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Characterization of PV module in reference to Tilt angle and Azimuth

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Abstract

Power generation from a solar photovoltaic system is one of the glowing research fields these days, even governments are also planning toward installation and production of power generation from renewable energy sources because in the future its feasibility and crisis of conventional energy sources will increase .Further government liberalization and technical developments encourages the use of renewable sources for electricity generation in terms of solar power. In any power production plant, improvement in the efficiency of the plant is a big and important issue. After installing the solar power plant, it is necessary to get maximum performance from them. With all other factors, the tilt angle and azimuth angle affect the efficiency of the solar panel. The output of the PV system is depends upon many geographical and climatic factors. In this paper, we study mono crystalline and poly crystalline solar cells, how their efficiency depends upon different tilt and azimuth angle.We will also do a comparative study of both types of solar cell that how much level their parameters changed under variation of orientation. The orientation angles keep an important role to expose the panel to high amount of solar energy. It increases the power output if chosen accurately. This paper draws a relationship between accuracy of tilt and azimuth angle impact on PV solar panel Thus, it is very important to orient the solar modules at optimum tilt angle and azimuth angle for any given location because they are most efficient when they are perpendicular to the sun's rays.

It is a critical issue to choose both tilt angle and azimuth angle to improve the efficiency of a power collector [1]. Literature study shows that to install the PV module for high efficiency the fixation and orientation of the module must be considered [2]. There is a big shortage of field data for power variation due to tilt angle and azimuth angle into day's photovoltaic (PV) empire. This paper tries to find out that what extent the power of the solar module is affected by the tilt angle.

Introduction

The surface of the earth is acquiring approximately 1018 kWh of solar radiation every year [3], but is hardly use just around 1/6000 of that bulk [4]. To take the advantage of incoming solar radiation, the solar module must be installed at the optimum tilt.

The sun performs as a black body at a temperature of 5777K that produces energy through nuclear fusion reactions. The solar radiation outside the earth's atmosphere is estimate data constant value of G_{SC}=1367W/m^{2}although it varies from 90%to110%roughlyfor a year. This difference may be larger when larger the deviation from the equator. This value is termed as the solar constant and it is defined as the total radiation collected from the Sun per unit time per unit area on a theoretical surface right angle to the Sun's rays and at Earth's mean distance from the Sun. [5] The solar constant has all types of solar radiation, not only visible light but also infra-red and ultra violet radiations .The solar radiation is lessening when it extends into the atmosphere.

The diffuse solar radiation or sky radiation (Gd) is the part of incident radiation that is scattered but continues to move toward Earth with a change in its direction. The direct radiation or beam radiation (Gb) is the one that reaches the Earth's surface in the same direction as it touches the atmosphere or in other words, it is not scattered. The total radiation or the global solar radiation (G)on to a horizontal surface on the ground is the addition of those two. For inclined surfaces, there is a component of the reflected radiation (Gr) has to be also considered[6].

The Earth moves around the sun and spins also so the sun's positions at the different parts of the earth vary. Due to this motion solar radiation coming from the sun depends on geographic latitude, season, and time of a day [7]. To boost the collection of solar radiation, a PV module should be installed at the optimum tilt angle and orientation under various conditions [8]Due to this motion solar radiation coming from the sun depends on geographic latitude, season and time of day[9].To boost the collection of solar radiation, a PV module should be installed at the optimum tilt angle and orientation under various conditions. Tile angle is the deflection of the solar module surface from the horizontal plane.It shows the orientation and location of the tilted plane. As depicted in figure5.5it varies between0^0to90^0. It is the azimuth angle of the sun; it expresses the direction of thesun [10]. The most commonly sanctioned convention for researching solar irradiation, e.g., for solar energy utilization, is counterclockwise from proper North, hence East is ninety degrees, South is one-eighty degrees and West is two seventy degrees Along with location, the tilt angle and azimuth angle are season dependent also. So, every location will have different tilt and azimuth angles for different months of a year.

The electricity generation capacity of a solar system depends not only on the power hold in the sunlight but also on the angle between the solar module and the sun. When the sunlight is incident perpendicular to the receiving surface, the power density will always be at its peak value and the production also. But the position of the earth always changing with respect to the sun so the angle between the incoming sunrays and a fixed surface is varying. The power density on a fixed PV module is low when the incident sunlight is below or above to 90^0.The quantity of solar radiation incident on a tilted module surface is the component of the incident solar radiation which is perpendicular to the module surface.

Many studies have been developed to decide the optimum solar energy collector orientation. When focusing on maximum annual irradiation on an inclined surface, it is mostly proposed to orient the collecting surface toward due south with a tilt angle equal to the latitude of the geographical location. Such theoretically derived suggestions are based on direct radiation only, and practical experience recommends that when diffuse radiation is involved, different results may be obtained [11]. There are various methods are available in the literature for solar module installation or mounting.

PV module is mounted on the fixed frame and then this frame is installed in tilted position with respect to horizontal plane. This is the

simplest and cost-effective method for acquiring the maximum solar flux density. Tilting the solar module at local geographic latitude, shrink the average incidence angle throughout the year. In practice, a smaller tilt angle is generally used to reduce shading of adjacent solar modules, lessen wind load, and take higher advantage of summer months when there is more solar flux and the sun is high up in the sky.

Considering only the aim of maximizing annual electricity yield, tilt angle (β) would be revised from latitude angle (L)of the site to collect more of summer's higher flux. It has been empirically calculated that the optimal tilt angle for annual yield can be estimated by equations written below[12].

$$Q = \mathbf{0.764}L + \mathbf{2.14}°, \qquad for\, L \leq 65°$$

$$Q = \mathbf{0.224}L + \mathbf{33.65}°, \qquad otherwise$$

Another option available to the experts is to enlarge the energy output by adjusting the azimuth angle of the module, when electricity consumption is usually highest, generally in the afternoon hours. In this case, the azimuth angle of the module can be adjusted in the range of 180^0 to 270^0 or west of due south. Still, doing so, would surrender the morning electricity production and total yield for the day. As one passes away from the equator then the energy harvest return so slanting module if the sun is deep in the sky.
The tilt angle and orientation of the PV modules are major factors that affect the efficiency of PV modules. It has been noticed that for every site on the planet with specific radiation aspect, there is an ideal tilt angle for the highest solar energy reception. By the Japan Meteorological Agency, solar radiation data has been assessed for about 60sites to find optimal tilt angle and provide enlarged AMeDAS Weather data for 842 places in Japan. Some theoretical research has been performed regarding the optimal tilt angle using these data [13].Data related to hourly diffused solar radiation and average incident radiation with tilt is collected at Delhi, India [14]. G. Hegde and T.V.Ramachandra collected energy requirement data for Kerala and Karnataka and then sector-wise solar energy consumption rate is explained in south India [15]. Various techniques and technology are being investigated to estimate the radiation on tilted surfaces[16-17]
R. Tang and T. Wu in his research for an optimal angle of solar surface predicated that intensity of solar radiation is higher for optimum angle in comparability to the horizontal surface [18]. Energy reception rate for different orientation is different according to the distance of the location from the equator and in southern hemisphere, the north face collector gains more power in comparison to any other orientation [19].
M. Lalwani et al. in India studied the size optimization of the SPV system under local climatic conditions. They reported that time duration of study, tilt angle, location of the site, and solar module orientation are the crucial factors for performance deviation of solar modules[20].Research activity for estimation of tilt angle for different locations is performed by eminent researchers since optimal tilt angle is hung on thelatitudeofthelocation,climatecondition,andsurroundinghurdle.Generally, the latitude angle of the site is considered as the tilt angle of that particular location on the condition that the clearness index is nearly the same during the year [21]. It is a very time-consuming and cost-effectivestrategytoadjustthesolarsurfaceaccordingtochangingincident solar radiation. Some researchers in their study for optimal tilt angle found that monthly tilted surface catch more solar radiation in comparison to the seasonal tilted surface followed by year fixed tilted surface [22]. Harnessing solar radiation can be improved if thetracingsystemisimplanted.ASingle-axistrackingsystemgetsapproximately 29% more radiation as compared to a fixed tilted module. Similarly, the level of capturing of radiation is enhanced by 29% with the use of a two-axis tracking system [23]. H. Moghadam and S.M.Deymeh researched for a solar system installed on the roof of a building concerning the shadow of adjoining neighbors.

