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Performance Analysis of a Self-Activating Solar Tracking Setup

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Abstract-Solar energy is rapidly gaining acclaim and acceptance as an important, efficient and dependable means to substitute conventional energy resources. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach for maximizing the efficiency of solar array system is sun tracking. In the present paper, an automatic solar tracking system is designed and constructed which offers a reliable and affordable method of aligning the solar module with the sun in order to maximise its energy output. This project also enables decentralized generation of energy which will give higher penetration in rural India where energy needs are yet to be fulfilled. The factors of photovoltaic module efficiency and electronic controlling are considered in the process of modelling to maximize the output energy and minimize the energy consumption of solar tracker. A comparison of power output between automatic solar tracking system and fixed tilt solar panel is also done. Average percentage increase in energy output of solar tracking system is found to be 22%. This investigation further provides scope for renewable energy education leading towards capacity building for extraction of higher solar energy.
Keywords: Solar tracking, Solar panels, Performance evaluation, Photovoltaic

I. INTRODUCTION

The increasing energy demands have forced the researchers to concentrate over renewable energy with environment friendly nature. Our Sun emits enormous amount of heat and light energy which will continue to exist for at least another billion years, so effective collection of the solar energy stands as an opportunity and a challenge. Various works are carried out with photo voltaic panels to increase the rate of energy collection. The flat plate solar collectors, depending on the conditions of the sky, absorb maximum amount of global solar irradiance especially around midday, when the solar beam radiation takes its maximum values [1-3]. Haung and Sun designed a single axis three positions tracking system. Theoretical results based on radiation predicted on clear sky conditions showed that the optimal stopping angle of the panel during morning and afternoon was about 50˚ from noon position, independent of the site latitude [4]. A study performed by Morcos showed that changing collectors' azimuth and tilt angles daily to their optimum values resulted in an increase in total solar radiation compared with a fixed collector with the tilt-angle equal to its geographic latitude [5]. A feasible approach for maximizing the efficiency of solar array system is sun tracking. The extra benefits from tracking the sun were about 20-40% of output power compared to that of fixed panel [6]. Dual-axis tracked panels performed best in term of the solar gain, but a complicated tracking system was required. Thus, single-axis tracking systems were technically and economically more attractive in practical applications of non-concentrating solar devices [7]. Energy generation from photovoltaic (PV) technology is simple, reliable, available everywhere, long lasting, almost maintenance free, clean, suitable for off-grid applications, and to certain extent has become affordable in the recent times. This type of energy has experienced a rapid growth due to environmental awareness and adverse effects of climate change on the human life. The analysis presented the effect of PV surface temperature and dust collected on the panels on the power output of individual arrays and total power from complete plant. Furthermore, the PV panel performance was studied by DC (Direct current) performance ratio variation with PV panel backside surface temperature [8]. A solar tracking system is a control system that consists of several sensors that check whether the sunlight is perpendicular to the PV panel or not, and a controller that give signals to one or more actuator to move the panel to the right position. The controller aims at maximizing the solar PV cell's efficiency by forcing sunlight to be incident perpendicularly to the PV panel at all times. The system consists of PV solar panel that is allowed to move using two motors, four PV sensors positioned at four different locations, and a fuzzy logic controller that takes the inputs from the four sensors and calculates the appropriate output speeds for both motors [9]. The objective of this work is to investigate the optical performance of solar panels tracking the sun about a horizontal axis with an automatic solar tracking system from east to west orientation by using light dependant resistor (LDR) and compare with fixed panels based on monthly horizontal radiation data.

II. METHODOLOGY

To investigate the effect of sun tracking mechanism on the performance of a flat plate photovoltaic system for different sky conditions, we have taken readings of seventeen completely clear sky days, eleven partially clear and three cloudy days at the geographical location of Bhubaneswar which is 20.2645˚ N and 85.8355˚ E. Out of the two panels, first one is facing north-south direction with fixed tilt angle of 5˚ and another one is tracking the sun facing at East-West direction. In this system two LDRs are fixed on the solar panel at a little distance apart from each other. LDR varies the resistance depending upon the intensity of the light falling on it. A partition of 4 inch is present between the two LDRs whose shadow is used for the change in resistance of the LDRs when the sun is not normally incident on the solar panel. The resistance of both the LDRs is changed to analog voltage signals. The analog voltage signals of both the LDRs were fed to the inbuilt analog to digital converter (ADC) of the microcontroller (ATMEGA16). Microcontroller receives the two digital signals from the ADC and compares them. The LDR signals are not equal except for normal incidence of sunlight. When there is a difference between the LDR voltage levels, the microcontroller program drives the motor towards normal incidence of sunlight. This process repeats itself after every 20 minutes. The microcontroller is programmed for the desired input and output for the desired functioning of the circuit with the help of software 'WinAVR'. The layout diagram of electronic circuit is shown in Fig 1. The battery powers the whole circuit for all of the time is a 7.4 volt Li- ion battery. KM-SPM-11 precision pyranometer has been used to measure the global solar irradiance.

