Comparison of Efficiencies of Solar Tracker systems with static panel Single-Axis Tracking System and Dual-Axis Tracking System with Fixed Mount

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Abstract—Electricity plays a key role now in our daily lives but the energy sources to electric power has been used in abundance and so researchers were compelled to find an alternate source of power leading to the discovery of solar energy. Solar energy is inexhaustible and eco-friendly and can be converted into electricity using photovoltaic panels. These panels can be used in a fixed form or used in a solar tracking system for single axis as well as for dual axis. In a fixed form their efficiency is low since the panels will be tilted in a particular angle whereas in a tracking system the panel is made to move either in single axis or dual axis. In a single axis system the panel is moved in an east to west direction with respect to the sun and it has better efficiency than panels in fixed form. But in a dual axis system the panel is made to rotate in all four directions in accordance with the sun. And dual axis has proved to have more efficiency than both fixed panels and single axis system.

***Index Terms*—Dual-axis solar tracker, Efficiency, Fixed mount solar system, Single-axis solar tracker, Solar energy.**

INTRODUCTION

Today the world is unimaginable without electricity such is the impact of electric power. It is the key to many technologies that had been developed over the years. In the process of converting solar energy to electricity we use photovoltaic panels which consist of silicon made solar cells. Photovoltaic effect is the concept used in the panels where light energy due to the sun's radiation is converted into electric power. The conversion of solar energy into electric power also depends on the angle at which the panel is fixed or made to rotate. There are two types of panel usage: 1) In fixed form and 2) In solar trackers. When a panel is fixed they are tilted in ground or on a roof at an angle appropriate for sun's radiation. In solar trackers the panel is made to rotate in the directions with respect to sun. We have experimentally verified that the efficiency and the output power of dual axis system are higher when compared to fixed panel and single axis solar tracker system.

SINGLE AXIS TRACKER

A Single axis tracking system is a method where the solar panel tracks the sun from east to west using a single pivot point to rotate. Under this system there are three types: Horizontal single axis tracking system, Vertical single axis tracking system and Tilted single axis tracking system. In the Horizontal system the axis of rotation is horizontal with respect to the ground, and the face of the module is oriented parallel to the axis of rotation. In the Vertical system the axis of rotation is vertical with respect to the ground and the face of the module is oriented at an angle with respect to the axis of rotation. In the Tilted tracking system the axes of rotation is

between horizontal and vertical axes and this also has the face of the module oriented parallel to the axis of rotation, similar to the Horizontal tracking system. The single axis tracking system consist of two LDR's placed on either side of the panel. Depending on the intensity of the sun rays one of the two LDR's will be shadowed and the other will be illuminated[1].The LDR with the maximum intensity of the sun's radiation sends stronger signal to the controller which inturn sends signal to the motor to rotate the panel in the direction in which the sun's intensity is maximum.

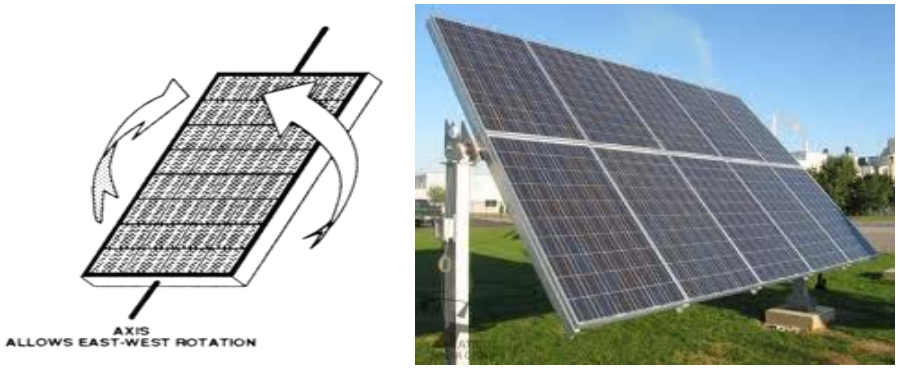


Figure 1. Single-Axis Tracker[1].