To collect the supreme solar radiation at high building modules should be installed at the southern edge from taller buildings in the northern hemi sphere. If the shadow of the two neighboring buildings covers the roof, then a solarmoduleshouldbeinstalledonthemidofthesouthernedgeatoptimaltilt angle [24-25]. Not only for electricity generation but also the role of tilt angled solar module is appreciable for other applications as a solar cooling system in summer and solar heating in winter all over the world[26]. P. Sunderman et al. studied the variation of tilt angle and azimuth angle for different months for the year. It is proved by them that for September to March the tilt angle $\beta=\varphi-\delta$ with $\gamma=0^0$ is best for energy capture and for April to August $\gamma=180^0$is the optimum angle in comparison to $\beta=0^0$ and $\beta=\varphi$ [27]. The variation in tilt angle is very strange since in summer it ranges in between 0^0 to 30^0 and for winter it acquires the value inbetween50^0to70^0 [28].

Data collection for solar radiation and performance evaluation is complex since solar modules are installed in an outdoor environment and all of these factors affect the performance of the system in different ways. Now, these days much advanced software is available to estimate the efficiency of the different solar utilization. By the use of this software,the standard of the different solar employment may be improved [29].

E.A. Handoyo et al. find the tilt angle for Indonesian location and they showed that it is varied between 0^0 to 30^0 for March to September month with the northern inclination and 0^0 to 40^0 for October to March with southern inclination. Daily change in tilt angle has the range from36^0 to 39.4^0 in parallel with east in the morning time and west in evening time [30]. D. Jain, andM. Lalwani reviewed the optimum tilt angle ofthe solar system for some important cities of India and many different sites of the world elicited from annual, seasonal and month-wise tilt angle.[31]

The efficiency of the solar collector is a complex phenomenon since it depends upon various factors as stated in previous chapters. The wind is one such important factor. It may degrade the efficiency as high wind lift the dust and another pollutant from far different places and accumulate them on the module but it also reduces the temperature of the module. Numerous causes of dust accumulation were studied by M.Mani and R. Pillai, reviewed and some solutions recommended [32]. Inanariddesertarea,A.M.El-Nasharstudiedthetransmittanceofaglancing surface with different dust density and tilt angle [33]. For lowe tilt angles the transmittance reductions are high. The inclination of the photovoltaic module to wind direction also modifies the transmittance ability of the surface.H.K.Elminiretal.foundthatwith30^0alterationsin tilt angle 12.38% change occur for transmittance [34]. M. Hanif et al. studied the power Output of photovoltaic solar modules with different temperatures along with tilt angles and conclude that on hot sunny days, the solar module must be adjusted at a place where it gets the highest wind currents so that its temperature remains minimal and power output remains maximal[35].

Amajama J. et al. studied the impact of wind on the efficiency of the module in Nigeria. They concluded that when the direction of the incident solar photonic particles is in phase along with the molecular particles of the wind than solar radiation intensity increases and not favored when the direction of the incident solar photonic particles is out of phase [36]

Irradiance

Solar irradiance is the count of radiant flux experienced by the earth's surface per unit area. More the solar irradiance accepted by the module more electrons are generated [37]. Performance of PV module is higher on clear bright days rather than on overclouded and rainy days[38]. In this study, solar irradiance is measured from 8 am to

5 pm with the help of the solar meter and the accompanying voltage and current data are measured witha multi-meter.

Temperature

Temperature is the most complex factor which influences the PV module's efficiency[39].It has an opposite relationship with module performance. In a real framework, all the photons attacking the solarpane surface are not able to generate useful energy. Some part of it is changed into heat which enhances the temperature of the module. Highly heated modules are less efficient than moderate ones.

In this work, the PV module temperature is measured by using RTD. Temperature is measured from 8 am to 5 pm. Variation of the temperature throughout the day.

Tilt angle

PV module fixation and orientation are an important factor which must be reviewed while analyzing the performance of the PV system[40].Usually, the modules are oriented in the south direction. The module's inclination must be matching the location's latitude subtracting declination angle which is the angle between the sun and the equator. Studies proved that the tilting effect is more noticeable than the orientation [41]. For optimal orientation, the PV modules are holding on facing south. In this work, the module was tilted at a different angle $0^0$to 90^0.

Research methodology

Orientation (tilt and azimuthal) angles vary with geographical location with daily, the monthly and yearly path of the sun. Which means these angles varies for any specific site from time to time. However, majorly mega PV projects or household's rooftop PV systems are of with fixed orientation angle PV system. Therefore, in such case, selection of PV system tilt and azimuth angles mainly depends upon annual average daily solar radiations to maximize the solar radiations on the surface of PV system. Tilt angle and azimuth angle of PV system maximizes the yield. To analyses the effect, a small-scale PV system at end energy user level. For this study, considered the location of PV system at Bhilwara .Orientation angles accuracy requires geographical location parameters information such as solar radiations etc. This data must be reliable to consider for actual research study. However, the ground data of solar radiations are not available for a large number of geographical locations or have other issues involved.

PV panel's efficiency plays a pivotal role in power production as well. Therefore, efficient PV panels are used for the analysis. However, in the case of less efficient PV panels and different geographical location, the method of analysis will remain almost the same.

Results and discussion

During the study ,we used two commercial PV module with the characteristic shown in Table 1 below

Mono Crystalline solar panel(Cell Area)Power Loom company India

Max Power pmax	Max Power voltage	Max Power current	Short circuit current	Open circuit voltage	Fill factor
50W	20Volt	2.50Amp	2.60Amp	23.50Volt	0.7864

Poly crystalline solar Panel(Cell Area)Genius company India

Max Power pmax	Max Power voltage	Max Power current	Short circuit current	Open circuit voltage	Fill factor
40W	18Volt	2.30Amp	2.50Amp	22.61Volt	.0.7686

Tilt angle impact

Tilt angle changes the solar radiations interception ability of PV systems. These variations have a direct impact on PV system performance and efficiency. Tilt angle impact can be observed through monthly average daily solar radiations values at any location. MA reaches to a maximum value at specific tilt angle and for the rest of the values it reduces the PV system solar radiations interception potential at any location.

Azimuth angle impact

Azimuth angle along with tilt angle plays an important part in PV system efficiency and performance, which is underestimated in most of the literature. Impact of azimuth angle at0°and180°is observed at different tilt angles ranging from 0°to90.

Experiments were conducted on different days at different tilt angles conditions with the mono crystalline and poly crystalline module. Electrical parameters at different orientation were collected from 8:00amto5:00pm.Then,data collected on each day was screened carefully for regular and symmetrical irradiance intensities and only the plausible values were considered over every 30 minutes interval. Hence, the corresponding recorded parameters (ambient and module temperatures and module electrical parameters) were curated based on a specific irradiance value, such as for 200, 300,400 … up to 1000 W/m^2. That is, upon screening and curation, the measured parameters at a particular tilt angle were arranged and stationed against specific irradiance levels(100to1000W/m^{2}at an interval of 100 W/m^2). For all tilt angles, data were collected and structured in the same manner provided that ambient temperature trend curve of that day of experiment virtually corresponds with the representative day (first day of experiment). In this way, equitability of solar irradiance levels and ambient temperatures ondifferent days of experiment were sustained. However, wind speedand humidity on different days were essentially not the same and the errors generated from this variation were neglected in performance evaluation.

