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Solar Tracking Methodologies for PV Panels

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ABSTRACT

Solar energy is rapidly gaining popularity as an important means of expanding renewable energy resources. Solar energy is used with photovoltaic modules or panels to convert it into electrical energy. As demand of electricity is increasing day by day it is vital to understand the technologies associated with these tracking methodologies. Solar panels can be used with a stationary balance structure or with a single axis or dual axis tracking system. This paper provides a comparative study of various tracking methods with a stationary structure system. Tracking can be done using LDR method or Uniform tracking method or Space time synchronization method. The analysis is carried out on a grid connected solar photovoltaic system (SPV) of rated capacity of 400 kW_P, designed and simulated on PVsyst V6.43 – Photovoltaic Systems Software. Analysis has been done for Jaipur location and it is found that in single axis tracking, the energy produced yearly by PV panels was increased by 4.91 % and by using dual axis tracking, the energy produced by PV panels increased by 22.91 % when compared with fixed solar system.

Keywords : PV Panel, Single-axis tracking, Dual-axis tracking, PVsyst software.

I. INTRODUCTION

Fossil fuel which dominates the energy sector is in the verge of depletion. Furthermore, repercussion of over reliance on fossil fuels can be noticed in cost of fuel and the environment. Solar energy is a feasible alternative to fossil fuels. It is abundantly available in the form of clean energy. Photovoltaics offer consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic systems comprised of photovoltaic cells. These cells convert light energy directly into electricity. It is predicted that photovoltaic systems will experience a huge increase in the decades to come. However, a successful integration of solar energy technologies depends also on a detailed knowledge of the solar resource. But it is essential to state the amount of literature on solar energy. The solar energy system and PV grid connected system is enormous. Grid interconnection of photovoltaic (PV) power generation system has the advantage as the generated power can be more effectively utilised.

The tracking or the panel positioning system is set in such a way that the panel rotation delay time is synchronized with Sun's position, hence maximizing the efficiency of solar panel that can be utilized. Here, the principle of 'heliotropism' is used and as it involves positioning of panels according to sun's movement throughout the day it is described as 'Panel Positioning System'. As the power generated depends on incident radiation and also the intensity varies with time and season at a particular point, hence the efficiency of the fixed system is far less to exploit commercially. For maximum generation of electrical power the PV Panels need to be directed normal always to the incident radiation. This technique, known as Solar tracking, is therefore essential for improved system performance and efficiency. The resulting increase in efficiency is substantial enough to make the tracking a feasible proportion in-spite of the improvement in the system cost.

II. METHODS OF TRACKING

Tracking methods can be classified on the basis of direction or axis of tracking.

A. **Single axis trackers:** Single-axis solar trackers rotate on one axis moving back and forth in a single direction. The turning axis of single axis trackers is mostly aligned along a true North meridian. It can be further classified as single-axis trackers include horizontal, vertical, tilted, and polar aligned trackers which rotate as the name imply.

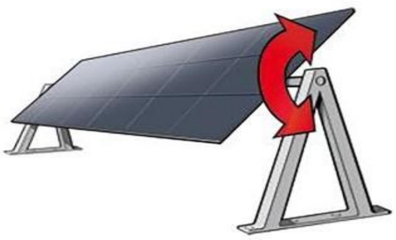

Figure 1. Single Axis Tracking

B. **Dual axis trackers:** Dual-axis trackers continually face the sun because they can move in two different directions. These trackers follow the sun vertically and horizontally they help to obtain maximum solar energy generation.

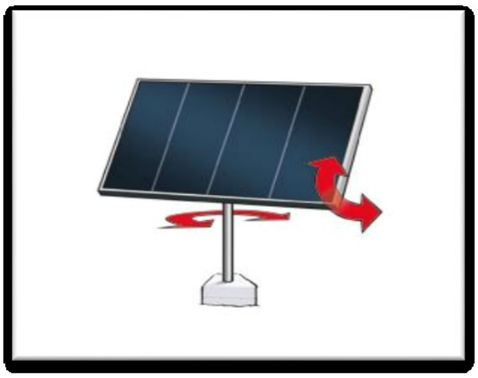

Figure 2. Dual Axis Tracking

III. TRACKING METHODOLOGIES:

Tracking can be done using different methods and these are:

A. LDR Method
B. Uniform Tracking Method
C. Space Time Synchronization Method

A. **LDR Based Tracking Method:** This method uses two LDRs to detect the intensity of sunlight and accordingly decides the motion of the panel. The output of these two LDRs is fed to the Micro-controller where the output of each LDR is sampled and then compared. The error signal goes to the micro controller which activates the respective relay which controls the direction of the motor. Hence, the panel rotates and makes real time adjustment of the incident angle between the sun's rays and solar panel.

