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Practical Study of the Effect of Solar Radiation on PV Cell in Syria

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Abstract-Damascus city suffers from lack of electricity, which forced the citizens to use electric generators that operates on gasoline or diesel fuel, both are fossil fuels and emitted high pollutants to the air. The use of solar energy is considered as a good option to reduce air pollution as it is a clean energy as well as it is available most of the year and free. In this study we try to evaluate the possibility of using PV panels to generate electricity and the effect of variables as inclination angle, temperature and solar radiation intensity.

The results reveal that the best panel's inclination angle is the angle that perpendicular to the solar radiation, and in our case (Damascus city) it is 30°. Increasing the panel temperature reduced the output voltage while increasing the solar radiation increase the voltage. The study concluded that the use of PV module to generate electricity in Damascus city is an acceptable and practical option.

Keywords: PV panel, voltage, solar radiation, inclination angle.

1. INTRODUCTION

Solar energy is a renewable energy that is available around the world and is free and it is God's gift to the earth. It is the origin of all energies, whether wind, waves or even underground energy. This energy has become the focus of the eyes of the world after it has suffered from the lack of serious environmental problems, including air pollution and the greenhouse phenomenon in addition to climate change [1, 2]. These phenomena have been in the past decades under the study of researchers, but today is a tangible reality affected by the normal man in all parts of the globe [3]. The excessive use of fossil fuels of oil, natural gas and coal caused the bulk of these problems that may put an end to the prosperity and progress we live today [4]. Oil has become today, especially after the fluctuation of price from very high to very low cause the collapse of the global economy and a threat to the economic security of all countries of the world produced by this material or imported it [5]. The gases emitted from car exhausts and generators all over the world emit tons of pollutants that reduce air quality and cause many risks to humans, animals and plants [6, 7, 8].

In contrast, clean and available solar energy is the ideal alternative to energy production. Currently, many countries in the world are starting to increase the share of solar energy in generating power in their countries [9]. Solar energy can be used in many applications as it can generate electricity at concentrated power plants [10-12]. This energy can also be used to heat water for residential or industrial purposes [13, 14]. This energy has a high temperature can be used to heat the role of the domestic and industrial buildings through solar air heaters or using a Trombe wall [15-19]. Solar distillation is one of the important applications of this energy [20-22]. Solar saline ponds provide great heat and are useful for heating the floor and glasshouses [23, 24]. Electricity can be produced using solar energy in the solar chimney successfully [25, 26]. It is now widely used to produce electricity via photovoltaic cells.

Solar cells have reached a high stage of progress in terms of their number, ways of production, and cost of production [27]. The cost of producing these cells has decreased with the development of their performance and increased efficiency [28]. It is currently used throughout the world in the production of electricity, whether as power stations, over rooftops connected to the network or off grid [29]. It also supplies electricity to remote sites such as health clinics and police stations [30, 31]. It is used today to operate irrigation pumps in remote and rugged terrain [32-34]. The use of solar cells to light streets and operates telecommunication towers become very popular all over the world [35, 36]. Photovoltaic cells have become a popular and governmental option in many regions of the world that is relegated to renewable solar energy to reduce dependence on near depletion fossil fuels [37].

The performance and efficiency of the photovoltaic cell is influenced by several factors, including weather and environmental factors [38]. They are affected by temperature [39], solar radiation [40], humidity [41, 42], wind [43], and dust [44-46]. The efficiency of the solar cell is reduced by increasing its temperature and treatments are being initiated to reduce this effect by using a PVT system that reduces the temperature and increases efficiency [47-49]. The use of nanoparticles and paraffin wax in such systems is under intense study [50-52]. Solar radiation is the source of heat, because when the radiation subjected to the cell bug, a small part of it is used to produce electricity while the bulk of it increases the temperature of the PV panel [53].The reduction of solar radiation by using colored transparency sheets proved its failure in enhancing the PV performance [54]. Dust is a major negative factor in reducing cell efficiency as the dusty atmosphere reduces the radiation of solar cells causing a kind of shade that reduces efficiency [55]. The type of accumulated dust and the components of its physical and chemical molecules play an important role in the functioning of the cell [56]. The new studies on dust have shown air pollutants and dust deposited on the surface of the cell reduces the performance of any solar application and not only the solar cell [57-59]. Since dust cannot be disposed of, the result must be treated by cleaning the solar application using special detergents for each application. Ref. [60] indicated that the use of a sodium solution or alcohol is considered appropriate to restore a large part of the efficiency of the cell.

