More Efficient Use Of Photovoltaic Solar Panel Using Multiple Fixed Directed Mirrors Or Aluminum Foils Instead Of Solar Trackers In Rural Perspective Of Bangladesh.

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Abstract: The main objective of this paper is to show the potential use of a solar panel using multiple fixed directed mirrors or aluminum foils as a reflector instead of ordinary solar tracker in rural perspective of Bangladesh. The solar panel only receives direct beam of sunlight and diffused sunlight. Experiment shows that if we use reflector (mirror or aluminium foil) to concentrate sunlight onto PV panels, each individual panel receives a lot of additional power. As a result, the number of solar panels needed to produce a certain amount of power can be reduced, and the money spent on ordinary solar trackers which are more expensive than reflectors is saved. This, therefore, is a cost-effective way - which allows solar energy to be more accessible to the rural people of Bangladesh-to generate more amount of solar power with less number of panels and a lower cost. With the help of multimeter we recorded the received power of a photovoltaic solar panel using reflector (mirror or aluminium foil) and without using reflector and compared this for calculating the performance of a panel. The simulation program is created in Matlab. Different assumptions are taken to make the system realistic and to reduce the complexity.

Index Terms: PV Cell, Received Power, Reflector, Solar Power, Solar Tracking, Tilt Angle.

1 Introduction

Bangladesh is a developing country with an acute power crisis. This solar energy is considered a great source for tackling this crisis. But the rural people are not economically solvent enough to use large solar panels to get more electricity for running their everyday needs [6]. Solar panels are installed at a tilt angle of 23° in Bangladesh, though this alignment depends upon the installation's geographic location [5], [7]. These panels are fixed facing south to get adequate sunlight all the year round. During winter season the panel will generate minimum power only from diffused sunlight in the morning and late afternoon since the sunlight falls transversely at that time [7]. So tilt angle of the solar panel should be around 45º to achieve maximum output power during day time in winter [7], [9], [10]. In this paper we have discussed the techniques to increase the light gathering ability of a solar panel in the morning and late afternoon by using multiple fixed directed mirrors or aluminum foil as a reflector instead of ordinary costly tracking system. Here we have shown the comparison graph that depicts how much extra power the panel can add to the system by using mirror or aluminum foil with a minimum cost.

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2 Photovoltaic Solar Cell and Tracking System

Extracting useable electricity from the sun was made possible by the discovery of the photoelectric mechanism and subsequent development of the solar cell [1], [2]. Solar cell is a semi conductive material that converts visible light into a direct current [1], [2], [3].

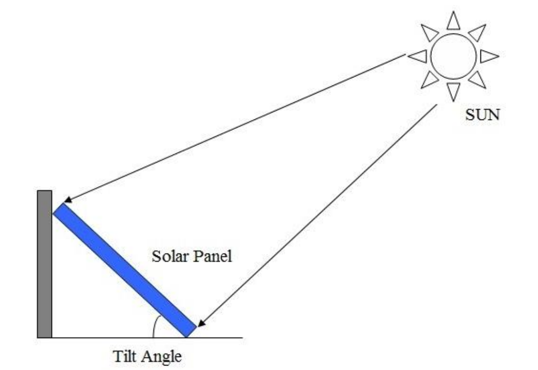

Fig.1. Simple Solar System.

The solar cell works in two steps:

- **I.** Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
- **II.** Electrons (negatively charged) are knocked loose from their atoms, causing an electric potential difference. Electricity starts flowing through the material to cancel the potential and this electricity is captured. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction.

In a solar panel, a series of solar cells are electrically connected; a DC voltage is generated which can be physically used on a load [1]. Solar panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where grid power is not available. This power source is gradually achieving greater popularity despite its higher cost and low conversion efficiency compared with other power sources. So it is necessary to accrue as much energy as possible from a solar power system. This includes reducing inverter losses, storage losses, and light gathering losses. Light gathering is dependent on the angle of incidence of the light source providing power (i.e. the sun) to the solar cell's surface, and the closer to perpendicular, the greater the power. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day the sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is minimum only from diffused sunlight, resulting low output. As the day progresses to midday, the angle of incidence approaches 0°, causing a steady increase in power until at the point where the light incident on the panel is completely perpendicular and the panel receives both diffused and direct sunlight (carrying 90% solar energy), and maximum power is received. As the day continues toward dusk, the reverse happens, and the increasing angle causes the power to decrease again toward minimum [4]. From this background, we see the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible [4]. In this case the only solution is to use a solar tracker. A solar tracker can add additional power but it is very costly for the rural people in Bangladesh and one can buy additional panel with the cost of a solar tracker. Also the amount of power a solar tracker uses in order to track the sun negates much of its benefits.

