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Efficiency and Performance Improvement Via Using Optical Reflectors of On-Grid CIGS PV Solar System

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Efficiency and Performance Improvement Via Using Optical Reflectors of On-Grid CIGS PV Solar System

Abstract

CIGS PV solar module is a thin film technology (second generation) that is fabricated from Copper-Indium Gallium Selenide. CIGS an abbreviation of Copper-Indium Gallium Selenide. The system, with which reflectors are incorporated, is 5kWp On-Grid CIGS PV Solar system is located at Al Mansour company, Iraq-Baghdad (latitude 33.3°N, longitude 44.4°E and 41m above the sea level). This study improves performance ratio, array efficiency, electrical power and current. All these improvements are done via increasing solar irradiance by using optical reflectors (fabricates from aluminum metal). The maximum values (at 12:00PM) of the improved and reference performance ratio, power, current and efficiency are 99% and 76.20%,1.959W and 1.508W, 5.145A and 3.9A, 15% and 11.60% respectively, while the maximum value of solar irradiance and panel temperature for improved and reference systems at 12:00 PM are 1118.9 W/m^2 and 844.8 W/m^2 ,64^{O}C and 58 ^{O}C respectively where the air temperature is 37^{O}C. The minimum value (at 6:00 PM) of the improved and reference performance ratio, power, current and efficiency are 9%and 8.80%, 0.179W and 0.173W, 0.189A and 0.184A, and 1.40% and 1.30%, while the solar irradiance and panel temperature for improved and reference systems at 6:00 PM are 93W/m^2 and 90.8 W/m^2 , 36 ^{O}C and 35.8 ^{O}C. The maximum values of gains (at 12:00PM) for performance ratio, power, current and efficiency, solar irradiance and panel temperature are 22.8%, 30%, 31.9%, 3.4%, 32.4% and 6^{O}C. The current study is achieved under clear sky conditions. The novelty in current study is that the improved part performance is 99% which is very close to the standard performance that is 100%, where the reference part performance is 76.2%.

Keywords

Grid- tied, CIGS, PV system, performance, Reflector

Cover Page Footnote

All the authors are grateful to AL-Mansour Factory/AL-Zawraa Company and Training & Energy Research Office / Ministry of Electricity as well as Mustansiriyah University for their great efforts in supporting the implementation of this work.

1. Introduction

Solar energy is a friendly-environment energy, which can be used to achieve worldwide energy needs. The energy demands are increasing while the fossil fuel resources, which dominate most traditional energy systems, are limited and forecast to become less quantity and more expensive in future [1]. The fossil fuels cause many effects on the environment such as acid rain, air pollutants, ozone layer depletion, reduction of air quality, greenhouse effect, pollution of underground and surface waters. The greenhouse effect (global warming) represents the main factor that infects the environment caused by the increase of CO_2 emitted into the air. The main source of CO_2 gas emission is fossil fuel combustion. Presently the maximum power consumption around the world at any given moment is 12.5 TW and it is (see Table 1)

Expected by 2030, the world will require 16.9 TW [2], in the same time using PV array reduces the amount of CO_2 emission more than 100 giga-tonnes [3]. The Concentrator Solar Photovoltaic (CPV) cell material contributes about 50%−60% of total cost of commercial PV module [4]. The application of solar energy is traditionally distributed into two types; solar thermal energy and solar photovoltaic (electric). The solar thermal energy field involves the application of converting solar radiation to useful heating, such as domestic solar heating by solar collectors and solar water heating, while the PV solar applications include the street lighting, traffic signals and Water Pumping etc. [5].

Previous work investigates the application of planar reflectors for both solar thermal and photovoltaic applications. Much of the early work on planar concentration focuses on the improvement of winter time yields for solar systems [6,7]. Some studies find that the optimal orientation for this at high latitudes is a vertical collector with a horizontal reflector [8]. A large group of works use several ray tracing models to calculate the increase in solar irradiation from a given reflector geometry [9]. In 2007, experiments work on Mumbai, India, are carried out by Sangani and Solanki. The CPV system type V-trough system with geometric concentration ratio of (2-sun), raise the power output to 44% compared with PV plane-plate (reference) system for passively cooled modules [10]. In 2009, reflectors of many different materials are fixed to high and down edges of PV module to study the solar PV module performance of different metal materials. The best type of reflector's material can yield more electrical energy. Experiments are carried out on aluminum; stainless steel and chrome film reflectors to set the highest efficient type of reflector's material that produce more PV power and less excess heat. When the reflectors are fabricated and tested, it is found that the chrome reflectors produce 27.65% extra PV power output compared to aluminum foil reflector and 34.05% more PV power output compared to stainless steel reflectors [11]. PV/T system with reflectors for solar radiation of 950 W/m^2 and water mass flow rate of 0.042 kg/s, the result through heat exchanger with reflectors shows that combined electrical and thermally efficiency are 71.40% with PV electrical efficiency that is 12.40% [12]. In 2015 (Pavlov et al.) states that the use of fixed planar concentrators results in gains in daily produced power of up to 35% during clear sky days for certain times of the year. The gains monthly produce energy of up to 26% and 18% which are measured by amorphous -Si and poly-Si modules, respectively [13]. In 2016 (Alshohani et al.) achieve experimental investigations to decrease the heat in a PV module [14]. Ronnelid et al. study the act of PV solar modules with V-trough in inconstant tilts and lengths at Swedish climates. They found the flat fixed reflector is able to increase the yearly electrical power product from 20 to 25% [15]. Dewi and Setiawan studied the flat reflector effect on the I−V characteristic curve of the solar PV modules.They found that the stainless steel and aluminum foil reflectors can increase the power output from the solar module around 21.5% and 31.5% respectively [16].

