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Efficiency Improvement of Solar Modules Using Mirror Technique

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Abstract— This paper is solely dedicated to enquire enhancement of optimum exploitation of solar generator plates by arrangement of providing extra light intensity on panel through mirror reflection and solar tracker. we can generate more solar energy by using mirror reflection including solar tracking. The improvement of the output power using plane mirror reflector very cheap and are easily available in market in variety. The average power output during mid-day as increased substantially using mirrorsand solar tracker, the solar panels equipped with such mirrors can also be utilized for loads/equipment's requiring higher power input during that period of the day.

KEYWORDS—Solar plates, Mirrors, solar panel angle, optical tilt angle, solar tracker

1. INTRODUCTION

The paper aims at developing more power using mirrors to harvest more of the incident solar irradiance and direct sunlight to qualified PV modules increases the electricity produced from a given area of PV panels. We are using mirror arrangement at one sides of solar panel for increasing it's power efficiency.

1.1 SOLAR ENERGY

Solar energy is vast renewable energy source from the sun's radiation. The sun is an powerful source of energy provides much possibility to enhance power pouring with arrangement of supports to generate more and more. India is country with diverse climate throughoutyear provincewise. In our view Rajasthan is state with clear sunny 300 to 330 days throughout year, which determines the best environment to produce solar power more and more. It is important that we continue to harness and increase our use of solar energy. One solution to make solar energy more competitive is to combine reflectors with the PV modules along with solar tracker in the system. Using solar mirrors to harvest more of the incident solar irradiance and direct sunlight to qualified PV modules increases the electricity produced from a given area of PV panels.

1.2 SOLAR CELL

Solarphotovoltaic (PV) panels convert the sun's rays into electricity by exciting electrons in silicon cells using the photons of light from the sun. A solar cell is an electronic device

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that produces electricity when light falls on it. The light is absorbed and the cell produces dc voltage and current. The device has a positive and a negative contact between which the voltage is generated and through which the current can flow.

1.3 SOLAR PANEL ANGLE

Solar panel angle will be different for everywhere as per the movement of sun on its

Fig. 1 Solar Panel

path. Solar panels give the highest energy output when they are directly facing the sun. The sun moves across the sky and output will be low or high depending on the time of the day and the season. For that reason, the ideal angle is never fixed.conventional understanding is that the solar panel facing south in location north of the equator) will receive the most sunlight and according to new study from pecan street research institute, west facing rooftop solar panels produced 49% more electricity during peak demand compare to south facing panels.To get the most sun reaching the panel throughout the day, we need to determine what direction the panels should face and calculate an optimal tilt angle.

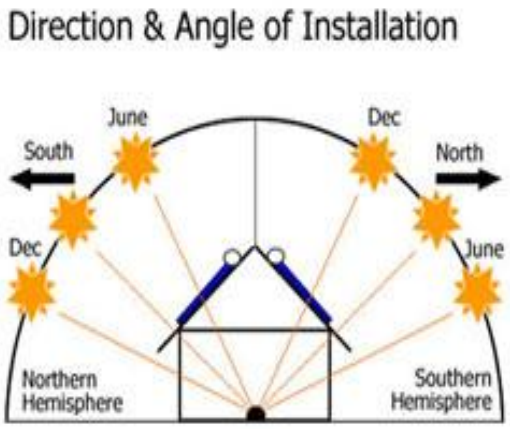

Fig.2 Solar Panel Angle

2. OPTIMAL SOLAR PANEL ANGLE

As a rule of thumb, solar panels should be more vertical during winter to gain most of the low winter sun, and more tilted during summer to maximize the output.The optimum tilt angle during summer is calculated by (latitude - 15) and during winter (latitude + 15).For instance, if Rajasthan latitude is 27°, the optimum tilt angle for your solar panels during winter will be 27+ 15 = 42°.The summer optimum tilt angle on the other hand will be 27 – 15 = 12°.to get better result during winter is calculated by multiplying the latitude by 0.9 and then adding 29°. In view of Rajasthan, latitude of 27°, the tilt angle will be (27 * 0.9) + 29 = 53.3°. This angle is 10° steeper than in the general method but very effective at tapping the midday sun which is the hottest in the short winter days.