The comparison between the PV performance and module electrical parameters at outdoor reported in this study is predominantly qualitative rather than quantitative.

Ambient temperature and irradiation distribution of the site

The effect of variation of module tilt on the PV electrical parameters and solar cell temperature has been explored in this experimental investigation. Experimental studies have been carried out for making a comparison between the upshots. Another purpose of study is to experimentally determine an optimum tilt angle. A PV module’s electrical performance is mostly effected by the outdoor climatic conditions where it is installed. The main factors are irradiation and temperature. Although both the component varies under weather conditions, figure1 and2 shows that both the parameters fluctuate with the time of the day. The data were collected in the month of February then the ambient temperature and solar radiation were estimated against the day time. We observe that the maximum ambient temperature is 35^o which occurs at midday. Again we see that maximum radiation does not accord with temperature,it occurs at 1pm approximately. This observation agrees well with that obtained by Rehman at al.[42].Electrical generation through PV module is significantly affected by cell temperature, which in turn is a function of ambient temperature[43].irradiation intensity also effect PV power output ,the high irradiation intensity means better PV performance. Hence to ensure the interception of the maximum incident radiation, PV panel are required to be inclined in such a way that sun rays fall vertically on the module

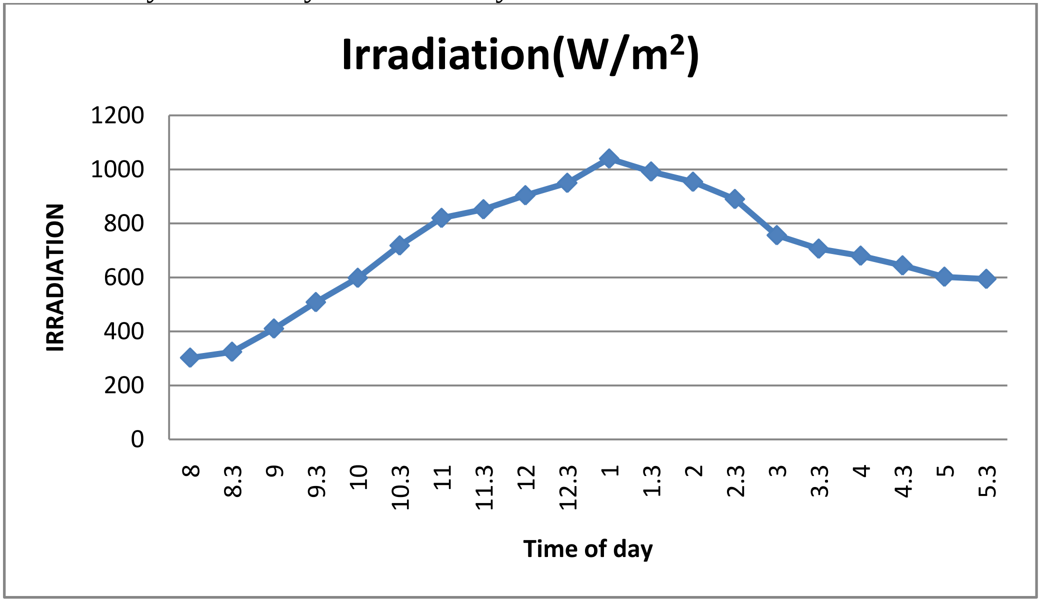


Figure 1 Irradiation

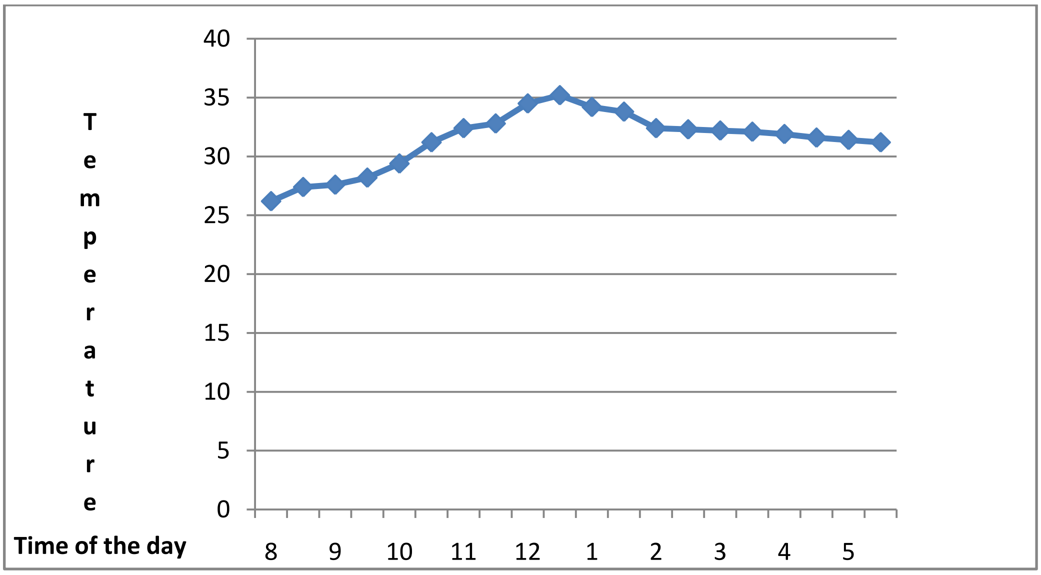


Figure 2 Ambient Temperature

Temperature distribution over PV module at different tilt angles

Temperature distribution of the module under variable tilt angles are showen in figure .In all figures one same trend as noticed is that top ,bottom and cell temperature fall rather gradually after 12pm though the rise is quite steep from morning to noon .As the tilt angle increases temperature of solar cell get relatively lower; and this become more apparent at 60 to 70 angles. At a 25^{o} tilt angle, the cell temperature of the system were 60.82,56.84 and 54.77 respectively. At optimum tint ,module faces due normal to the sun rays and the system can intercept maximum irradiation from the sun. That is why temperature of module surfaces and PV cell becomes the highest at this position .Ahmad and Tiwari [44] found 1%reduction in electricity due to cell temperature rise as a result of fixed tilt.