3 Proposed Model

In Bangladesh the sunlight falls directly in summer and transversely in winter.

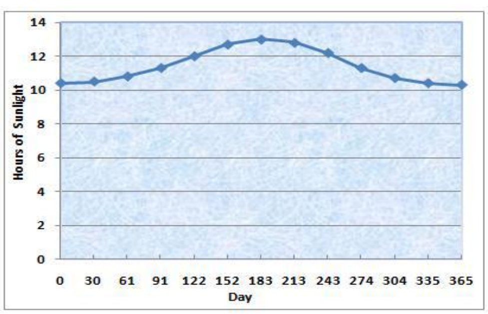

Fig. 2. The number of hours of sunlight in Bangladesh.

In winter the duration of the day is much shorter (shown in Fig. 2) and the incident angle of sunlight is a little bit lower compared with summer and spring seasons [8]. The sun will rise south of East and set at the south of West in any of the day at that time of the year (shown in Fig. 3). So to get maximum sunlight in winter the panel needs to reorient at a tilt angle of around 45º [7], [10]. But some problems arise in the morning and late afternoon when the panel can receive minimum sunlight as the incident angle of sun beam is lower compared with spring and summer seasons. In Fig. 4 we have shown our proposed model which uses curved aluminium foil or mirror as a reflector to concentrate sunlight onto the panel in the morning and late afternoon because at that time the panel only receives diffused sunlight.

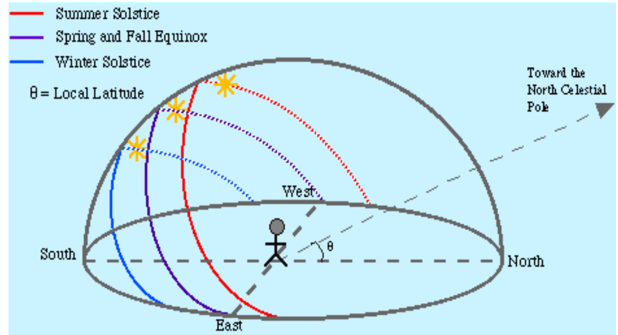

Fig. 3. The sun in the sky in the northern hemisphere.

We know mirror or aluminium foil is a good quality reflector. In our proposed model we have seen these reflectors plays a vital role for achieving a large amount of additional power all over the day especially in the morning and the late afternoon.

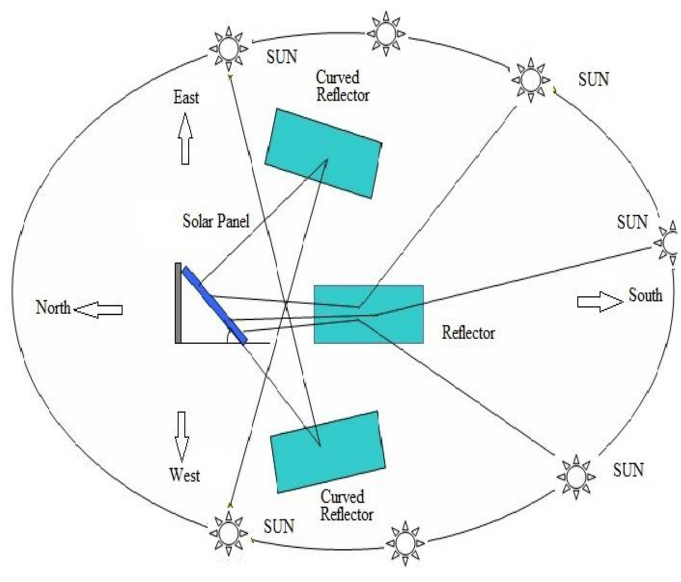

Fig. 4. Proposed model using multiple curved aluminium foil or mirror.

We have also used a fixed aluminium foil during mid day and found some variation of received power in the panel.

