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Impact of Reflectors on Solar Energy Systems

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***Abstract*—**The paper aims to show that implementing different types of reflectors in solar energy systems, will dramatically improve energy production by means of concentrating and intensifying more sunlight onto a solar cell. The Solar Intensifier unit is designed to increase efficiency and performance of a set of solar panels. The unit was fabricated and tested. The experimental results show good improvement in the performance of the solar energy system.

***Keywords*—**Renewable Energy, Power optimization, Solar Energy.

I. Introduction

WORLD production of solar cells soared to 742 megawatts (MW) in 2003, a jump of 32 percent in just one year. With solar cell production growing by 27 percent annually over the past five years, cumulative world production now stands at 3,145 MW, enough to meet the electricity needs of more than a million homes. This extraordinary growth is driven to some degree by improvements in materials and technology [1-3].

In the past 30 years till present, solar energy has increased in efficiency and its price levels have improved dramatically. The price of photovoltaic solar cells has decreased from around $25 to a current price of $5 per peak watt. Today the theoretical efficiency of a solar PV cell is said to be around the 25% to 30% mark and a practical efficiency around the 17% mark [4]. The improvement in efficiency production of solar energy system will make big difference in the use of solar panels.

A flat panel solar module is a practical way in which common households and business can produce electrical or mechanical energy from solar energy conversion. The solar energy is still more expensive then the classical fossil burned electricity [1-3]. However, by implementing a reflector system for these flat panel modules, a theory that has been tested and developed that overall output and efficiency can be improved.

Renewable energy systems especially solar energy systems over the past 20 years has became one of the main focal points in developing new technologies were energy can be produced with efficient results. However with new technologies comes the fact that they will not be cheap to purchase and run. The main aim of this paper is to see what means of solar concentration can produce efficient power for homes and other environments.

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II. Solar Intensifier Unit

A flat solar panel can incorporate reflectors at the side. The idea is to increase the sunlight intensity onto the panel by reflecting sunlight that would normally have missed panel.

Fig. 1 Parabolic dish concentrator [5]

Reflectors can be situated at an optimum angle to gain the greatest possible level of sunlight that can be achieved onto the panel. This idea of using this type of reflector is a lot simpler and less complicated than the existing concentrators, for example the parabolic concentrator shown in Fig. 1. By increasing the amount of sunlight onto the panel you also increase the amount of heat that is being produced as well. Therefore a heat factor must be taken into consideration when designing a reflector system onto the panel.

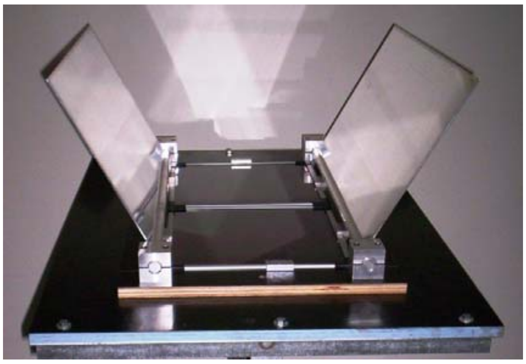

Fig. 2 Front view of a Solar Intensifier Unit

Fig. 2 shows one of the solar reflectors designed and fabricated in the school of Engineering, University of Western Sydney.

The final solar panel and stand was built at the University of Western Sydney. It will consist of two 4-Watt amorphous solar panels connected in series to obtain output voltage and output current readings of each result with respect to the tests. Amorphous solar cells might don’t produce as much power as mono and poly-crystalline cells, have better heat tolerances and don’t not degrade in performance with excess heat radiated onto the solar cell. Although the temperature range of both mono and poly-crystalline solar cells is better than the amorphous type, amorphous solar cells don’t drop in performance from excess heat radiation.

This solar intensifier unit will be used to show that for ordinary households, producing energy using solar power can not only save electricity usage and create a clean energy source but also save money. These solar energy systems will highlight savings in both average power produced and cost per kilowatt-hour. Initial costs of each solar energy system will be taken into account when determining overall money savings.

