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Performance Enhancement of PV Modules Using Reflectors

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Abstract

To convert solar energy directly into electrical energy, photovoltaic cells are widely being used. Different techniques like concentrators and reflectors are retrofitted to increase the incident radiation flux on the PV cells thereby increasing the out put from PV cells. The present work investigates the effect of non -imaging flat mirror reflectors and reflecting plastics material on the performance of small photovoltaic modules. Performance of two modules one fitted with reflectors and one without reflectors were compared under identical environmental conditions, the one fitted with reflectors shows 11-13% increase in output. This increase depends on sky condition, clear sky gives better results, and in cloudy conditions, the reflectors are almost ineffective. Temperature rise of the panel fitted with reflectors is around 2-10 ^{0}C more than the panel without reflectors.

Nomenclature

b	PV panel length, meter
c	PV panel width, meter
Fr-c	View factor from reflector to collector
I	Current, amp
P	Power, watt
r	Reflector width, meter
V	Voltage, volt
ψ	Angle between reflector and PV panel

Introduction

In remote areas where grid line cannot reach due to physical or economical constraints and in island areas, photovoltaic system is a promising option. In PV installation, high initial investment is required which in many a cases become deterrent for such options.

Another problem associated with PV installation is that solar energy is seasonal, and not available at night, electric energy storage system (battery) is required to maintain supply of electricity during such period. Moreover solar energy is a dilute source of energy, rarely exceeds 1 kW/m^2 , use of reflectors can increase the intensity of solar insolation over the panel.

Neil Kaminar et al [1], Stacy, R.W and McCormic, P.G [2], and others studied the effect of concentrators on the performance of PV system but all their systems were large and for commercial power plants. The objective of the present work was to study the effects of non-imaging, non-tracking reflectors on passively cooled PV panel and compare its results with an identical panel placed side by side and experimental data for both the panels were collected under similar environmental conditions.

Experimental set-up

The set-up was installed on the roof of a six storied building in Bangladesh University of Engineering and Technology campus (longitude 90.0^0 and Latitude 23.5^0).

A structure was specially designed to mount the PV panel and flat reflectors on all four sides of the panel; the angle of each reflector with relation to panel could be varied independently thereby varying the view factor.

40 watt TATA BP solar panels were used in this experiment, Kipp and Zonen solar integrator CC12 and CM 5 pyranometer were used to measure solar isolation, T-type thermocouples having digital readout were used to measure temperatures at different parts of the two PV panels. Wind speed was measured using hand held anemometer; psychometric data were recorded during experiment.

Load to the PV panels were supplied by Rheostats and corresponding voltage and ampere were recorded by digital meters, the data were used to generate I-V curve and Power-Voltage. Curve Fig. 1 shows the experimental set up.

