"Study of solar tracking systems and different factors affecting on its performance and efficiency"

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***Abstract*—Now a days solar energy is one of the important renewable source of energy. The renewable energy like PV Solar energy is important where the advanced of electricity is difficult. It is important due to the reduction in fossil fuels.In this study we are studied about the solar tracking systemand whether the fix PV system is better or the tracking system is better.A PV tracking system track the sun from sunrise to sunset for maximum extraction of power.Solar irradiance is important factor decide to whether used the PV panel with tracking system or without tracking system.We can improve the energy output by keeping the PV panel perpendicular to incoming solar radiation. The solar tracking system which is best alternative to increase the efficiency of PV panel's .Tracking is helpful in case of cloudy days.**

In this study we studied the factors affects the performance of PV panels like the overheating in hot region countries. It is found that thetracking system is not feasible in hot country due to overheating effect. The effect of slope and the orientation on maximum power extracted from PV module .For this study the three positions are considered Normal (fully tracking), Tiltedfixed, and horizontal. For that it is important to understand the solar angle azimuth (a), Latitude (h), and inclination (β) of PV Panel.The cost of fixed tracking system is less than the PV tracking system due to motor and moving parts. But in case the system produce the high power then it is possible to reduce the 20% in capital cost.The dual axis solar tracking is beneficial to maintain the position of PV panel without any effect of clouds and other environmental condition. But according to cost and flexibility point of view the single axis tracking system is more effective than dual.

***Keywords* – single axis, dual axis, locations, angles, tracking positions**

I. INTRODUCTION

Now a day solar energy is considerable and beneficial to use as renewable source of energy. The renewable energy like PV Solar energy is very important where the advanced of electricity is very difficult. Solar irradiance is important factor decide to whether used the PV panel with tracking system or without tracking system. The idea of converting solar energy into electrical energy using PV panels is very important due to the reduction fossil fuels. The PV system is convert the solar energy into electrical system and the research going on whether the fix PV system is better or the tracking system is better. Mainly which factors affect it..? What are the important factors need to understand for this study..? This study we are going to understand about the solar tracking system. And what is the different factors effect on its performance and efficiency under the different operating condition. A tracking system is track the sun from sunrise to sunset for optimum energy extraction. We can improve the energy output by keeping the PV panel perpendicular to incoming solar radiation. Tracking is beneficial for cloudy days. For this study we refer the some research paper regarding to the solar tracking system and some important parameters which effect on it.

S.A.SharafEldin, M.S. Abd-Elhady[1]. Solar tracking system increase the efficiency of PV panel .But some factors affects the efficiency of PV panels for example the overheating in hot region countries. The **S.A.SharafEldin , M.S. Abd-Elhady** studied about the determination of mathematical performance of PV panels under different operating condition . And from this study it is cleared that the increase in electrical energy from tracking system is 39% in the cold regions (Berlin &Germany). The increase in energy is only up to 8% in worm countries (Aswan,Egypt) because of overheating problem. By considering above factors it concluded the tracking system is not feasible in hot country.

Ekte and Sentruk[2]performed the experiment in Turkey and they are conclude that 30% power increase can achieve by usingPV solar tracking system as comparing with fix PV system. **Senpinar&Cebeci[3]** in Turkey found that the dual axis solar tracking is beneficial to maintain the position of PV panel without any effect of clouds and other environmental condition. **Koussa et al[4]** studied the difference in efficiencies between single and dual axis system and it is conclude that the increase in energy does not exceed 3%.

Alexandru and Tatu[5]studied about the tracking system, from the study it is conclude that the cost of fixed system is less than PV tracking systembut at the same time energetic efficiency of PV tracking system much more than fixed. But in case the system produce the high power then it is possible to reduce the 20% in capital cost. The price reduction will not change too if size of PV module is larger than 160Wpeak. Temperature is the main important parameter which has effect on PV system performance. The especially crystalline silicon panel is overheating because of the excess radiation and excess temperature and due to this efficiency of panel get reduces. In the study of **Moharaam et al[6]** it is conclude that , the they used the temperature

coefficient factor of PV panel is -0.5%/degree cel. ,it is indicated that for 1 degree Celsius of temperature increases 0.5% efficiency get reduces because of these reason tracking system is not beneficial in sunbelt countries e.g. Egypt.