The aims of this study are to get good economic feasibility and decrease degradation which the PV solar panels experience that is caused by rising temperature because the electrical efficiency of photovoltaic solar cells is inversely proportional to the temperature, as well as the increase of electricity energy. Also the PV solar system can be designed and equipped to eliminate extra heat generated in the PV solar panel via cooling, which aids enhancing its efficiency because its resistance will decrease. These aims can be realized by implementing the cooling and reflectors. There is a way used to improve the

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performance of the solar modules by using optical reflectors and cooling [17,18]. Since solar power installation is significant investment, designing PV solar systems that use the conventional PV panels require to keep them at their peak efficiency as long as this is possible.

2. Solar PV system details

The current solar PV system in Fig. 1 is located at north Baghdad/Al-Taji city in Al-Mansour Factory at coordinate (latitude 33.3°N and longitude 44.4°E).

3. Solar PV and reflector systems

The CIGS PV solar system consists of 30 panels that are divided into two parts; the 1st part consists of 12 panels that regard improved part and the 2nd part consists of 18 panels that regard reference part, then comparing the improved part with reference part to know the increasing in electrical parameters when the 1st part (improved) experiences to large amount of solar radiation (that comes from sun and the other which comes from optical reflectors). The optical reflectors are put in front of MPPT1 (Maximum Power Point Tracker) [19] as shown in Fig. 2 (12 panels), while the MPPT2 (18 panels) which regard reference part stays without reflectors. An inverter in this system consists of two inputs; one of this inputs (MPPT1) has 12 panels (1980 kWp) and the other input (MPPT2) has 18 panels (2970 kWp). The data are gotten by using Speedwire that connects the PC with inverter, where the inverter displays data in two groups (A and B) as shown in Fig. 4. An inverter in Fig. 2 contains two inverters, each one is called maximum point tracker (MPPT) (see Fig. 3).

4. Experimental set-up

The current study is accomplished at Mansour Factory, Iraq-Baghdad (latitude 33.3°N, longitude 44.4°E). The study parameters include: current, power, efficiency and performance ratio as well as air and panels temperature (panels temperature is measured for improved and reference parts). All electrical parameters aforementioned are recorded for improved and reference parts, where the data for each MPPT are gotten from an inverter which exhibits the parts of

Fig. 1. CIGS solar PV system.

Table 1
System and PV solar Panel Specifications.

Panel Characteristics	Value	System Characteristics	Value
Panel model	TS-165C2 CIGS	Inverter model	SMA SB-5000T-21
Max power (Pmax)	165 W	Number of panels	30
Open-circuit voltage (Voc)	88.7 V	Inverter Size	5.30 kWp
Short-circuit current (I_{sc})	2.66 A	Inverter efficiency	97%
Max power voltage (V_{mpp})	68.5 V	System Size	5 kWp
Max power current (I_{mpp})	2.41 A	Tilt Angle	30°
Max reverse current (I_R)	6.5 A		
Operating temperature	−40 °C−85 °C		

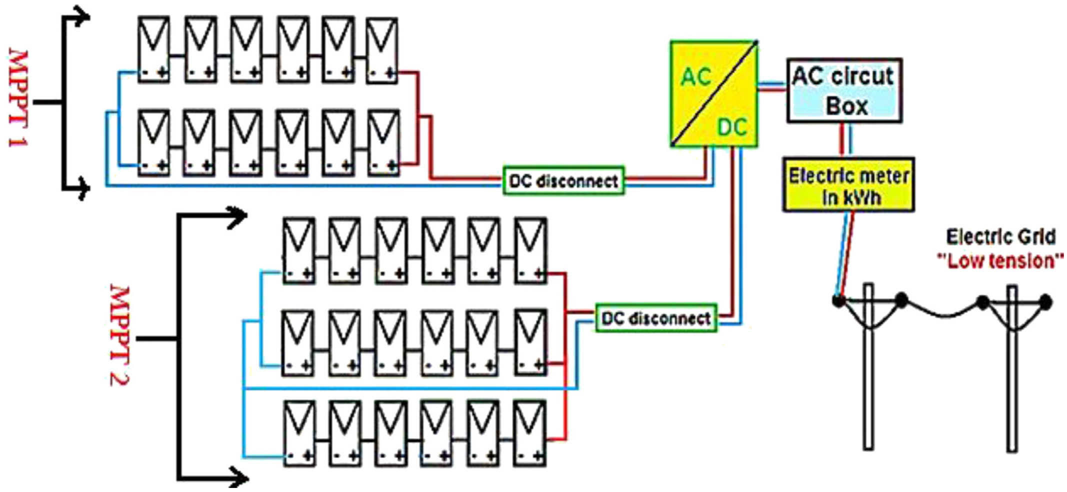

Fig. 2. Single line diagram of CIGS grid-tied solar PV system.

solar PV system separately in shape of (B) that represents MPPT which consists of 18 panels and (A) which represents MPPT that consists of 12 panels as shown in Fig. 4. In the terms of studying time, the experiment extent from 8:00 AM until 6:00 PM in day of 21 may 2019, where the sky is clear and all panels of solar PV system are clean.