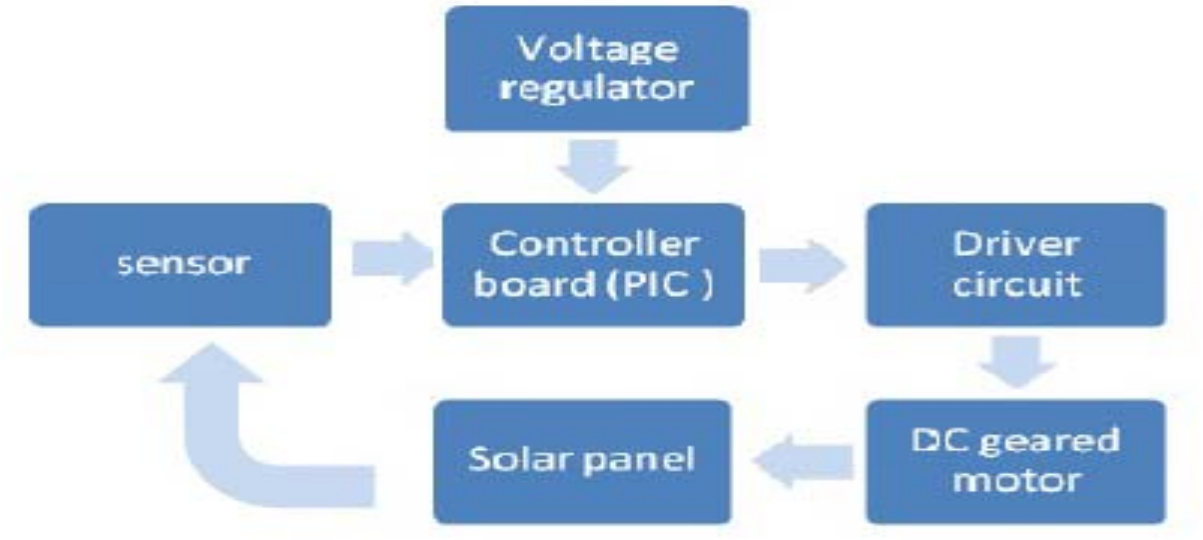


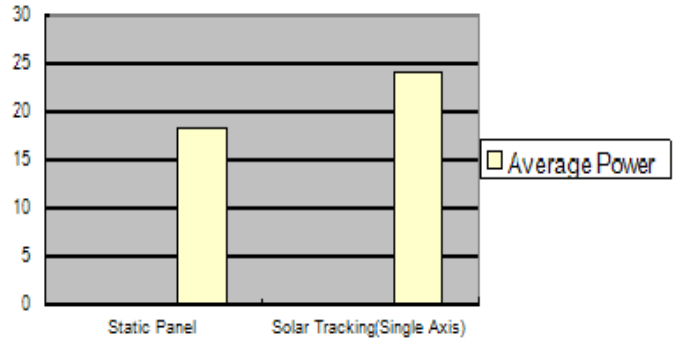
Figure 3. Block Diagram for Single Axis Tracker

A. Efficiency Of Single-Axis Tracking System over Fixed Mount

The readings for both the static panel and single-axis tracker are taken for a single day from morning 8 am to evening 6 pm for every one hour. The following readings are tabulated and a graph was generated using MATLAB as follows