In this study, the focus will be to evaluate the effect of solar radiation variation on solar cell efficiency. The tests were conducted indoor in the renewable energies laboratory. The most severs climatic condition of Damascus City were simulated in the laboratory to find out the possibility of using these cell in widely.

Study location

Damascus is located about 80 kilometers from the Mediterranean Sea in comparison to the eastern Lebanon mountain range. It is also situated on a plateau reaching 690 meters above sea level. Beirut is 58 kilometers from the

western side and 180 kilometers from Amman. , And about 220 km from the south.

The dry, semi-dry continental climate prevails in the city due to its occurrence in comparison to the eastern Lebanon mountain range. This prevents the Mediterranean from reaching the Mediterranean Sea, in addition to its openness to the Levant from the eastern and south-eastern parts of the country. The temperature in the summer to about 40 degrees Celsius, and fall in winter until up to seven degrees Celsius. Table 1 shows the average weather condition of Damascus city.

Table 1, the average weather conditions of Damascus city [61, 62]

The month	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	The yearly average
Average max. temp. °C	12.6	14.8	18.9	24.5	29.7	34.2	36.5	36.2	33.4	28.0	20.3	14.2	24.6
Average min. temp. °C	0.4	1.3	3.7	7.0	10.5	14.2	16.9	16.5	13.0	8.9	4.9	1.3	10.5
Rainfall mm	27.9	22.7	16.9	7.9	3.3	0.4	0.0	0.0	0.2	7.1	21.4	25.8	134

II. EXPERIMENTAL SETUP

In this study, we did several tests that needed connecting the solar panel (which specifications are listed in Table 1) to the measuring module, reading irradiation, temperature, and voltage.Also, the adjustment of solar panel to gain the highest irradiation by testing different inclinations and directions of the solar panel was made. Fig. 1 shows a photo for the solar panel used in the experiments.

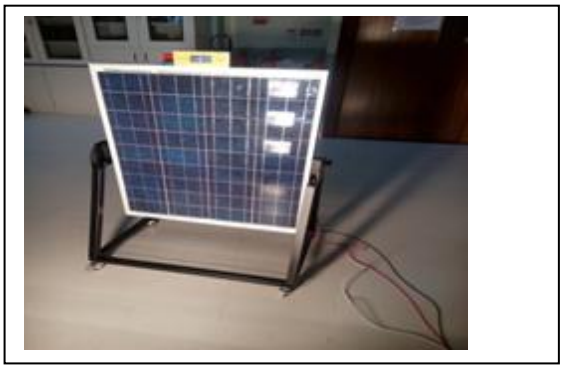

Fig.1 solar panel used in the tests

Fig. 2 represents the measuring DC power source type (DL 9032) used in the tests. Fig. 3 shows the lights used to simulate the solar radiation. As Fig 3 declares the lights used were with high radiation.

Tests procedure

In the first set of tests the solar panel inclination was changed while the light intensity was fixed to evaluate the best solar inclination. After this stage, the panel's inclination was fixed at an angle of 30^0 (for constant azimuth of Damascus city). Finally, the relation between the solar radiation and PV voltage/temperature were measured.

Fig. 2 DC power source (DL 9032)

Fig. 3, the lights used in the tests

III. RESULTS AND DISCUSSIONS

Table 1 describes the result of the tests that were made on the PV panel inclination. In the tests the horizontal angle was put as zero degree while 90° represents the vertical position. The measurements declare that increasing the inclination angle caused the irradiation power reached the panel to be increased. The maximum irradiation achieved was when the panel was facing the lights at 90° inclination angle. This results means that the best inclination angle of the solar panels in Damascus city is 30°, which makes the solar radiation vertically face panel and will makes the panel achieve the best possible power of the PV module. This result is compatible with References [63, 64].