5. Evaluation system power

The improved and referenced parts are evaluated in terms of aforementioned electrical parameters (power, current, performance ratio and array efficiency). Power and current are gotten from the inverter directly, while the array efficiency and performance ratio are gotten by using the bellow equations. Air and PV solar panels temperature are measured by using digital thermometer.

5.1. System efficiencies

The PV solar system efficiencies are classified into the following: Array, System and Inverter Efficiency. These efficiencies can be calculated on the basis of annually, monthly, daily and hourly. The system efficiency (ηsys) is built on the alternating current energy product and the array efficiency (ηPV) is built on the direct current energy product [20]. The array efficiency is the ratio of (daily, monthly or annually) average of array energy product (DC) to the (daily, monthly or

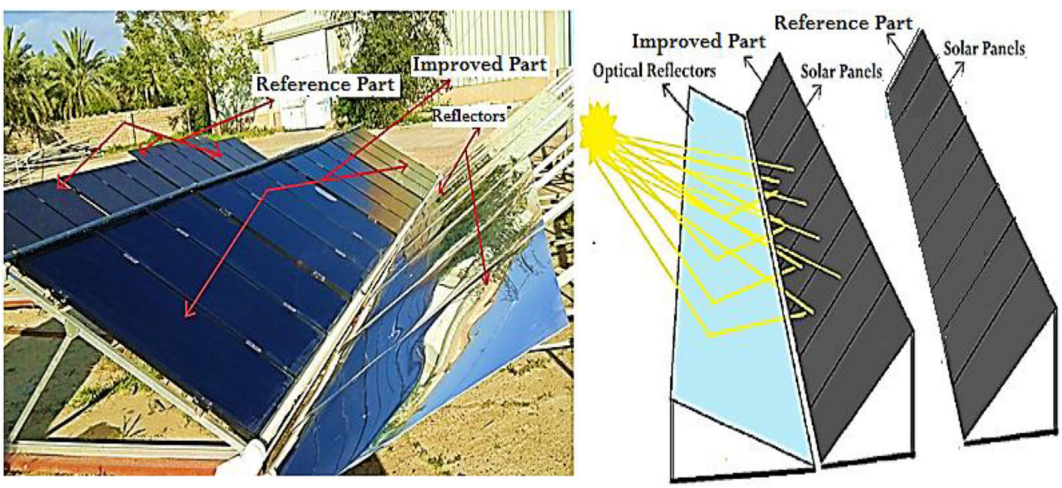

Fig. 3. Optical reflectors and PV solar system.

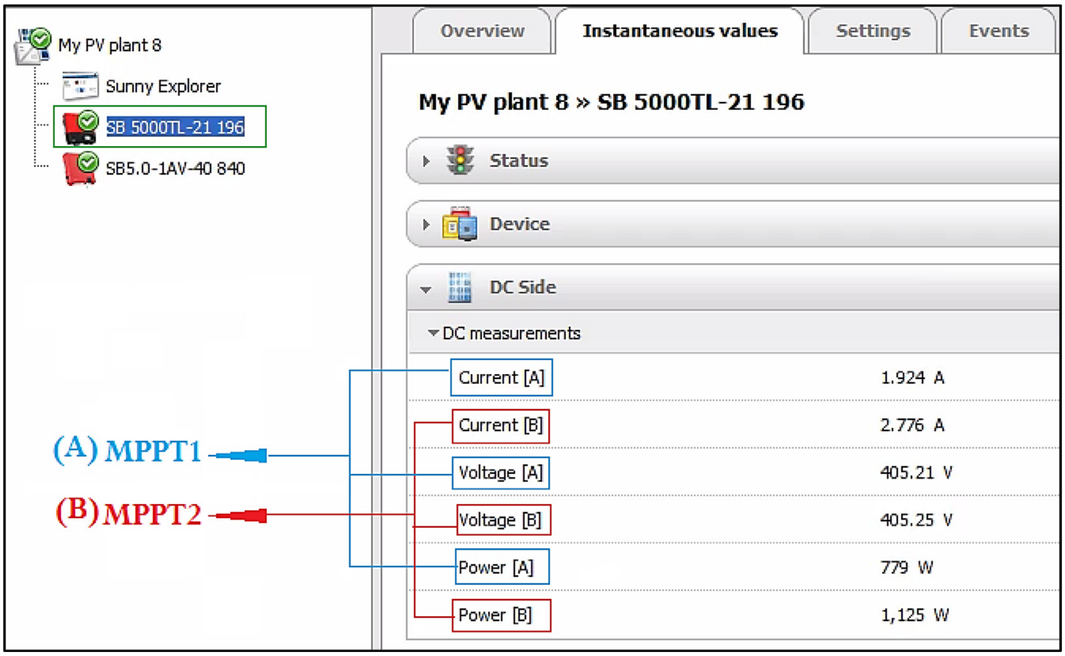

Fig. 4. Screenshot of inverter data display in PC.

