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Dust Effect on Photovoltaic Electric Systems

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ABSTRACT

The accumulation of dust on the surface of a photovoltaic panel reduces the performance of solar panel, but the results were not clearly quantified.

Our objective has been study the effect several of dust accumulation on the performance of solar PV panel, because different type and amount of dust have been on the atmosphere.

Our study showed the results which done at the Faculty of Engineering Technology- zarqa privet university practically to quantify losses caused by the accumulation of dust in and out door and with and without shadow on the surface of photovoltaic module.

It was found from the study and practical measurements that the accumulated dust on the surface of photovoltaic solar panel reduces the system's efficiency depended on amount and kind of accumulated dust.

INTRODUCTION

The destruction of the environment and global warming are among the problems first mentioned in many public opinion polls. Today's energy resources are largely responsible for the human gas sources effect, acid rain and other negative impacts on health and the environment. [1] The current trend is clearly not sustainable, especially given the enormous demand for energy predicted for the future. Several energy sources, however, offer the opportunity to cover our energy demand sustainably, i.e. with almost no negative influence on health and nature. These are also called renewable energy systems, The main focus is on the sun provides a tremendous resource for generating clean and sustainable electricity without toxic pollution or global warming emissions such as solar thermal systems, photovoltaic and wind power.[6]

Photovoltaic

A photovoltaic (PV) system consists of solar cell that generates electricity by the direct conversion of the sun's energy into electricity. The solar cell consists of semiconductor material, with Silicon being the most commonly used. The components of a PV system are the solar cells connected in a suitable form and the electronic devices that interface the storage elements and the AC or DC loads.[4]

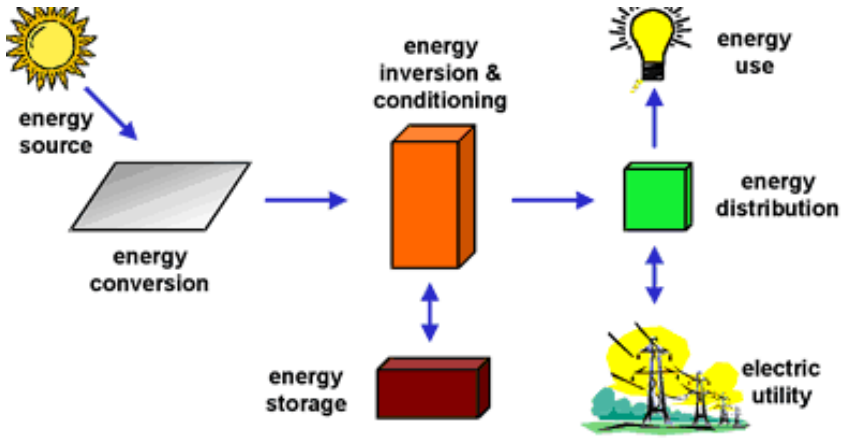

Figure1. *photovoltaic power system components*

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SOLAR CELL CHARACTERISTICS EQUATION

Real equivalent circuit that the current produced by solar cell is equal to that produced by the current source minus which can flow throw the diode minus that flow throw the shunt resistor which give in equation 1.1: [3]

$$I = IL - ID - Ish \quad (1.1)$$

Where I: output current (A).

IL: photo generated current (A).

ID: diode current (A).

Ish : shunt current (A).

The output voltage is given by 1.2 equations:

$$V = Vj - I * Rs \quad (1.2)$$

Where: : Voltage across both diode and shunt resistance (V).

V: output voltage (V).

I: output current (A) .

Rs: series resistance (Ω).

The current diverted throw the diode is given by the equation 1.3:

$$ID = I_i \{exp\,[qVj/nKT] - 1\} \quad (1.3)$$

Where: ID : the diode current (amperes)

I_i : reverse saturation current (amperes)

q : elementary charge

K : Boltzmann's constant

T : absolute temperature (for silicon = 25˚ c)

Where:

$$KT/q \approx 0.0259$$

The current flow throw the shunt resistance is given by equation 1.4:

$$Ish = Vj/Rsh \quad (1.4)$$

So the output current can be give in final formula as we shown in equation 1.5:

$$I = IL - I_i \{ exp[(q(V + IRs))/ nKT] - 1\} - ((V + IRs)/Rsh) \ldots . (1.5)$$

The output voltage can be calculated by put the V in the left hand side of this equation. ***[5]***

PV EFFICIENCY VARIABLE

Environmental effects on the performance of PV are caused by many factors either natural like clouds, dust and temperature, or artificial like evaporation of pollution from different factories. These effects may cause variation on the PV electrical output due to spectrum, intensity, local shadowing or reflection and variations of solar radiation distribution falling on it.

