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A review on solar tracking mechanism with optimized energy consumption and less tracking error

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ABSTRACT: Sun, the most abundant renewable energy resource in the universe in which the solar energy can be converted into electrical energy by the use of Photovoltaic modules. Photovoltaic modules can be set into solar panels. This paper describes the various sun tracking mechanisms for solar Panels, its energy efficiency/consumption and optimization algorithms used in the system.
Keywords: Solar tracking mechanism, Tracking error,Energy efficiency /consumption, optimization algorithm

I. INTRODUCTION:

There are papers deals with solar energy harvesting and focusing methods, various methods of energy focus on different geographical areas, solar tracking mechanisms, and different optimization algorithms to reduce the tracking error and increment in energy efficiency as well. The comparison of different papers with their main part of illustration is as follows. It gives an excellent analytics about the work.

The paper **[1]** deals with a technique for optimizing a category of robotic solar tracking systems with two degrees of freedom employing a heuristic approach. With the help of two manipulation strategies this system finds a balance between energy consumption and tracking accuracy in the tracking system. The system implemented with a heuristic approach and it has four energy saving strategies and three energy saving strategies. Result [1], A novel methodology uses heuristic optimization, results with low energy consumption and high accuracy in solar applications.

Simulation result led to 31.55% energy savings compared to the reference values, with a tracking error of 0.06◦. But in practical case, the 26.98% energy which represents 2.0318Wh is being saved, with an azimuthal tracking error of 0.062◦and elevation tracking error of 0.071◦. In the future, an STS with the lifetime of 10 years is taken to account, with a median of 7.94 hours of sunlight per day in Madrid, the proposed approach will save 58.92 kW.

The paper 'Developing a parallel kinematic solar tracker for HCPV' **[2]** describes new quite solar tracker intended to satisfy precision requirements using high concentration photovoltaic systems. This shows how kinematics works in this system and moreover algorithm used is sensor chain and control algorithm. The parallel kinematic solar tracker determines the orientation towards the sun is detected by four photodiodes separated by two orthogonal opaque walls. If any error occurs, at least one of the photo diodes will not be enlightened. This allows detecting the direction of azimuthal–zenithal space along which the sensor must be moved to be aligned towards the sun. Control algorithm is used for the implementation of this concept. Positioning, safety, waiting and active tracking.

Photovoltaic technology compared with nuclear fusion and production by photovoltaic conversion. The tracker is designed according to delta–type parallel schematics. The promising energy to be focused by low cost optical devices characterized by small size and high efficiency. Expensive triple junction cell can be replaced by these cells. So it can have more efficiency with fewer modules. Reduced price of solar cell decreased the interest in concentration system but still photovoltaic grade silicon energy required to build concentration photovoltaic modules. Expected to be much lower than that required to construct traditional modules. Moreover, to preserve landscapes it is better to go for concentration modules. It can play major role for construction of large photovoltaic power station.

Result **[2],** High efficiency upto 28% can be obtained by coupling a high concentration ratio between the surfaces of the optical concentrating device. Commercially 97% of rated production when the alignment error is lower than 04degree and production falls to zero if the error exceeds 1 degree.

Control algorithm implemented and developed in lab view environment. The system composed of mechanical tracker it is ideally hosting orientation of concentration photo voltaic module within the precision limits defined by a control sensor 0.4degree. The prototype resolution set 0.00075 degree in joint space and 0.002 degree in azimuthally –zenithal space

The paper ‘A novel open loop tracking strategy for photovoltaic systems’**[3]** is a dual axis tracking system to perform well in the conversion of solar resource into electrical one. The panel movement mechanism is mainly done by DC motors. The timely basis angular movement of the PV modules in a day will be fed as input parameters to the mechanical device. While the output obtained will be forwarded to the controller are considered as motor torques. The controller parameter’s tuning is done by the parametric optimization process using design of experiments and response surface methodology techniques, in a multiple regression. There can be two types of tracking system like mono axis and dual axis as per this paper **[3].**

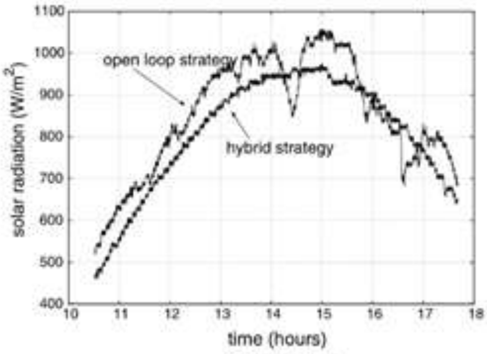
Result **[3]**, The system in this paper follows dual tracking system. Many papers follow open loop control method whereas this paper equatorial tracking system for individual PV module is followed. Solar tracking system follows ‘daily motion half law’. The particular optimization algorithm used for tracking the system**.** Annual gain of energy is 35%.