Table 1: the result of the inclination and irradiation (W/m^2)

inclination	irradiation (W/m^2)
0	10.22
10	16.89
20	23.27
30	52.44
40	77.79
50	105.5
60	131
70	161.2
80	194
90	220.8

Table 2 lists the voltage results from the PV panel after concentrating the lights on its face with the effect of time and temperature on the achieved voltage. As the radiation is constant and high, a great part of it will be changed into heat that increases the panel temperature. Increasing the panel temperature affects the resulted voltage and forced it to be reduced. This result compatible with what Ref. [65] declared. In real live, the solar radiation changes instantaneously and it is not constant, however, the PV panel temperature is affected

by solar radiation and its temperature increases as long it is subjected to the sun [66].

Table 2, the result of the voltage (V) and Temperature (℃) at different time

time (min)	Voltage (V)	Temperature C^0
0	20.21	25.24
5	19.93	27.3
10	19.78	29.09
15	19.71	30.4
20	19.66	31.57
25	19.63	32.41
30	19.63	32.93

Fig. 4 clarifies this relation between the voltage and the panel's temperature. It is clear that increasing the panel temperature reduces the resulted voltage which causes a reduction in the outcome power and hence the PV panel's efficiency.

Fig. 5 represents the relation between the PV output voltage and the light intensity. When the light intensity increased, the output voltage of PV panel was increased. The solar radiation is most significant variable that affects the PV outcomes. Damascus city enjoy a good solar radiation intensity with moderate air temperature, these two variables together makes the use of PV modules a favorite procedure to generate electricity compared to fossil fuels generators [67].

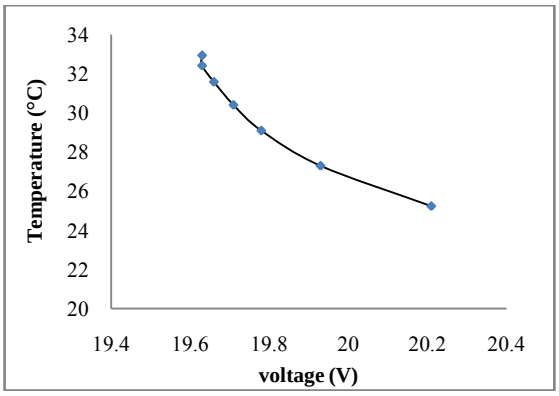

Fig. 4 the relation between the voltage and PV panel's temperature.

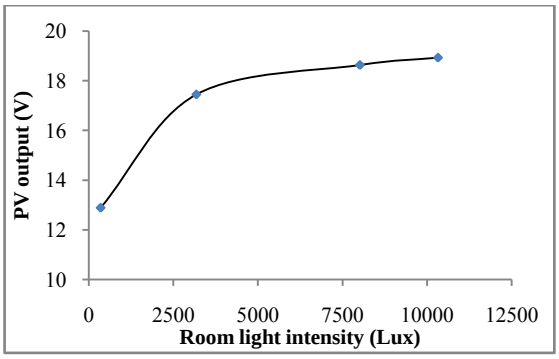

Fig. 5, the relation between the light intensity and PV panel's voltage.

CONCLUSION

The solar cell is related to sunlight and any covered will affect its efficiency, and this most disadvantage of solar energy. It depends on the weather, its cloudy or not. Also, it depends on seasons, so that the PV cells can perform highest value of power and current during one season and lower efficiency in the other season. The results show that there is a direct proportionality between solar flux and output current as well as solar flux and efficiency of solar panel.All in all, using the PV cells and sun light to produce power and energy become very common and most effective way regarding to expenses or environment and renewable. The clean solar energy technologies will have huge longer-term benefits. The results confirmed that the use of PV panels in Damascus city is a good option to face the high air pollution resulted from using diesel generators.

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