TABLE I.
COMPARISON OF FIXED MOUNT WITH SINGLE AXIS TRACKER SYSTEM

Hours	Static Panel			Solar Tracking (Single Axis)		
	V	mA	mW	V	mA	mW
08.00 AM	08.4	0.60	05.04	09.15	1.70	15.60
09.00 AM	08.5	1.17	09.94	09.45	1.78	16.86
10.00 AM	08.6	1.25	10.75	09.70	1.99	19.30
11.00 AM	09.7	1.82	17.65	09.85	2.38	23.44
12.00 PM	09.9	2.22	21.97	10.20	2.70	27.54
01.00 PM	10.3	2.56	26.36	10.80	3.20	34.29
02.00 PM	10.5	2.97	31.18	10.70	3.05	32.68
03.00 PM	09.7	2.71	26.28	10.25	2.93	30.08
04.00 PM	08.6	2.50	21.5	09.80	2.63	25.77
05.00 PM	08.3	2.14	17.76	09.25	2.43	22.47
06.00 PM	08.1	1.43	11.58	08.75	1.87	16.40
Average Power			18.18			24.03



The efficiency of the single axis tracking system over that of the static panel is calculated to be **32.17%.**

B. Disadvantage

The main disadvantage of the single axis tracker is that it can only track the daily movement of the sun and not the yearly movement. The efficiency of the single axis tracking system is also reduced during cloudy days since it can only track the east-west movement of the sun.

DUAL AXIS SOLAR TRACKING SYSTEM

Dual axis tracking system uses the solar panel to track the sun from east to west and north to south using two pivot points to rotate. The dual axis tracking system uses four LDR's, two motors and a controller. The four LDR's are placed at four different directions. One set of sensors and one motor is used to tilt the tracker in sun's east - west direction and the other set of sensors and the other motor which is fixed at the bottom of the tracker

is used to tilt the tracker in the sun's north-south direction [1]. The controller detects the signal from the LDR's and commands the motor to rotate the panel in respective direction.

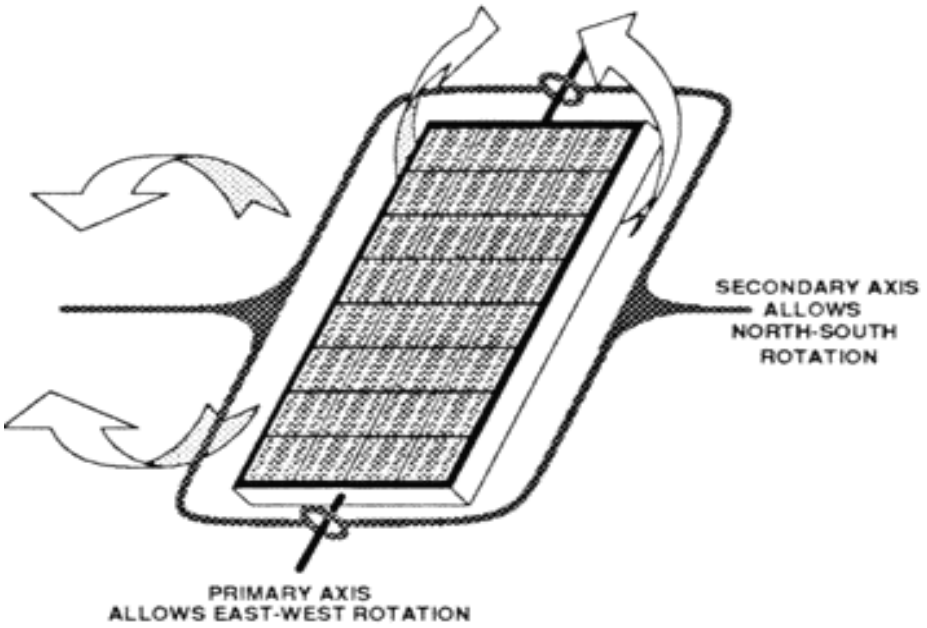


Figure 4. Dual Axis Tracker[1].