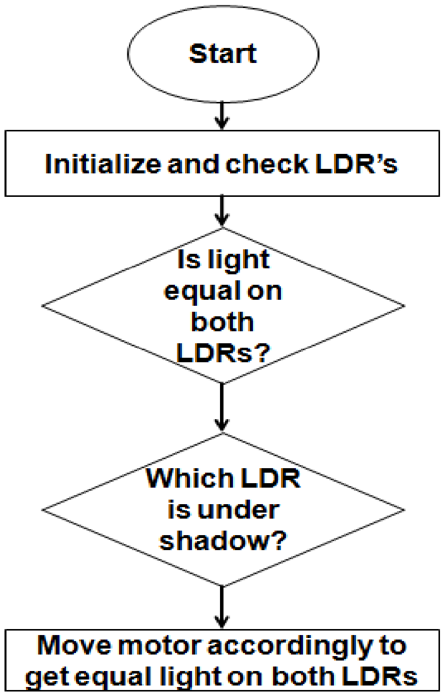

Figure 3. flow chart LDR Based Tracking method

B. **Uniform Tracking Method:** As for this method the earth rotates at a constant speed, 24hr for one rotation .If 180°rotation is considered for 12hrs then for every one hour the sun rotates by 15°. This is implemented by a program that will rotate the panel 15° every one hour. This program is feed to the Micro-controller.

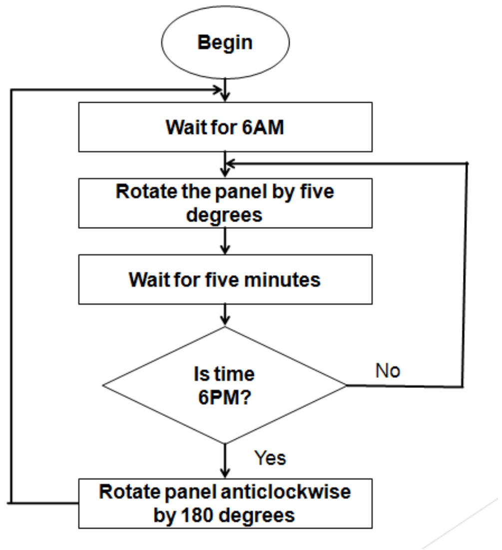

Figure 4. Flow chart Uniform Tracking method

A. Space Time Synchronization Method: The difference between both these methods lies in the program that is fed to the Micro- controller. In this process an algorithm is used called the Solar Position Algorithm. In this method solar azimuth and zenith angle is calculated with minimum uncertainities based on the date, time, and location on Earth. This way the solar panel rotates to follow the position of the sun very accurately and efficiently.

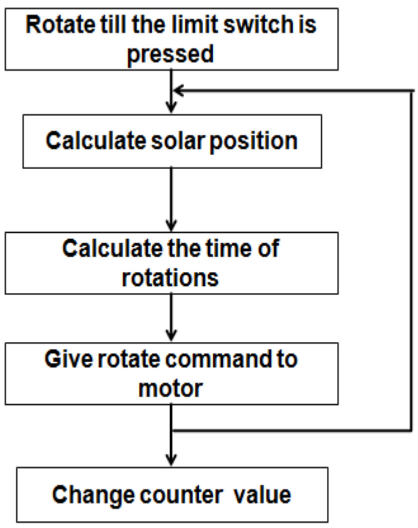

Figure 5. flow chart of Space time synchronization method

III. SIMULATION WORK

A. Software used: PVsyst which is a simulation based software used for design and performance analysis of solar photovoltaic power plants. It allows the user to import the metrological data from various sources and analyze grid connected, stand alone, dc grid and pumping systems depending on the specifications of the system and characteristics of its components such as PV module , inverters etc. Details of various losses and near shadings can also be obtained for accurate energy yield.

B. Geographical Location: The solar power plant is located at latitude of 26.8°N and Longitude of 75.9°E at an altitude of 368m. To obtain the Irradiation, temperature and Horizon data of the location, PVGIS solar resource database has been used available through internet.