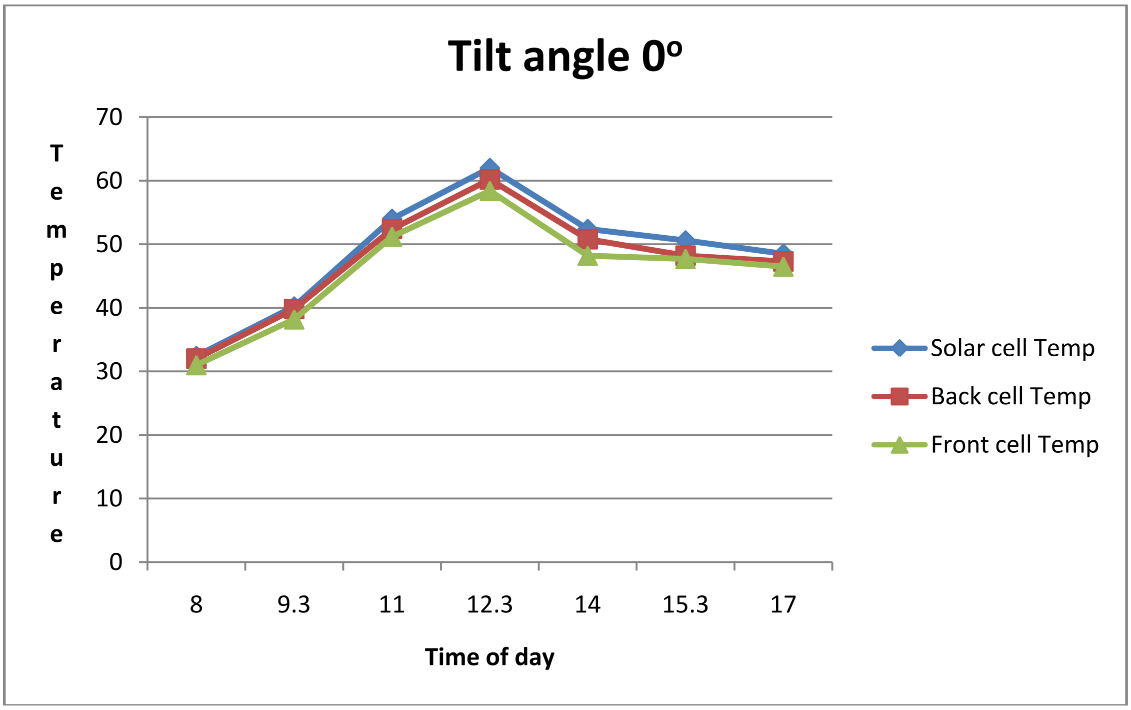
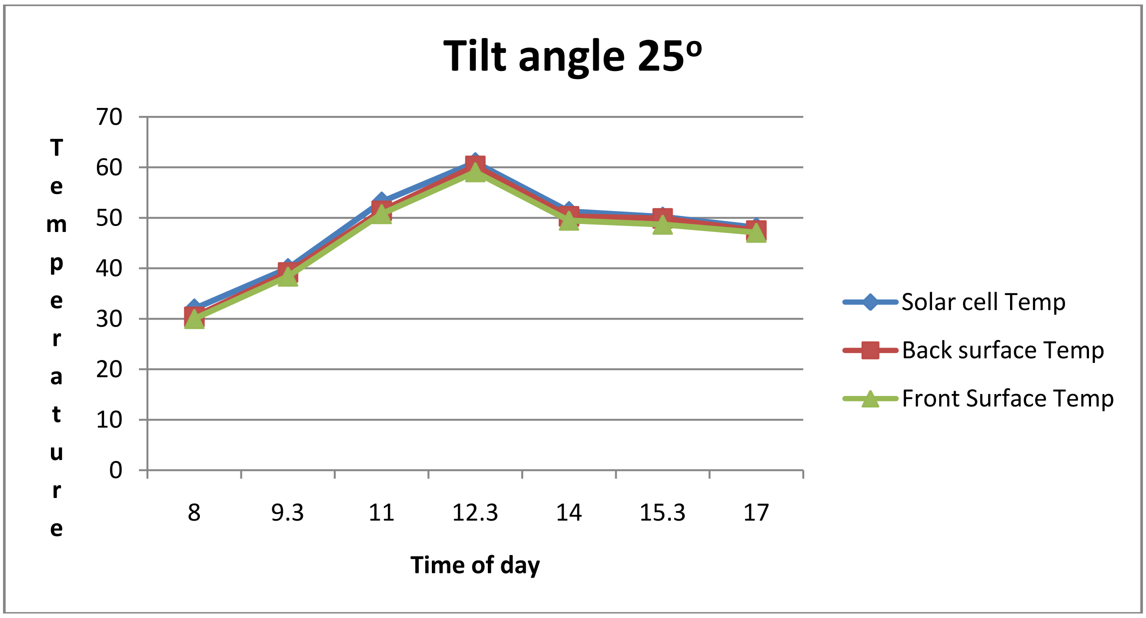


Figure 3



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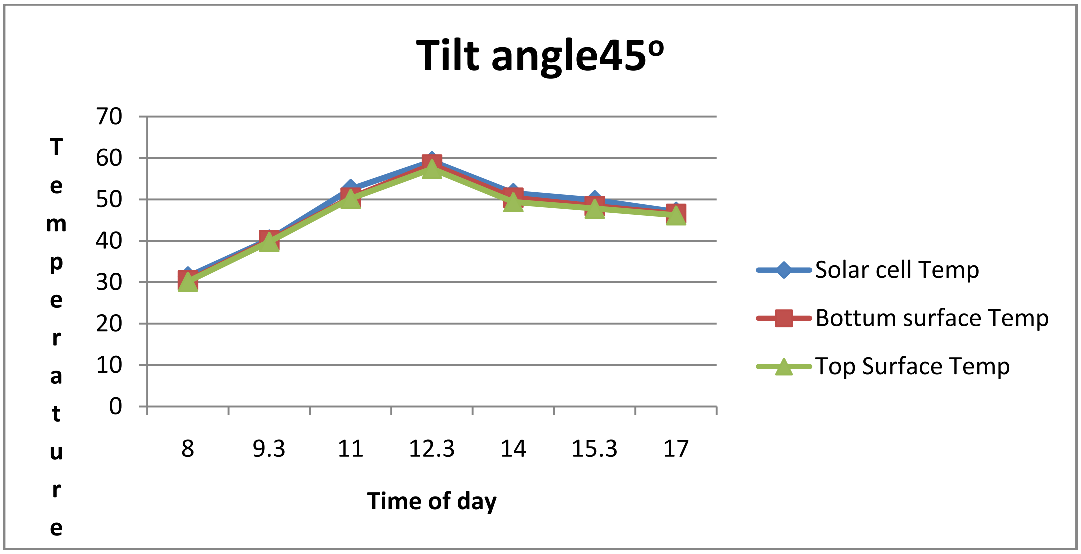

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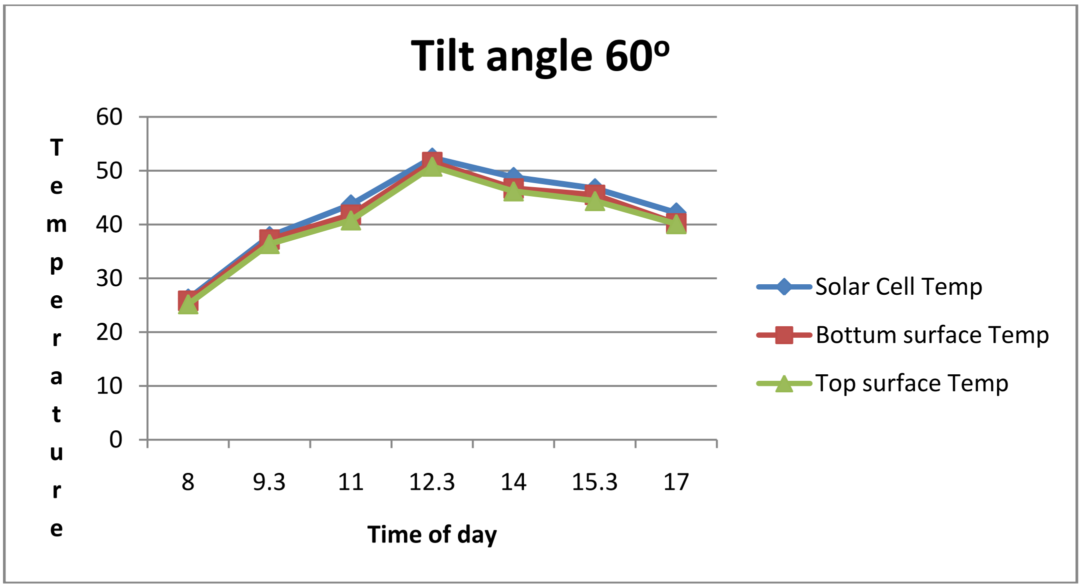