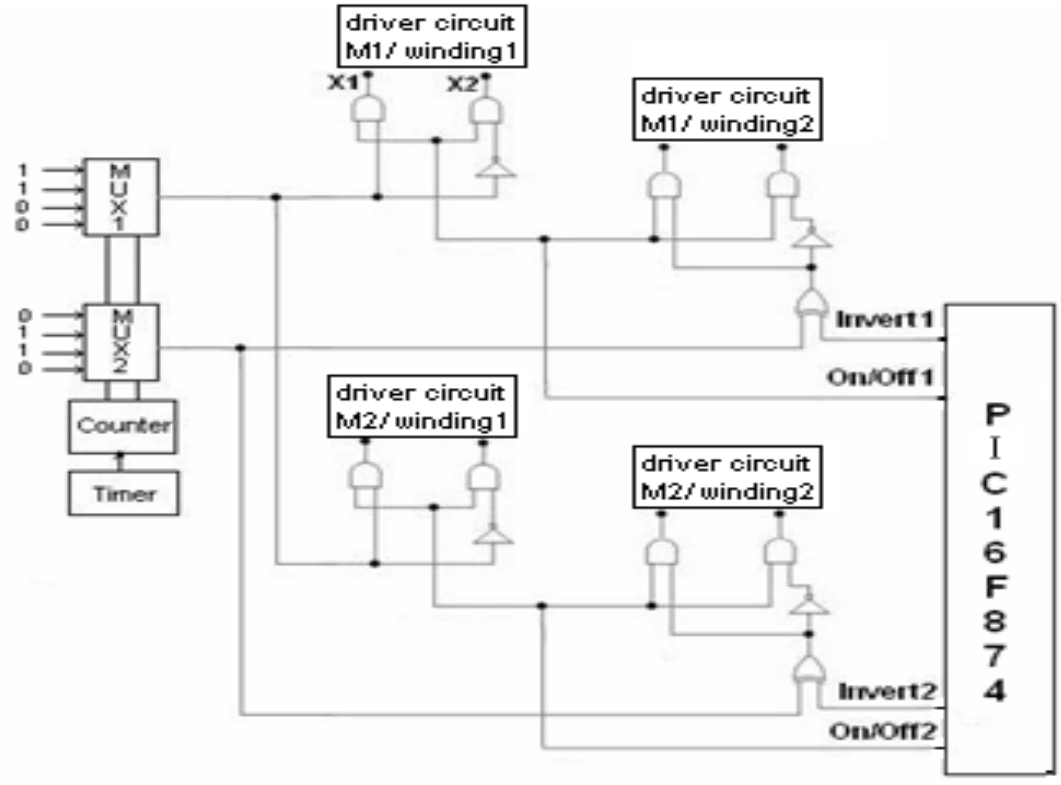
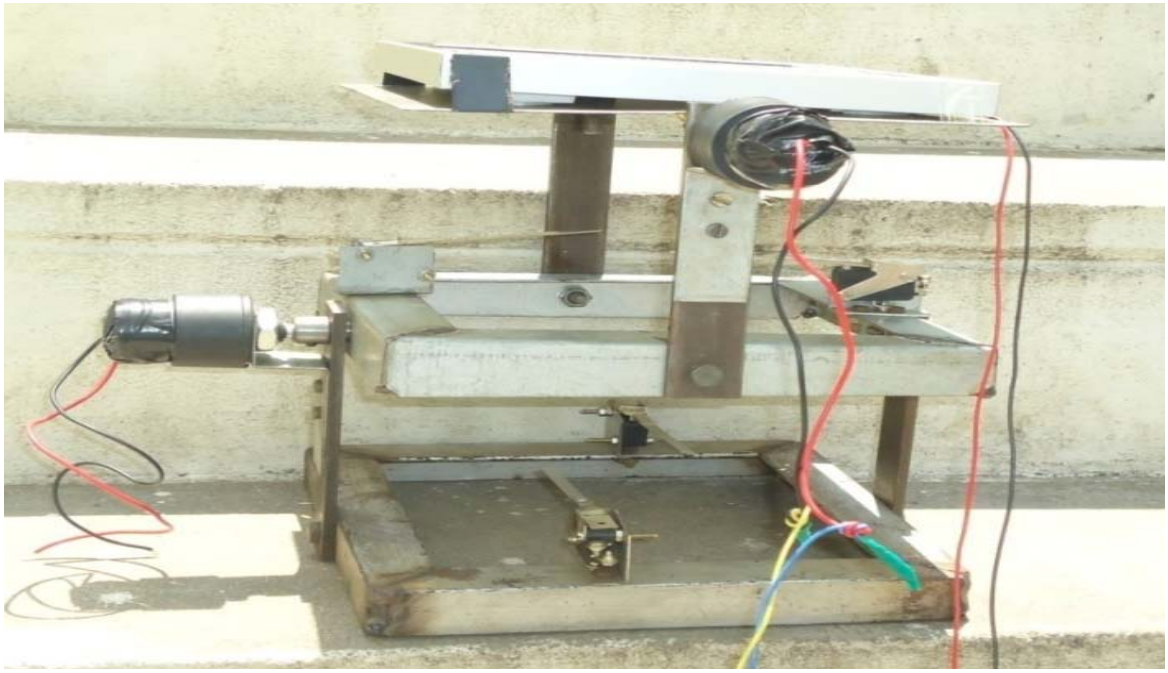