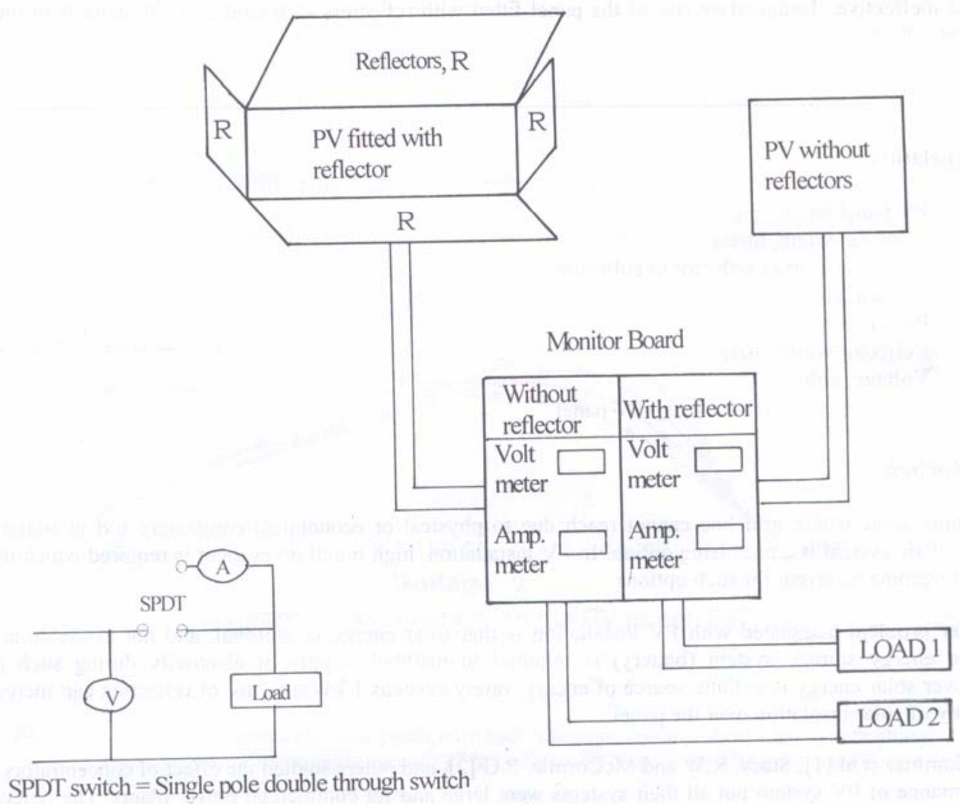

Fig. 1. Experimental facility with wiring diagram for voltage and current measurement

Two types of reflecting materials were used, one set comprised of shiny reflecting plastic sheets and another set comprised of plane mirror.

The PV panel was placed facing south and at an angle of 23.5^{O} from the horizontal plane.

I-V curve and Power-Voltage curve were generated, temperature at different points on the module were measured to study the temperature effect of reflectors on the panel. Each experiment lasted about 10 to 15 minutes and average value of the solar insolation was taken as considered for reference.

Planar reflectors on all sides increase the radiation incident on the PV panel thereby achieving radiation augmentation. The view factor varied throughout the season and also over the day. Theoretical values were calculated from relations given by equation [5]

$$F_{r-c} = \frac{c + r - s}{2r}$$

here

$$S = [c^2 + r^2 - 2 * c * r * \cos\psi]^{1/2}$$

For a particular settings of the reflector. Fig. 2 shows the angles of the reflectors.

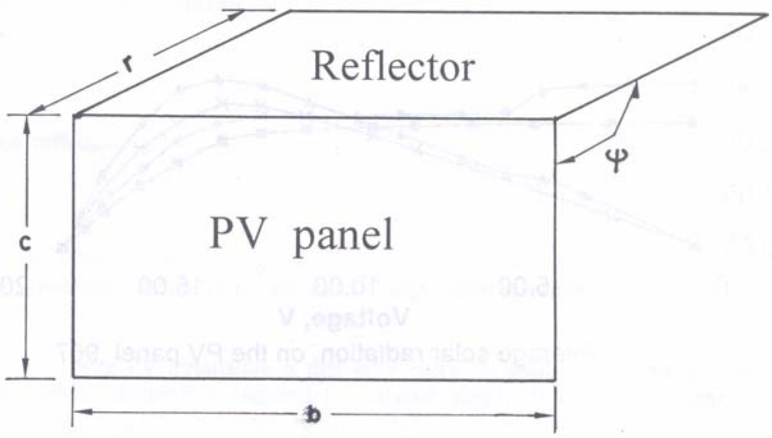

Fig. 2. Geometric relationship of reflector and photovoltaic panel

For each reflector material two sets of experiments were done, one set involved all four reflectors placed at the top, bottom, east and west side of the panel and another set involved only top and bottom reflectors.

Results and discussion

In the present experiment the effect of non-imaging reflectors on the performance of PV panel were studied. Fig. 3 to Fig. 7 shows performance of the panel with reflectors and without reflectors. It can be observed from Fig. 3 to Fig. 6 that there is augment using reflectors on clear days however when the sky is cloudy there is almost no effect as seen from Fig. 7.

Plastic coated reflectors initially gave results comparable with mirror but with time their surface showed weathering effect thereby reflective properties.

The temperature of Fig. 8 is a very interesting one showing that clear sky increases surface temperatures of the panel fitted with reflectors. The temperature rise of the panel was around 2-10 ^{0}C more than the panel without reflector.