The dimensions of the solar reflector panels are 63cm by 31.5cm. The widths of the reflectors were chosen so that they were the same dimensions as of the two solar cells side by side. This allows that any sunlight hitting the top, bottom or centre of the reflector at an optimum angle, will reflect onto the solar cell at the opposite point that it hit the reflector (angle of incidence equals the angle of reflectance).

III. Type of Reflectors Panels

The type of reflector panel is used in a concentrating solar panel can influence the output power. This test will incorporate aluminium; stainless steel and chrome film reflectors to determine which type of reflector will be both efficient, practical and do not produce excess heat.

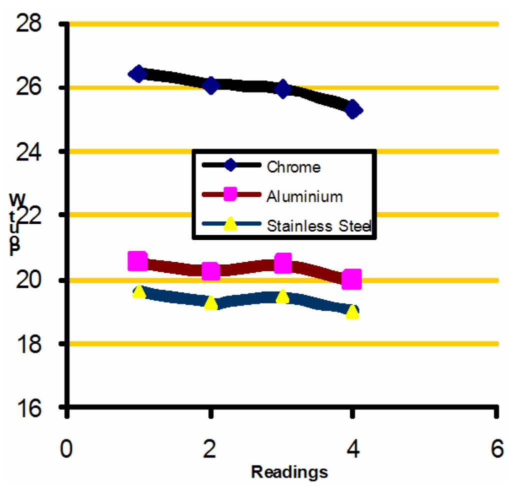

Fig. 3 Power outputs of various reflector panels

An overwhelming increase in power output when chrome film is used on the reflector plate came be seen from Fig. 3. An average power output of 25.94W was recorded for chrome reflectors. These chrome reflectors produce a 27.65% increase in power output against aluminium foil and a 34.05% increase in power output against stainless steel. This is a substantial amount against the two other reflectors and even thou the chrome film cost overall $50 for both reflectors, the increase in power output large enough to warrant using this expensive reflective film.

These results were all conducted using a single-axis tracker adjusting the suns latitude angle and the longitude angle was set to 70˚. (Approximately longitude angle in October when results were taken). The stand was fixed to face due north.

IV. Number of Reflectors

The solar panel has been built with only two reflectors running along. Fig. 4 has optional reflectors 1 and 2. Both will be added on and a value of the output power will be recorded and compared to the result when using only 2 reflectors. This is merely a control test to see what effect the extra reflectors to the solar panel design would achieve. The final design will only incorporate 2 side reflectors regardless of the outcome of using 4 reflectors.

On a mass scale using four reflectors on a solar intensifier unit, could produce an extra 1.44% on top of the power output. For example if a 1000W output was produced by using 2 reflectors on an array of solar cells, an extra 144W could be produced from this output by implementing and extra 2 reflectors onto the system. By adding to more reflectors to the system we also create a more expensive and complex design structure to the unit. Using 2 reflectors can still provide a sufficient and efficient output from a solar cell or cells. Fig. 5 shows the experimental results of a solar enrgy system with different number of reflectors.

