Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 14, Issue 3, 2014
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFECT OF REFLECTOR APPLICATION ON PV PANEL PERFORMANCE UNDER EGYPTIAN CONDITIONS

Mamdouh Abbas HELMY[1], E. M. KHALIFA[2], A. M. OKSHA[3], A. W. ELHADDAD[4]

[1]Modern University for Technology and Information, Cairo, Faculty of Agriculture, Center of Training and continuing Education, Egypt. Phone: 002-01122357007, Fax. : 002-02-27272148,Email:prof_mamdouh@hotmail.com
[2,3] Kafrelsheikh University, Faculty of Agriculture, Agricultural Engineering Department, Egypt
[4]Agricultural Engineering Research Institute, Giza, Egypt

Corresponding author: prof_mamdouh@hotmail.com

Abstract

The proposed approach in the present study is to employ a mirror augmented PV solar panel to track the sun and reflect rays on to the PV panel. Its performance was compared with same PV module without reflector under the same environmental conditions. The mirror augmented solar PV panel tracked sun from East to West along the daytime in Winter 2011 with tilt angle0.523 rad (30 deg) for panel and 0.122 rad (7deg) for mirror which are estimated by experiment. The average energy output values of 1.11 and 0.95 kWh/day were recorded for panel with and without mirror, respectively. The average daily η_{panel} values of 12.6 and 11.02 % were recorded for panel with and without mirror, respectively. The increase percentages in the output of panel and discharge differs with the solar radiation along daytime. The application of mirror is an efficient and an effective way to enhance the performance of solar photovoltaic pumping system with the same panel area.

Key words**:** *Egyptian conditions, performance, pv panel, reflector application*

INTRODUCTION

Egypt has a high potential of solar energy, which can be considered as a reliable energy source even during the winter season. It lies within the subtropical regain. The annual daily average of solar radiation intensity during winter is about 7kW/ (m^2 .day) and the measured annual daily sunshine duration amounts to approximately llh [4].
Photovolatic (PV) water pumping has become a widely adopted solar energy technology in the last two decades [1].
Achieving low cost solar electricity is the driving force behind the research and development in photovoltaic technology. Research is in progress in different fields like material, manufacturing process to make effective photovoltaics [2].The proposed approach is to use a tracking flat mirror to continuously track the sun and reflect the solar radiation on a tracking PV panel. The solar tracking reflective mirror will increase the incident solar radiation. Thus increased solar radiation will improve the total output of the PV panel and the free discharge of the submersible pump.
The present investigation aims to determine the outputs of the PV module and the volume of pumped water with and without the application of mirror under Egyptian conditions.

MATERIALS AND METHODS

Experiments were performed in Meet Eldeeba, Kafresheikh Governorate, Rice Mechanization Center, Egypt which lies at latitude 31.07^0N and longitude 30.57^0E during Winter 2011.
Augmented device to reflect solar radiation on the PV modules:
The material of the reflector was a flat mirror to reflect the sunlight on the modules.
The PV array has a capacity of 140 peak Watt. The photovoltaic panel is following the sun's track from its rising in the East to its setting in the West. Panel and mirror were moved until the index has no shadow around. Therefore, the output power was the highest

one. Panel tilt angle is 0.523 rad (30 deg) and mirror tilt angle is 0.122 rad (7deg).

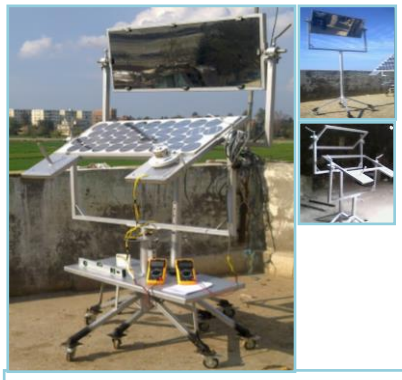

Fig. 1: Augmented device to reflect solar radiation on the PV modules.

The experiments were divided to five processes as follows: 1) Panel tilted at suitable tilt angle [0.549 rad (20deg) in Summer and 0.872 rad (50deg) in Winter] and the panel tracking sun from East to West along day time. 2) Panel tilted at 0.523 rad (30deg) [latitude angle] and the panel tracking sun from East to West along day time. 3) Panel tilted at suitable tilt angle [0.349 rad (20deg) in Summer and 0.872 rad (50deg) in Winter] and panel was oriented toward south along day time. 4) Panel tilted at 0.523 rad (30deg) [latitude angle] and panel was oriented toward South along day time.5) Panel positioned horizontally along day time.

The insolation to the PV array(P_{in})was calculated by using the following equation [3]:

$P_{in} = I_{ns} \times a$, W ……1

Where:

I_{ns} = insolation, W/m^2, and a = solar module area, m^2

The DC output power (P_{output}) from the PV array is given by:

$P_{output} = V_{oc} \times I_{sc}$, W …… 2

Where:

V_{oc} = open circuit voltage, Volt and

I_{sc} = short circuit current, Amp.

