A Review on The Axis Tracking Used for Solar PV Application

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Abstract- Today, the world is facing an immense challenge, such as the energy crisis, and we know that only small quantities of fossil fuels are available and these will be lost after 35-40 years or their quantities will be very limited. Hence, to fulfill our energy demand, the right option is to use renewable energy. Renewable energy is various types like wind energy, biomass energy (such as ethanol), hydropower energy, solar energy, etc. But we use solar energy the most because this energy is installed at a very low cost. And also, many important factors affect solar PV power production. Out of these, the most important is the solar tracking system which achieves very high efficiency in comparison to fixed systems. This paper uses various types of tracking techniques like active tracking, passive tracking, and chronological tracking, and also a comparison with the different tracking is also discussed. From these discussions, one can select the tracking method adopted for a specific application.

Keywords: Axis tracking, solar PV, efficiency, renewable

1. INTRODUCTION:

Various researchers around the world have expanded their emphasis on Renewable Energy Production. The Origins of Green Sources are more environmentally friendly and more competitive relative to fossil fuels. The key sources of renewable energy are wind, hydro, biomass, geothermal, solar, etc. [1]. With the help of A PV solar device that transforms sunlight energy into electricity. The invention of the photovoltaic process and the consequent development of the photovoltaic cells allowed the sun's useful electricity to be extracted [1]. Although the performance Photovoltaic cells depend upon the strength of sunlight and the angle of incidence, Silicon (Si) is used as the primary feature of photovoltaic cells [2]. The maximum efficiency of 24.5 percent turns visible light into a direct current [3]-[4]. Among the non - traditional renewable energy sources, solar electricity holds great opportunities for electricity debate, but also economic analysis of large-scale solar energy applications [5]. Challenging energy technologies, such as cells of titanium oxide [6]. It is clean, quiet, and secure, including relatively low costs for operation and negligible environmental impact with a 32 Percent overall lab efficiency and an average 15-20 percent performance in continuous production [7]. Renewable power generators are distributed in several nations [8]. During the whole day, the solar panels must stay in front of the sun. But these panels cannot always hold their position in front of the sun due to the rotation of the earth [9].

In 1962, Finster developed the first tracking system and it was entirely controllable. In 1963, Saavedra introduced automatic control circuitry of the “Eppley pyrheliometer” used to spin the device to sun [10]. Its energy is a wide range of applications and one such resource is multi-effect distillation Gholinejad et al. (2016) demonstrate the consequences of the use of tracking systems for MED plants. In his research, he concluded that 341%, 135 percent, 246%, and 291% more freshwater were provided by the solar MED plant using complete tracking systems, N-S tracking systems, E-W tracking systems, and polar axis tracking systems compared with fixed system systems. To improve the performance and efficiency of the overall device, many such different applications deplete tracking systems in solar plants. Adds to a tracking method an rise in the generation of energy by more than 30 percent [11].

Solar system drive modules are broken into three categories based on their monitoring systems, i.e. Active, passive and Chronological tracking while the method of solar monitoring is the mechanism in which the direction of the sun's route in the sky is determined with the help of sensors. To increase the efficiency of the solar power system, there are three main approaches The first solution is to increase the production of power cell production, the second solution is Rising the performance of power conversion controller design, and the third is to implement a monitoring system to accomplish maximum solar power [12]. Usually, photovoltaic devices are fitted with functions that measure optimum monitoring of power points [13]. To solve the problem, the Automatic Solar Tracking System (ASTS) was designed as a prototype [14]. To optimize the solar radiation effects on the solar collectors and panels, the systems are oriented from the horizon with optimum Angles of inclination toward the
equator [15]. Solar energy has been thoroughly studied and solar energy rates have now surpassed other ways of producing energy or an electricity within a few cents per kilowatt per hour (kW / h) [16].

The main objective of this study is to review the methods of solar tracking systems to determine which solar system is the best tracking method to best optimal condition form, and architecture are optimal [17]. The use of the MPPT tracking system is to accurately monitor and discern the general worldwide MPPT, and the total full power set [18].