The gain with reflector is very much dependent on sky condition; the gain was of the order of 11-13 percent when compared with the panel without reflector.

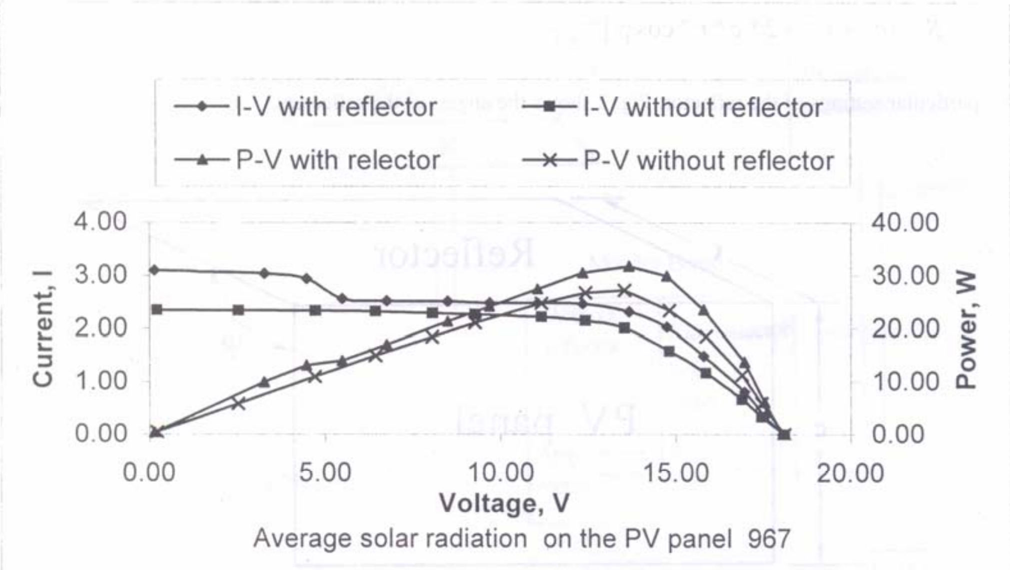

Fig. 3. I-V and P-V curves for solar panel with four reflectors (plastic sheet coated with shiny material) and without reflector on 23rd September 1999 at 11.50 AM (Sky condition: Clear)