EFFECT OF RADIATION

The efficiency of PV is increase when the radiation is increase as shown in fig. (2).

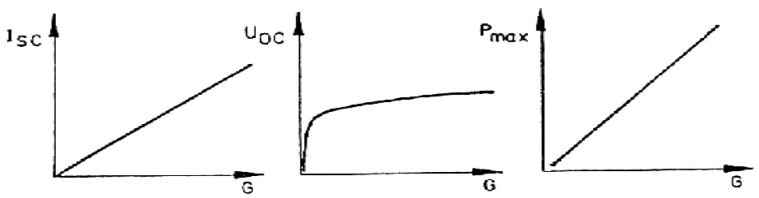


Fig2. *Effect radiation in PV efficiency*

EFFECT OF TEMPERATURE

The efficiency of PV is decrease when the temperature is increase as shown in fig (3).

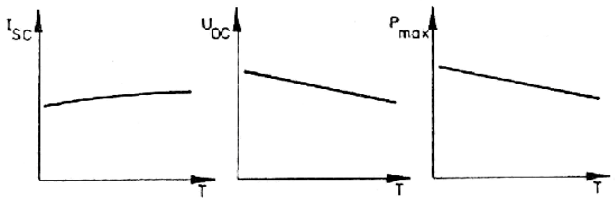


Fig3. *Effect of temperature in PV efficiency*

EFFECT OF DUST

Dust has been 40% degradation in peak power of photovoltaic's, there is surprisingly little scientific work done on the subject. Since no information about the type of dust, density of dust, or rate of accumulation of dust was noted, no general understanding of the underlying physical principles could be resulted. Therefore, their test is specific only to the time and location of their test. Dust accumulation on the photovoltaic (PV) panel surface depends on different parameters such as PV panel inclination and kind of installation

In this part, the short circuit current Isc and the open circuit Voc for a silicon solar cell name plate fig (4) through a period of exposure of constant radiation on midday approximately from 12 AM to 13 PM , fixed tilt angles and varies of accumulation dust was measured in my paper.

Fig4. *photovoltaic panel specifications*

PRACTICAL MEASUREMENT

1- Measurement Value Has Been Got At 13/05/2015 from 12AM - 1PM

Effect dust on photovoltaic with varies the accumulation of dust, fixed tilt angles and clear sky of clouds show at table 1 and Fig (5).

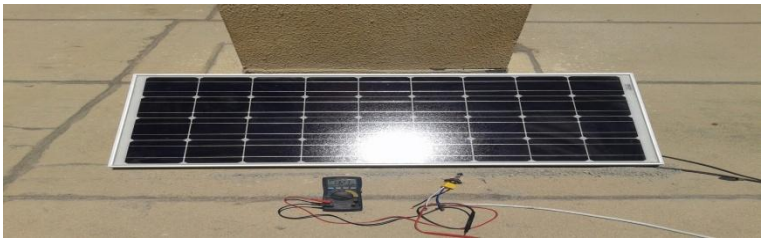


Fig5. *Photovoltaic panel pure clean*

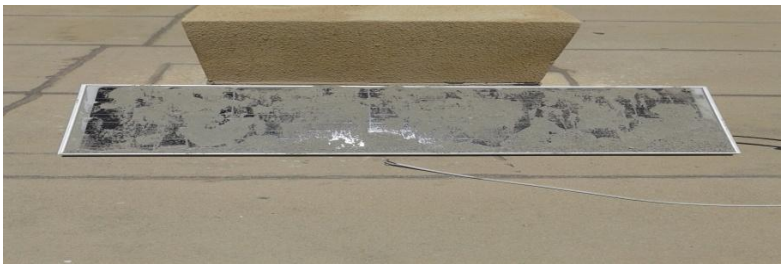


Fig6. *Photovoltaic panel with dust*

Table1. *when* ***clear sky of clouds***

Current(A)	Voltage(V)	Power(VA)	case	NO.
2.397	19.26	46.16	Clean	1
2.25	18.54	41.71	little dust	2
2.22	16.03	35.58	Increase dust(1)	3
2.05	15.09	30.93	Increase dust(2)	4
1.88	12.36	23.23	Increase dust (3)	5
1.80	11.87	21.36	Increase dust (4)	6
1.537	9.04	13.92	Increase dust (5)	7
1.339	6.66	8.92	Increase dust (6)	8
1.257	5.95	7.49	Increase dust (7)	9
1.097	4.04	4.4	completed cover	10

