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Energy improvement in solar PV tracking systems

P.Shunmugakani[1], M.Visalakshi[2], Priscilla Gomes[3], N.Ayishwariya[4]
Department of Electronics & Instrumentation, Jeppiaar Engineering College, Rajiv Gandhi Salai, Chennai - 600119 India
***Corresponding author: Email: kanishashu@gmail.com**

ABSTRACT

The high demand for energy can be met by using solar collection methods which include the techniques of PV tracking & without tracking. The fixed tilt panel which lies at a fixed orientation, and seasonal tilt adjustment panel that can be manually adjusted are the methods without tracking. The tracking techniques can be implemented by tracking the sun in one or two axes. The single axis tracker & dual axis tracker improve the solar collection efficiency & give more power output due to the tracking of sun's position. The PV systems are simulated & analyzed for their performance so as to determine the most suitable technique for a given geographical location.

Keywords: solar collection methods, fixed tilt, seasonal tilt adjustment, single axis tracker, dual axis tracker, solar collection efficiency.

INTRODUCTION

The increase in demand for energy in the recent times creates a high call for a reliable & sustainable form of energy which is satisfied by renewable energy forms such as solar, wind, geothermal, hydro energy. Of these, solar energy is an eco-friendly, long lasting, reliable, profitable and cost effective which can be implemented by techniques like photovoltaic panels. Using PV panels, different systems can be installed. Panels at fixed orientation collect solar energy throughout the day incurring the ineffectiveness due to the sun's movement. This can be overcome by tracking the sun's position continually thus improving efficiency & maximizing the power output of the panel.

SIMULATION USING PVSYST

The PV systems can be studied & designed using many software tools like, PVSyst, PVSol, Archelios. Of these, PVSyst is a most commonly used, reliable & user friendly tool, used for simulation of PV systems.

PVSystan educative tool,is designed to be used by engineers, researchers & architects. The program offers three main design options. The preliminary design option allows you to evaluate grid-connected, stand-alone and pumping systems, and use monthly values to perform a quick evaluation of system yield. For each project you have to specify the location and the system to be used.The project design option allows the creation of full-featured study and analysis of grid-connected, stand-alone, pumping, and dc-grid systems with accurately system yields computed using detailed hourly simulation data. Different simulation variants, horizon shadings, include detailed losses, and add real components to make economic evaluations can be used.

The system sizing for panels & inverters can be designed using the system design board window. The simulation report with detailed analysis including efficiency, performance ratio, and energy produced & lost etc. is generated. The tools option includes databases of meteorological information, components, solar toolboxes & analysis of measured data.

The simulation tool of version 5_0, is used here to analyze the efficiency of fixed tilt, seasonal adjustment, single & dual axis tracker systems for their performances.Advantages of the tool include quick evaluation of the system yield & its full featured study, easier analysis of the grid-connected, stand-alone, pumping, dc-grid systems.

Simulation Analysis: The fixed tilt panel, seasonal tilt adjustment panel both of which do not involve tracking produce certain efficiency at their respective orientations. Using single axis & dual axis tracking, the solar panel is oriented in such a way that it tracks the path of the sun so as to give an improved efficiency.

Considering a 10kW system in Chennai conditions, using polycrystalline silicon panels, at free horizon and no shading nearby, the performance & efficiency of the four systems are analyzed. The PV module SEM 50 is chosen for the analysis of grid load. The PV systemfor these specifications consists of 36 modules in series in 6 such parallel strings. The inverter is also selected according to the power & voltage specifications for the system.

Fixed Tiltpanel: The fixed tilt system is designed as described & simulation reports are obtained in PVSyst. Efficiency & energy output are generated along with yearly report of performance of the system as shown in Fig 1.

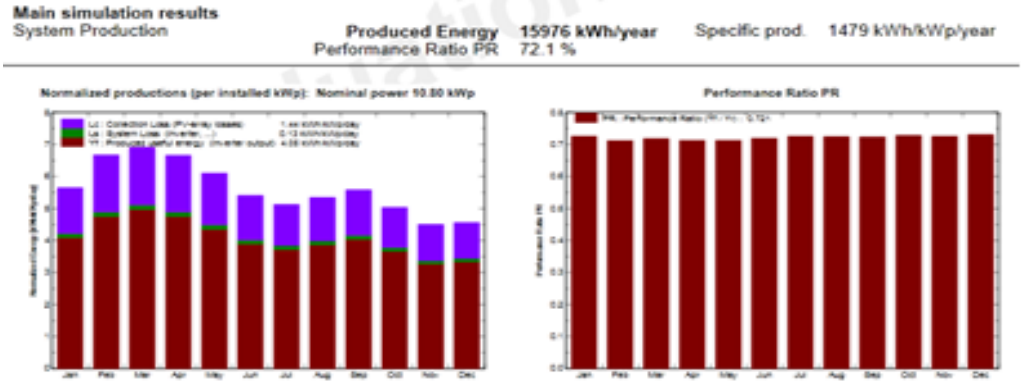


Fig.1.Performance details in the PVSyst Simulation Report

The simulation for various tilt angles ranging from 0 to 90 , with a fixed azimuth angle 0 is compared to get an optimum tilt angle.

