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THE INFLUENCE OF DUST ON THE IMAGE OF SOLAR PANEL AND ITS OPERATION IN LIBYA

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The Libyan state, which created the strategic plan for renewable energy 2013–2030, which strives to encourage initiatives aimed at achieving sustainability, is one of the developing nations vying to gain from solar energy in the sector of electrical energy. The agreement to build a 500-MW solar power project made this plan quite evident. The primary barrier to the best possible use of solar energy is pollution, specifically the buildup of dust and bird droppings on solar panels. The efficiency of power generation from solar panels is significantly affected by dust accumulated on them. As a result of the research, quantitative indicators of the impact of dust on photovoltaic systems in Libya were determined and images of the solar panel were obtained with different densities of dust on its surface. The field experiments show that with the increase in dust density, the short-circuit current, open-circuit voltage, and output power of the PV both decrease. The dust with a density of 40 g/m^2 can reduce the maximum power of the PV more than on 20 %. The resulting images of the solar panel can be used to assess the degree of dust in automated systems for solar panels cleaning.

Ключевые слова: *PV solar panel, Solar panel image, Automated system for solar panels cleaning, Dust deposition, solar radiation, artificial intelligence, Hot spots, PV surface temperature*

Введение

Fossil fuels account for 80 % of all energy in the globe, which eventually leads to the depletion of natural resources and an energy crisis [1]. Renewable energy sources like photovoltaic (PV) systems are becoming more important in the production of electricity, with the global cumulative solar PV capacity expected to reach 773.2 GW in 2020 [2]. Fault detection is essential for PV systems to improve dependability, economy, and safety. Solar PV systems have unpredictable characteristics, so it's crucial to assess their economic viability [3]. The efficiency of the energy conversion process is directly related to various factors such as the type of PV cell, orientation and inclination angle of PV module, installation type, location, cell temperature, shading, deposition of dust and pollution on module surface [4]. According to study, desert regions where there is a lot of dust and little rain could lose power up to 80 % due to dust deposition [1]. On the other hand, research also confirmed that a single dust storm could reduce PV module output by about 20 % [5].

A number of cleaning techniques for solar panels have been tried by several researchers and studies, and they have a beneficial impact. These automatic self-cleaning techniques can be divided into two primary groups called active and passive techniques. For self-cleaning techniques, active techniques are those that need power, such as electrostatic and mechanical techniques. In contrast, passive techniques, like coating approaches, don't use any electricity to do self-cleaning [6].

Dust amounts and solar radiation rates in Libya

Depending on the geographic region, different natural elements have different effects on the effectiveness of solar panels. For instance, Libya has a high rate of solar radiation throughout the year, with an average of 3500 hours of sunlight per year and an intensity of 7.1 kW/m^2 per day in the north and roughly 8.1 kW/m^2 per day in the south [7,8].

The type, size, and density of deposited dust and dirt have a considerable impact on the efficiency of solar panels due to their contribution to blocking solar radiation.

Table 1 displays reported rates of dust deposition in several Libyan locations. These rates range from 311.05 g/m^2 annually in coastal metropolitan region (Tripoli) with relatively high humidity to 82 g/m^2 annually in southern areas with a dry desert nature and are thought to represent a significant barrier to solar energy projects [9].

Table 1. Rates of dust deposition in several locations in Libya [9]

Area	Deposition rate (g/ m^2)
Tripoli	297.89
Gefara Plains	215
Gulf of Sirt	105
Central zone	276
Southern zone	82

The wind that causes sandstorms contributes to transporting huge amounts of dust. Figure 1 shows solar panels before and after sandstorm accumulation, the characteristics of which vary in size and composition from one area to another, which causes confusion in determining a cleaning schedule.

Figure 1. Solar panels before and after sandstorm accumulation

The effect of dust accumulation on solar panels in Tripoli

Tripoli is located on the coast of the Mediterranean Sea and includes approximately one-third of the population of Libya. The population of the city of Tripoli reached 2,220,000 people, and the population of Libya reached 6,903,467 people, which increases the percentage of air pollution with the need to use solar energy as a source of electricity. Table 2 shows the rates of dust deposition in Tripoli.