The panel efficiency was calculated by using the following equation:

$$\eta_{panel} = \frac{P_{max}}{P_{in}} = \frac{V_{oc} \times I_{sc} \times FF}{I_{ns} \times a} \times 100 \quad \text{.....3}$$

Where:

η_{panel} = panel efficiency,% and

FF = fill factor which equals about 0.67 for silicon.

The gain in collected radiation and output electric power due to the application of reflector (mirror) as compared with the gain without reflector can be obtained by using the following relation:

$$\text{Benefit Ratio of Power (BRP)} = \frac{P\ (with\ reflector)}{P\ (without\ reflector)} \quad \text{..... 4}$$

Where:

P = output electric power, W.

RESULTS AND DISCUSSIONS

Effect of stationary reflector on the efficiency and temperature of the photovoltaic panel:

Table 1.Performance parameters of the panel at different levels of solar radiation and constant panel temperature of 303.15K(30 ^oC.)

Radiation, W/m^2	I_{SC}, Amp.	V_{OC}, Volt	Power, W	η_{panel}, %
200	1.53	19.1	29.223	11.75
314.29	2.4	19.5	46.8	11.97
571.43	4.35	19.7	85.695	12.06
730.85	5.22	19.9	103.878	12.44
911.39	6.42	19.95	128.079	12.76

From Tables 1 and 2, panel performance affect positively by incident solar radiation but affect negatively by panel temperature.

Table 2. Performance parameters of the panel at different panel temperatures and constant solar radiation of 557.14 W/m^2

$T_{panel, k}$ (°C)	I_{SC}, Amp.	V_{OC}, Volt	Power, W	η_{npanel}, %
300.15(27)	4.31	19.7	84.9	12.25
304.15(31)	3.8	19.6	74.48	12.15
320.15(47)	3.73	18.73	69.86	10.08

With the application of reflector on the

photovoltaic panel the incident, the actual effect is the increase in the amount of solar radiation on the panel surface. Consequently, temperature of the panel increased with the application of the reflector due to extra solar radiation. Therefore, it is necessary to evaluate if the power and efficiency of the panel increased with application of reflector.

From Table 3, it is clear that the performance of the panel improved by the application of the reflector.

Table 3. Performance indicators of the panel at different solar radiation values due to the application of reflector in Winter 2011.

Processes		1	2	3	4	5
Average	Radiation,W/m²	135.714	504.761	729.428	803.809	878.928
ISC, Amp.	With out reflector	1.290	3.610	5.128	5.657	5.968
ISC, Amp.	with reflector	1.290	3.763	5.504	6.360	7.365
VOC , Volt	With out reflector	19.000	19.666	19.814	19.880	19.915
VOC , Volt	with reflector	19.000	19.777	19.914	19.943	19.983
Power, W	With out reflector	24.510	71.068	101.610	112.456	118.847
Power, W	with reflector	24.510	74.497	109.610	126.840	147.174
ηpanel , %	With out reflector	14.520	11.349	11.208	11.248	10.948
ηpanel , %	with reflector	14.520	11.885	12.099	12.686	13.558
Improvement	ηpanel , %	0.000	4.723	7.947	12.786	23.839

The effect of reflector on the performance of the panel can be divided into five groups according to different values of solar radiation as shown in Table 3. Also, it can be seen in Table 3 that the percentage of improvement efficiency differs according to different values of solar radiation. When the average radiation value (R) was $\leq$ 35.714W/m², there was no improvement efficiency (η panel). When average R values were 504.701, 729.428, 803.809 and 878.928 W/m², the average η panel values were 4.723, 7.947, 12.786 and 23.839%, respectively. Thus, the positive effect of increase of solar radiation on the panel efficiency (η panel) is more than the negative effect. This is due to the increase in panel temperature (T panel).

CONCLUSIONS

The averaged energy output values of 1.11 and 0.95 kWh/day were recorded for panel with and without mirror. The average daily η_{panel} values of 12.6 and 11.02 % were recorded for panel with and without mirror, respectively. Benefit Ratio of Power (BRP) due to the application of mirror was 1.32. The optimum tilt angles for using mirror with panel were 0.523 rad (30deg) for panel and 0.122rad (7deg) for mirror. The application of mirror is an efficient and effective way to enhance and improve the performance of solar photovoltaic panel.

ACKNOWLEDGMENTS

The authors wish express their thanks to Mr.Gamal Abou El-Hadeed for his contribution in correcting the present investigation to be in proper form for publication.

REFERENCES

[1]Awady, M.N., Sallam, M.F.A., Hegazi, A.M., 2002, Performance of solar powered dirp irrigation system. Misr J.Ag.Eng., 19(2): 297-312

[2]Badescu, V., 2003, Time dependent model of a complex PV water pumping system. Renewable Energy, 28: 543–560

[3]Hamza,A.A., Taha, A.Z., 1995, Performance of submersible PV solar pumping system under conditions

in the Sudan. Renewable Energy, 6(5):491-495
[4] Moharam,A.F.A., 1993, Utilization of solar energy for irrigation and its evaluation. Unpublished M.Sc. Thesis. Ag.Eng.Dept., Fac of Ag.,Ain Shams Univ., Cairo, Egypt