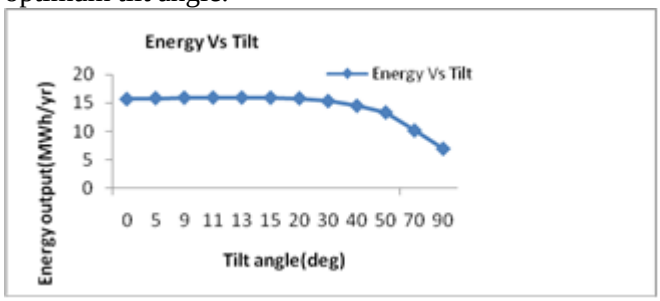


Fig.2.Fixed Tilt Panel Performance

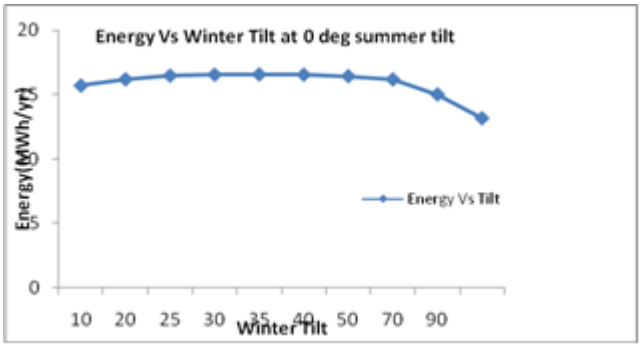


Fig.3.Seasonal Tilt panel performance

For the latitude position of Chennai, the optimum tilt is found to be 11 as shown in Fig 2.

Seasonal Tilt Adjustment panel: The orientation is changed to seasonal tilt & a similar procedure is carried out as in the fixed tilt panel. With azimuth angle fixed at 0, the summer tilt & winter tilt are varied from 0 to 90, to get maximum output & hence the optimum orientation is obtained. Optimum summer tilt is found to be at 0 from different results & optimum winter tilt is found to be at 30. The performance graph with respect to winter tilt angle is as shown in Fig 3.

Single Axis Tracking System: The single axis tracking system tracks the sun in one axis and hence requires orientation specifications for one of the axes as the other one varies for an optimum range. The optimum range of variation for azimuth angle is fixed to be from -180 to +180. The tilt angle orientation is determined to be optimum at certain angle for this system.

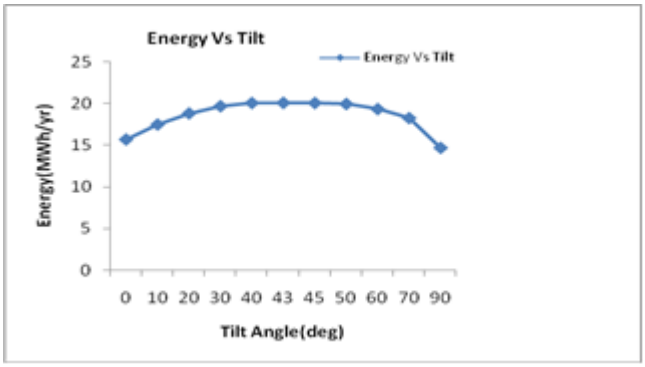


Fig.4.Performance of one axis tracker

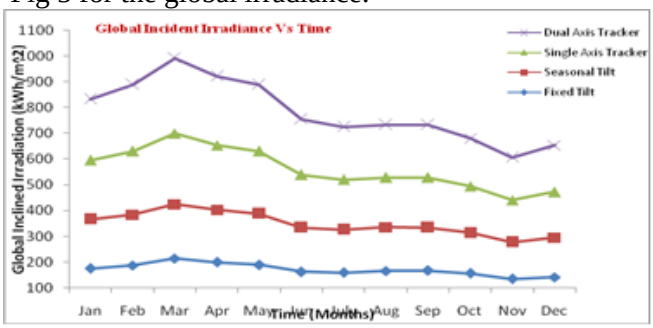
The performance graph as described is shown in Fig 4. It helps in orienting the tilt of the panel.