3. MIRRORREFLECTION

Mirror helps to increase voltage using reflection technique of rays. Mirror reflects rays when solar panel is not able to tack energy from sun because of that we collect large output voltage from solar panel because of mirror reflections. The Sun is a distant object, so the rays coming from it are parallel to the principal axis and are incident on a

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concave mirror. Then after reflection, they converge to a single point.In Fig. 3 we haveshown our proposed model which uses curved Mirror as a reflector to concentrate sunlight onto the panelin the morning to evening.

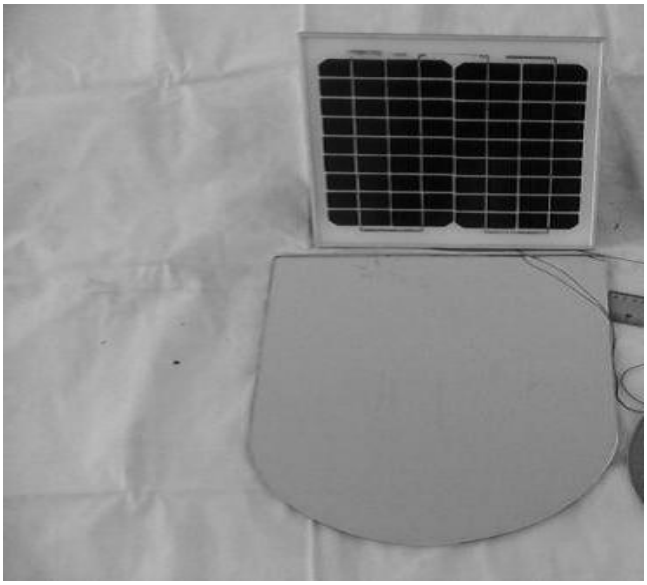

Fig. 3 Equipment used in experiment
(Solar Panel,Reflector,)

We know that a decent quality reflector is a mirror or aluminium foil. These reflectors play a critical role in our suggested approach for achieving a considerable quantity of additional electricity throughout the day, particularly in the early and late afternoon.For the experiment we used a solar panel, which has the following features:

Table: 1Data Sheet of the Solar Panel

S. No	**Features**	**Ratting**
1	Power (Pmax)	130watt
2	Open circuit voltage(Voc)	21.40 volt
3	Short circuit current (Isc)	5.30 amp
4	Current at maximum power(Ipm)	7.70-Amp
4	Voltage at Maximum Power(Vpm)	17.70
5	Tolerance	+-5%
6	Dimension (mm)	600*800

At the peak period, the solar panel's Pmax power is rated at 130 watt, as indicated in Table 1. At no load, the open circuit voltage is 21.40 volts, and the short circuit current is 5.30 amps, with a tolerance of +-5 percent of the solar panel's total capacity.On the whole, we can see that there are numerous opportunities to improve the efficiency of solar energy, i.e. the sun's radiation on the planet. In light of Rajasthan, we are confident that we can create more by combining certain technologies with solar panels and technical data, such as improving the capture of sun rays using mirror techniques. All readings were taken in April of 2020.

Table-2:Open Circuit Voltage Measured for 100-Watt PV Solar Panel with and without Using Mirror as Reflector.

Time	**Open Circuit Voltage (Voc)**	
	Without Mirror	**With Mirror**
07:00 AM	17.20	17.40
07:30 AM	17.80	17.90
08:00 AM	18.60	18.80
08:30 AM	19.50	19.90
09:00 AM	20.50	21.00
09:30 AM	20.70	21.10
10:00 AM	20.70	21.10
10:30 AM	21.00	21.20
11:00 AM	21.00	21.20
11:30 AM	21.10	21.30
12:00	21.10	21.30

12:30 PM	21.10	21.30
01:00 PM	20.60	21.20
01:30 PM	20.20	21.00
02:00 PM	20.00	20.80
02:30 PM	20.00	20.80
03:00 PM	19.80	20.60
03:30 PM	19.50	20.50
04:00 PM	19.30	19.90
04:30 PM	19.00	19.40
05:00 PM	18.50	18.90
05:30 PM	18.10	18.70
06:00 PM	17.6	18.00

We placed solar panel towards south at a tilt angle of around 45º and taken data by using clamp meter for a a day in April 2020. We usedmirror as reflector materials to concentrate sunlight onto the panel from the morning to the late afternoon. Using clamp meter we took both open circuit voltage and short circuit current and then calculate the power received by the panel.

$$Pmax = Voc*Isc$$

Table 2 shows the voltage variations of a photovoltaic solar panel with and without a reflector (mirror). Those values were taken from 7:00 a.m. to 6:00 p.m., with a half-hour interwall. Without a mirror, the solar panel generates a maximum voltage of 21.10 volts and a minimum value of 17.20 volts. With the mirror, the solar panel generates a maximum voltage of 21.30 volts and a minimum value of 17.40 volts. Early in the morning and late in the evening, the panel produces the least amount of power, whether with or without a reflector. It's also worth noting that the mirror reflector improves the voltage level of the Voc.