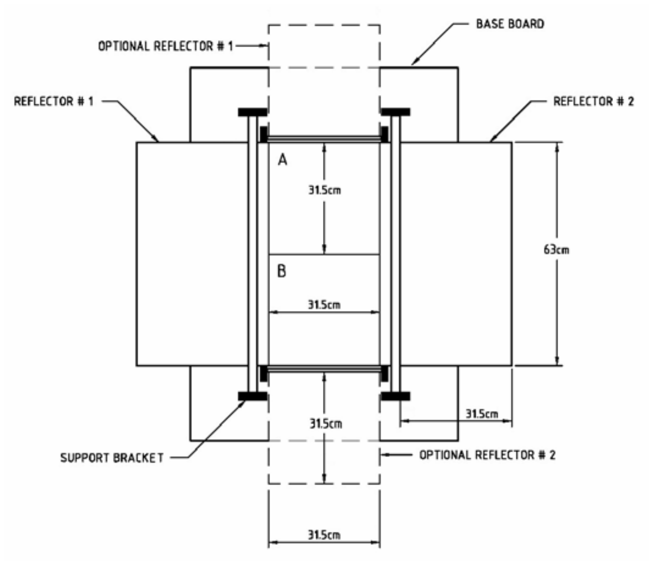

Fig. 4 Solar Intensifier Unit with 4 reflectors

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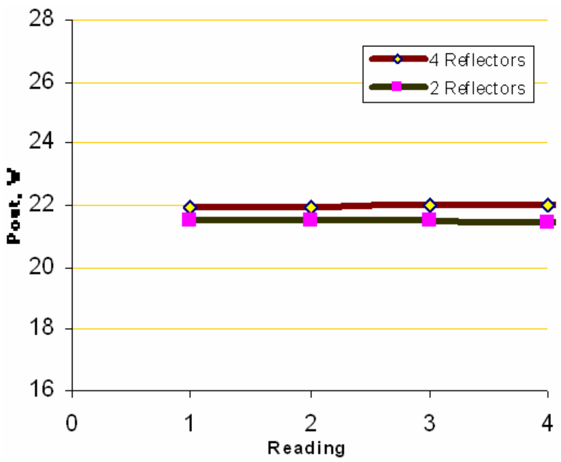

Fig. 5 Power outputs from the number of reflectors used

This test was conducted with the solar panels stand set to a fixed longitude angle of 70˚ as this is the common roof angle discussed previously.

The reflectors were fixed to optimal angle of 22.5˚ throughout the recordings. Note that the recordings for 6:00 AM and 6:30 AM outputs were estimated by the curve characteristics.

The reflectors tracked the suns lateral movements throughout the recordings. Note that the recordings for 6:00 AM and 6:30 AM outputs were estimated by the curve characteristics.

The results indicate that having tracking reflectors results in higher power output than that of stationary reflectors. Both seem to peak at the same time of 11AM, however the tracking reflectors give the output power of the reflectors a constant and spread out curve characteristic but with added complexity to the solar energy system.

The curves are not symmetrical for this system as both curves start to taper off after midday. This system does not provided a constant and predicable output and that can be crucial when incorporating this energy into a system that needs constant and predicable power.

The output voltages for both systems were relatively the same throughout and the output current varied depending on the amount and intensity of light that was applied to the solar cells.

A. *Single Axis Tracking Panel*

The single axis tracking panel test scenario was conducted by having the solar panel tracking the sun lateral movements and the longitude angle set to approximately 70˚, (Approximately longitude angle in October when results were taken). The stand was fixed to face due north. The reflectors were set to an optimum angle of 22.5˚ along the side.

B. *Two-axis Tracking Panel*

The two-axis tracking panel test scenario was conducted by having the solar panel tracking the sun lateral and the longitude angle was tracked Results were taken in October with the solar energy system having a longitude angle of approximately 70˚ with the solar panel facing due north. The reflectors were set to an optimum angle of 22.5˚ along the side.

Both the single-axis and two-axis trackers gave the solar intensifier unit the most consist and produced the highest power readings. The resulting curve characteristics of both systems were as expected being both that they gave a close to symmetrical shape and that the two-axis tracker gave the highest power readings. The peak readings for both systems occurred between the hours of 11:00AM and 1:00 PM were the sun was at its highest point in the sky and most intense. The peak reading for the single-axis tracker was 23.35W and 24.07W for the two-axis tracker. Both systems require complex and detailed automated systems but the power output is much larger than the other system scenarios and will compensate for this added complexity. Fig. 7 shows the output power for both tracking systems.

V. Power Analysis

After looking at all the results from the solar panel tests, Fig. 8 shows an overall comparison of the outputs.

The graph clearly shows the axis tracking panels to be far superior to the rest. The two-axis tracker generates more power than the single-axis tracker due to the fact the two-axis tracking panel was facing directly at the sun at all times. The single-axis tracker however creates a lot more than the rest of the solar energy systems with minimal complexity compared with the two-axis tracker.