Figure 5. Block Diagram for Dual Axis Tracker [1]

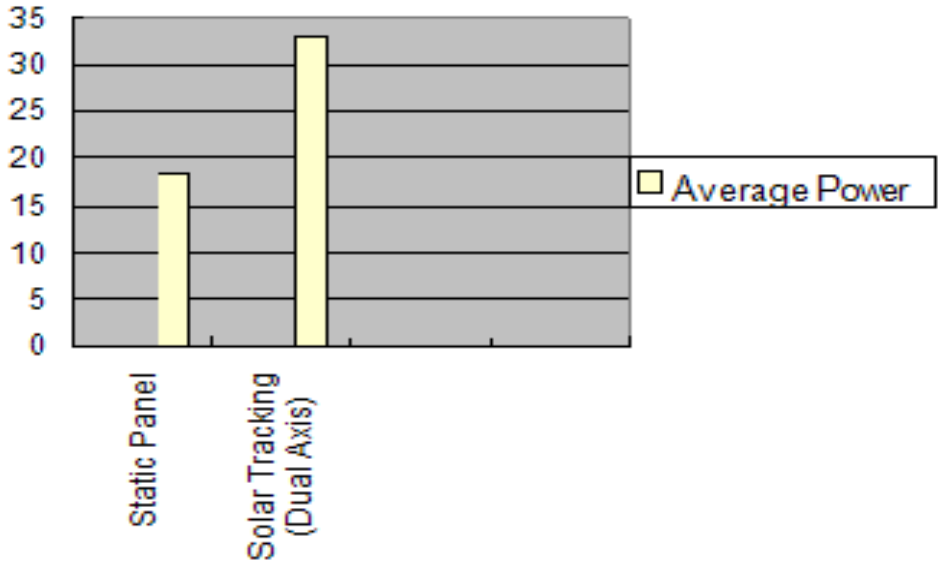
C. Experimental Setup



D. Efficiency of Dual-Axis Tracking System over Fixed Mount

The readings for both the static panel and dual-axis tracker are taken for from morning 8 am to evening 6 pm for every one hour. The following readings are tabulated and a graph was generated using MATLAB as follows

Hours	Static Panel			Solar Tracking (Dual Axis)		
	V	mA	mW	V	mA	mW
08.00 AM	08.4	0.60	05.04	10.20	2.93	29.88
09.00 AM	08.5	1.17	09.94	10.35	3.02	31.25
10.00 AM	08.6	1.25	10.75	10.42	3.00	31.26
11.00 AM	09.7	1.82	17.65	10.51	3.23	33.94
12.00 PM	09.9	2.22	21.97	10.60	3.20	33.92
01.00 PM	10.3	2.56	26.36	10.80	3.35	36.18
02.00 PM	10.5	2.97	31.18	10.73	3.41	36.58
03.00 PM	09.7	2.71	26.28	10.40	3.29	34.21
04.00 PM	08.6	2.50	21.5	10.55	3.30	34.81
05.00 PM	08.3	2.14	17.76	10.36	3.12	32.32
06.00 PM	08.1	1.43	11.58	10.29	2.82	29.01
Average Power			18.18			33.03