annually) average of in-collimated plane solar insolation multiplied by the area of the PV solar array [20]. The PV solar array efficiency is given as:

$$\eta_{PV} = \frac{100 * E_{DC}}{H_T * A_m}\% \tag{1}$$

where A_m = array area (m^2),H_T = solar irradiation (in-collimated plane) and E_{DC} = DC energy.

The system efficiency is given as:

$$\eta_{SYS} = \frac{100 * E_{AC}}{H_t * E_m}\% \tag{2}$$

where A_m = array area (m^2), H_T = solar irradiation (in-collimated plane) and E_{AC} = AC energy.

The inverter efficiency is given as:

$$\eta_{INV} = \frac{100 * E_{AC}}{E_{DC}}\% \tag{3}$$

The inverter efficiency is 97%—96% because it is indoor.

5.2. *Performance ratio* (PR)

(PR) appears all impacts of loss on the PV solar system. Value of PR shows how close it approaches from perfect performance through actual work and permits comparison of Photovoltaic solar systems regardless of orientation, tilt angle, and their rated power capacity [21]. PR can be found as the ratio of the (**Y_F**) over (**Yr**), it given as [22].

$$P_R = \frac{Y_F}{Y_R}\% \tag{4}$$

where: Y_F is final yield that is given in equation (5) and Y_R is the reference yield that is given in equation (6).

Final yield (Y_F) is the AC energy product for a specific duration over the rated capacity value of the PV solar system [23]. It represents how many hours per day at which the PV solar system works at its rated power. It is calculated as:

$$Y_F = \frac{E_{AC}}{P_{rated}} (kWh / kW_P) \tag{5}$$

where: **E_{AC}** represents AC energy product in unit of (kWh), while the **Reference Yield Y_R** is defined as the global irradiation (in-collimated plane) divided by the reference irradiance that equals 1 kW/m^2. The Reference yield is given as:

$$Y_R = \frac{H_T}{H_R} (kWh / kW_P) \tag{6}$$

where: H_T and H_R are the solar irradiation (in-collimated plane) and reference Irradiance respectively.

When compensating equations (5) and (6) in equation (4), equation (7) is obtained

$$PR = \frac{E_{AC} * HR}{P_{PV,rated} * HT} \% \quad (7)$$

On the other hand, the performance ratio can be given in simple formula as follows:

$$PR = \frac{\text{Actual Power}}{\text{Rated Power}(P_{rated})} 100\% \quad (8)$$

Equation (8) is used to find performance ratio and equation (13) is used to find solar irradiance.

The Actual and nominal (rated) power are given as:

$$\text{ActualPower}(P_{AC}) = H_R * \eta_{Actual} * A_m \quad (9)$$

$$\text{RatedPower}(P_{rated}) = H_R * \eta_{ref} * A \quad (10)$$

The actual efficiency (η_{Actua}) is given as:

$$\eta_{Actual} = \eta_{ref}\left[1 - \beta\left(T_p - T_{ref}\right)\right] \quad (11)$$

where: η_{ref}**:** rated efficiency (15.2% for CIGS panel), A_m**:** area of improved and reference parts (13.04m2), β**:** Temperature Coefficient which equals to 0.3%/OC, Tref: reference temperature = 25^{O}C and T_p: panel temperature.

When compensating equation (11) in 9 then 9 in 8, equation (12) is obtained as follows:-

$$PR = \frac{H_R * A_m * \eta ref\ \left[1 - \beta\left(T_p - \text{Tref}\right)\right]}{P_{rated}} \quad (12)$$

From equation (12), equation (13) can be obtained.

$$H_R = \frac{PR * P_{rated}}{A_m * \eta ref\ [1 - \beta(T_C - \text{Tref})]} \quad (13)$$

$$PR = \frac{\eta Actual}{\eta ref} \quad (14)$$

Equations (13) and (14) are used to find solar irradiance (H_R) and actual efficiency (η_{Actual}) respectively.

The relations used to find the increment percentage in power and current are given as follows:

$$INC_P = (P_{im} - P_{ref})/P_{ref} * 100\% \quad 15)$$

$$INC_I = (I_{im} - I_{ref})/I_{ref} * 100\% \quad (16)$$

where: $P_{im,}$ and P_{ref} are the improved and reference parts power respectively. I_{im}, and I_{ref} are the improved and reference parts current respectively. $INCP_P$ and $INCP_I$ are the increment percentage (INCP) in power and current to the improved and reference parts respectively.