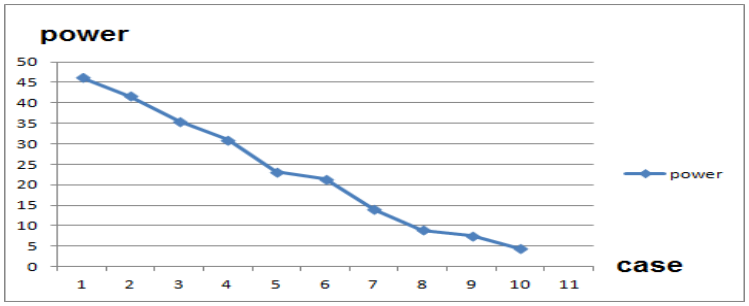


Fig7. *power output solar cell at multiple cases*

2- Measurement Value has been Got at 14/05/2015 from 12AM - 1PM

Effect dust on photovoltaic with varies the accumulation of dust, fixed tilt angles and cloudy of sky shown at table 2 and Fig (8).

Table2. *when cloudy of sky*

Current(A)	Voltage(V)	Power(VA)	case	No.
2.18	18.11	39.48	Clean	1
1.72	10.87	18.69	little dust	2
1.49	8.54	12.73	Increase dust	3
1.45	7.53	10.91	Increase dust (1)	4
1.29	6.85	8.84	Increase dust (2)	5
1.16	5.4	6.26	Increase dust (3)	6
1.09	3.89	4.24	Increase dust (4)	7
0.972	2.85	2.77	Increase dust (5)	8
0.628	1.83	1.15	Increase dust (6)	9
0.558	0.98	0.54	Increase dust (7)	10
0.243	0.222	0.054	completed cover	11

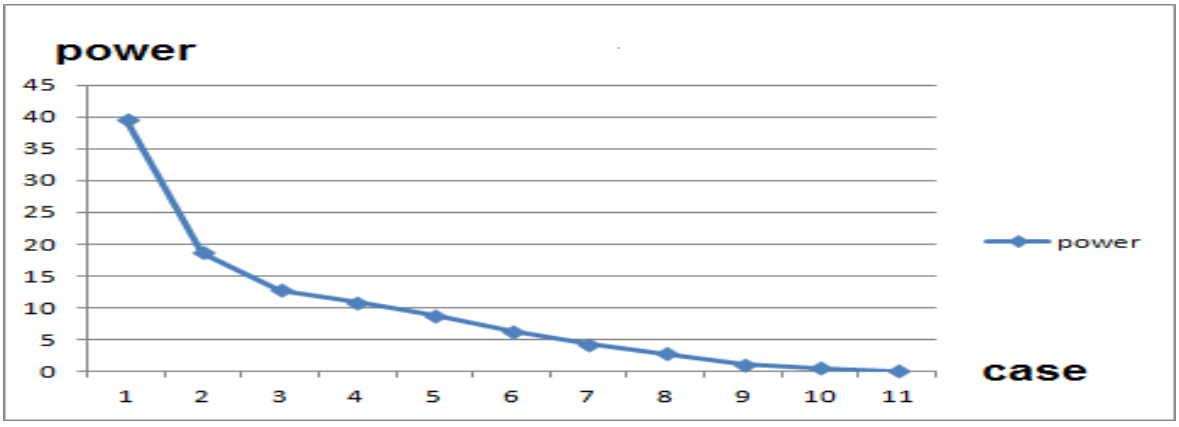


Fig8. *power output solar cell at multiple cases*

3- Measurement Value has been got at 20/05/2015 from 12AM - 1PM

Effect dust on photovoltaic with shadow outdoor, fixed tilt angles and varies the accumulation of dust fig (9), table 3.