The wide variation in dust deposition rates makes determining cleaning schedules complicated the second is the temperature effect. The dust on the PV can cause change in the form of heat transfer. The existing heat balance model of the PV modules is established under the condition of dust. However, affected by the dust, the heat balance has changed in the PV panels actually put into use. Because of the presence of dust, some of the cells are blocked and cannot work properly, and then the electric current of the shielding cells is reduced. When the cell operating current is less than the entire PV array operating current, the cell voltage ends in a reverse bias state. Then the cell becomes the load of other photovoltaic cells and consumes the power to convert into heat energy to make the temperature of the PV increase [10]. Usually, the limit of a single PV cell reverse bias is 25 W, if higher than the limit, it will be easy to form hot spots.

Hot spots will not only affect the power generation efficiency of PV but also damage the whole PV system and cause irreparable damage [11]. Hence, it was necessary to study the impact of dust in Libya to choose the appropriate methods for cleaning and the timing for conducting.

To study the effect of PV surface contamination on its efficiency, we studied its efficiency by taking into account the effect of temperature. Two solar panels with the characteristics shown in Table 3, Figure 2 were used.

Table 2. Total and monthly deposition rate of dust (g/m^2)

Month	**Dust g/m^2**
January	10.55
February	14.22
March	22.79
April	11.34
May	3.38
June	35.27
July	27.53
August	47.53
September	12.67
October	8.01
November	70.92
December	33.64
Year	297.85

Table 3. The characteristics of solar panel

PV Module Characteristics	**Description**
Module	Shell SQ85-P
Maximum Power (P-max)	85 W
Rated Current	4.95A
Rated Voltage	17.2V
Open Circuit Voltage (Voc)	22.2V
Short Circuit Current (Isc)	5.45 A
Size	1.20*0.527 m
STC	1000 W/m^2. 25C.AM 1.5

Figure 2. The characteristics of solar panel

The aim of the preparation was to describe the effect on the PV's performance depending on its contamination, as well as to clarify the effect of temperature.

Figure 3. Installing the solar panels

The solar panels were installed as shown on the Figure 3 to make it easy to add amounts of sand in the mid-day.

The solar panels and the reference Cell were connected to the device (PVPM 1000C) and Figure 4,5 show the two devices (PVPM 1000C) and (Reference Cell). The device (PVPM 1000C) contains an internal variable resistor that automatically adjusts to obtain both the Rated voltage and the Rated current and then P max .Figure 6 shows connecting the solar panels to the devices used.

Figure 4. PVPM 1000C

Figure 5. Reference Cell

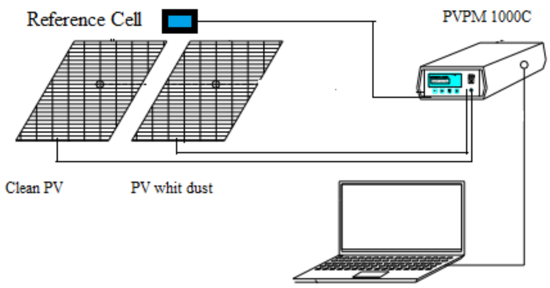


Figure 6. Schematic diagram of test instrument layout

Results and discussion

As shown in Table 4 and Figure 7, the surface temperature at solar radiation (1010,1071) of clean PV and dusty with a difference of 0.5 °C with 5 g/m^2 of dust, to 1.1 °C with 40g/m^2 of dust. As the decrease in solar radiation makes the effect of dust greater on the temperature of the solar panel, at a solar radiation value of 371 W/m^2 and a dust density of 30 g/m^2, the temperature of the dusted solar panel was 1.2 °C higher than the clean panel. Dust causes the cooling effect of the PV panel to weaken, resulting in the increase of PV surface temperature and the reduction of power generation efficiency.