The resulting power produced by all six solar energy systems shows the impact of tracking panels or reflectors has onto solar cells. The roof-mounted system with tracking reflectors gave more power output than that of the stationary stand. This is due to the fact that the roof was set to a longitude angle of 70˚. This angle is closer to the sun's longitude angle during testing. The tests were conducted in October, which has a longitude angle of around 70˚ to 75˚. The stationary stand however was sitting at an angle of 60˚. This angle was chosen as mentioned before to be half way in between the peak summer and winter angles. The roof-mounted system with tracking reflectors would be one of the least complex systems to setup at home and would provide sufficient power output. If the power out for the stationary stand was tested for every day the results would indicate a more stable and constant power output.

VI. System Components and Requirements

The solar panel converts sunlight into DC electricity. This DC voltage charges the battery and is then fed to the battery via a solar regulator which ensures the battery is charged properly and not damaged. DC appliances can be powered directly from the battery, but AC appliances require an inverter to convert the DC electricity into 240 Volt AC power. A regulated DC voltage can then be fed into the axis and reflector tracking system to provide movement for the solar panel stand and reflectors.

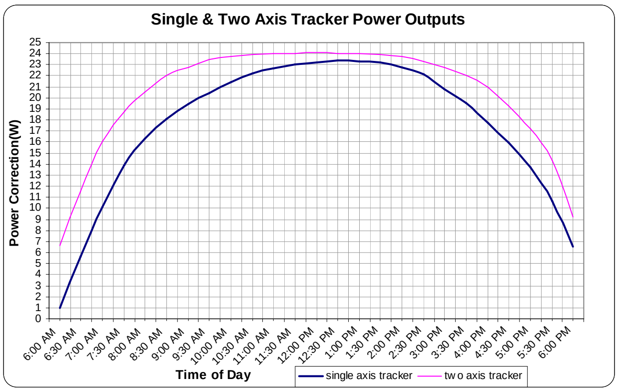

Fig. 7 Power outputs of axis tracking solar energy systems

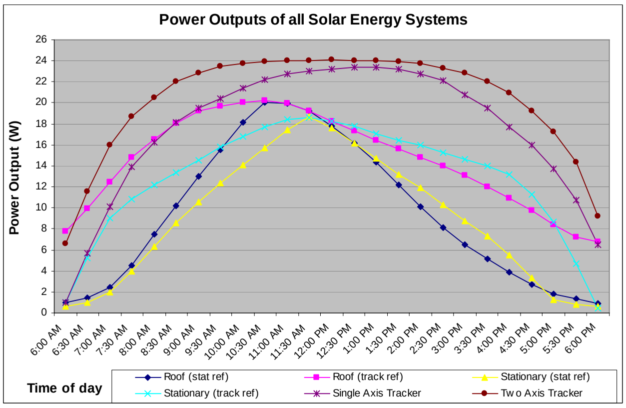

Fig. 8 Power outputs of all solar energy systems

A microcontroller acts is the central controller of the unit and controls and regulates all the feedback coming from the motors and sensors. Temperature sensors can be setup to monitor the heat radiating off the solar panels and if the rated heat is exceed than it can be programmed to close the reflectors till its cools down to a safe level. Steppers motors move the stands longitude and latitude angles and the tracking reflectors as well. The Stepper motor driver and controller move these motors and can be programmed to track to suns movement during the day. Fig. 9 shows such a system.

VII. Conclusion

The first analysis was to see how this concentration can be achieved and what type of setup would prove to produce good power outages. By implementing reflector panels with a reflective finish on it, the rated output of a solar cell can be increased and surpassed. The affect found that an increase of around 40% can be achieved by using this method of concentration. Another factor that also improved the output of the solar cell was to add a chrome finish to the reflector panels. This alone created an increase in output power by a further 34%. These simple but effective measures are beneficial to the energy production of a solar energy system. Solar energy systems can come in various designs, shapes, looks and structures. The four solar panel scenarios tested were a roof-mounted, stationary stand, single-axis tracker and two-axis tracker solar panels. All have pros and cons when in various aspects and areas of power and complexity.

