-crystalline panels is known to be 18%.

2. Color filter (colored cellophane papers):
Cellophane papers with one color out of the seven visible colors of light spectrum: violet, blue, green, yellow, orange, red.

3. A battery operated portable multimeter:
A mains operated one is fine indoor, but a battery operated portable meter is easier if the experiment is taken outdoor.

4. A Mount (frame):
A mount made of steel with planes inclined at an angle of 45° to the horizontal facing south. This angle is dynamic and depends on the geographic location of the site of experiment. The multimeter is used to take voltage reading from the solar panel terminal.

5. Atmospheric thermometer:
It is a device that measures the temperature of the indoor or outdoor atmosphere. The most common type consists of a long tube that contains mercury or colored alcohol at the base. When the atmospheric temperature rises, it causes the material inside the air thermometer to expand. Conversely, when the air gets colder, the material contracts and travels back down. This thermometer scales Celsius to provide a measure of heat in degrees.

Two experiments were performed during this research:
1. The solar panel output reading were taken at three different times of the day without color filter.
2. The various color filters were placed on the panel while their individual output readings were taken at different times of the day.

The values of efficiency were calculated for each day for four to five hour interval and from that the weekly monthly average values were calculated. The weekly monthly average values of ambient temperature were calculated by the digital thermometer. For the present study the solar photovoltaic module was placed on the roof top. General variation in efficiency of color filters with respect to ambient temperature has been evaluated from with the required data. The values of ambient temperature at an interval of 4-5 hours were recorded on weekly basis and from that monthly average values of ambient temperature and effect of color filters have been measured for duration of six months. Graphs shows the variation of voltage, current and power with respect to the average values of ambient temperature from Jan 2017 to June 2017. The aim of the present study is to find out the variation of efficiency of solar photovoltaic module with ambient temperature corresponding to the use of filters. Dependency of efficiency of solar photovoltaic module on different factors except ambient temperature and color filters are neglected for the analysis. The simple correlation coefficient determined considering efficiency as dependent variable and ambient temperature and different wavelengths as independent variable separately. The ambient temperature varies with different months of the year throughout the period of the study for a particular area [25].

Experimental setup with all components
Electrical specifications of polycrystalline solar panel which is being used are as follows:
Rated Power: 5W
Power Error: +-5%
Working Voltage: 9V
Working Current: 0.55A
Open Circuit Voltage: 10.8V
Size: 303MM*183MM*17MM
All technical data at standard test condition with TC= 25°C
In this work; a detailed experimental study of all solar module parameters for polycrystalline silicon under different light intensity and temperature.

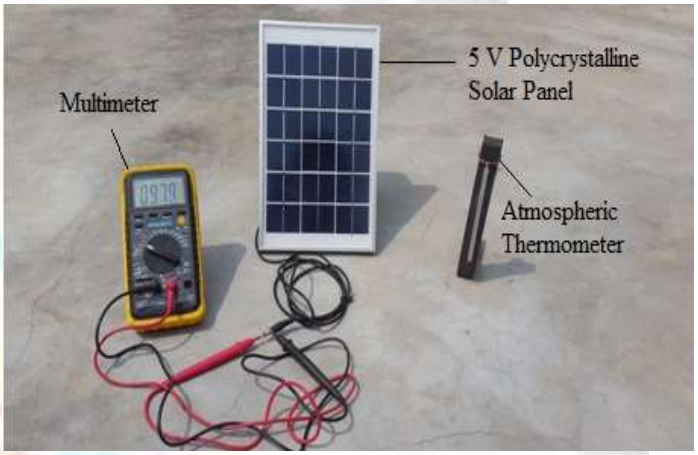


Fig7: Experimental setup without the use of filter

Fig8: Experimental setup with the use of filter

IV. RESULTS & DISCUSSION

There are number of factors upon which the output of a solar panel is dependent, in our work we have considered only two factors, that is the temperature and the wavelength of color filters. Results concluded that the red color has the least amount of light pass through panel because it didn't

have more energy to excite the electrons on the silicon atoms. Table 2 represents the color effect on the panel produced voltage and current. When no filter was used (visible light) the PV power was the highest. The results show in different filters the power was significantly reduced in comparison with module without the filter. For the photovoltaic solar cells, the cells output such as voltage is a function of many parameters as the temperature, solar intensity, and the wavelength(color) of the incident light. The voltages (Fig9), current(Fig.10) and power(Fig.11) variations of the used module with different filters are presented.