C. Description of solar system: The total rating of the plant is of 400KW. The shading losses are not considered in this study. The solar panels used are Renesola JC310M-24/Ab with open circuit voltage (Voc) of 45.0 V and short circuit current (Isc) of 8.80 A. Single inverter is used SUNWAY TG 485 - 800V – MT with the nominal power of about 374kw.

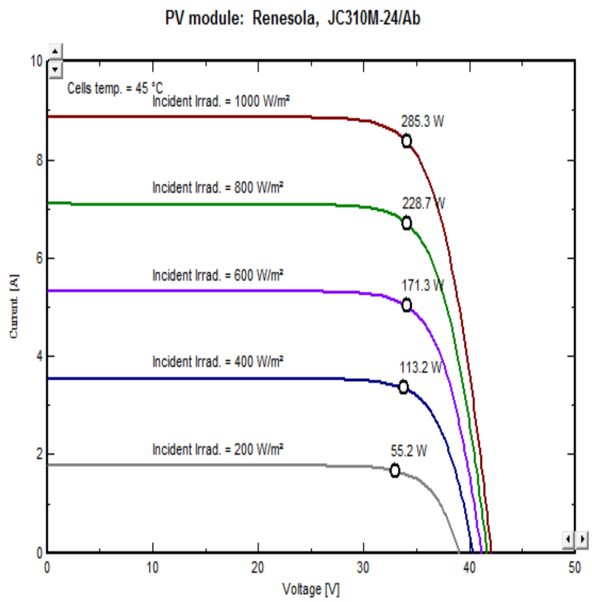

Figure 3. V-I Characteristics of PV panel

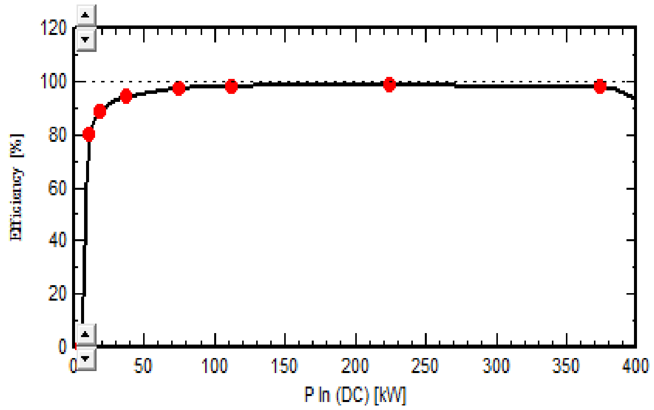

Figure 7. Efficiency curve of 374 KW Inverter

D. System orientation: Three different orientations were used on the above solar system which are:

- In Fixed tilted plane in this the angle of inclination of the solar panels is 30° with an Azimuth of 0°.

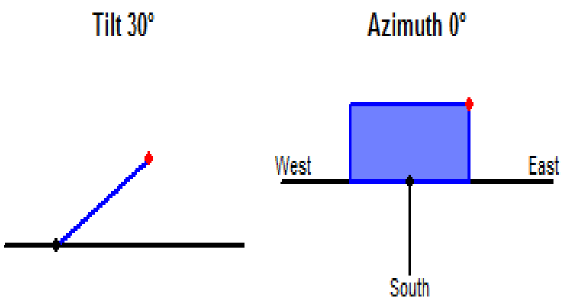

Figure 8. Fixed tilted plane

On Single Axis tracking plane minimum tilt 10° maximum tilt 80°andnormalazimuth to axis 0°.

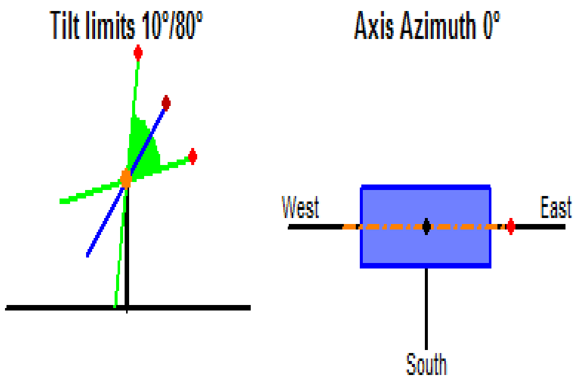

Figure 9. Tracking horizontal axis E-W

On dual axis tracking plane minimum tilt 0° maximum tilt 80° and minimum azimuth -120° and maximum azimuth angle obtained is 120°.