The paper, ‘Power feasibility of a low power consumption solar tracker’ **[4]** discusses on generated power and power consumption of open loop time. The two axis tracking system used a PLC maneuver photo voltaic module based 10 degree altitudes and 1 degree azimuth solar tracking. PLC has been used to move fixed panels. It moves from sunrise to sunset with the help of 10degree precision controller and to 1 degree in the azimuthal direction.

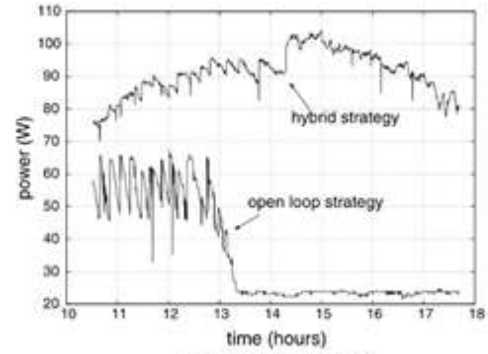
Result **[4],** The daily consumption of tracking motor is 0.05% and controller is 5.84% in a sunny day. The system consumes 5.89% of the total power.polar axis azimuth/elevation types having accuracy than a fixed tilt device and it is about 30-50%.the solar potential varies from place to place and the radiation can be calculated by Id=TdNcos (theta)**.** The whole system consumes an energy of 8.71Wh and specifically to the controller is a considerable value, about 8.64wh.

The paper **‘**Application of new control Strategy for sun tracking’ **[5]** deals with role of number of high concentration solar cells per unit area and its incremental output nature. To make this happen,a hybrid tracking system with combination of open loop tracking strategies based on solar movement models and closed loop strategies using a dynamic feedback controller is presented. By taking energy saving factors into account that is, among other factors, the sun is not constantly tracked with the same accuracy, to prevent energy over consumption by the motors. Simulation and experimental results with a low cost two axes solar tracker are exposed, Including a comparison between a classical open loop movement mechanism and the proposed hybrid one.

Results **[5]**,The following graph shows the performance and efficiency of this paper.



Solar radiation



Electric power generated

The Paper ‘The gain of single-axis tracked panel according to extra terrestrial radiation’ **[6]** presents the gain in extraterrestrial radiation received by a single-axis tracked panel relative to a fixed panel was systematically analyzed over a specific period. The panel has fixed with an optimal angle.Result**[6],**The tilt angle with which the panel was installed is the yearly optimal angle, and is 23.8 degree for a perticular place. The yearly

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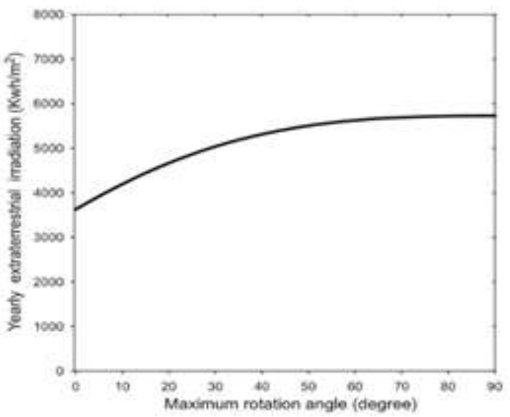
optimal angle of a south-facing fixed panel is approximately ad equate 0.9 multiplied by the latitude (i.e. 0.9 psi) for latitudes below 65degree and is about 56 + 0.4 * (psi - 65) otherwise. Paper[6] demonstrated that yearly gains of a single-axis sun tracker with the yearly optimal change of tilt of angle from the extra terrestrial, predicted and observed radiation are 51.4%, 28.5%and 18.7%, respectively.



The paper 'Comparative analysis of fixed and sun tracking low power PV systems considering energy consumption'**[7]** convey us that, conversion of solar power into electrical one will have some clear advantages like no environmental impact during operation. The reliability and long- lasting nature of the systems, lower operating and maintenance costs and ability to connect both electrical network and remote customers. An analytical approach is used to comapare one fixed and one equipped with sun tracker.