FILTER COLOR	WAVELENGTH (nm)	VOLTAGE (V)	CURRENT (A)	POWER (W)
No Filter	390-780	11.2	0.66	7.392
Red	625-780	10.83	0.47	5.0901
Green	495-575	10.68	0.43	4.5924
Blue	455-495	10.62	0.40	4.248

Table 1: The PV panel average outcomes

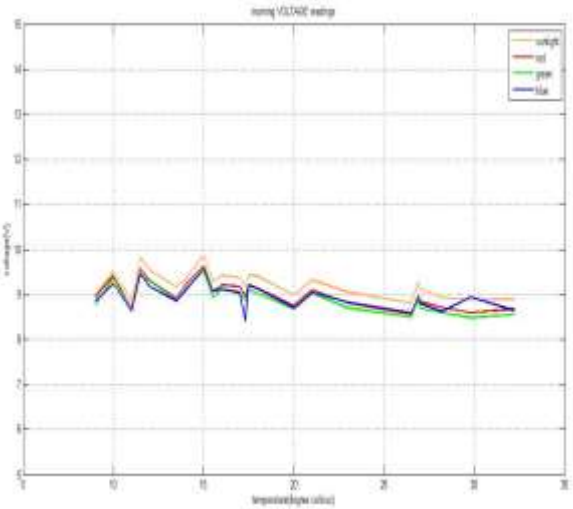
GRAPHS

After taking out all the parameters, and then in-corporate all necessary data in MATLAB simulation program. Now on the basis of data which was collected for six months were analyzed carefully to understand the influence it could have on solar panel output in real operating conditions. Graphs were developed to comprehend the trends of output voltage, current and power variations due to the effect of temperature and wavelength.

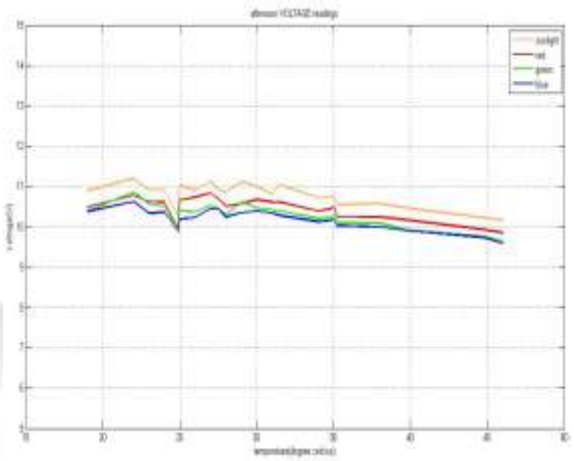
- Voltage-temperature
- Current-temperature
- Power-temperature

Voltage: Here in this section temperature-voltage graph is shown which shows the behavior of voltage for this PV unit with the use of spectrum colored filters at different temperature and timings.

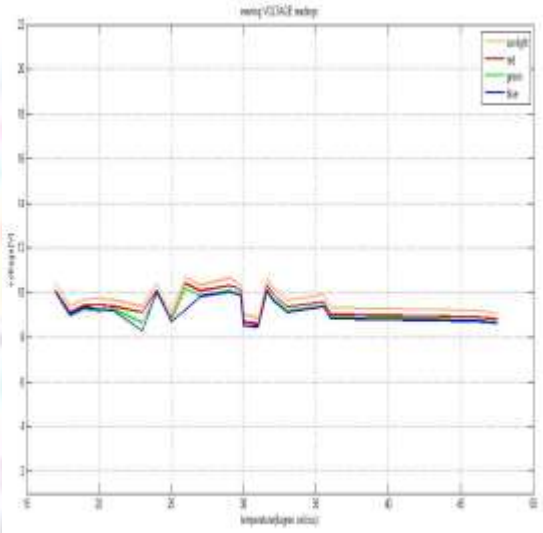
- **Morning Graph**



- **Afternoon Graph**



- **Evening Graph**



After analyzing the facts, we get the following relationship between the filters color and the voltage shown in figure.