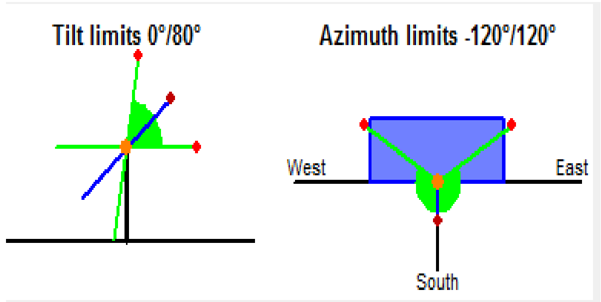

Figure 10. Tracking dual axis

IV. RESULTS AND ANALYSIS

A. **Normalized production and loss diagrams:** The figures,& show the normalized production of fixed solar system, single axis tracking system & dual axis tracking system respectively.

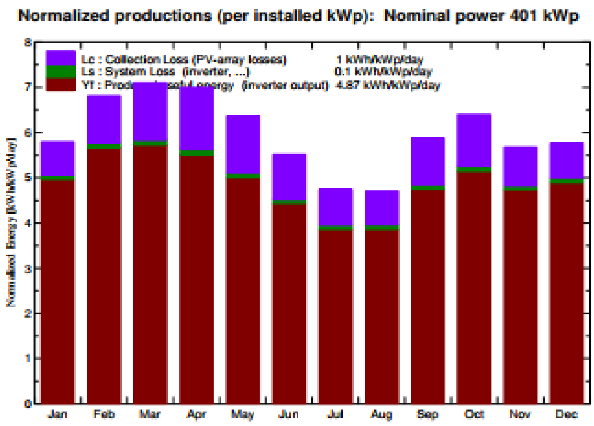

Figure 11. Normalized production for fixed solar system

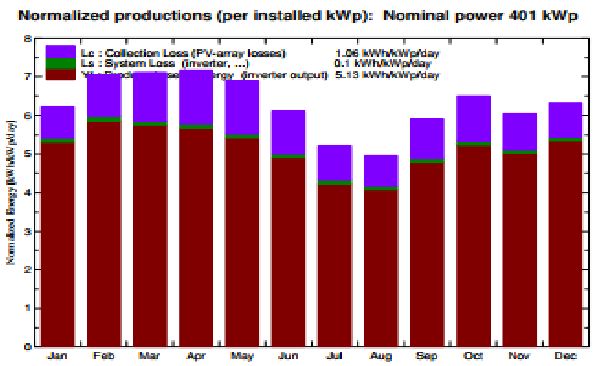

Figure 12. Normalized production for single axis tracking system.

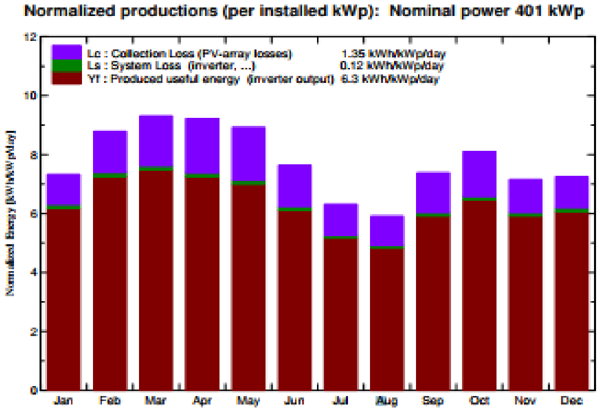

Figure 13. Normalized production for dual axis tracking system.

Thus the normalized energy from dual axis tracking system is 6.3 KWh/KWp/day it is more than both fixed and single axis tracking system which have value 4.87KWh/KWp/day and 5.13KWh/KWp/day respectively. PV- array losses remains same for fixed system and single axis system where as in dual axis tracking system it increases from .1KWh/KWp/day to .12 KWh/KWp/day

V. CONCLUSION

The tracking methods are very useful for continuous use. The three methods have advantages and disadvantages. The uniform tracking method is simple and inaccurate. The LDR based method is simple, and has high accuracy, but could not work in the overcast environment. And space time synchronization method is precise, but the program is complicated. Depending on various situations and practicability various tracking methods can be implemented. The space time synchronization method is the most accurate of all the methods. The study of the solar photovoltaic power plant using PVsyst shows that the 400 KW plant produces more energy when installed with a solar tracking system i.e. single axis tracking system or dual axis tracking system in place of fixed solar system. The energy produced yearly is 4.91 % more in single axis tracking system when compared to fixed solar system where as in case of dual axis tracking system it is energy produced yearly is 22.46 % more than fixed solar system.

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