Mathematical Model:- For the study of output of PV panels in case of fixed, tracking, and miss tracking the sun the**S.A. SharafEldin** used mathematical model. They validate the model experimentally and then applied to different locations having different condition for comparing the powers. This experiment performed in hot countries like Aswan, Egypt, and cold countries like Berlin, Germany. The panel is perpendicular to solar irradiance during tracking the sun, parallel during miss tracking the sun and for no tracking condition the PV panel is fixed.

For the calculating the module temperature **S.A. SharafEldin**used the following equation, which is referred from the empirical model designed by **Garcia and Balenzatgui**[7]

$T_m=T_{amb}+[(NOCT-20)E]/800$

E and T_{amb} changes with time and location. Energy output depends on T_m and calculated based on model developed by **Skoplaki and Palyvos[8]**.

$P=E*\eta*T_{ref}*A(1-\beta_{ref}*(T_m-25))$

For tracking system, the solar irradiance reaching the PV panel (E_{panel})

$E_{panel}= E$

For miss tracking system :-

$E_{panel}=E_{diffused}$

The solar irradiance considered 20% from total solar irradiance. Miss tracking condition is useful to avoiding overheating of PV panels in worm countries.

For fixed (no tracking system), the PV panel is fixed at an angle of θ with horizontal towards south,θis known as tilt angle. And it is equal to latitude angle. In this condition solar irradiance is function of total irradiance

$E_{panel} =E* \cos\theta_{sun}$

θ_{sun}= solar incidence angle = 0 for tracking system.

For the angle of incidence for northen hemisphere refer the **Duffie and Beckman [9] model**

$\cos\theta_{sun} = \sin(L-\theta) * \sin\delta + \cos(L-\theta) * \cos\delta * \cos h$

The experiment set up used by **S.A. SharafEldin** consist of 1) Turn table consist of PV module. 2) PV module 3) measuring system. Specifically in measuring system includes IV Char device, solar radiation sensor and temperature.From this experiment they clearly concluded that, the solar irradiation in case of tracking system is higher than no tracking system during morning period from 8am-12pm. The solar irradiation in case of tracking and non tracking system is almost same at noon time. The solar irradiation in tracking system again higher in case of after the noon time. The power output of panel for no tracking system is same as the tracking system from 11am until sunset in the Cairo (i.e. sunbelt country)so it is conclude that the tracking system is just waste of energy in case of hot countries. The energy gain from tracking panel in Cairo compared to no tracking is not exceeding to 10.61%.The tracking PV panel is more power output through day except the afternoon time. At afternoon time both tracking and no tracking system have almost equal output power. Because same inclination angle with the sun. The tracking PV panel has 16.8% energy gain over no tracking system and the cost for the maintenance isgenerally equal to 10% of generated power. In the Berlin the tracking PV panel have 40% energy gain as compare to no tracking PV panel. Finally it is conclude that from the **S.A. SharafEldin** experiment , tracking system is beneficial and useful for cloudy and cold countries and from the cost analysis it is highly usefulthe solar tracking system in cold regions.

The **LaliaMiloudi[10]** in Algeria studied about the effect of slope and the orientation on maximum power extracted from PV module .They also presents the sun trajectory tracking with PV panel keeping continuously the panel surface oriented face the sun. The three positions are considered to the study 1.Normal (fully tracking), 2.Tiltedfixed, and 3.horizontal. During the study they maintained the panel perpendicular to solar ray. For that it is important to understand the solar angle azimuth (a), Latitude (h),and inclination (β) of PV Panel at each hour of day. They carried out the program of sun trajectory tracking along the day using MATLAB software. The**Laliamiloudi** performed the experiment in Algeria which one of the very hot countries, in this country the sun is shining about 3500 hours. He chooses the four days for experiment in the year 21stmarch, 21stJune, 21st

September, and 21st December. The PV module under consideration for the simulation is the PWX 500 polycrystalline. The system used for the experiment is as shown in figure it generally include the computer, actuator and PV panel.

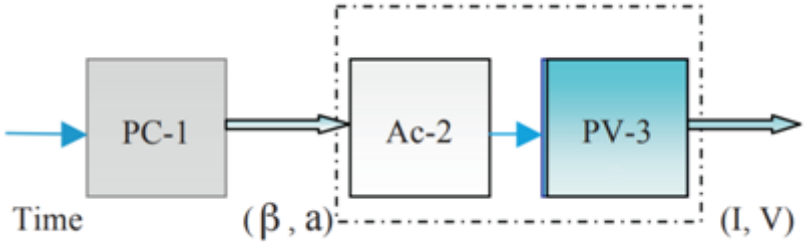

Fig.(1) System used for the experiment

The slope of the panel is directly depend on solar angle altitude (h) and azimuth (a) as shown in fig.