Table 4. Dusty PV Temperature and Clean PV Temperature

DUST g/m^2	Panel temp °C dusty panel	Panel temp °C clean panel
5	56.8	56.3
20	58.9	58.5
30	59	57.8
40	51.9	50.8

The weather was partly cloudy where solar radiation ranged between (1010, 1071) W/m^2, and the dust with a covering density of 5 g/m^2, 20 g/m^2, 30 g/m^2, and 40 g/m^2 was set on the PV surface respectively, while the other solar panel was completely clean. By adjusting the resistance automatically by

(PVPM 1000C) the corresponding current under the different partial pressures of PV is obtained. As shown in figure 8 it can be seen that the presence of dust with a density of 40 g/m^2 causes the output performance of the photovoltaic cell, and causes decreases in the short circuit current of the PV 22.12 %. Indicating that dust has a greater influence on the PV short circuit current and a smaller influence on the open circuit voltage.

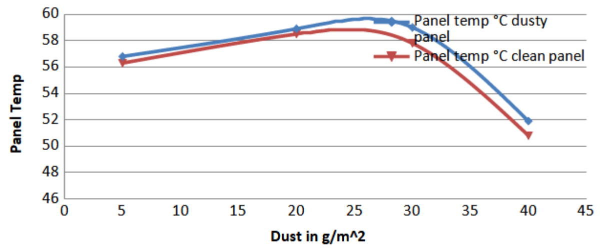
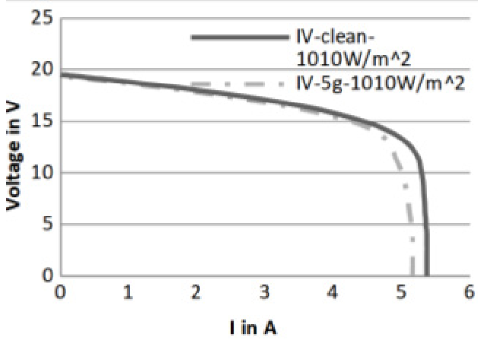
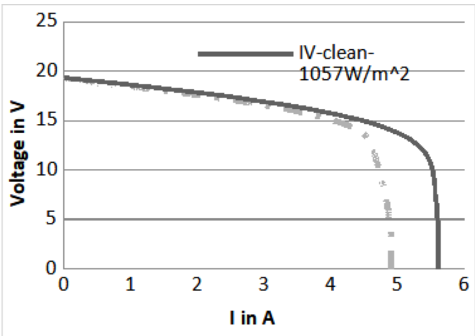


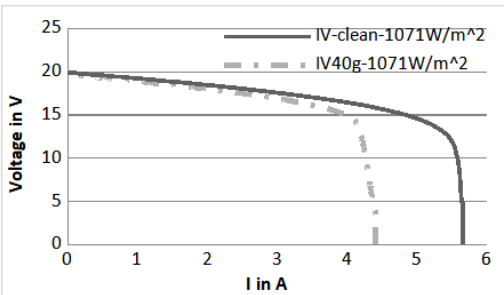
Figure 7. Effect of dust on PV surface temperature



a



b



c

Figure 8. Effect of dust *a* (5g,1010W/m^2), *b* (20g1057W/m^2), *c* (40g,1071W/m^2

To find the actual effect of dust, the effect of variation in solar radiation had to be excluded, as solar radiation of 1010 W/m^2 has adopted for all readings. The final ratio of the output power for different amounts of dust is shown in figure 9.

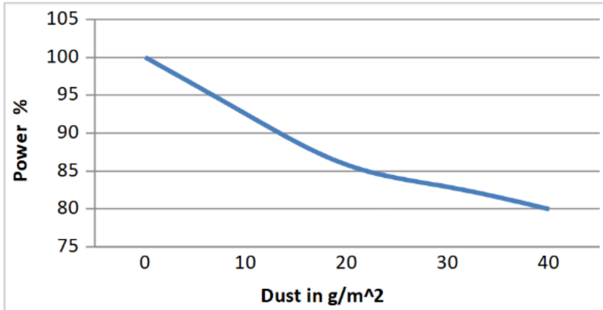


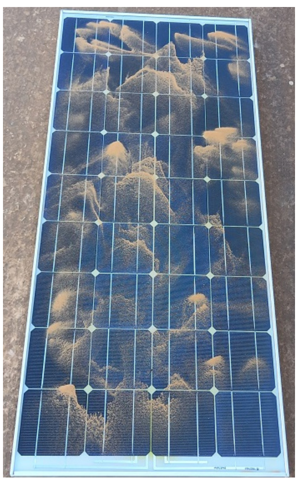
Figure 9. The ratio of the output power for different amounts of dust at 1010 W/m^2