Result**[7]**, The presented paper proves that a single-axis sun tracker using a closed-loop operation with two photo sensors increases 12–20% of the produced energy **[7].**

The paper 'Effect of manual tilt adjustments on incident irradiance on fixed and tracking solar panels' **[8]** deals with the optimum angular movement of the system for maximizing annual irradiation on a fixed south-facing panel can be changed from being equal to angle at low-latitude, highly visible sites, up to 14^0 less than the latitude at a north-western coastal site with very low visibility index for a particular geographical area. The monthly angular changes even resulted in an average annual irradiation increase of 5% for fixed panels and 1% for azimuth tracked surfaces, relative to using a single optimized tilt angle in each case.Result**[8]**,The presented paper proves that, the single-axis and dual-axis sun tracking mechanism increases annual solar irradiation incident by an average of 29% and 34% relative to the fixed angular movement, respectively.

The paper 'Novel high accurate sensorless dual-axis solar tracking system controlled by maximum power point tracking unit of photovoltaic systems' **[9]** deals with a completely unique high accurate sensor less dual-axis solar tracker controlled by the utmost powerpoint tracking unit available in most photovoltaic systems. Proposed system consists of various advantages, in the absence and presence of rated sensors. But these systems do not have the demerits of the same. The proposed solar tracking system follows the path of the Sun with the tracking error of $0.11^{0,}$ which is less than the noted tracking errors of the system with and without the sensor in solar trackers. Result **[9],**An increase of 28.8–43.6%, depending on the seasons in the energy efficiency is the main advantage of sensor less closed-loop dual-axis tracker, utilizing the proposed solar tracking system. The efficiency of the dual-axis sun tracker is higher than those of the single-axis sun tracker and the fixed PV system.

The paper 'Analysis of fixed tilt and sun tracking photovoltaic–micro wind based hybrid power systems**'[10]** reveals the comparative power generation analysis in different configurations of hybrid systems with fixed angular movement, monthly optimum tilt, yearly optimum tilt and 6 different sun tracking photovoltaic systems is carried out using Hybrid Optimization Model for Electric Renewables. To identify the appropriate configuration, optimization of the system, electric load demand of building, uses Homer software version 2.68 beta. its is user-friendly software and best for PV-wind hybrid system analysis. To get an optimized value, the decision values taken into consideration are (i) Size of the PV array, (ii) number of wind turbines (iii) number of batteries (iv) size of the inverter.

Result **[10],**A two-axis sun tracker generates 4.88%–26.29% more energy per year than the fixed PV system.

The Paper 'The effect of latitude on the performance of different solar trackers in Europe and Africa**'** **[11]** discussed the concept of solar radiation data of different locations and potential of different solar tracking systems.Different solar trackers namely, Full/dual-axis, East-West(EW), North-South(NS), Inclined East-West(IEW), andVertical-axis(V) trackers are considered in calculating the available solar potential of various locations.

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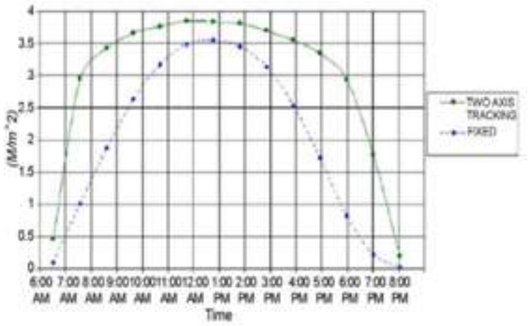
Result **[11],** The result highly depends on tracking systems and locations. The effect of latitude on the performance of different sun trackers, including dual-axis, East West (EW), North-South (NS), Inclined East-West (IEW), and Vertical axis (V) trackers. The performance of the IEW tracker indicated as per results is close to that of the dual-axis tracker and better than any other single-axis trackers. The percentage variation among the implemented single-axis tracking options comparative to dual-axis trackers ranges from a value 0.42% to 23.4%.In total, the increase in the energy gain of dual-axis trackers varies from 17.72% to 31.23% while comparing to the optimal fixed panel for the locations, thus ensures the importance of solar trackers. Finally, the study is focus to the designers in the selection and installation of appropriate solar trackers in the selected regions.