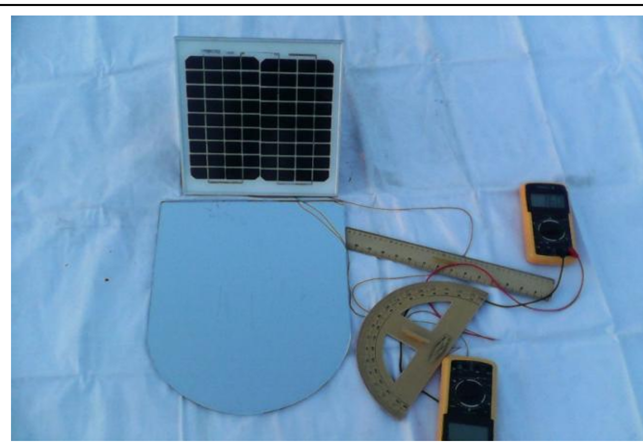

Fig. 5. Equipments used in experiment (Solar Panel, Reflector, Multimeter, etc.)

4 Results and Observation

For the experiment we used a solar panel, which has the following features:

Model No: T-10M, Power Rating: 10 W, Short Circuit Current = 0.61 A

Open Circuit Voltage = 22.5 V, Maximum Power Current = 0.56 A

Maximum Power Voltage = 18 V, Dimension of Panel: 320*290*18mm

Table 1

Received Data of a PV Solar Panel using Mirror as Reflector and without using Reflector.

Time	Open Circuit Voltage (V)		Short Circuit Current (A)		No load Output Power (W)	
	No Mirror	Using Mirror	No Mirror	Using Mirror	No Mirror	Using Mirror
7.00 AM	19.0	19.60	0.052	0.064	0.99	1.25
7.10 AM	19.46	19.75	0.058	0.076	1.13	1.50
8.30 AM	20.0	20.8	0.15	0.30	3.00	6.24
8.40 AM	19.7	20.3	0.21	0.30	4.14	6.09
8.55 AM	20.0	20.6	0.23	0.35	4.60	7.21
9.20 AM	20.1	20.5	0.33	0.52	6.63	10.66
10.30 AM	20.2	20.5	0.40	0.52	8.08	10.66
11.30 AM	19.4	19.5	0.47	0.57	9.12	11.12
1.00 PM	20.2	20.5	0.60	0.67	12.12	13.73
1.10 PM	19.0	19.5	0.60	0.67	11.40	13.06
3.00 PM	20.1	20.4	0.49	0.61	9.65	12.44
4.00 PM	20.5	20.7	0.25	0.47	5.13	9.73
4.10 PM	19.7	20.3	0.27	0.44	5.32	8.93
4.20 PM	19.4	19.9	0.18	0.32	3.49	6.37
4.40 PM	19.3	19.8	0.10	0.18	1.93	3.56
5.00 PM	17.5	19.0	0.09	0.16	1.56	3.04

We placed solar panel towards south at a tilt angle of around 45º and taken data by using multimeter for a week in January 2013 in the same weather and temperature. We used both aluminium foil and mirror as reflector materials to concentrate sunlight onto the panel from the morning to the late afternoon. Using multimeter we took both open circuit voltage and short circuit current and then calculate the power received by the panel.

Power (W) = Open Circuit Voltage (V) * Short Circuit Current (A)

Table 1 shows the variation of current, voltage and power of a photovoltaic solar panel using reflector (mirror) and without using reflector. We took those values from 7.00 AM to 5.00 PM. The solar panel received maximum 13.73 W and minimum 1.25 W using reflector. Table 2 presents the received data of the solar panel using reflector (aluminium foil) and without using reflector. It is observed that in the early morning and late afternoon the panel gives minimum power both by using reflector and without reflector.

Table 2

Received Data of a PV Solar Panel using Aluminium Foil as Reflector and without using Reflector.

Time	Open Circuit Voltage (V)		Short Circuit Current (A)		No load Output Power (W)	
	No Foil	Using Foil	No Foil	Using Foil	No Foil	Using Foil
7.40 AM	19.4	19.7	0.0876	0.1038	1.70	2.04
7.45 AM	19.5	19.8	0.0890	0.1153	1.74	2.28
8.00 AM	19.2	20.0	0.105	0.15	2.02	3.00
8.10 AM	19.5	20.2	0.1145	0.19	2.23	3.84
8.20 AM	19.8	20.2	0.16	0.26	3.17	5.25
9.15 AM	20.1	20.7	0.22	0.45	4.42	9.32
10.30 AM	19.8	20.1	0.42	0.52	8.316	10.45
11.30 AM	19.3	19.5	0.46	0.58	8.88	11.31
1.00 PM	20.2	20.5	0.60	0.67	12.12	13.94
1.10 PM	19.3	19.7	0.61	0.72	11.77	13.15
3.00 PM	19.2	19.6	0.40	0.56	7.68	10.98
4.00 PM	20.0	20.6	0.28	0.46	5.6	9.476
4.10 PM	19.4	19.9	0.25	0.41	4.85	8.16
4.30 PM	19.0	19.5	0.07	0.13	1.33	2.535
4.55 PM	18.5	19.5	0.07	0.15	1.30	2.93
5.15 PM	18.5	19.3	0.05	0.10	0.93	1.93