Efficiency of Dual-Axis Tracking System over Static panel

HOUR	POWER FOR FIXED MOUNT(mW)	POWER FOR SINGLE-AXIS(mW)
0800	20.664	62.403
0900	39.780	67.473
1000	44.176	77.212
1100	70.616	93.772
1200	88.110	110.430
1300	104.960	137.160
1400	125.334	130.754
1500	105.342	120.335
1600	86.172	103.096
1700	70.620	89.910
1800	46.494	65.625

TABLE I
FIXED VS SINGLE-AXIS [1]

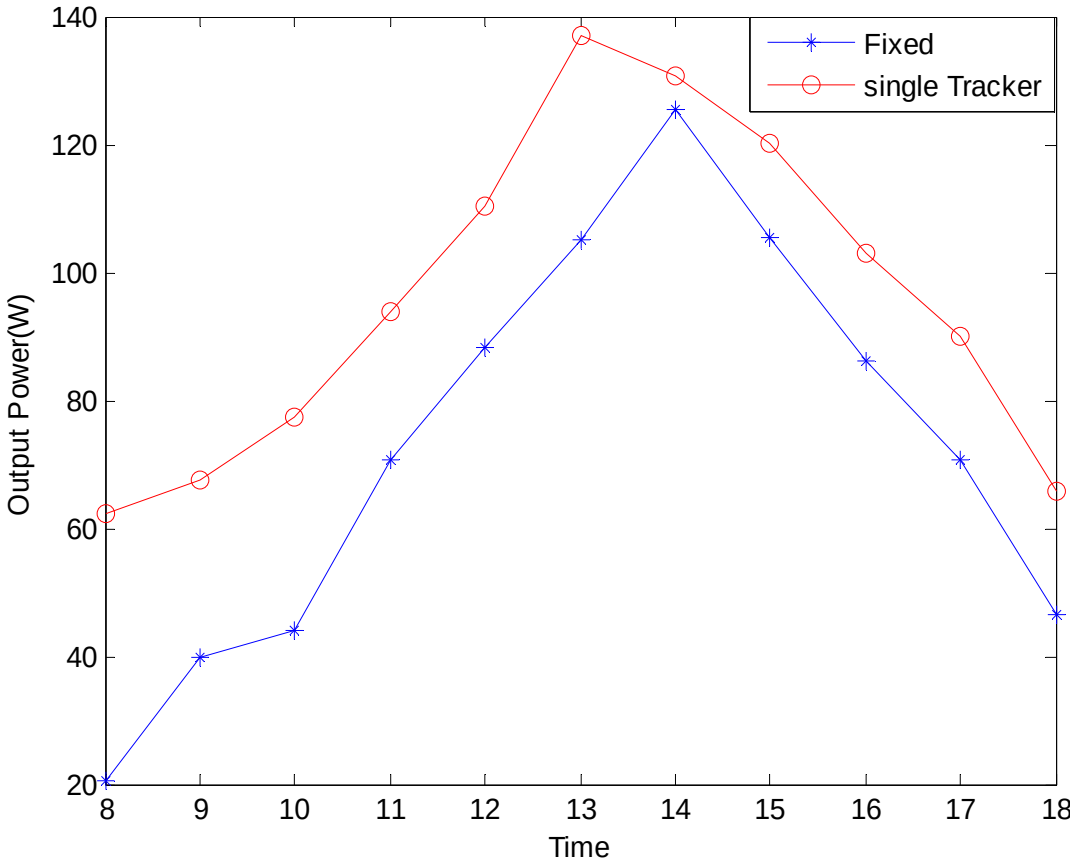


Fig.4 Simulation Result for Comparison of Fixed mount and Single-Axis Tracker System[1]

TABLE 2

FIXED VS DUAL-AXIS [2]