1.1. SOLAR ENERGY:

The oldest primary source of electricity is solar energy. In any part of the planet, it is clean, renewable, and plentiful. Sunlight and heat are radiant energy from the Sun, but it is possible to transform solar energy with ample efficiency into mechanical or electrical energy [19]. Many ever-evolving technologies are being used to harness this, such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants, and artificial photosynthesis. It is predicted that the planet will receive approx. 1KW/m². But there is also a direct shift from photon energy to electricity already accomplished at high noon and large-scale solar power plants are now being set up [20]. This involves the elimination of inverter losses, storage losses, and light gathering losses. Light accumulation depends on the slant of incidence of the light source (i.e. the sun) supplying power to the surface of the solar cell, and the closer the power is to the vertical one [21]. Of all the benefits of solar energy, the most important thing is that solar energy is a fully renewable source of energy. Electricity bills are reduced and maintenance costs are minimal. Solar Energy Storage is costly, Technology Growth, Weather Based, It does not refuse radioactive particles or heat and carbon dioxide, hence It is fully climate-friendly. Normally, the Hilly area has an abundance of solar energy with a high energy potential that can be used for energy generation. And transmission via the power line is always expensive or very unlikely. Furthermore, urbanized Energization by a photovoltaic panel with the help of street lights is becoming common [22]. Today, there are many solar energy gadgets such as electric cars, smart grid systems, integrated solar system design. There is a chance for more solar energy to move in, such as a rocket, a satellite that can stay on the earth for a long time.

**TABLE 1. Technology Used for The Different Axis Tracking**

| S.N. | Year | Authors | Technologies | Description | Pros | Cons |
|------|------|---------|--------------|-------------|------|------|
| 1.   | 2010 | Arturo, Minor M. [49] | Commercial webcam (genius 3125) as a sensor element. | Accuracy higher than 0.1 degree; Use LDR or photodiode; Use a sophisticated control system; It is implemented by MATLAB software. | Cheap; It takes only 1/32 sec to locate the sun. | The installation procedure of the discrete element is more complex. |
| 2.   | 2016 | Ray, Shashwati and Abhishek Kumar [48] | Light-dependent resistor [LDR] | It is used AT Mega 16 microcontroller; Used stepper motor; High tracking accuracy; Power output 30% - 60% increased; Used a Photo Resistor. | Cheap; High tracking accuracy. | It is very costly. |
| 3.   | 2001 | Abouzeid, M. [54] | Programmable logic array (PLA) controller [52] | It is used in remote areas. Control automatically using (PLA). Step moment 15 degrees or 7.5 degrees. | It is used in remote areas. Control automatically using (PLA). Step moment 15 degrees or 7.5 degrees. | Costly; Complicated. |
| 4.   | 2018 | Nadia, AL- Rousan [50] | Temperature sensor [48] | It is used LABVIEW software. It is used for the thermometer sensor. Used stepper motor. Single-axis system. | Gain maximum of energy. Efficiency is increased. | |
1.2 PHOTOVOLTAIC TECHNOLOGY:

Photovoltaic (PV in short), which transforms this process from light (photons) into electrical (voltage) energy. This technique is a very useful technique that generates electrical power through the installation of silicon cells in photovoltaic panels. The p-N crossover diodes convert energy from the solar light into usable electric energy. When solar cells are exposed to sunlight [23]. The energy emitted by photons reach the solar panel's surface causes the electrons to knock out and release from their bands and These released electrons are attracted by electric fields in photovoltaic modules into a lateral current which can produce electricity in photovoltaic modules through metal contact. The term photovoltaic determines a photodiode's general impartial working state in which the transduced light energy is due to current through the appliance [24]. The solar cells in the photovoltaic panel produce direct current electricity and battery recharging is very useful.

2. SOLAR MODULE:

A solar module is a single solar cell that is an assembly of linked solar cells, also called solar panels. Sunlight is consumed by solar cells as a source of energy to produce electricity. To supply power to houses, an array of modules is used. A solar panel usually consists of a 6x10 solar cell assembly. Depending on the form of solar cells used and their consistency, the effectiveness and wattage performance of the solar cells can differ. When generating energy, the DC electricity of a solar module can range from 100-365 watts. The higher the wattage output, the greater the solar cell output. The key application of photovoltaics was to power both satellites and Spacelab. Nowadays, however, most solar panels are used for the group of grid electricity [25]. We often use the inverter in these solar systems, which converts the direct current into an alternate current.

2.1. SOLAR TRACKER FUNDAMENTAL:

Solar tracker, a device that positions an object relative to the Sun at an angle. Photovoltaic (PV) panels are the most popular applications for solar trackers so that they remain vertical to the emissions of the Sun and position space telescopes so that they can determine the path of the Sun.