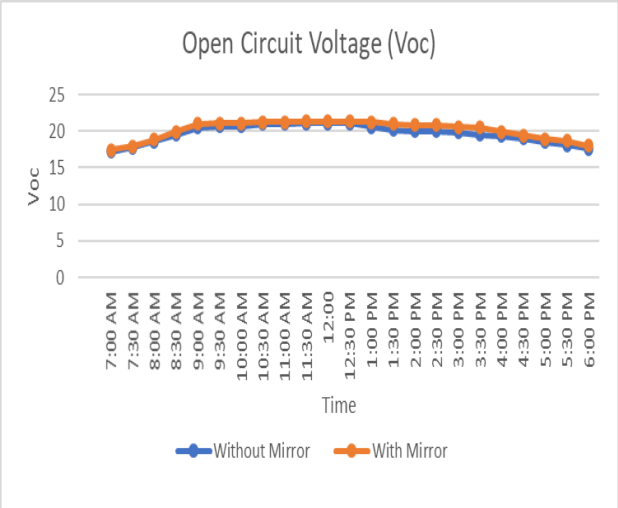

Fig. 4 Open Circuit Voltage(Voc) with and Without Mirror

Fig. 4 showing graph between open circuit voltage without mirror and with mirror. reflector.It is found that solar panel using mirror as reflector gives some extra power in the early morning and itis gradually increased at around 9.20 am.

Table-3:Short circuit current Measured for 100-Watt PV Solar Panel with and without Using Mirror as Reflector.

Time	Short Circuit Current (Isc)	
	Without Mirror	With Mirror
07:00 AM	00.10	00.30
07:30 AM	00.30	00.60
08:00 AM	01.10	01.40
08:30 AM	01.40	01.70
09:00 AM	01.90	02.10
09:30 AM	02.20	02.50
10:00 AM	02.80	03.10
10:30 AM	03.10	03.50
11:00 AM	03.60	03.90
11:30 AM	04.20	04.40
12:00	04.80	05.20
12:30 PM	05.00	05.40
01:00 PM	05.20	05.60

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01:30 PM	05.40	05.70
02:00 PM	05.20	05.60
02:30 PM	05.00	05.40
03:00 PM	04.80	05.20
03:30 PM	03.80	04.10
04:00 PM	03.20	03.70
04:30 PM	02.10	02.60
05:00 PM	01.30	01.40
05:30 PM	00.80	00.90
06:00 PM	00.11	00.10

Table 3 shows the current variations of a photovoltaic solar panel with and without a reflector (mirror). Those values were taken from 7:00 a.m. to 6:00 p.m., with a half-hour interwall. Without a mirror, the solar panel generates a maximum current of 5.40amp and a minimum value of 0.10 amp.With the mirror, the solar panel generates a maximum current of 5.70 amp and a minimum value of .10amp.

Fig. 5 showing graph between short circuit current with respect of time, without mirror and with mirror. reflector. It is found that solar panel using mirror as reflector gives some extra power.

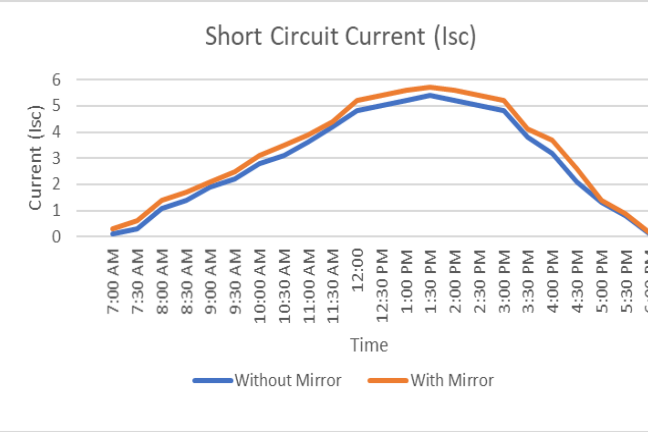

Fig. 5 Short Circuit Current (Isc) with and Without Mirror

Table-4:Power output without Measured for 100 Watt PV Solar Panel without Using Mirror as Reflector.