The paper 'Tracking strategy for photovoltaic solar systems in high latitudes' **[12]** proves that solar photo voltaic systems which is tracking the Sun, set a fixed angle can recover 20% to 50% more solar energy. Compared to a panel which follows the Sun's path, in this case, claims that a horizontal panel increases the amount of solar radiation captured and subsequently the quantity of electricity produced. The current work analyses a solar tracking photovoltaic panel hourly and seasonally in high latitude ranges.Result **[12]**,The study confirmed that a zenith-set sun tracking strategy for overcast or mostly cloudy days in summer will not result in any merit. Moreover, the design of a dual-axis sun tracker is more complex.

The paper 'A review of principle and sun-tracking methods for maximizing solar systems output' **[13]** deals with introduction of sun trackers in the solar energy reception systems and it will compensate the motions and orientation of panel relative to the sun. The movements of earth, affect the reception of solar energy.

The below graph shows energy comparison between tracking and fixed systems. The solar panel output the paper discussed [13]



different sun tracking systems and the most efficient and popular sun-tracking device was found to be in the form of polar-axis and azimuth/elevation types. The driving system improves the performance and it is found that the power consumption by tracking device is 2–3% of the increased energy. The dual-axis sun tracker is more expensive and has higher energy consumption.

The Paper 'Design and construction of sun tracking systems for solar parabolic concentrator displacement' **[14]** discuss about the manufacturing of solar concentrators and its angle of movement for its energy related in focus. The comparative study of the three sun tracking systems with a commercial tracker gives a perfect feedback of the system. Based on efficiency and economical criteria one of the sun tracking systems from the group was selected.

Result **[14]**, The total price of the chosen tracker is estimated to be less in cost and its tracking error is inferior to 0.2°. The advanced accuracy of the new tracker was achieved with the utlization of gearing unit. In the final stage ,designed a relatively simple with less cost, two-axis sun tracker system.

The Paper 'Comparison of optimum tilt angles of solar collectors determined at yearly, seasonal and monthly levels' **[15]** deals with the amount of energy that is transformed in solar collector depends on its tilt angle with relevance horizontal plane and orientation of the collector. There had been taking place a comparison study of atleast ten seasonal variations and different tilt angles. Result **[15],** The values of some comparisons are PV modules with yearly, seasonal and monthly optimum tilt angles increase annual energy by 5.98%, 13.55% and 15.42% respectively, Compared with the PV modules on the roof with the specified angles. Atleast two tilt angle shifts is required per year for the panel.

The Paper 'Feasibility study of one axis three positions tracking solar PV with low concentration ratio reflector' **[16]** deals with a new PV design, called ''one axis three position sun tracking PV module'', with low concentration ratio reflector. Every PV module is designed intentionally with a low concentration ratio reflection and is mounted on an separate sun tracking frame. The one axis tracking mechanism adjusts the PV module position only at three fixed angles (three position tracking): morning, noon and afternoon. This ''one axis three position sun tracking PV module'' may be designed in a simple structure with low cost.Result **[16]**,The developed one-axis three-position sun tracker (1A-3P), which is a type of building-integrated photovoltaic system (BIPV) and The power generation increases by approximately 24.5% as compared to a fixed PV module for latitude / < 50. The analysis also shows that the effect of installation misalignment away from the true south direction is negligible.

The paper 'A novel algorithm for single-axis maximum power generation sun trackers**[17]** deals with a novel algorithm for single axis maximum power generation tracker and it operates between 50^0east to 50^0west. And it checks each and every position where it's getting the maximum energy. It is a PWM based embedded control system. Daily electric energy production will be reviewed.

A novel algorithm named 'direct search method' is proposed to increase the electric energy production. The novelty in this is the solar panel rotates once per hour to avoid the effect of shading (cloud cover and shadows from adjacent buildings) and confirms the position where the maximum energy is available.

Result **[17]**, the detection range is halved to reduce the energy consumption. The electric energy production increases by 3.4% in spring and autumn, 5.4%in summer and 8.3% in winter compared with the full rotation from 50^0 east to 50^0 west. 1A-MPG trackers have high efficiency than 1A-3P tracker. In future can reduce the detection range and can enhance the electrical energy production.

II. CONCLUSION

The above papers discuss the details of various sun tracking mechanisms. These comparative analyses enhance the vision that how an effective sun tracking with less tracking error can be done using optimization algorithms. The same will result in reduced energy consumption for the system as well.

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