Compared to modules at a fixed angle, using solar trackers will increase power generation by about one-third, with some claiming up to 40 percent in some regions. Of its 9W, or 3.51W, premeditated over 12 hours, the fixed
panel provided an average of 39 percent. The tracked solar panel, by contrast, achieved overall productivity of 71 percent, or 6.3W concluded the identical period frame. The power increases across the fixed (PV) panel extended to 400 percent in the early and later hours. This means that the solar cell is opposite to the Sun by an average power increase of 30 per cent [26].

When it comes solar panel are constantly calibrated to the right angle when the sun enters the sky, the conversion efficiency in any Solar application is increased [27]. The sun in the sky fluctuates during the periods (upwards) and the day that the sun is in the sky. Whenever the sun is seen, solar devices can work better and thus enhance the efficiency of devices at the cost of more system complexity over any checked position [28]. Based on their tracking technologies are active, passive, semi-passive, manual tracking, and chronological tracking [29]. Active trackers are effective at low temperatures, such as panel-carrying axis linked motors, although passive trackers [30]. New tracking hold is being installed for solar (PV) specialization Active and passive tracking that can achieve better efficiency.

The solar tracking system's commercial purpose:

- Enhance the performance of the solar panel
- The Full Panel Performance,
- Maximize per unit area electricity,
- Capable of capturing energy during the day.

2.2. SUN, AZIMUTH, PATH & ALTITUDE ANGLE:

The Sun's direction still keeps shifting. Due to the World Still Holds Periodic Revolution and Rotation at various times and seasons to seasons. As a consequence, for a specific moment, it has become important to locate the sun's orientation. The positions are placed on the Sun Path Map, a special form of a chart. A diagram illustrates orientation, angle of elevation, sunrises, times of sunrise and sunset, etc. [31].
2.2.1. The declination angle ($\delta$)

It is the corner between the center of the sun and the center of the earth and the line into the equilateral terrestrial plane. An equation to determine the angle of declination ($\delta$).

$$\delta = \frac{46.90}{2} \sin \left(\frac{360(n-180)}{365}\right)$$

where,

- $n$ = the number of days specified in the year
- $\delta$ = Positive in north-equator angles and negative in south-equator angles.

2.2.2. Zenith Angle ($V_z$)

Now, to measure the zenith angle, the slant of the horizontal plane among sun rays follows the equation

$$V_z = \Phi - \delta$$

Where, $\Phi$ is the angle latitude.

2.2.3. Solar Azimuth Angle

The horizontal plane is placed among the southern side and the horizontal plane's sun-ray plane. Where in solar irradiance, the sum of sun-released radiant energy over all wavelengths, is known as the total solar irradiance. Not only visible light, falling on a perpendicular plane of 1 square meter outside the earth's atmosphere every second, the power density of sunlight is measured and its unit is Watt per meter square or an instantaneous amount [32]. The radiance the sample absorbs from solar rays is 1367 watt per metre square. The radiation on the surface after being absorbed by the atmosphere becomes 1000 W / m² when it passes through it. The efficiency of solar cell production is influenced by solar radiation and is, therefore, a very significant aspect in this area. Sunlight is the resource that is given by a variety of electromagnetic wave spectrums. However, no photovoltaic cell can consume literally the entire power phase [33]. The main aim of a solar cell is to harvest part of the total radiation spectrum. The visible spectrum of the photovoltaic solar panel only. Direct natural solar radiation is given by,

$$I_t, k = I_b, k \cos V_z + I_d, k$$

Where,

- $I_t, k$ = The radiance that comes straight since the sun
- $I_d, k$ = Disseminated radioactivity

Solar irradiance is a measure specifically correlated with the solar energy usual from the solar panel and the limit after the rays are vertical to the panel flat. It is important to rotate the face of the panel towards the sun to achieve full solar energy. The device used to do this is named the Solar Tracker.

3. VARIOUS TYPE OF TRACKING

Its degrees of rotation are classified by the solar tracking system. It is possible to group rotation trackers into two primary categories based on degrees of rotation.

- Single Axis Solar Tracker
- Dual Axis Solar Tracker
3.1.1. **Single-Axis Solar Tracking System**

It is the strategy of tracking the sun using a solar pivot to rotate from one side to the other. This system has three key types of tracking systems: Vertical axis, longitudinal axis, and single axis. The horizontal assortment of solar trackers stays used in tropical areas wherever the sun gets identical high at noon, except that the days will be short [34]. The longitudinal shape is found in high elevations (including the UK) where the sun will not get too large, but it does take long warm days. On the other hand, concerning the ground, the axis of rotation of the vertical monolayer is vertical [35].