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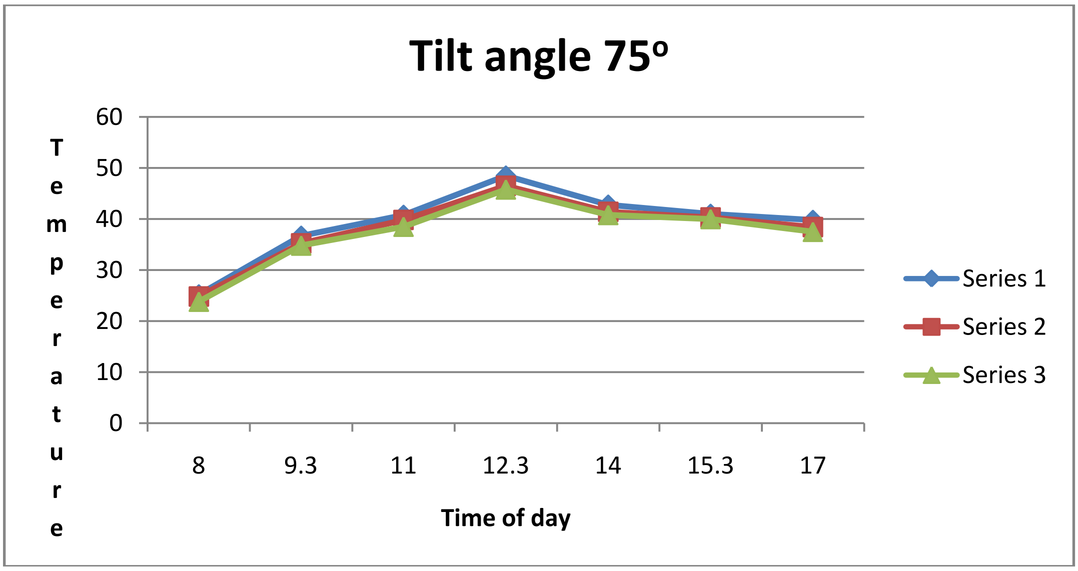

Figure 7

Effect of tilt angle variation under constant irradiation

In this section, the impact of varying module tilt angle under a specific irradiation condition has been analyzed for both the mono and poly crystalline module in outdoor conditions. Since peak radiation intensity of 1000 W/m^{2}subsists for a very little time span, while means irradiance level over the maximum period of a sunny day is 750 W/m^{2}analyses has been carried out at this irradiation.

Effect on power output and efficiency

The effect of module tilt change on power output and efficiency of mono-crystalline and poly crystalline module at 750 W/m^2 irradiation intensity has been presented Fig. 7 and 8. Both power output and efficiency are found to drop with increasing tilt. The highest power output and the maximum efficiency occur near a 25^{o}tilt angle in outdoor conditions.

It may be revealed from Fig that for every increase in the tilt, power output decreases .George and Anto [45]observed that slight changes (5^o) in tilt angle cause a power loss of approximately 2% or more. Adiyasuren E.[46]shows that in Mongolia, yearly rough power output generation sat the module-angle 45are 10% larger than that achieved with a tilt angle of 60^o.In another experimental study, it was found that if the module-angle was decreased from 50^{o}to 10^o, the module power output was increased by 26.15% [47]. Hence, the present results are concurrent with the previous research outcomes. On the other hand, with every increase in tilt angle, efficiency decreases. Asl-Soleimani et al. [48]and Mamun et al. [49] commented that effect of tilt angle on PV performance is generally investigated on a theoretical basis, while the experimental studies are essential to realize the real-time consequences. It has been reported that the temperature coefficient of the power output is influenced by the module tilt; if temperature coefficient increases, the corresponding value of the optimum tilt angle at the maximum value point decreases [50]. On the other hand, dust deposition rate decreases with increasing tilt angle promotes due to gravity, which in turn improve electrical performance [51].