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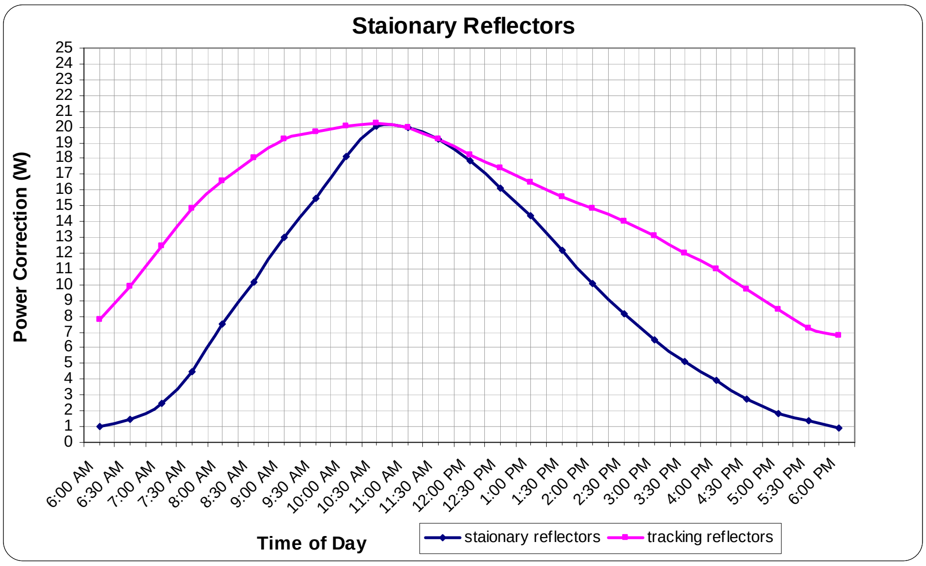

Fig. 6 Power outputs of the roof-mounted solar energy system

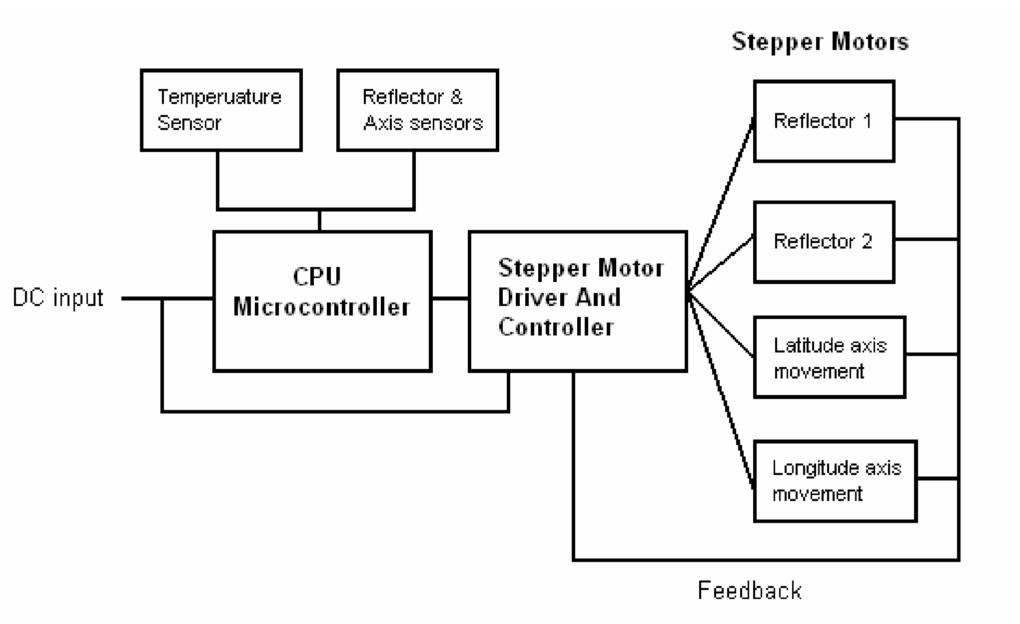

Fig. 9 Components of an automated solar panel