From figure 9 it can be confirmed that at 40 g/m^2 of dust on the solar panel and a solar radiation rate of 1010 W/m^2, the output power will decrease by about 20 %.

Figure 10 shows images of a solar panel with different densities of dust on its surface.

a

b



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d

e

Figure 10. Images of the solar panel with different densities of dust on its surfaces: a – 0 g/m^2; b – 10 g/m^2; c – 20 g/m^2; d – 30 g/m^2; e – 40 g/m^2

From Figure 10 it can be seen that the image of the panel changes significantly when the density of dust on its surface changes. Therefore, from the image of the panel, you can assess the degree of dust on the solar panel, and therefore the level of reduction in the energy it generates, and therefore make a timely decision to clean the panel, which can increase the electricity generation of the panel by at least 10-20 %.We also confirm the following:

• Determining the reason for the reduction in output power is very complex, as all climatic conditions (temperature, humidity, solar radiation, shading, etc.) affect the percentage of output power.

• Dustiness of the solar panel significantly reduces the output power of the solar panel due to the decrease in solar radiation falling directly on the surface of the panel.

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• Dustiness of the solar panel significantly reduces the output power of the solar panel due to the decrease in solar radiation falling directly on the surface of the panel.

Conclusion

Libya is rich in renewable energy resources, including solar energy. At present, Libya uses fossil fuels to meet energy demand, and the share of renewable energy in consumption is almost negligible. Libya suffers from a high level of pollution and is considered one of the most polluted countries in the world due to its dependence on fossil fuels and climatic conditions. In its current state, Libya's plan to transition to solar energy faces technical and economic challenges. These difficulties may be limited to the climate, most notably the impact of dust and pollution, methods for finding appropriate cleaning methods, and the high cost of cleaning for huge solar energy projects in light of unexpected weather fluctuations. This study represents the real input for the use of artificial intelligence, which in turn determines the type and time of cleaning, taking into account the financial cost and protecting solar panels from damage resulting from unjustified cleaning operations.

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АЛБАГОУШ АЛААЕДДИ АЛИ, АБУАУБА А.Б., КУПРИЯНОВ А.Б.

ВЛИЯНИЕ ПЫЛИ НА РАБОТУ СОЛНЕЧНЫХ ПАНЕЛЕЙ В ЛИВИИ

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Ливийское государство, разработавшее стратегический план развития возобновляемой энергетики на 2013–2030 годы, направленный на поощрение инициатив, направленных на достижение устойчивости, является одной из развивающихся стран, соперничающих за получение выгоды от солнечной энергии в секторе электроэнергетики. Соглашение о строительстве солнечной электростанции мощностью 500 МВт сделало этот план вполне очевидным. Основным препятствием на пути наилучшего использования солнечной энергии является загрязнение окружающей среды, в частности накопление пыли и птичьего помета на солнечных панелях. На эффективность выработки электроэнергии солнечными панелями существенно влияет скопившаяся на них пыль. В результате исследований были определены количественные показатели воздействия пыли на фотоэлектрические системы в Ливии и получены изображения солнечной панели при различной плотности пыли на ее поверхности. Натурные эксперименты показывают, что с увеличением плотности пыли ток короткого замыкания, напряжение холостого хода и выходная мощность фотоэлектрической батареи уменьшаются. Пыль плотностью 40 г/м² может снизить максимальную мощность фотоэлектрических панелей более чем на 20 %. Полученные результаты могут быть использованы в автоматизированных системах очистки солнечных батарей.

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