	Without Mirror Power Output in Watt		
Time	**Voc Without Mirror**	**Isc without Mirror**	**Power in Watt (P)**
7:00 AM	17.2	0.1	1.72
7:30 AM	17.8	0.3	5.34
8:00 AM	18.6	1.1	20.46
8:30 AM	19.5	1.4	27.30
9:00 AM	20.5	1.9	38.95
9:30 AM	20.7	2.2	45.54
10:00 AM	20.7	2.8	57.96
10:30 AM	21	3.1	65.10
11:00 AM	21	3.6	75.60
11:30 AM	21.1	4.2	88.62
12:00	21.1	4.8	101.28
12:30 PM	21.1	5	105.50
1:00 PM	20.6	5.2	107.12
1:30 PM	20.2	5.4	109.08
2:00 PM	20	5.2	104.00
2:30 PM	20	5	100.00
3:00 PM	19.8	4.8	95.04
3:30 PM	19.5	3.8	74.10
4:00 PM	19.3	3.2	61.76
4:30 PM	19	2.1	39.90
5:00 PM	18.5	1.3	24.05
5:30 PM	18.1	0.8	14.48
6:00 PM	17.6	0.11	1.94

Table4 shows the power output of a photovoltaic solar panel without a reflector (mirror). Those values were taken from 7:00 a.m. to 6:00 p.m., with a half-hour interwall. Without a mirror, the solar panel generates a maximum power 109.08 watt at 1:30Pm.

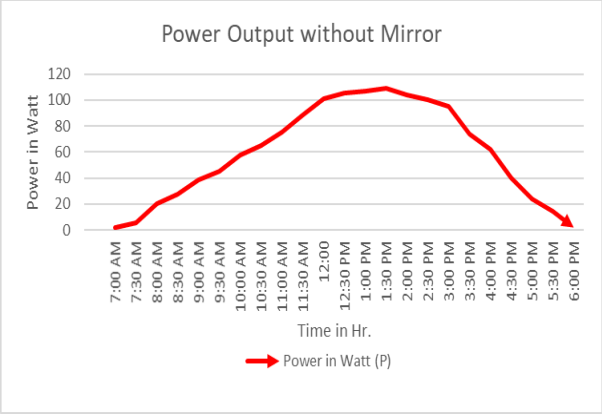

Fig. 6Power output of solar module without Mirror

Fig. 6 showing graph between Time and power output of the solar panel without mirror reflector. It is found that solar panel using mirror as reflector gives maximum power output at the time of 1:30 PM.

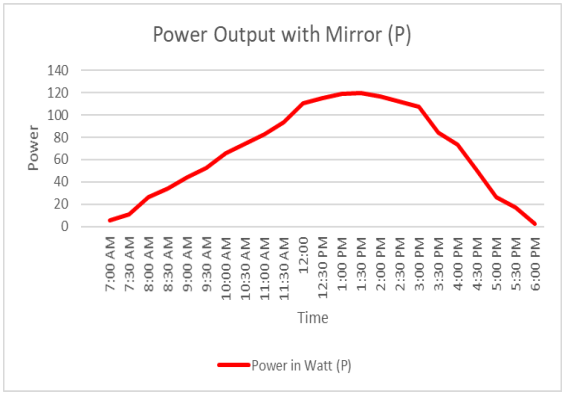

Fig. 7 Power output of solar module with Mirror

Fig. 7 showing graph between Time and power output of the solar panel with mirror reflector. It is found that solar panel using mirror as reflector gives maximum power output at the time of 1:30 PM.

Table-5: Power output Measured for 100-Watt PV Solar Panel with Using Mirror as Reflector.