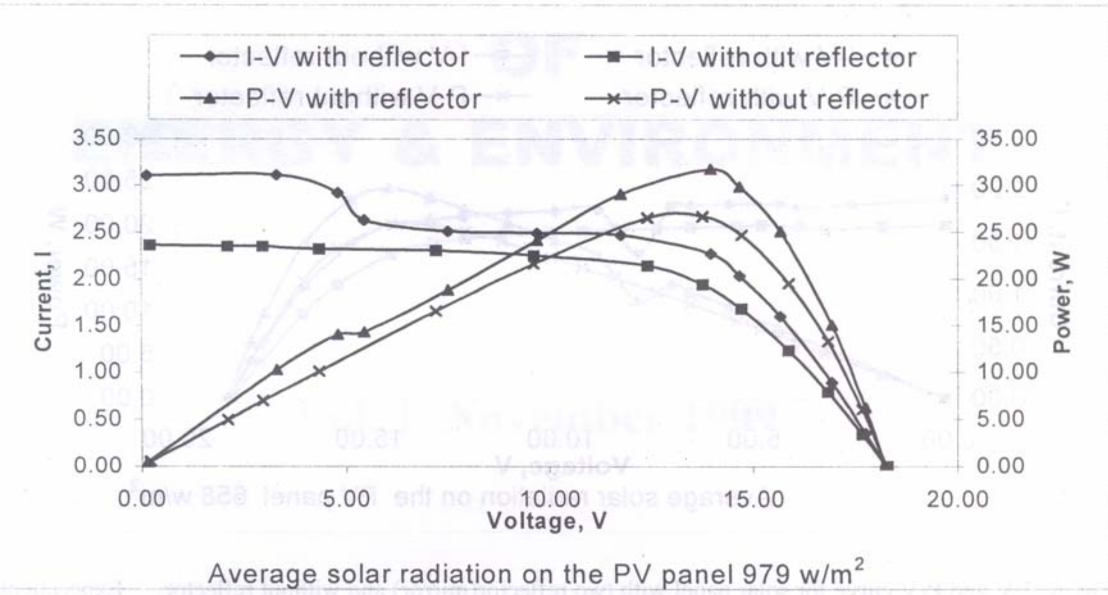

Fig. 4 I-V and P-V curves for solar panel with two reflectors (plastic sheet coated with shiny material) and without reflector on 23rd September, 1999 at 11.36 AM (Sky condition: Clear)

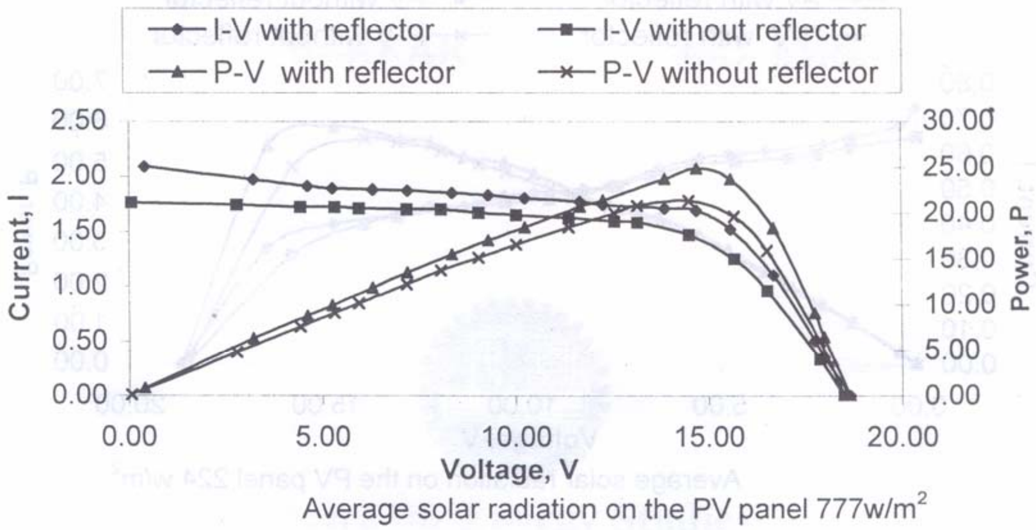

Fig 5. I-V and P-V curves for solar panel with four reflectors (mirror) and without reflector on 25th October 1999 at 13.30 PM (Sky condition: Clear)

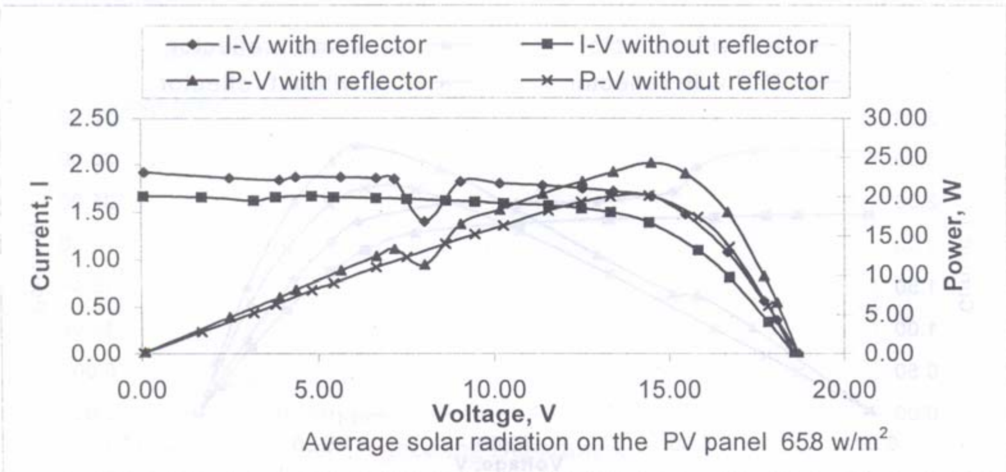

Fig 6. I-V and P-V curve for solar panel with two reflector(mirror) and without reflector. Experiment done on 12th October 1999 at 13.57 PM (Sky Condition: Clear)