Dual Axis Tracking System: The azimuth angle range for tracking is found to be -180 to +180 for optimum performance. By generating simulation for various angle ranges, optimal tilt angle range is determined to be -90 to +90. The four systems are compared on the basis of global irradiation obtained throughout the year as well as the energy generated. These are taken relative to a system at a fixed tilt panel at 0 for a better inference.

Table.1.Global Irradiance with time relative to Fixed tilt 0 Panel

Time	Fixed Tilt optimum (11°) % Increase in Global Irradiance in kWh/m^2	Seasonal Tilt Optimum % Increase in Global Irradiance in kWh/m^2	Single Axis optimum % Increase in Global Irradiance in kWh/m^2	Dual Axis optimum % Increase in Global Irradiance in kWh/m^2
Jan	10.70	21.33	44.62	50.00
Feb	8.03	13.93	42.60	49.54
Mar	3.03	0.82	32.45	40.19
Apr	-1.58	0.00	23.25	32.02
May	-4.87	0.00	21.76	29.90
Jun	-5.70	0.00	19.01	25.70
July	-4.73	0.00	16.05	22.51
Aug	-2.65	0.00	13.59	20.59
Sep	0.84	0.00	17.29	23.13
Oct	4.13	4.73	20.60	24.27
Nov	7.30	13.10	28.89	32.14
Dec	9.69	19.22	37.21	40.93
Average	2.02	6.09	26.44	32.58

The simulation results for optimum orientation in obtained graphically for an easier analysis as shown in Fig 5 for the global irradiance.



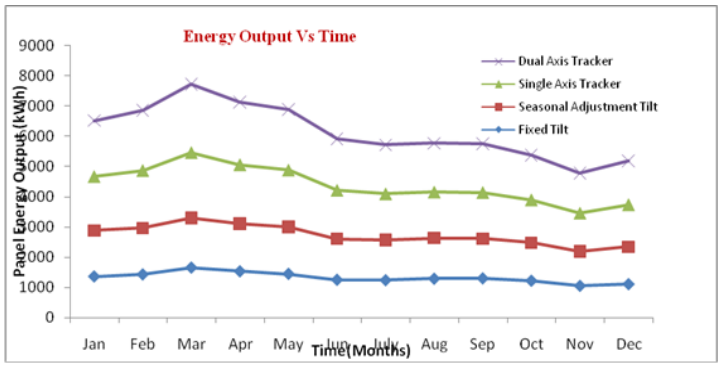


Fig.5.Global Irradiance with & without Tracker **Fig.6. Energy Output with & without Tracker**

Similar to the comparison using global irradiance, the four systems can be compared using energy to the grid as a basis. The Table 2 shows the energy comparison of the systems.

Table.2.Energyoutput with time relative to Fixed Tilt 0° panel

Time	Fixed Tilt Optimum (11) (% Increase in Energy output in kWh)	Seasonal Tilt optimum (% Increase in Energy output in kWh)	Single Axis optimum (% Increase in Energy output in kWh)	Dual Axis optimum (% Increase in Energy output in kWh)
Jan	10.84	21.44	45.15	50.32
Feb	7.96	13.82	43.65	50.34
Mar	2.91	0.87	33.81	41.18
Apr	-1.6	0	24.68	32.93
May	-4.9	0	23.45	31.22
Jun	-5.69	0	20.96	27.54
July	-4.74	0	17.81	24.08
Aug	-2.56	0	15.21	21.84
Sep	0.93	0	18.67	24.31
Oct	4.33	5.18	21.92	25.32
Nov	7.62	13.72	30.39	33.43
Dec	10.17	20.14	38.99	42.65

Average	2.11	6.26	27.89	33.76

The simulation results for optimum orientation in obtained graphically for an easier analysis as shown in Fig 6 for energy output. These form the important parameters of the simulation analysis of the solar panel systems with & without tracking.

Conclusion

The simulation as discussed above gives the following inferences: Performance Ratio PR = (panel output obtained / desired output of design), with each system, energy increases but with slight increase in PR. The simulation of solar panel systems with & without tracking lands us to the point that performance is increased in the tracker systems than those without tracker. This owes to the fact that the panel orients itself always in a normal direction to the sun. However, the techno - economic analysis has to be performed for a proper conclusion as to know if dual axis or single axis tracker is better to be installed in a site which depends on the geographical conditions.

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