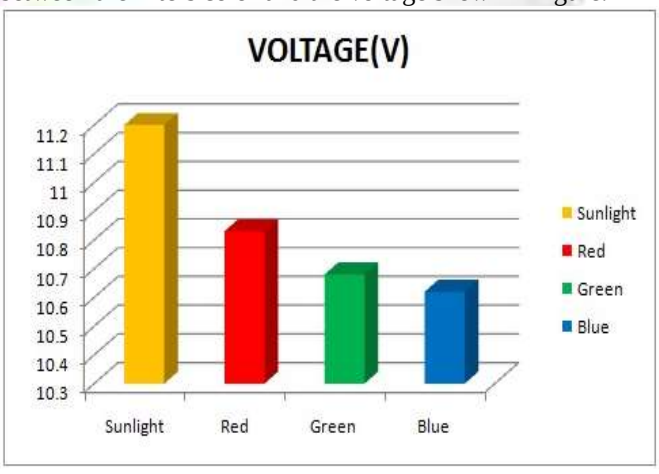
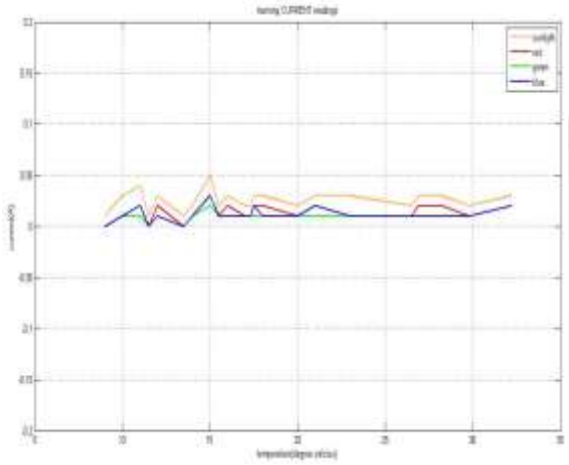


Fig.9 average outcomes of output voltage of PV panel

Current: Here in this section temperature-current graph is shown which shows the behavior of current for this PV unit with the use of spectrum colored filters at different temperature and timings.

- **Morning Graph**



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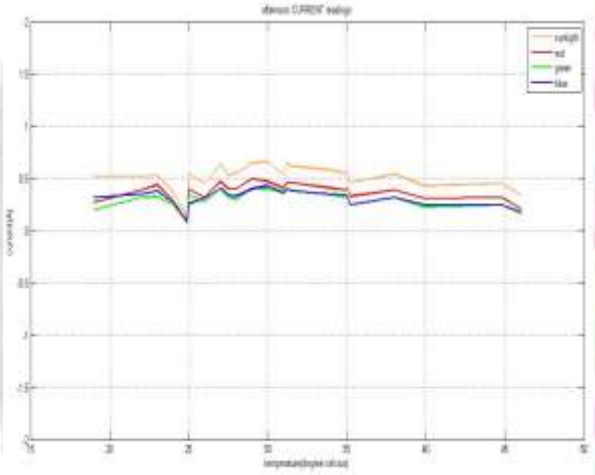

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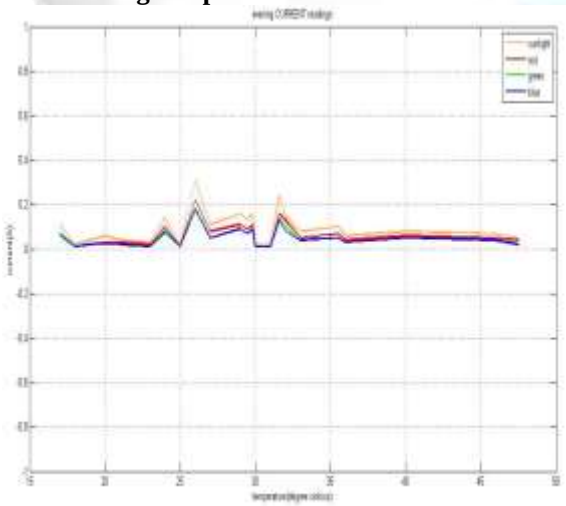


After analyzing the facts, we get the following relationship between the filters color and the current shown in figure.

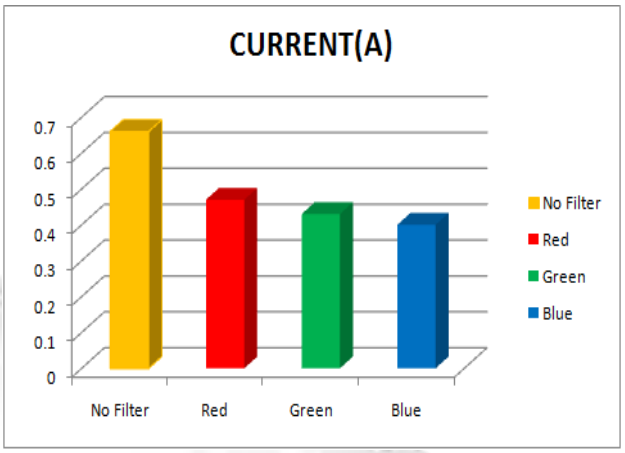
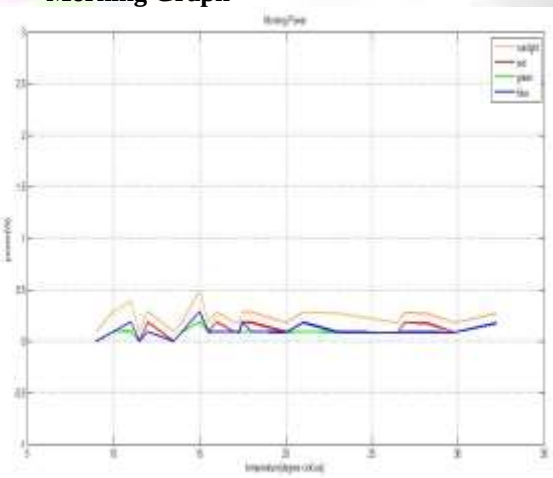