Note: Before using all equations, the reference part is divided by 18 and multiplied it by 12 to achieve an equalization in number of panels between the reference and the improved parts, all equations can then be used in this study

6. Results and discussion

Figure (5) displays the difference in electrical power between improved and reference parts. The figure displays clear difference between the two parts where the maximum power for improved and reference parts are 1.959kWp and 1.508 kWp respectively, at 12:00 PM where the increment percentage is 30%, This value represents a significant gain and has a significant impact on the economic feasibility of renewable energy, while the minimum value of increment percentage is at 6:00 PM of 3.5% and the average value throughout the day is 22.3%.

Figure (6) illustrates the electrical current of the improved and reference part. The maximum values of

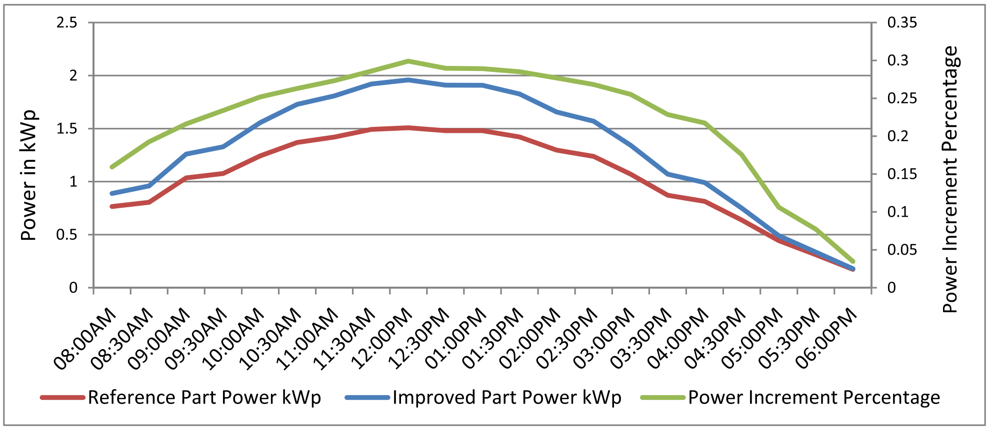

Fig. 5. Power increment percentage, improved and reference parts power.

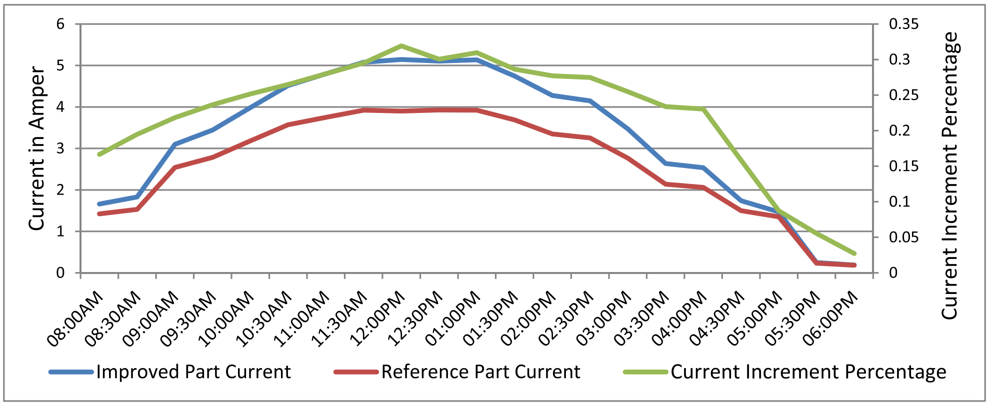

Fig. 6. Current increment percentage, improved and reference parts electrical current.

electrical current of the increment percentage (the gain), improved and reference part are at 12:00 PM of 31.9%, 5.145 A and 3.9 A respectively, and the minimum value of the increment percentage is at 6:00 PM of 2.7%. The average of increment percentage throughout the day is 22.5%. In the period from 8:00 AM to 4:00 PM, the superiority is to current upon power because optical reflectors increase solar radiation and temperature and these two parameters increase the current because they increase electrons, but temperature reduces the voltage so the power reduces. On the contrary, in the period from 4:30 PM to 6:00 PM the superiority is to power in account of current that because the temperature decreases and the solar radiation reflected from optical reflectors to panels deflects away from some of these panels.

Figure (7) displays increment percentage and performance ratio (PR) to the improved and reference parts. The maximum values of performance ratio of increment percentage (the gain), improved and reference parts are 22.8%, 99% and 76.2% respectively at 12:00 PM, this increment percentage (22.8%) represents 30% of reference part value. This means that gain is 30%, while the minimum values of PR for increment percentage, improved and reference parts are 2%, 9% and 8.8% respectively at 6:00 PM. Performance ratio is a measurement index for how close a system approaches ideal performance during real operation and permits comparison of Photovoltaic solar systems irrespective of the orientation angle, tilt angle, and their rated power capacity [21].