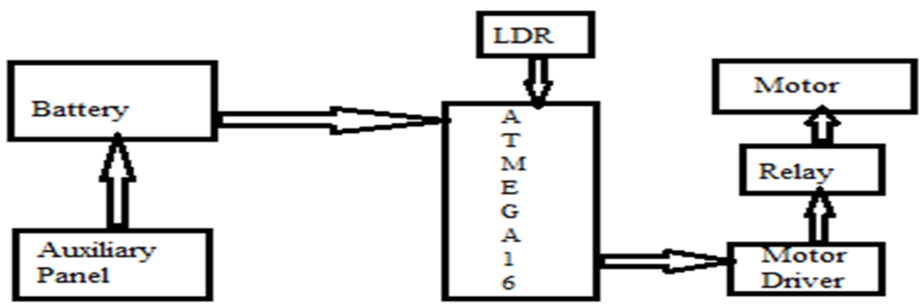

Fig 1. Layout diagram of electronic circuit.

The input from this battery is fed to the voltage regulator which supplies current to the electronics parts. These batteries consist of two Li-ion cells of 3.7 V each. They have a capacity of 2000 mAh each. An auxiliary smaller solar panel is fixed to the side by the bigger panel which charges the battery continuously. The actual setup is shown in Fig 2. The specifications of the photo voltaic panel are given in Table 1.

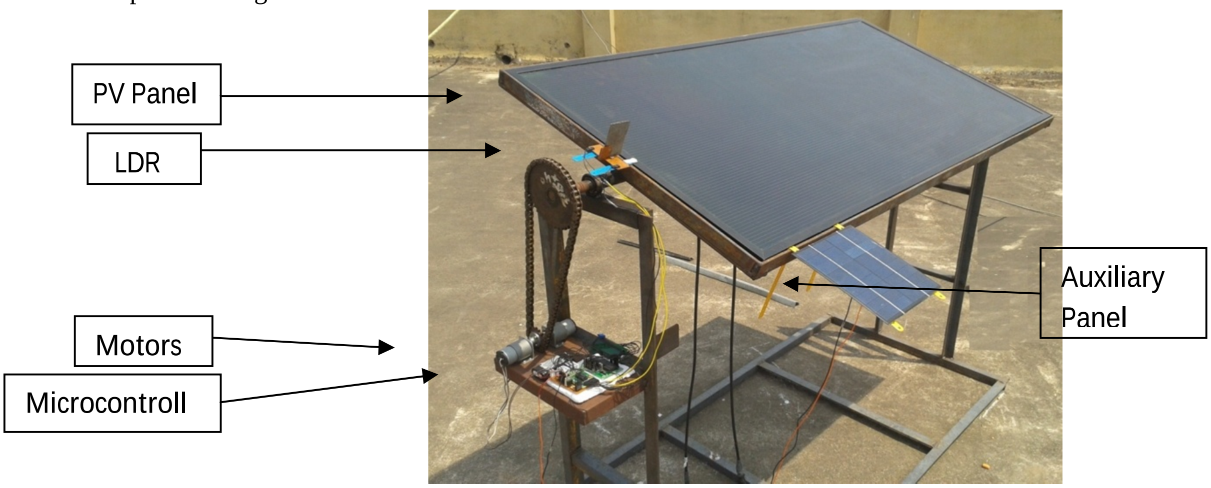

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Fig 2. Actual setup

Table 1. Specifications of the photo voltaic panel

Model	SCG55-HV-F
Dimension	1260mm x 660mm
Material	CIGS (Copper, Indium, Galium, Diselenide)
Power	55W
V_{OC}	51.5 Volt
I_{SC}	1.7Amp

III. RESULTS AND DISCUSSION

In view of the received amount of solar energy for different sky conditions, the average value of output power of both tracking system and fixed system for clear sky, partially clear sky and cloudy sky are shown in Fig 3, 4 and 5 respectively. For clear sky days throughout the day length tracking system have shown comparatively higher performance than fixed tilt system. The graph indicates that the power output of fixed tilt panel gradually decreases with time, while for tracking system the power output marginally decreases with time due to decrease in intensity of solar radiation. Similar results are obtained for average clear sky days with marginally lower average output than that of clear sky days for both sun tracking system and fixed tilt system. This indicates that automatic sun tracking system boosts the energy collection of photo voltaic panel. It is observed from the daily amounts of produced electrical energy, that the increase in solar gain for East-West tracking system as compared to fixed tilt system strongly depends on climatic conditions of the location.