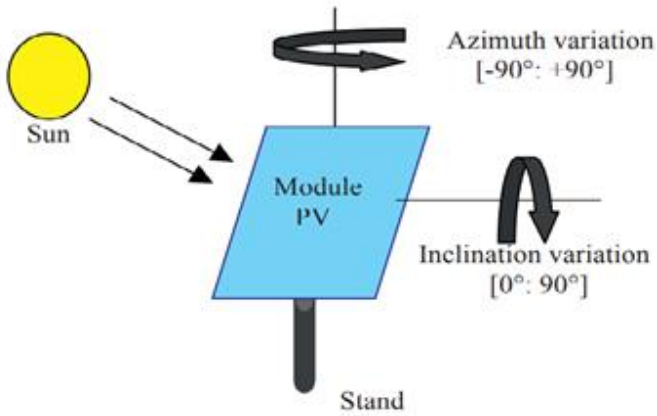

Fig.(2) Orientation of the PV panel following two axes the azimuth and the inclination

The mathematical expression used for the finding the angle of azimuth is reference from the **LaliaMiloudi**

Sin(a) = {cos (δ) * sin(ω)} / cos(h)

Where,

δIs solar declination,

ωIs hour angle

h is altitude angle

The solar radiation is calculated by

S = F* C1

Where,

F is incidental flux

C1 is coefficient of orientation

Finally from the experiment **LaliaMiloudi** is concluded that the effect of the solar angles and inclination on the solar flux collected by the panel for various positions and also the effect of the irradiation to give the maximum power . The radiation of 21st march the power extracted in perpendicular case is 42 W , in case of inclination with 37degree the power extracted is 40W and in case of horizontal 29W. Hence it is concluded that the maximum power extraction is at perpendicular level as compared to horizontal and inclined but the difference between perpendiculars and inclined is not too large. The solar radiation on 21st June reaches 1044W/m^2 on perpendicular; in case of inclination at 18 degree it approaches 943W/m^2. And for horizontal case it is about 960W/m^2 . Hence it is concluded that in this case also the solar radiation is maximum at perpendicular condition as compared to inclined and horizontal .The result on 21st September is the solar radiation on reaches 960W/m^2 on perpendicular, in case of inclination at 35 degree it approaches 873W/m^2. And for horizontal case it is about 780W/m^2. In this case also the solar radiation is maximum at perpendicular condition. The solar radiation on 21stDecember reaches 714W/m^2 on

perpendicular, in case of fixed plan it approaches 668W/m^2. And for horizontal case it is about 437W/m^2. For this condition also the maximum solar radiation is at perpendicular condition . By comparing the above four condition it is concluded that the power extracted by the PV panel is considerably in December it is the effect of the season changes.

The**Arian Bahrami[11]** studied the effect of solar irradiance on the PV panels by considering both technical and economic performance with different solar trackers. They mainly focused on location classified as medium and high latitude countries (Europe, Africa, Asia, North America). They considered the different solar trackers such as dual/full/2 axis/single axis/ trackers. The **Arian Bahrami** considered the technical as well as the economical parameters for the study of the solar trackers. In the technical point of view considered the following parameters, Choice of the tracker, Tracking period, tracking orientation, geographical condition and the required power for tracking. But without considering economic feasibility, the only based on the technical performance studies which in the form of energy is may benot right. For this study select the different cities in 13 countries.From the various studies it is clearly indicated that it is possible for an energy generation in the technically but it is not possible to economically because of the local financial condition and restriction. The economical feasibility is depending on the interest rate, inflation rate, wages, and system technology cost. To check the accuracy of the MATLAB program the **Arian Bahrami** considered yearly energy output of full axis PV tracker are compared with result of generic system advisor model. The different type solar trackers considered during this study like single axis tracking system like EW(East - west), IEW(Inclined east west), NS (north south), VO(vertical) tracker. From that he is concluded that according to the technical point of view full axis tracker give the best performance by comparing with all five solar tracking. But in the case of China the VO and IEWO trackers give better performance than full axis tracker because of the lowest value of solar beam and highest value of the diffuse irradiation. At the same timeduring cloudy days it is clearly proved that the horizontal orientation increases the solar energy by 50% as compared to the full axis solar tracking system. It is noticeable that the VO tracker has better rank in location having lower solar irradiation level as compared with higher irradiance level location. It is noticeable that the IEW tracker has better in higher solar irradiation level location compared to lower irradiance level location. Finally it is concluded that from this study for any given latitude PV installation cost is high for full axis tracker and VO tracker as compared to NS, EW. As the latitude increases EW tracker is better as compared to VO and NS. EW and NS tracker is useful at low irradiance level. The VO &IEW and full axis trackers are better at higher irradiance level.