Figure (8) displays the efficiency (η) of the increment percentage, improved and reference parts. Efficiency maximum values for increment percentage (the gain), improved and reference parts are 3.4%, 15% and 11.6% respectively at 12:00 PM, this increment percentage (3.4%) represents 30% of reference. This means that gain is 30%, while the minimum value for

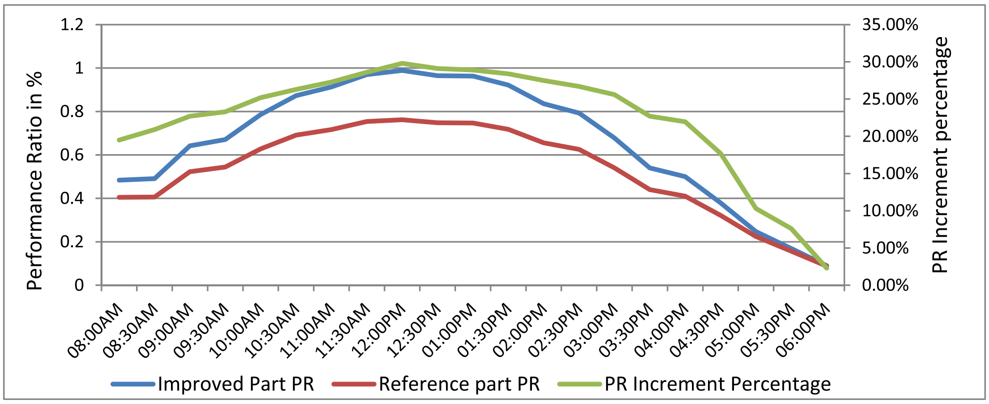

Fig. 7. PR increment percentage, improved and reference parts PR.

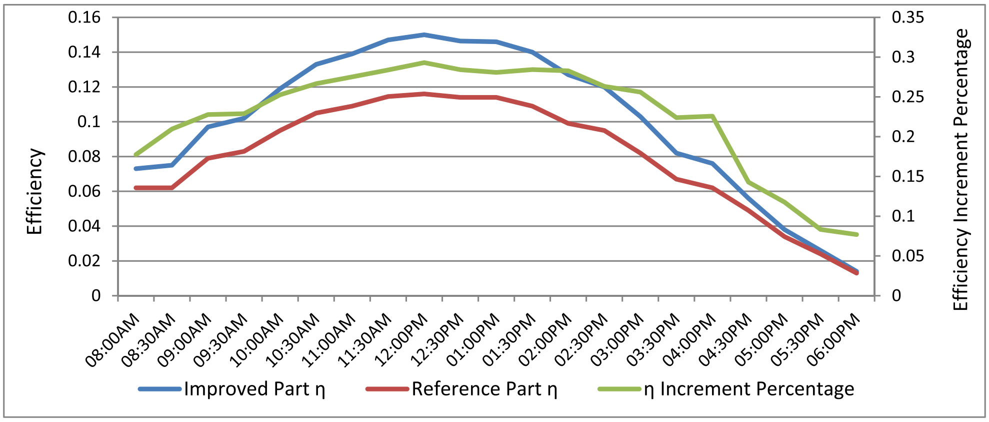

Fig. 8. Efficiency increment percentage, improved and reference part efficiency.

increment percentage, improved and reference efficiency are 0.1%, 1.4% and 1.3% respectively at 6:00 PM.

Figure (9) displays the increment percentage, improved and reference parts solar irradiance (S.R). The maximum values of solar irradiance for increment percentage (the gain), improved and reference part are 32.4%,1118.9 W/m^2 and 844.8 W/m^2 respectively at 12:00 PM, while the minimum values of solar irradiance for increment percentage, improved and reference parts are 2.2%, 93 W/m^2 and 91W/m^2 respectively at 6:00 PM. Through time periods limited from 4:30PM to 6:00PM and from 8:AM to 8:30 there are convergence between improved and reference parts values because the solar radiation that reflects from optical reflectors to PV solar panels deflects away from these panels, on the contrary, at mid noon where, no deflection happens to solar radiation but it reflects directly on the panels. This means that the improved part gets large amount of solar radiation compared to the reference part, so there are divergence between improved and reference part values.

Figure (10) displays air temperature, temperature of improved panels (improved (T)) and temperature of reference panels (reference (T)). The maximum value of air temperature, improved (T) and reference (T) are 37^{O}C, 64^{O}C and 58^{O}C respectively at 12:00 PM, while the minimum value of air temperature, improved (T) and reference(T) are 32.2^{O}C,36^{O}C and 35.8^{O}C respectively at 6:00 PM. At 12:00 PM. The increase in temperature caused by using optical reflectors is 6^{O}C Solely, this means that the optical reflectors do not add significant heat to PV panels, so this addition in temperature has very small effect on voltage. On the contrary of maximum air temperature that occurs at 3:00PM, the maximum temperature of PV panel occurs in 12:00PM.