HOUR	POWER FOR FIXED MOUNT(W)	POWER FOR DUAL-AXIS(W)
0700	14.575	38
0800	23.987	49.728
0900	43.876	52.701
1000	47.94	54.9519
1100	52	52.974
1200	57.6666	59.6156
1300	57.96	58.0488
1400	56.412	56.5687
1500	54.6883	55.3151
1600	48.174	54.8562
1700	36.96	52.3698
1800	27.72	52.668
1900	12.69	33.22

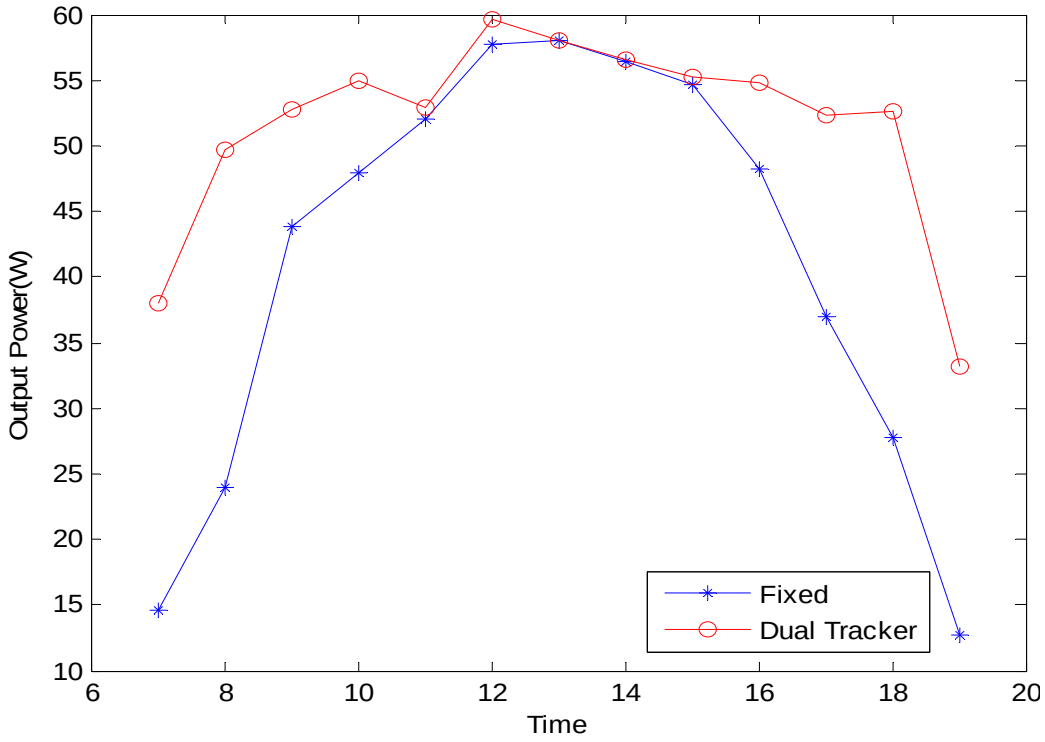


Fig. Simulation Result for Comparison of Fixed Mount and Dual Axis Tracker System [1]

The efficiency of the dual axis tracking system over that of the static panel is calculated to be **81.68%.**

Future Work

The efficiency of the dual-axis tracking system can be increased even more by placing a mirror or concave lens on top of the panel. The use of lens or mirror increases the tracker's efficiency since large amount of sunlight is concentrated on the panel and large power is generated. It can also reduce the size of the solar cell required to generate large power. It also has high optical efficiency.

Conclusion

The proposed model of the dual axis solar tracker is capable of tracking the sun throughout the year. The dual axis tracker provides higher output power when compared to single axis tracker and fixed panel. According to the measured readings the efficiency of the dual axis tracker is found to be 81.68% higher than that of fixed panel whereas the efficiency of the single axis tracker is only 32.17% higher than that of fixed panel.

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