Such kind of research in going on in India also **K.Rajan[12]** studied about the solar tracking system which is best alternative to increase the efficiency of PV panels. In this study the **K.Rajan** concluded that azimuth and altitude dual axis tracking system is more efficient than other. But according to cost and flexibility point of view the single axis tracking system is more effective than dual.

The **Dr. K.V. Vidyanandan[13]** studied the factors affecting the performance of PV system regarding to the location and the environment. **Dr. K.V. Vidyanandan** studied such few factors including material degradation, solar irradiance, module temperature, soiling, tilt-angle etc.

Material degradation: - The degradation of the PV panel is at faster rate in the few years of the life. Because of the degradation the output of the PV panel reduce to the 0.5%/annual. Generally the thin PV panels degrade faster than the silicon based panels[14].There are the some reasons of the degradation like thermal, electrical, mechanical, and the chemical processes. There are some technical reasons also like error in design, quality of the material, manufacturing faults. From the experiment **Dr. K.V. Vidyanandan** conclude that Copper Indium Gallium Selenide (CIGS) type PV panels have maximum loss of output whereas Monocrystalline Silicon (mono-Si) have the minimum loss in output due to material degradation.

Module Temperature:- A PV panels are sensitive to the temperature . The output of the PV cell decreases with increase in temperature. The temperature rises with the solar radiation and air temperature but it is decreases with the wind speed.

Soiling:- This is also important factor which is affecting the performance of PV panel. Basically the soiling is the storing the dust, dirt, and other particles on PV module. Because of these contaminants the intensity of the solar radiation get reduces. **Dr. K.V. Vidyanandan** concluded from the study due to soiling effect the yearly power loss is 5.17% or more. This power loss due to soiling is minimizing the effect of the soling by regularly cleaning of the PV panels.

PV Panel orientation: - By using the single axis trackers the output can be increased against the daily changes in position of the sun from morning to the evening. And by using the dual axis system the maximum output can be achieved against the daily as well as seasonal variation.

There are the some remedies suggested by the **Dr. K.V. Vidyanandan**, the PV solar radiation having low energy density. It requires the 10 times more area than the thermal power plant. To avoid this defect the latest technology can use like floating PV system and the solar roads. The basically floating PV panels means installed the panels over the water bodies like lakes, pond, canals etc. In some countries this technique used such as Japan &Brazil . There are some advantages of this technique like the cooling of the panels is done naturally cooled by water body. It also reduces the water evaporation and the algae growth. In

India small scale floating system are in service. Another major technology is solar roadways [15]. These panels strong to withstand heavy vehicles and skid resistant to reduce accidents .

II. CONCLUSION

From this study we are conclude that based on several researches and experiments,**S.A. SharafEldin**concluded that tracking system is beneficial and useful for cloudy and cold countries and from the cost analysis it is highly useful the solar tracking system in cold regions. And the tracking system is just waste of energy in case of hot countries. From the experiment **LaliaMiloudi**is concluded that themaximum power extraction is at perpendicular level as compared to horizontal and inclined on 21st march. For 21st June the solar radiation is maximum at perpendicular condition as compared to inclined and horizontal. In 21st September case also the solar radiation is maximum at perpendicular condition. For 21st December condition also the maximum solar radiation is at perpendicular condition. By comparing the above four condition it is concluded that the power extracted by the PV panel is considerably in December it is the effect of the season changes.**ArianBahrami**from the experiment concluded that from this study for any given latitude PV installation cost is high for full axis tracker and VO tracker as compared to NS, EW. As the latitude increases EW tracker is better as compared to VO and NS. EW and NS tracker is useful at low irradiance level. The VO & IEW and full axis trackers are better at higher irradiance level.**K.Rajan** concluded that from his study azimuth and altitude dual axis tracking system is more efficient than other. But according to cost and flexibility point of view the single axis tracking system is more effective than dual.There are the some remedies suggested by the **Dr. K.V. Vidyanandan**,It requires the 10 times more area than the thermal power plant. To avoid this defect the latest technology can use like floating PV system and the solar roads.

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