Fig9. *Photovoltaic panel with dust and shadow outdoor*

Table3. *Result when dust and shadow outdoor*

Current (A)	Voltage(V)	Power(W)	case	No.
0.91	2.28	2.07	Clean	1
0.83	2.2	1.83	Little dust	2
0.80	1.9	1.58	Increase dust	3
0.72	1.6	1.15	Increase dust (1)	4
0.72	.91	0.655	Increase dust (2)	5
0.61	.87	0.53	Increase dust (3)	6
0.45	.66	0.29	Increase dust (4)	7
0.25	.383	0.09	Increase dust (5)	8
0.132	.363	0.048	completed cover	9

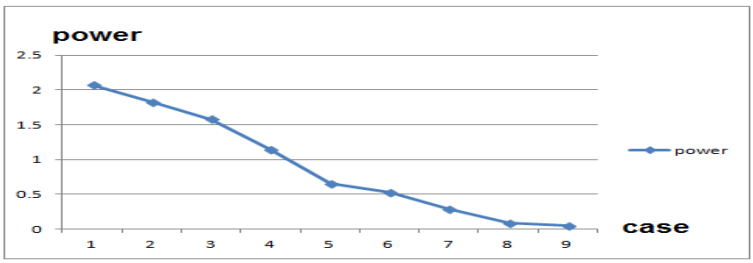


Fig10. *I-V characteristics for silicon solar cell*

Measurement Value has been got at 17/05/2015 from 12AM - 1PM.

Effect dust on photovoltaic with shadow indoor, fixed tilt

Angles and varies the accumulation of dust fig (11), table 4.

Fig11. *Photovoltaic panel with full accumulation of dust and shadow indoor*

Result Table4. *dust and shadow indoor*

Current(A)	voltage(V)	Power(W)	Case	No.
0.07	0.05	0.0035	Clean	1
0.062	0.045	0.0028	Little dust	2
0.06	0.042	0.0025	increase dust	3
0.042	0.03	0.00126	Increase dust (1)	4
0.032	0.0222	0.0007	Increase dust (2)	5
0.026	0.018	0.00047	Increase dust (3)	6
0.021	0.015	0.00031	Increase dust (4)	7
0.017	0.012	0.0002	completed cover	8

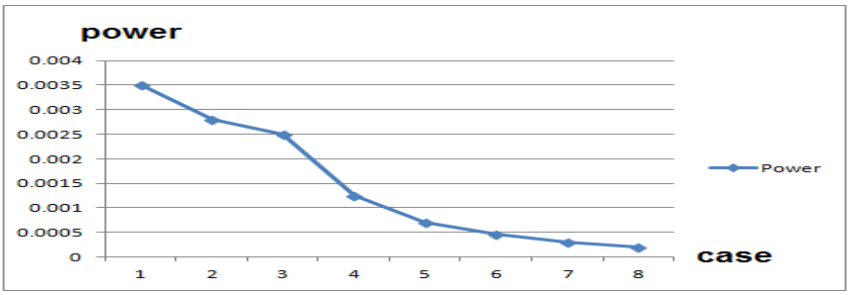
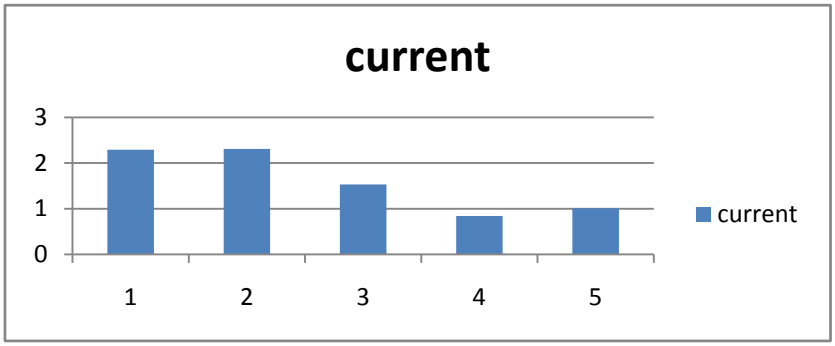


Fig12. *I-V characteristics for silicon solar cell*

Multiple Effected and Variables on pv as Show in Table Below

1- Photovoltaic is very clean
2- Effect the water on photovoltaic panel
3- Effect the dust photovoltaic panel
4- Effect the dust when increase it on photovoltaic panel
5- Effect the shadow on photovoltaic panel



CONCLUSIONS

1- In our project we have studied in general the energy losses due to accumulated dust on the surface of photovoltaic modules.

2- We have measured output current and voltage values for photovoltaic panel with variable amount of dust, in and out door and with and without shadow at:

A- Fixed the angle of incidence θ.

B- Constant irradiance incidence

3- Output power is a reduction direct proportional with amount of dust is accumulated on surface photovoltaic panel.

4- The dust caused decreases irradiance to reached solar cell.

5- Maximum output power when PV panel is clean.

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