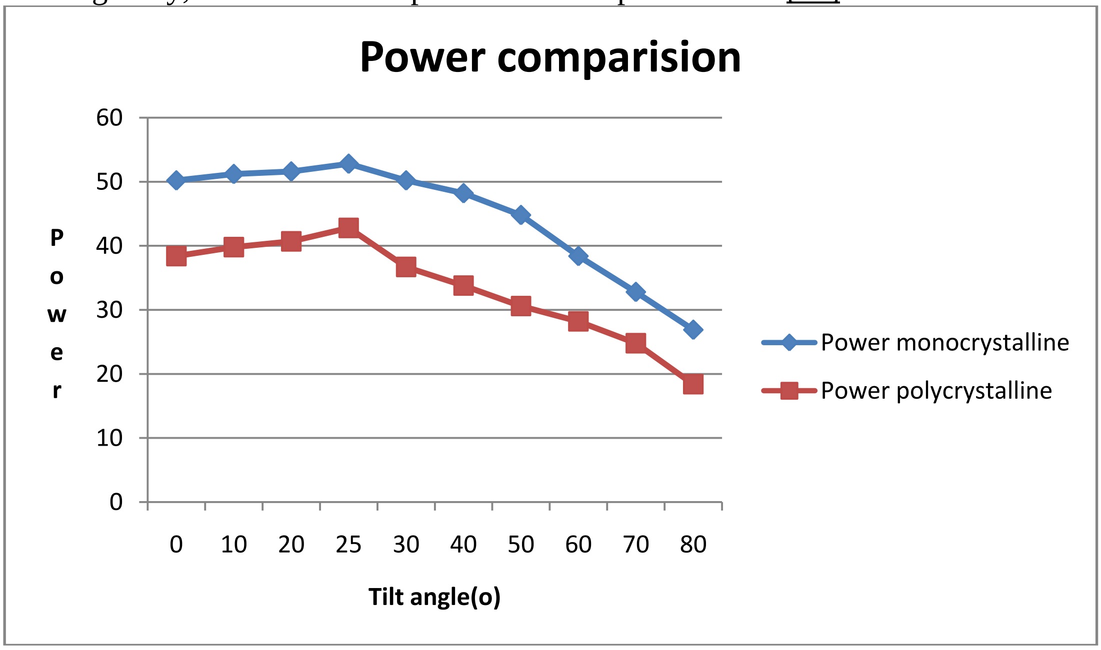

Figure 7

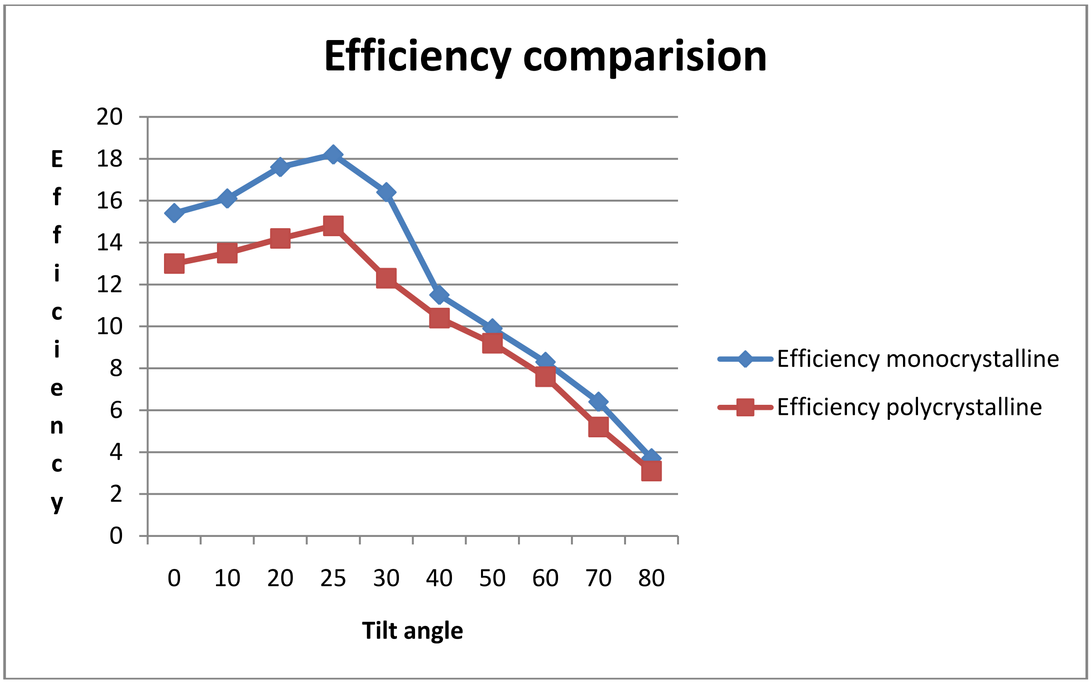

Figure 8

Effect on module electrical parameters

Effect of changing tilt angle on PV electrical parameters (Isc, Voc ,Imp and Vpm)at 750 W/m^2 irradiation intensity has been showed in figure. All the parameters decline with an increase in the module's angle.. The highest values of all the parameters($V_{oc(max)}$=23.4V and 22.4V,$V_{mpp(max)}$= 19.4 V and 17.8 V, $I_{sc(max)}$= 2.5A and 2.32 A,$I_{mpp(max)}$= 2.49 A and 2.24A and FF = 0.786 and.768) are attained near 25^{o}tilt angle. Everyincrease in tilt result in drop in short-circuits current and open-circuit voltage as well. On the other hand, dwindles in maximum power point current and maximum power point voltages for the same tilt change are 0.1775 A and 0.117 V. As of fill factor, the decline is not that significant.

It has been reported that module's short-circuit current influences several factors, such as the number of photons, solar cell area, the spectrum of the incident light and optical properties, etc. [52, 53]. Further-more, V_{oc} influences by dark situation current, temperature, and light produced current, etc. The temperature is linearly affected on the V_{oc}[54].Likewise,after15^{o} angle ,the module temperature decreases with an increase in tilt angle, thus the V_{oc} and V_{mpp} also decrease. Nevertheless, the module's temperature decrement rate is lower than the irradiation owing to the tilt angle. As a result, the V_{oc} and V_{mpp} decrease gradually, while the I_{sc} and I_{mpp} decline significantly. Sabryand Ghitas[55]mentioned that FF increases as a result of a decrease in I_{mpp} and V_{mpp} that are generally lower than I_{sc} and V_{oc}. So, increasing of both V_{mpp} and V_{oc} does not offset the reduction of $I_{mpp}$and I_{sc}. Therefore, the maximum power output decreases and FF increases respectively. Chan-der et al. [56]observed that a significant influence on the electrical parameter of PV performance.