Wherever, concerning the axis of rotation, the face of the device collector or else segment is angled and is habitually used in high-latitude sites of this kind. The axis is between the upper and lower surfaces of the tracking device of the tilted single-axis, where the collector's face or component is paralleled with the rotation axis. The main drawback of the tracking system with one axis is that the Sun can only be monitored during the day and not the yearly movement, and the Tracking System effectiveness is reduced significantly during cloudy days due to only one axis rotation [36].

3.1.2. **Dual Axis Solar Tracking System**

A two-axis solar system is a method used to rotate the sun on two opposite axes by two pivot points. This type of solar tracker device usually has both horizontal and vertical axes. This type of tracker can be used anywhere in the world and ensures optimum solar energy efficiency as well. Dual-axis trackers track the sun to additional power output (approx. 40% gain) and comfort in both the east and the west and north to the south.
The dual-axis application of concentrated solar power (CSP) includes solar tower structures and photovoltaic systems where there were angular errors in the results [37].

![Dual Axis Solar Tracking](image1)

**FIGURE 5.** Dual Axis Solar Tracking

### 3.2. METHODS OF SOLAR TRACKING

Solar tracker drives can be classified into three key categories according to the drive shape and the sensing or positioning system they implement.

- Active Tracking
- Passive Tracking
- Chronological Tracking

![Percentage of uses in recent studies of the forms of solar tracker drive systems](image2)

**FIGURE 6.** Percentage of uses in recent studies of the forms of solar tracker drive systems

#### 3.2.1. Active Tracking System

The first active tracking device developed by MC Fee in 1975, an Active solar tracking system that evaluates the position of the sun's path in the sky throughout the day with sense. The sensor activates the movement of the motor or actuator to allow the solar panel to continue to face the sun throughout the day [38].

However, as stated earlier, the downside of the two principal types of active tracking systems (auxiliary bifacial cell-based and electrical optical sensors based on the microprocessor) is that they are not effective on cloudy days because they both use light sensors, both of which in this case would be deficient [39].

#### 3.2.2. Passive Tracking System
Passive monitoring, dependent upon material thermal expansion or pressure imbalance, is one of the solar tracking systems which does not use sensors such as active tracking at the ends of the track. Typically, such assets (liquid or gas) should be used as the fluid. With passive trackers, the degrees of complexity are lower than active trackers, but at low temperatures, it does not offer high performance [40].

An affordable passive single-axis tracker based on actuators from the Form Memory Alloy (SMA) was developed by Poulek. Also, at relatively low temperatures, it is easy to deform the tracker actuator SMA (under 70 °C tracker actuators). When heated above the transformation temperatures, it produces mechanical work by returning to its original form. The authors noted that the tracker was very well done in short field tests with an efficiency of 2% for the SMA actuators [41].

3.2.3. Chronological Tracking

A solar tracking device is a chronological tracking system that uses the system collector or modulus for days and months at a fixed rate and a fixed angle. The drive is operated to rotate at a low speed while the sun is continuously flying about 15 degrees per hour through the sky.

Based on a chronological model of its motion, this tracking device is a traditional open-loop control tracker. One of the key benefits of this device, due to low tracking error, is more effective in energy and at this calibration monitoring, there are no energy losses. However, data storage, Ongoing data transmission measurements are energy consumption and the excessive rotation of sunlight can never be prevented. With a single axis and dual-axis tracking system, all three methods are valid. Installation location, generation purpose, and solar power demand determine which method is best suited. Modern trackers combine sensor monitoring and the sensor-less control approach to growth performance simultaneously [42].

**TABLE 2. Comparison Between Active Tracker, Passive Tracker, And Chronological Tracker**

| Sr.no. | ACTIVE TRACKING                                                                 | PASSIVE TRACKING                                                                 | CHRONOLOGICAL TRACKING                                                                 |
|--------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1.     | The position of the sun in these intelligent monitoring systems is defined by the sensor. | Manually sun location in passive tracking system determined. | It is a time-based mechanism in which the structure is shifted during the day at a fixed rate. |
| 2.     | Azimuth Angle Continuously Changes, Due to sensor Triggered | The azimuth angle is fixed. it is changed manually | The azimuth angle is also dependent on a time-based mechanism. The chronological tracker solar system uses the timer tracker to move the tracker across the sky. |
| 3.     | Active tracker solar system is used electronic sensor and motor or actuator drives | The passive tracker system no use of the motor, no gears, and no controls. | The first passive tracker was developed in 1969 by Zomewords it is an American company. |
| 4.     | The first active tracker system was developed in 1975, by MC Fee. | The first passive tracker was developed in 1969 by Zomewords it is an American company. | It is measuring the light intensity from the sun by using a light sensor. |
| 5.     | It is measuring the light intensity from the sun by using a light sensor. | Passive tracker uses a compressed gas fluid in two canisters. | Often named the open-loop solar tracker, the chronological tracker. The location of the sun decides using computer algorithms or an easy time scheme. |