Also, when partial shading occurred the panel did not get direct beam of sunlight and produced lower output power. This is shown in table 3. But, using mirror we received a maximum variation of power under partial shading. Lastly in Table 4 we have shown the data which compares the output power of a solar panel using reflector (mirror and aluminium foil) and without using reflector.

Table 3

Received Data of PV Solar Panel under Partial Shading.

Time	Open Circuit Voltage (V)		Short Circuit Current (A)		No load Output Power (W)	
	No Mirror	Using Mirror	No Mirror	Using Mirror	No Mirror	Using Mirror
8.05 AM	18.70	19.8	0.052	0.125	0.972	2.475
8.10 AM	18.7	19.8	0.057	0.1292	1.07	2.56
8.15 AM	19.0	19.8	0.0583	0.15	1.11	2.97
8.40 AM	18.4	19.5	0.06	0.14	1.104	2.73
9.00 AM	19.0	19.9	0.0856	0.1812	1.63	3.61
9.10 AM	18.6	19.8	0.08	0.22	1.488	4.356
9.20 AM	18.7	19.7	0.12	0.25	2.244	4.925
9.30 AM	18.4	19.6	0.07	0.25	1.288	4.9

TABLE 4

RECEIVED DATA OF A PV SOLAR PANEL USING REFLECTORS (MIRROR AND ALUMINIUM FOIL) AND WITHOUT USING REFLECTOR.

Time	Open Circuit Voltage (V)		Short Circuit Current (A)		No load Output Power (W)		
	Using Mirror	Using Foil	Using Mirror	Using Foil	No Mirror or Foil	Using Mirror	Using Foil
8.00 AM	20.9	21.0	0.39	0.40	3.50	8.15	8.40
8.15 AM	20.6	20.7	0.44	0.45	4.42	9.06	9.32
8.30 AM	20.7	20.6	0.60	0.60	9.64	12.42	12.36
10.30 AM	20.5	20.1	0.53	0.57	8.48	10.87	11.46
11.30 AM	19.6	19.6	0.59	0.59	9.31	11.56	11.56
1.00 PM	20.5	19.7	0.73	0.75	13.13	14.97	14.78
1.10 PM	19.5	20.5	0.74	0.67	12.73	14.43	13.74
4.00 PM	20.7	20.6	0.47	0.46	5.13	9.73	9.476
4.10 PM	20.3	19.9	0.44	0.41	5.32	8.93	8.16
4.30 PM	19.3	19.5	0.11	0.13	1.52	2.13	2.535

5 DISCUSSION

It is found in Fig. 6 that solar panel using aluminium foil as reflector gives some extra power in the early morning and it is gradually increased at around 9.20 am. At that time panel received additional 4.03 W using aluminium foil as a reflector. If we consider 10 hours' period from 7.00 AM to 5.00 PM, the panel without using reflector receives average power of 4.87 W which is 48.7% of the panel power. Whereas using reflector (Aluminium foil) the panel receives average power of 6.9 W which is 69% of the panel power. So the panel receives extra 20.3% power using aluminium foil as a reflector. In Fig. 7, the panel receives 55% without using reflector and 78% using reflector (mirror) of the panel capacity.

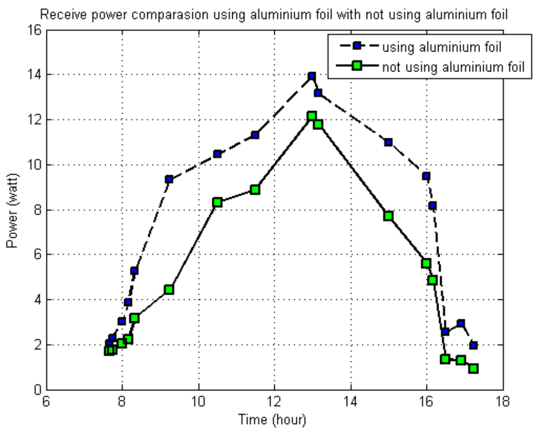

Fig. 6. Receive power comparison using reflector (aluminium foil) and without using reflector.