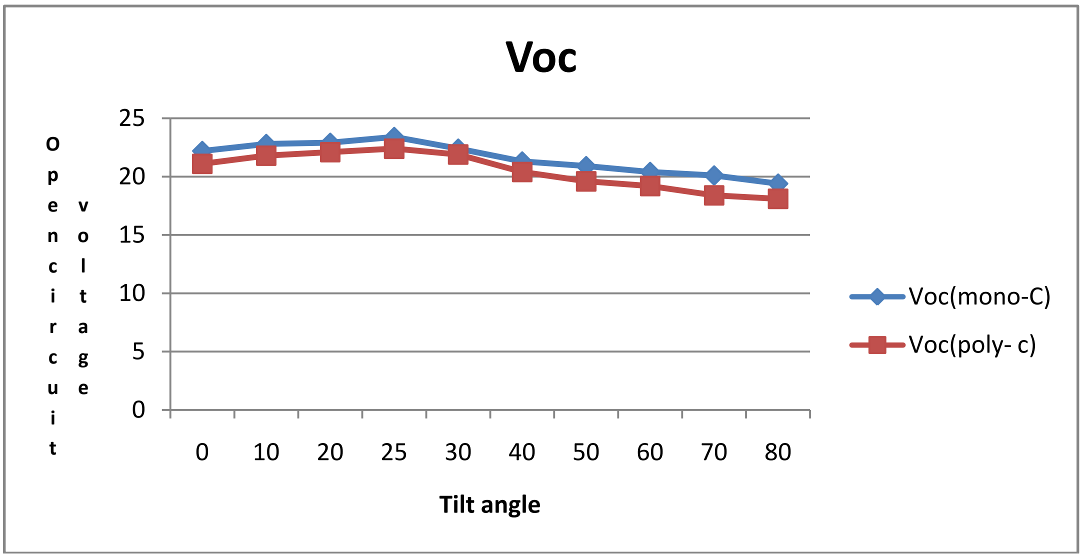

Figure 10

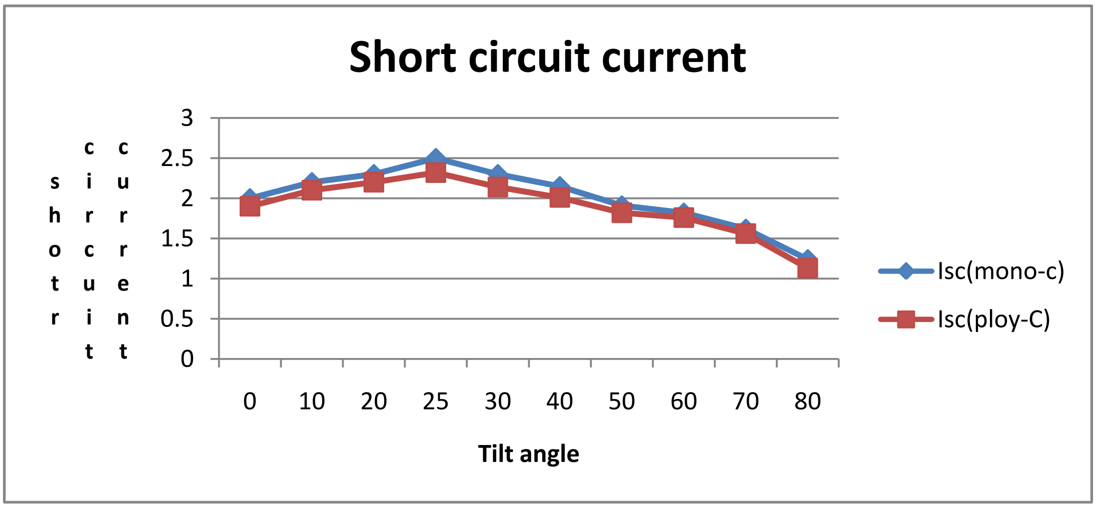

Figure 11

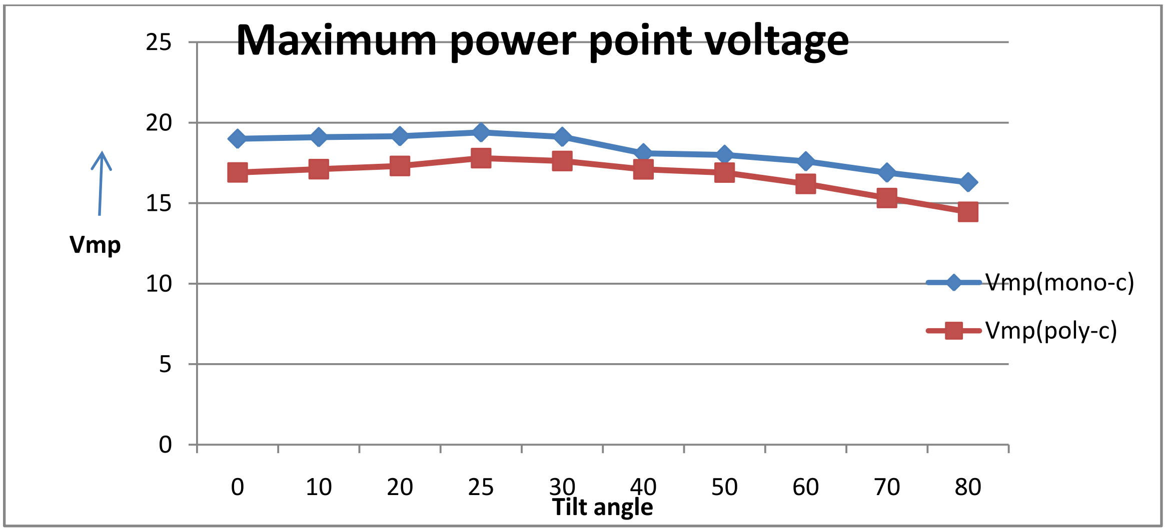

Figure 12

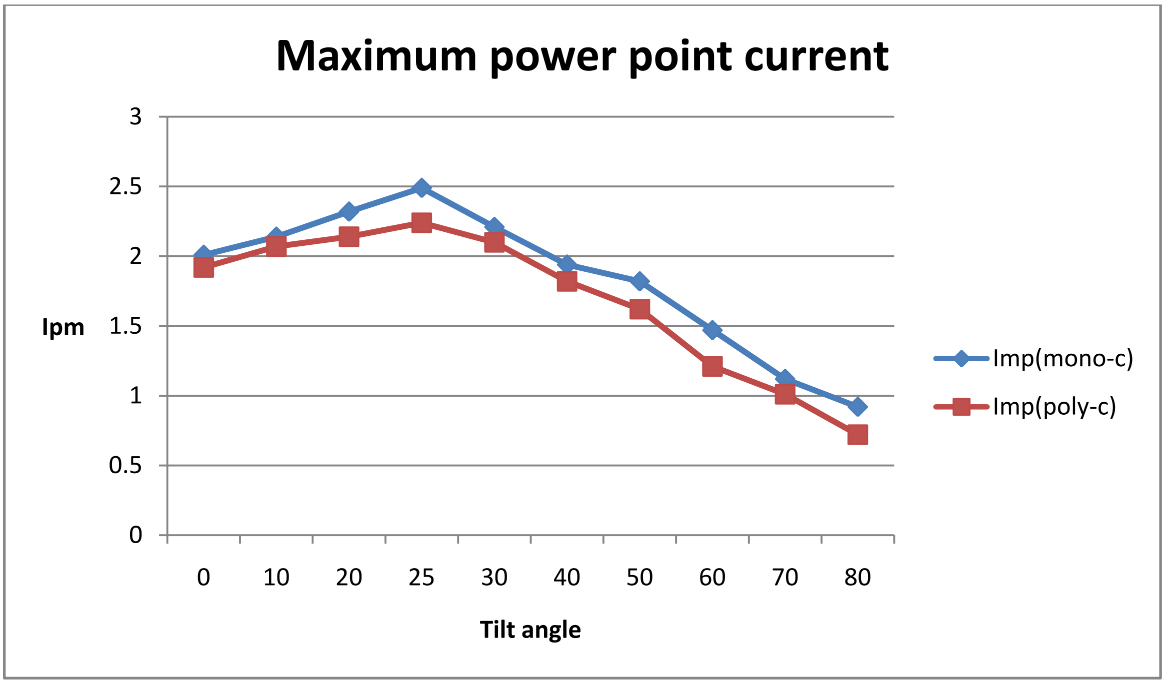

Figure13

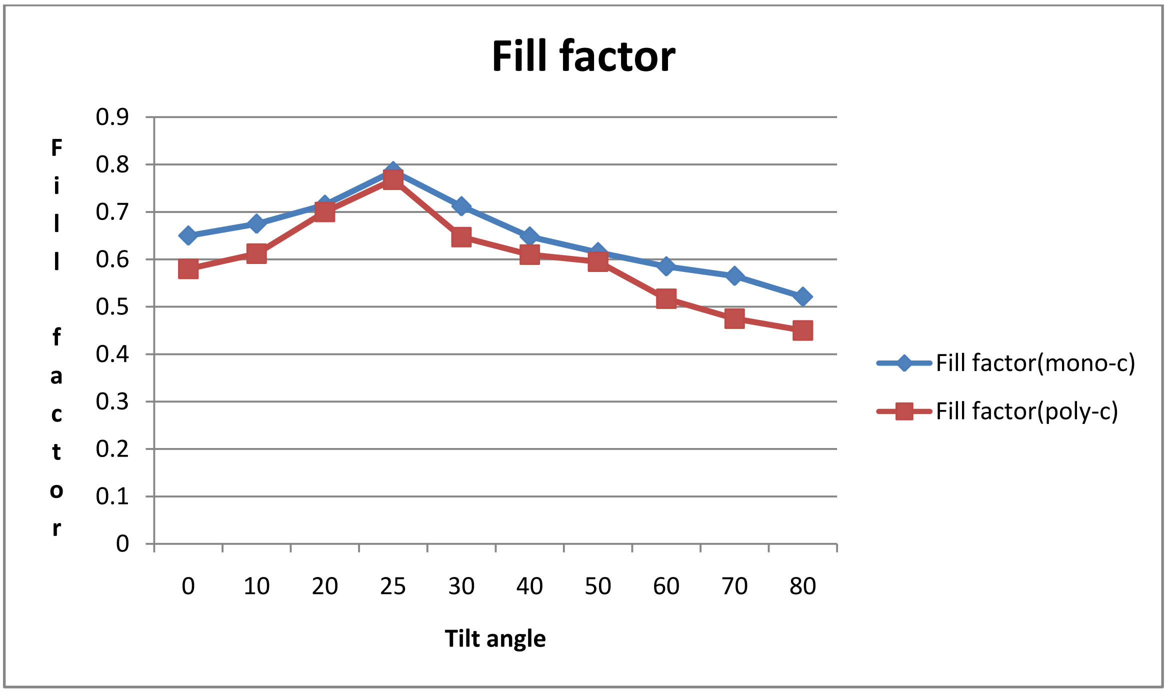

Figure14

Effect on cell temperature

Fig 3presents the solar cell temperature as a function of varying tilt angles. Cell temperature decreases with increasing tilt angle. This is because PV top surface cannot intercept solar irradiance perpendicularly as the module is tilted; consequently, the module's top surface temperature also decreases. Besides, as the tilt angle is increased more heat is removed from the module back surface by convection, thereby reducing the cell temperature, the outdoor ambient temperature was uncontrolled that in turn prompted cell temperature rise. For every increase in tilt angle, solar cell temperature decreases.

Determination of optimum til tfo rBhilwara's conditions

The PV performance parameters (power output, efficiency) and solar cell temperature obtained at outdoor conditions have been presented in as functions of both variation in irradiation and tilt angle shows that in order to attain a commendable power output under 750W/m^2 the tilt angle should be maintained between 20^o–26^o.On the other hand, a practicable efficiency of 12 – 14% at 750 W/m^{2}is also achieved below. From the above considerations, it may be concluded that the module tilts optimum value to maintain a trade-off among power output efficiency, and solar cell temperature under Bhilwara district conditionswouldbe25^o.Hence, the module's orientation at 25° can be confirmed as the optimum tilt for Bhilwara's conditions.

Effect of variation in radiation intensity at the optimum tilt

This section describes the effect of radiation intensity on PV performance and electrical parameters at outdoor conditions while the module is oriented at its optimum tilt (25^o) under local conditions.