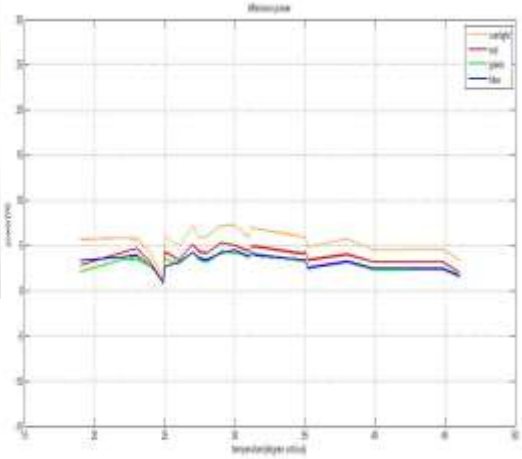
Fig.10 average outcomes of output current of PV panel

Power: Here in this section temperature-power graph is shown which shows the behavior of power for this PV unit with the use of spectrum colored filters at different temperature and timings.

- **Morning Graph**



- **Afternoon Graph**



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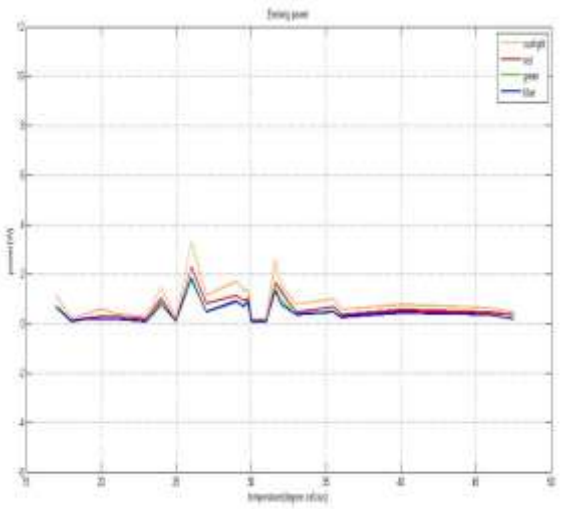

After analyzing the facts, we get the following relationship between the filters color and the power shown in figure.

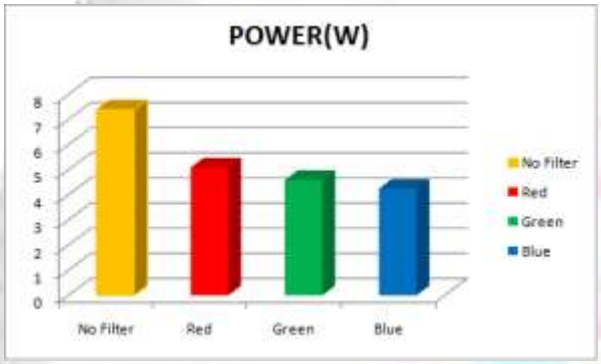

Fig.11 average outcomes of output power of PV panel

After analyzing the results, graphs shows the variation of voltage ,current and power of polycrystalline silicon module with color filters. And from there, we come to know the relation between the filters color and the output voltage, current and power at different temperatures.

V. CONCLUSION

In this, the effects of temperature on photovoltaic module output performance were investigated and the purpose of this study is to determine the color effect on the performance of Polycrystalline Solar panel. The Performance of solar cells is dependent on environmental conditions and their output parameters such as output voltage, current, power vary by temperature. Experimental results showed that the most significant changed by temperature is voltage which decreases with increasing temperature while output current slightly increase by temperature. After analyzing the results, it was concluded that the wavelengths of light do affect the performance of solar cell. It was determined that the output of the panel under sunlight was significantly higher than any of the other colored light. Whereas, Red color light generates more electricity than other colors.

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