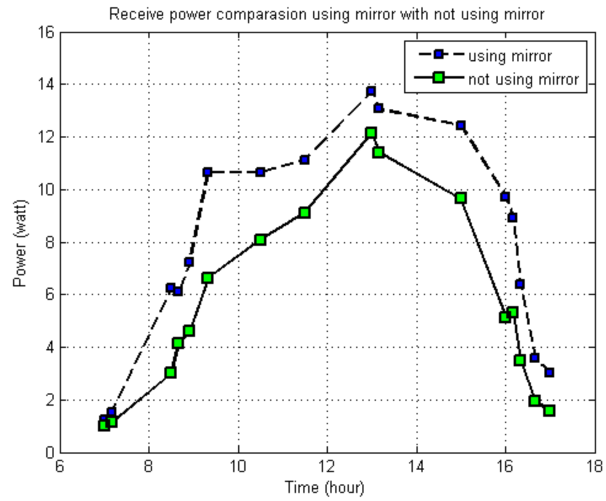

Fig. 7. Receive power comparison using reflector (mirror) and without using reflector.

A large variation of power when the panel is in partial shading is shown in Fig. 8. At that time the reflector concentrate beam of sunlight to the panel and panel receives a lot of power without line-of-sight of the sunlight.

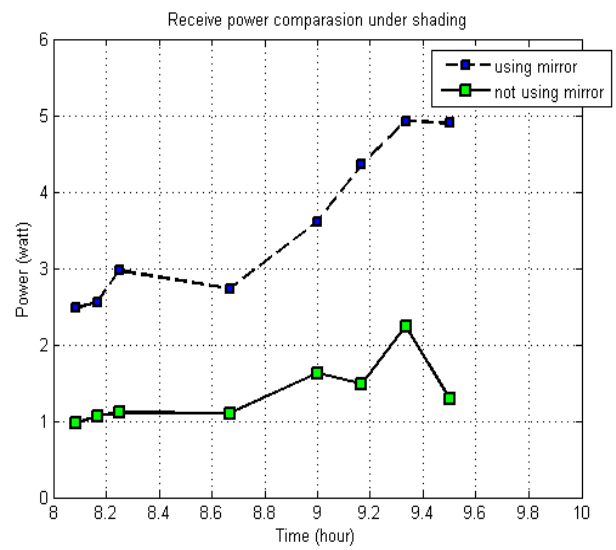

Fig. 8. Receive power comparison under partial shading.

The received power comparison using reflector (mirror and aluminium foil) and without using reflector is shown in Fig. 9. We observe that using both reflectors the panel receives approximately same amount of average power (Mirror 10.22 W, Aluminium foil 10.18 W) for 8.5 hours' period.

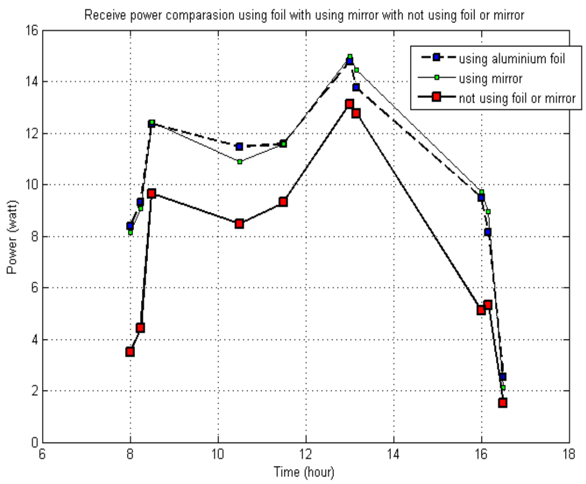

Fig. 9. Receive power comparison among mirror, aluminium foil and without using reflector.

6 Conclusion

From the simulation of the received power comparison using reflector and without using reflector; we can conclude that reflector plays a vital role in a solar power system. Photovoltaic solar panel using reflectors increases received power efficiency all day long specially in the morning and late afternoon. Using this technique the rural people can efficiently use their solar panel all the year round especially during winter.

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