Effect on power output and efficiency

Fig15 illustrates the impact of increasing irradiation intensity on the power output and efficiency of the PV module. For outdoor cases power output increases while efficiency decreases with increasing irradiation intensity. The reason behind this increasing trend of power output consists in the increasing tendency of both current and voltage increase with irradiation wherein current follows linear and voltage follows logarithmic increasing rate [57]. On the contrary, efficiency shows a trend opposite to power output; that is, it decreases with increasing irradiance level. This is because of the limitation of cell powerconversioncapability.Solarcellscannotconvertmorethan33.7%ofthe sunlight into electrical energy (known as Shockley-Queisser limit), which is further diminished by cell temperature rise and other factors.

Both module power output and efficiency at outdoor conditions are showed in figure for both mono and poly crystalline module. Danu et al. [58]observed that at outdoor conditions,the peak power of the module showed when the module tilted to the optimum angle condition. For every 100 W/m^{2}increase in radiationintensity, efficiency drops by1.44% atoutdoor

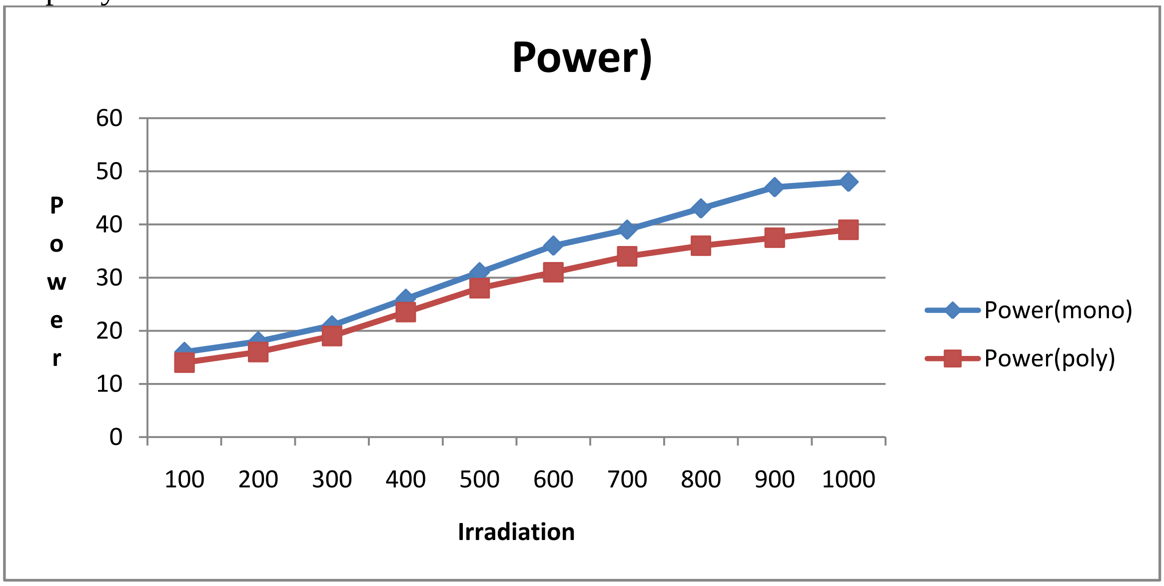

Figure15

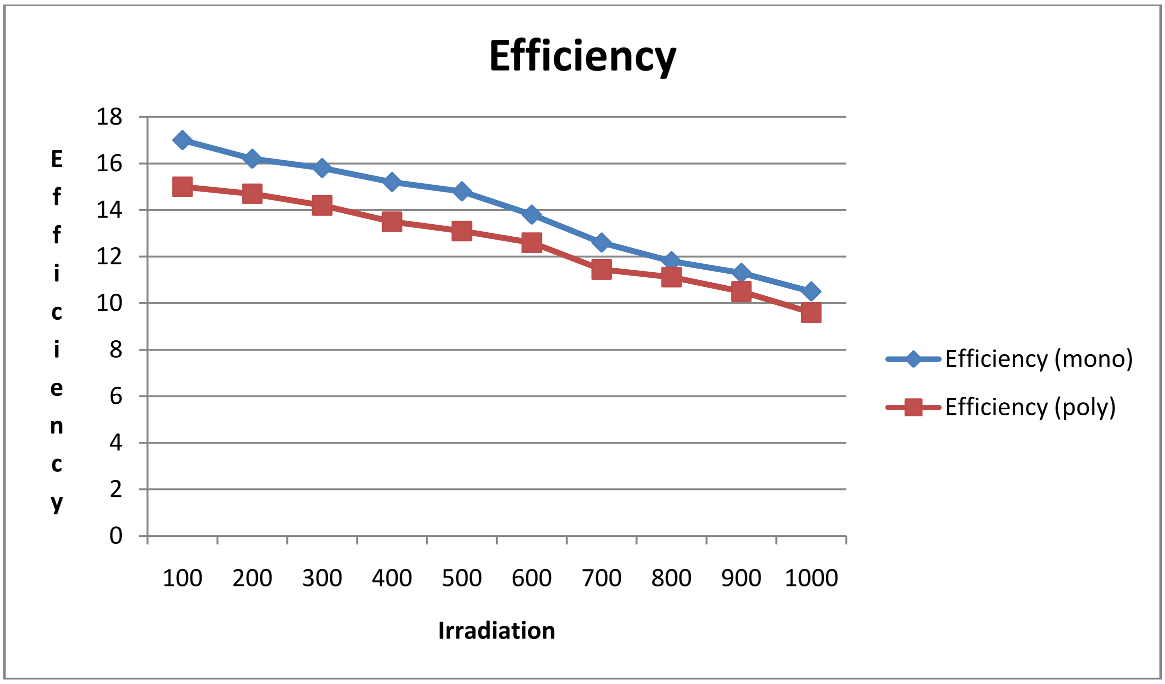

Figure16

Conclusion

Solar electricity generation depends on many factors, among which module tilt is a crucial one. Operative interception of solar irradiance plays a vital role in the performance of the PVsystems,where in the tilt angle works as one of the control parameters. In the present article,the effect of varying tilt angles of a PV module on its performance and electrical parameters has been investigated through indoor and outdoor experimentations. The current study is performed for duration of the day. Data are collected for every alternate day. In the above experimental analysis two factors are tested and maximum power and efficiency are calculated for each factor. In a nut shell, irradiance and temperature are the major factors whereas tilt angle, dust, wind velocity, are directly or indirectly affects irradiance and temperature. Solar flux density is measured by using a solar meter for the period of the study. The daily irradiation levels let out the important feature that the photo voltaic modules

output power during the noonday since the irradiance levels are at peak during that time. Temperature is an important signal of intensity of radiation and meteorological conditions prevailing over the experiment. Relative humidity and wind velocity have significant effects on performance of the modules. Humidity diverts some amount of radiation and block also, resulting in the drop of direct radiation. Wind at mild velocity reduces the efficiency of the module due to the accumulation of the dust whereas higher speed winds do a cleaning action. It is observed that mean wind speed varies from 11.8 mph to 2mph during period of study. Power is calculated from current and voltage readings measured from multi-meter *connected to solar modules using the formula.*

$$P=I\times V$$

. It is evident that Solar module tilted at 25^0 generate higher power than Solar module tilted at 0^0 tilted module, The purpose of the study is not associated with the optimization of the tilt angles so no attempts are done to perceive the effective tilt angle β.
Formula for calculation of efficiencies for the different modules, calculated from power, area of solar module and solar flux as given below:

$$\eta = \frac{P \times 100}{Area \times SolarFlux}$$

The angular position of PV modules is found to have an immense impact on its electrical performance. By performing a few adjustments in modules tilt angle a substantial cost of employing manpower or tracker motors can be reduced. Further research can be conducted to analyze the impact of latitude and different climates on determining the optimum tilt angle.

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