	Power Output in WattWith Mirror Technique		
Time	**Voc With Mirror**	**Isc with Mirror**	**Power in Watt (P)**
7:00 AM	17.4	0.3	5.2
7:30 AM	17.9	0.6	10.7
8:00 AM	18.8	1.4	26.3
8:30 AM	19.9	1.7	33.8
9:00 AM	21	2.1	44.1
9:30 AM	21.1	2.5	52.8
10:00 AM	21.1	3.1	65.4
10:30 AM	21.2	3.5	74.2
11:00 AM	21.2	3.9	82.7
11:30 AM	21.3	4.4	93.7
12:00	21.3	5.2	110.8
12:30 PM	21.3	5.4	115.0
1:00 PM	21.2	5.6	118.7
1:30 PM	21	5.7	119.7
2:00 PM	20.8	5.6	116.5
2:30 PM	20.8	5.4	112.3
3:00 PM	20.6	5.2	107.1
3:30 PM	20.5	4.1	84.1
4:00 PM	19.9	3.7	73.6
4:30 PM	19.4	2.6	50.4
5:00 PM	18.9	1.4	26.5
5:30 PM	18.7	0.9	16.8
6:00 PM	18	0.1	1.8

Table5shows the power output of a photovoltaic solar panel with a reflector (mirror). Those values were taken from 7:00 a.m. to 6:00 p.m., with a half-hour interwall. With a mirror, the solar panel generates a maximum power 119.7 wattat 1:30Pm.

Table-6: Power output Measured for 100-Watt PV Solar Panel with and without Using Mirror as Reflector.

	Power Output Comparison with and Without Mirror Technique in (Watt)		
Time	**Power Without Mirror**	**Power With Mirror**	**Power Difference**
7:00 AM	1.72	5.2	3.5
7:30 AM	5.34	10.7	5.4
8:00 AM	20.46	26.3	5.9
8:30 AM	27.30	33.8	6.5
9:00 AM	38.95	44.1	5.2
9:30 AM	45.54	52.8	7.2
10:00 AM	57.96	65.4	7.5
10:30 AM	65.10	74.2	9.1
11:00 AM	75.60	82.7	7.1
11:30 AM	88.62	93.7	5.1
12:00	101.28	110.8	9.5
12:30 PM	105.50	115.0	9.5
1:00 PM	107.12	118.7	11.6
1:30 PM	109.08	119.7	10.6
2:00 PM	104.00	116.5	12.5
2:30 PM	100.00	112.3	12.3
3:00 PM	95.04	107.1	12.1
3:30 PM	74.10	84.1	10.0
4:00 PM	61.76	73.6	11.9
4:30 PM	39.90	50.4	10.5
5:00 PM	24.05	26.5	2.4
5:30 PM	14.48	16.8	2.4
6:00 PM	1.94	2.3	0.4

Table6shows the power output variation of a photovoltaic solar panel with andwithout a reflector (mirror). efficiency of the solar panel is improved due to the mirror reflector. A maximum power output received at time of 1:30 Pm from both systems. Solar module generates the maximum power 109.08 watt without mirror techniques while with mirror itgenerates the 119.7 Watt. Those values were taken from 7:00 a.m. to 6:00 p.m., with a half-hour interwall.

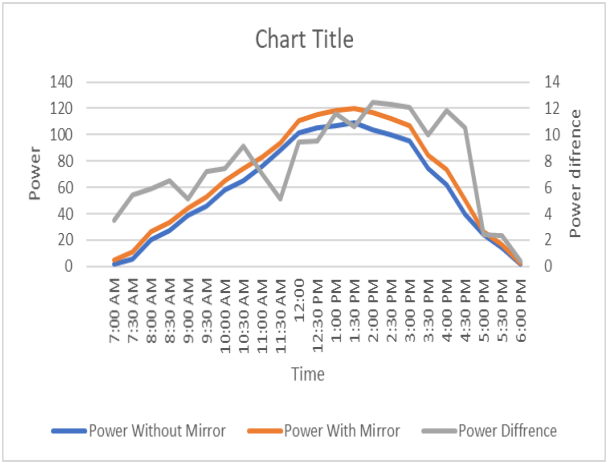

Fig. 8 Power output comparison with and without Mirror

Fig. 8 showing graph between Time and power output of the solar panel without and with mirror reflector. It is found that solar panel using mirror as

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reflector gives maximum power output at the time of 1:30 PM.

Conclusion: Solar power is an environmentally beneficial, long-lasting source of energy; photovoltaic cells are one medium for generating electricity that is expensive at first but can be covered by a financial arrangement. However, this technology's primary cost is still greater than nuclear, thermal, or wind power. Adding techniques in solar power stations, such as combining reflectors with PV panels to gather more light from the modules, can make this less expensive. According to the optical analysis, the power output of the mirror reflector system is higher than the power output of the system without the mirror.

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