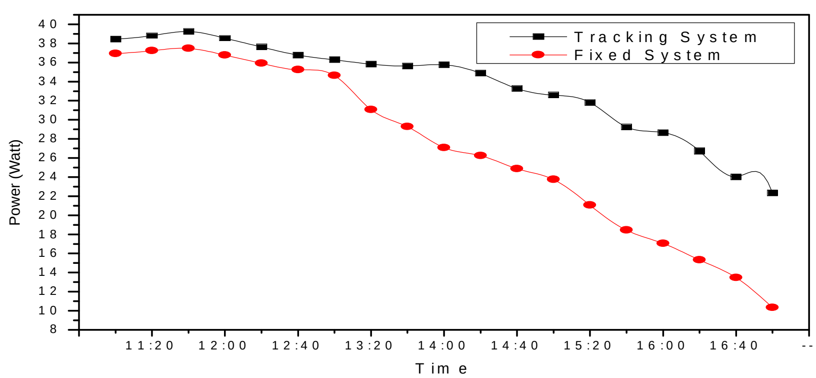

Fig 3. Variation of power with time for clear sky day.

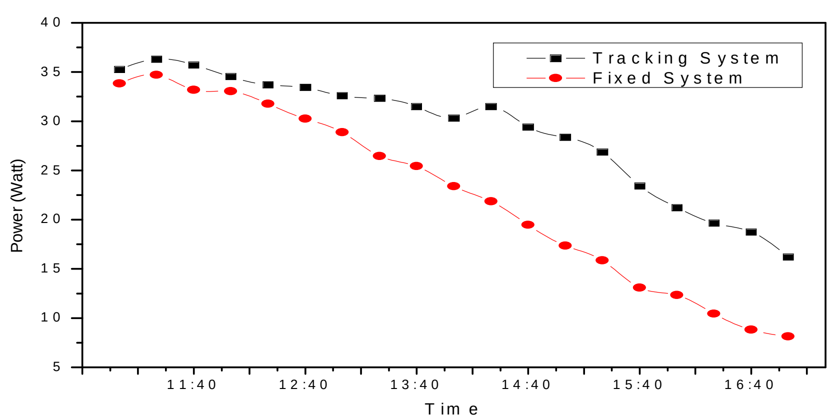

Fig 4. Variation of power with time for partially clear sky day

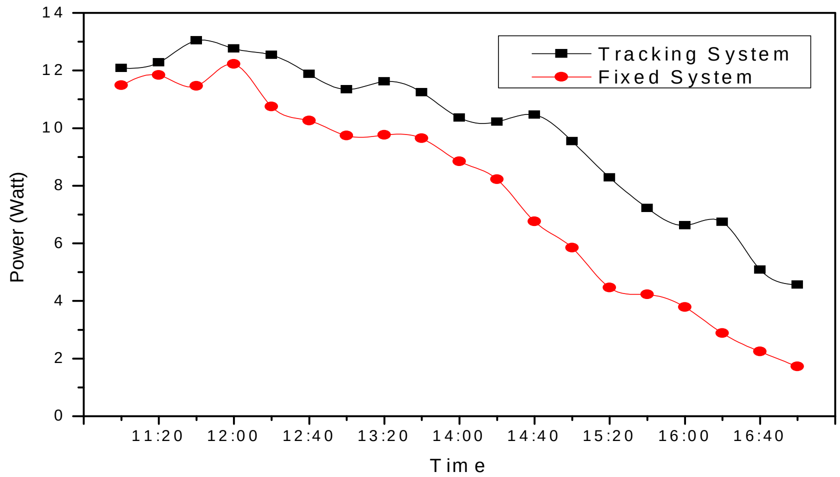

Fig 5. Variation of power with time for cloudy sky day

On cloudy days the daily collected direct solar irradiance is very small. Mainly diffused radiation and reflected radiations provide little power generation from the photo voltaic panel. Comparatively low power output was recorded on cloudy days. Hence use of automatic sun tracking system is unnecessary during cloudy days.

IV. CONCLUSIONS

In this work, the performance of north-south fixed tilt photo voltaic panel is compared with automatic east-west sun tracking system. The factors of photovoltaic module efficiency and electronic controlling are considered in the process of modelling to maximize the output energy and minimize the energy consumption of solar tracker. Additional amount of electrical energy produced by the photo voltaic panel with automatic sun tracking system mainly depends on sky clarity. A comparison of power output between automatic solar tracking system and fixed tilt solar panel is done. Average percentage increase in energy output of solar tracking system is found to be 22%. The use of LDR based sun tracking system contributes considerably to increase the performance of photo voltaic panel.

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