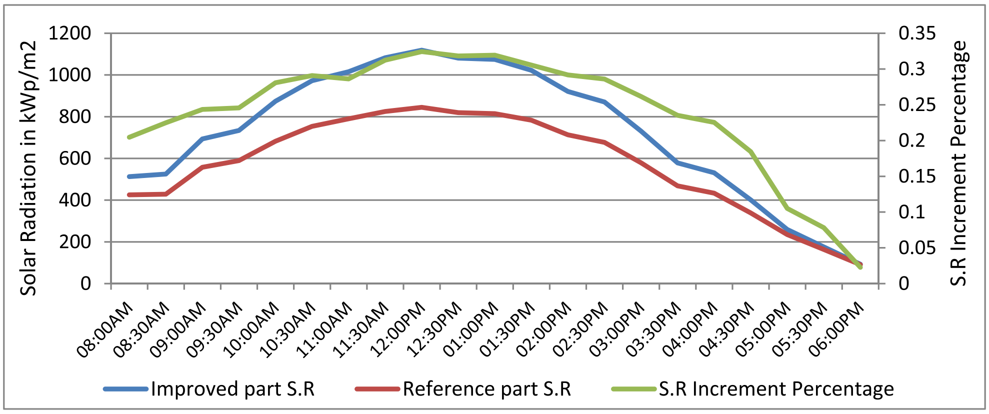

Fig. 9. S.R increment percentage, improved and reference parts solar irradiance (S.R).

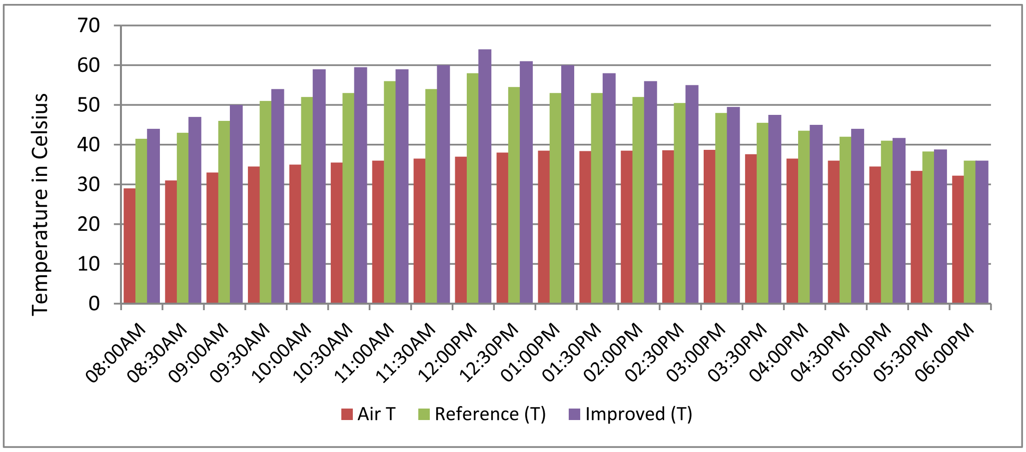

Fig. 10. Air (T), Improved (T) and Reference (T).

7. Conclusions

- There are large gains that are got from all electrical parameters which are, power, current, performance ratio, efficiency and solar radiation**.**
- Nearly, the gain average of all electrical parameter is 30% at 12:00PM.
- Performance ratio and efficiency are improved in percentage of 22.5% as an average throughout the day.
- Current and power are improved in a percentage of 22.4% as an average throughout the day.
- The solar radiation is improved in a percentage of 24.3% as an average throughout the day.
- Effect of rising temperature caused by optical reflectors does not has significant impact on the PV solar panels because this rising is 3.7^{O}C solely throughout the day, so optical reflectors can be added to two sides of PV solar panels string.
- The novelty in current study makes the improved part work approximately at standard performance, where the improved part performance of 99% and standard performance is 100%, while the reference performance is 76.2%.
- According to the seven points aforementioned, it can be said there is a good economic feasibility that can be obtained when using optical reflectors.

Acknowledgment

All the authors are grateful to AL-Mansour Factory/ AL-Zawraa Company and Training & Energy Research Office/Ministry of Electricity as well as Mustansiriyah University for their great efforts in supporting the implementation of this work.

Appendix A.

Table 2
Improved and Reference Power and Current

Time	Improved Power kWp	Reference Power kWp	INC Power	ImprovedCurrent (A)	Reference Current (A)	INC Current
8:00 AM	0.958	0.802	19.5%	1.7	1.423	19.5%
8:30 AM	0.972	0.805	20.75%	1.845	1.53	20.5%
9:00 AM	1.271	1.036	22.7%	3.198	2.542	25.8%
9:30 AM	1.329	1.077	23.4%	3.445	2.786	23.7%
10:00 AM	1.556	1.243	25.2%	3.985	3.184	25.2%
10:30 AM	1.729	1.369	26.3%	4.517	3.571	26.5%
11:00 AM	1.808	1.420	27.3%	4.80	3.750	28%
11:30 AM	1.92	1.493	28.6%	5.078	3.921	29.5%
12:00 PM	1.959	1.508	30%	5.145	3.9	31.9%

(*continued on next page*)

Table 2 (*continued*)