3.3 ELEMENTARY COMPONENTS OF SOLAR TRACKING SYSTEM:

Normal photovoltaic solar panels (PV) are the primary elements in the solar tracking system. Sensor input, single processing unit (SPU), control system, relay, servo motor, and power supply (5-volt, 2 amperes). The block illustration of the arrangement is displayed in figure 7.
3.3.1 SUN TRACKING TECHNIQUE

Solar monitoring may provide an algorithm for an open-loop control or closed-loop control. This procedure measures the angles of the sun's solar azimuth and zenith. The solar panel or reflector is then used to point to the sun at these angles. The open-loop control algorithm contains equations based on the astronomical references of the sun's azimuth and angle of altitude on a purely mathematical basis. As clouds can block the sun, eliminate or distort the feedback signals, the open-loop aspect is necessary. The Closed-loop control algorithm uses real-time light-sensing techniques to detect the location of the sun and is crucial to removing errors due to installation, assembly, calibration, and mounting variability in the encoder. Both approaches can be combined to align economic design with enhanced performance.

3.3.2 TRACKER CONTROL UNIT

The control unit implements the algorithm for sun tracking and synchronizes the positioning system's program. The middle of the control unit may be used as a microprocessor or a computer. It typically has command input and interfacing mechanisms for data output. The automated tracking control system is ideally suited for trackers positioned in remote regions [43].

3.3.3 POSITIONING SYSTEM

At the optimum angles, to face the sun, the positioning mechanism changes the panel or reflector. Some systems for positioning are electrical besides some are hydraulic. The electrical structures are used to monitor the present panel location and transfer to the desired position by encoders and variable frequency drives or linear actuators [44].

3.3.4 DERIVE MECHANISM / TRANSMISSION

Linear actuators are the controlling factors, linear engines, hydraulic cylinder engines, and motor swivel engines [45].

3.3.5 SENSING DEVICES

Sensors are used to sense the site of the sun accurately. The light sensors are castoff to correct measurement and mechanical errors for the open-loop device. Only many light-sensing devices are used by the closed-loop method. The detection system for light intensity requires a photo resistor, etc. Solar control plants also use moisture, airstream speed, temperature radiation from solar panels, and other required tracker parameter monitoring systems [46].
4. FACTORS LIMITING SOLAR TRACKER EFFICIENCY AND ALLOCATION

The effect of tracking on the efficiency of PV modules is analyzed based on the number of tracking axes in the device. They verified their ability, without any effect on clouds or other environmental factors, to hold their positions on both axes. Approx. 13.25% higher than the average output power for your double axis tracker [47].

The efficiency discrepancy between the single axis and the double-axis, as well as the double-axis trackers, was measured in an earlier study. The benefit difference between these two forms of trackers is sometimes 3 percent, they further added. All of the process mappings above were carried out in different domains with different weather conditions. The popular phrase is that the solar tracker's total growth depends on the number of axes used, nevertheless he other that the efficiency of these devices, especially in hot weather regions, could be dramatically modified by both the climate conditions and the technologies used.

- Region atmospheric and climatic conditions
- Technology and Materials
- The auxiliary machine facilities
- PV Generator Connection from the grid
- Solar monitoring device costs and availability

5. CONCLUSION

So far, based on the above discussion, in this manuscript, solar efficiency is being increased by using the solar tracker in the solar module. It is found that there are more successful trackers (active trackers) As opposed to passive trackers, it is widely used than a passive tracker. Among the active Trackers are considered to be independent of preservation issue double axes Responsive trackers optimize the performance of PV System and it makes Regulated and professional energy generation and delivery Energy. The active tracking system seems to be the most effective tracking system which Improves power generation by an estimate of 30% relative to the passive tracking Scenario. Increasing benefit mark due to the successful monitoring of the static system by about 30%. This study is also planned to examine all of the important parameters necessary for the optimization of solar trackers. In future works, this will take major parts are extensive tentative assessment must be carried outperformed to confirm our plan. And another one compares various methodologies in a common way the operational situation can lead to the option of the right solution, based on the state.

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