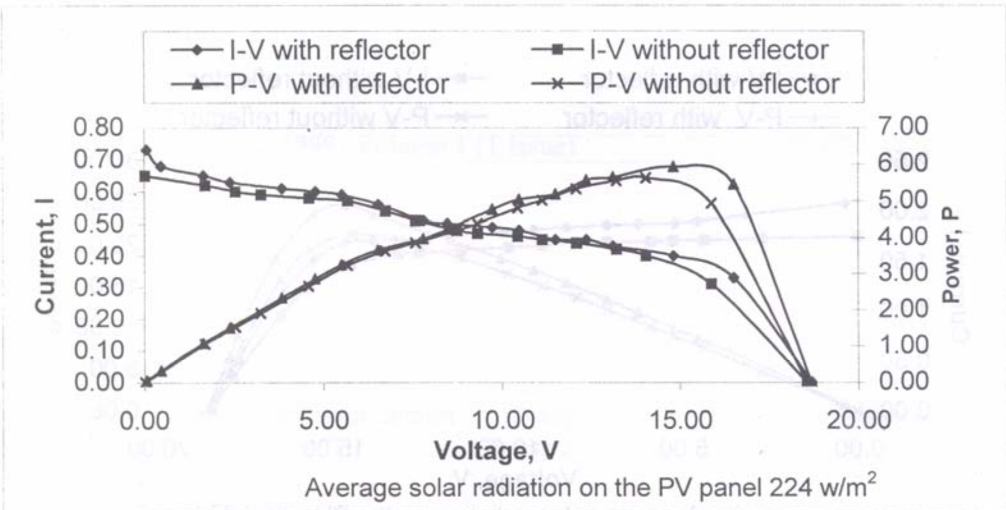

Fig 7. I-V and P-V curves for solar panel with four reflectors (mirror) and without reflector. on 25th October 1999 at 12.04 PM (Sky condition: Clear)

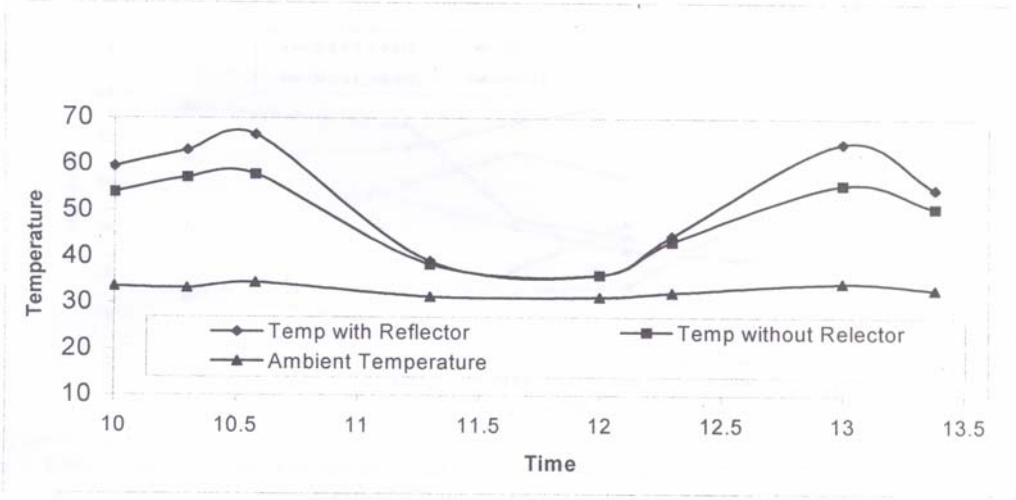

Fig 8. Temperature curve for solar panel with four reflectors (mirror) and without reflector for various time of the day on 25th October, 1998

Conclusion

The experiment and findings presented in the paper was performed for a very limited period of time and it is felt that extensive study is required for finding out the right type of material to act as reflectors for performance enhancement of PV modules.

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