Time	Improved Power kWp	Reference Power kWp	INC Power	ImprovedCurrent (A)	Reference Current (A)	INC Current
12:30 PM	1.91	1.481	29%	5.107	3.927	30.1%
1:00 PM	1.908	1.480	28.9%	5.137	3.922	30%
1:30 PM	1.826	1.421	28.5%	4.745	3.688	28.7%
2:00 PM	1.656	1.297	27.8%	4.276	3.348	27.7%
2:30 PM	1.57	1.238	26.82%	4.147	3.253	27.5%
3:00 PM	1.343	1.07	25.5%	3.471	2.766	25.5%
3:30 PM	1.07	0.871	22.85%	2.638	2.138	23.4%
4:00 PM	0.991	0.814	21.7%	2.536	2.061	23%
4:30 PM	0.75	0.638	17.6	1.739	1.501	15.9%
5:00 PM	0.49	0.443	10.6%	1.469	1.351	8.7%
5:30 PM	0.335	0.311	7.7%	0.247	0.234	5.6%
6:00 PM	0.179	0.173	3.5%	0.189	0.184	3%

Table 3
Improved and Reference PR and η

Time	Improved η	Reference η	INC η	Improved PR	Reference PR	INC PR
8:00 AM	7.3%	6.2%	17.7%	48.4%	40.5%	19.5%
8:30 AM	7.5%	6.2%	20.96%	49.1%	40.6%	20.9%
9:00 AM	9.7%	7.9%	22.78%	64.2%	52.3%	22.7%
9:30 AM	10.2%	8. %3	22.89%	67.1%	54.4%	23.3%
10:00 AM	11.9%	9.5%	25.3%	78.6%	62.8%	25.2%
10:30 AM	13.3%	10.5%	26.66%	87.3%	69.1%	26.3%
11:00 AM	13.9%	10.9%	27.5%	91.3%	71.7%	27.3%
11:30 AM	14.7%	11.45%	28.4%	97%	75.4%	28.6%
12:00 PM	15%	11.6%	29.3%	99%	76.2%	29.8%
12:30 PM	14.64	11.4%	28.4%	96.5%	74.8%	29.1%
1:00 PM	14.6%	11.4	28.1%	96.3%	74.7%	28.9%
1:30 PM	14%	10.9%	28.4%	92.2%	71.8%	28.4%
2:00 PM	12.7%	9.9%	28.3%	83.6%	65.58%	27.5%
2:30 PM	12%	9.5%	26.3%	79.3%	62.58%	26.7%
3:00 PM	10.3%	8.2%	25.6%	67.8%	54%	25.6%
3:30 PM	8.2%	6.7%	22.4%	54%	44%	22.7%
4:00 PM	7.6%	6.2%	22.6%	50%	41%	21.95%
4:30 PM	5.6%	4.9%	14.3%	37.9%	32.2%	17.7%
5:00 PM	3.8%	3.4%	11.8%	24.7%	22.4%	10.3%
5:30 PM	2.6%	2.4%	8.3%	16.9%	15.7%	7.6%
6:00 PM	1.4%	1.3%	7.7%	9%	8.8%	2.3%

Table 4
Air and Panel Temperature, Improved and Reference Solar Irradiance

Time	Air T	T of Reference Panels	T of impro Panels	T INC	Impro S.RW/M^2	Reference S.R W/M2	INC SR
8:00 AM	29 °C	41.5 °C	44 °C	2.5	512.7	425.6	20.5%
8:30 AM	31 °C	43 °C	47 °C	4	525.14	428.7	22.5%
9:00 AM	33 °C	46 °C	50 °C	4	693.3	557.6	24.3%
9:30 AM	34.5 °C	51 °C	54 °C	3	734.17	589.4	24.5%
10:00 AM	35 °C	52 °C	59 °C	7	874.4	682.6	28.1%
10:30 AM	35.5°C	53 °C	59.5 °C	6.5	972.8	753.6	29%
11:00 AM	36 °C	56 °C	59 °C	3	1015.6	789.7	29%
11:30 AM	36.5 °C	54 °C	60 °C	6	1082.7	825	31.2%
12:00 PM	37 °C	58 °C	64 °C	6	1118.9	844.8	32.4%
12:30 PM	38 °C	54.5 °C	61 °C	6.5	1080.7	819.8	31.8%

(*continued on next page*)

Table 4 (*continued*)

Time	Air T	T of Reference Panels	T of impro Panels	T INC	Impro S.RW/M^2	Reference S.R W/M2	INC SR
1:00 PM	38.5 °C	53 °C	60 °C	7	1074.8	814.6	31.7%
1:30 PM	38.4 °C	53 °C	58 °C	5	1022.2	783.02	30.5%
2:00 PM	38.5 °C	52°C	56 °C	4	920.8	712.9	29%
2:30 PM	38.6 °C	50.5 °C	55 °C	4.5	870.5	676.9	28.6%
3:00 PM	38.7 °C	48 °C	49.5 °C	1.5	731.02	579.4	26.2%
3:30 PM	37.6 °C	45.5 °C	47.5 °C	2	578.5	468.3	23.5%
4:00 PM	36.5 °C	43.5 °C	45 °C	1.5	531.4	433.6	22.5%
4:30 PM	36 °C	42 °C	44 °C	2	401.5	338.9	18.5%
5:00 PM	34.5 °C	41 °C	41.7 °C	0.7	259.8	235.05	10.5%
5:30 PM	33.4 °C	38.3 °C	38.8 °C	0.5	176.1	163.4	7.8%
6:00 PM	32.2 °C	35.8 °C	36 °C	0.2	93	91	2.2%

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