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Assessment of the energy production from PV racks based on using different Solar canopy form factors in Amman-Jordan

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Abstract

In Jordan, renewable energy, particularly solar energy, is the most convenient renewable resource to help produce energy for various daily uses. This is because the rate of solar radiation in Jordan is high which is in the range of 4-8 KWh/m^2. Therefore, investing in solar energy is the most successful investment in the energy sector in Jordan. This assessment comes to compare the outputs of solar panel racks with different solar canopy form factors.

Keywords: Renewable energy; PV racks; Solar radiation; Solar canopy form factors

1. INTRODUCTION

Jordan is a rich country in renewable energy resources, especially the solar energy, taking in the consideration that Jordan has more than 300 sunny days over the year with a high rate of solar radiation if compared to other neighboring countries and the world, where the rate of solar radiation in Jordan between 4 to 8 kWh/m^2 Makes investing in renewable energy and solar energy an unrivaled investment [1-10]. However, Jordan did not get the full benefit from the renewable energy resources and the solar energy it owns because investment in these sectors is still very weak and Jordan is still dependent on conventional fuels to meet the energy needs for daily use [4, 11-14].

The investment in renewable energy, especially solar energy, is a worthwhile investment. A thorough study of the components of these systems and a comprehensive study on the reality of these sources and the possibility of working with them should be done through accurate knowledge of the solar reality of Jordan. In this regard, it should be mentioned that many national and international researchers have shown interest in studying the possibility of benefiting from renewable energy, especially solar energy, in Jordan because they believe in the utility and capacity of renewable energy to meet the energy deficit in Jordan. On the other hand, it is necessary to support these growing sources and take their hand in the growth to maintain the sound ecosystem of future generations [5-10, 15-30].

Mohammad et.al. present a case study to improve an existing building in Amman to become environmental friendly by using a PV system to cove the electricity required for the building [31]. Mohammad and Saad present a study dealing with designing a PV system covering the electricity required of the school of engineering at Mutah University in Jordan and they found by implementing a PV system will reach the goal in covering the needs of the school of engineering [32].

The design of PV systems is not so easy because a complex set of factors affects the design. These factors include the environmental factors and the natural factors represented by the availability of solar radiation and the space required to work with PV systems in addition to the need to study the mechanism of interaction of all system parts. From here, many studies have emerged that deal with choosing the best site to use solar energy. [33-38]. There are also many studies that address the use of solar energy systems in part to help reduce the electrical load of residential and commercial buildings [39-44].

There are many factors limiting the ability of PV systems to generate energy from these determinants of PV technology such as sun-tracking systems and natural determinants such as dust, which is attached to the surface of the cells and collectively leads to a weakening of production[7, 45-50]. In this study a simulation of several canopy form factors using Energy-3D simulation is investigated in a selected location in Jordan which is Amman the capital of Jordan to select the best canopy form factors allow the system generate the maximum energy.

2. GEOGRAPHICAL AND METEOROLOGICAL DATA

Amman is the capital of the Hashemite Kingdom of Jordan, which is located in the middle of Jordan within a latitude of 32º North and longitude of 36º East. The average number of sunny hours in Amman is about 3300 hours per year. With the highest number of sunny hours in June and the lowest in December. Figure. 1 shows the distribution of the temperature over the worst sunny day in the year which is 10th of December (A) and over the year (B) at different heights.

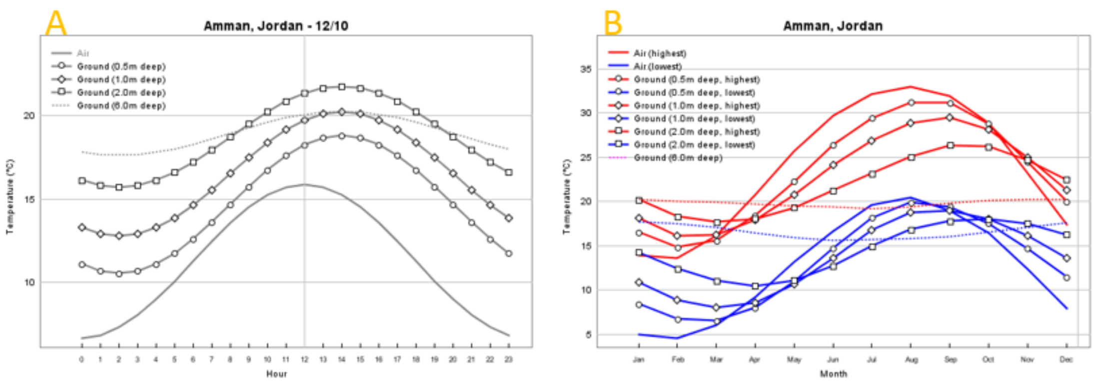

Figure 1. Distribution of the temperature over the day of 10th of Dec. (A) and over the year (B).

3. SOLAR PV SYSTEM

The solar energy is the best way to generate the electricity directly using the PV systems or indirectly using the concentrated solar power technology. For this work the following steps are followed. Estimating the monthly solar irradiation, Estimating the hourly solar irradiation for the tilted surface and Estimating the energy output. The calculation is based on the following mathematical model [51-57].

Firstly, the Estimating the monthly solar irradiation. Declination calculation is relying on the 10th of December the worst day in the solar radiation over the year. Declination is equal to -23.05˚, the Sunset hour angle ω_s will be 74.8˚, daily extraterrestrial radiation on a horizontal surface,H_o will be 18937499 J/m^2, monthly average clearness index,$\overline{K_T}$ will be 0.5 and monthly average daily diffuse radiation $\overline{H}_d$ will be 3916700 J/m^2. Secondly, Estimating the hourly solar irradiation for the tilted surface. Ratio of hourly total to daily total global radiation r_t will be 0.0188 taking into consideration that this value based on $\omega = -67.5°$ for the midpoint of the hour (i.e. 7:30 AM), ratio of hourly total to daily total diffuse radiation r_d will be 0.025 and the global horizontal irradiance I and it's beam component I_b will be 25.85 and 26 Wh/m^2, and hourly irradiance in the plane of the tilted surfaces I_T will be 162.5 Wh/m^2.

4. RESULT AND DISCUSSION

The radiation received by a surface per unit area represents the solar radiation in a unit of Wh / m^2 and can be assessed by the average daily radiation for a given month. Figure. 2 present an overview of the simulation used in this study which is Energy-3D for the selected canopy form factors which are: Bufferly, Flat and Ridge arrangements.

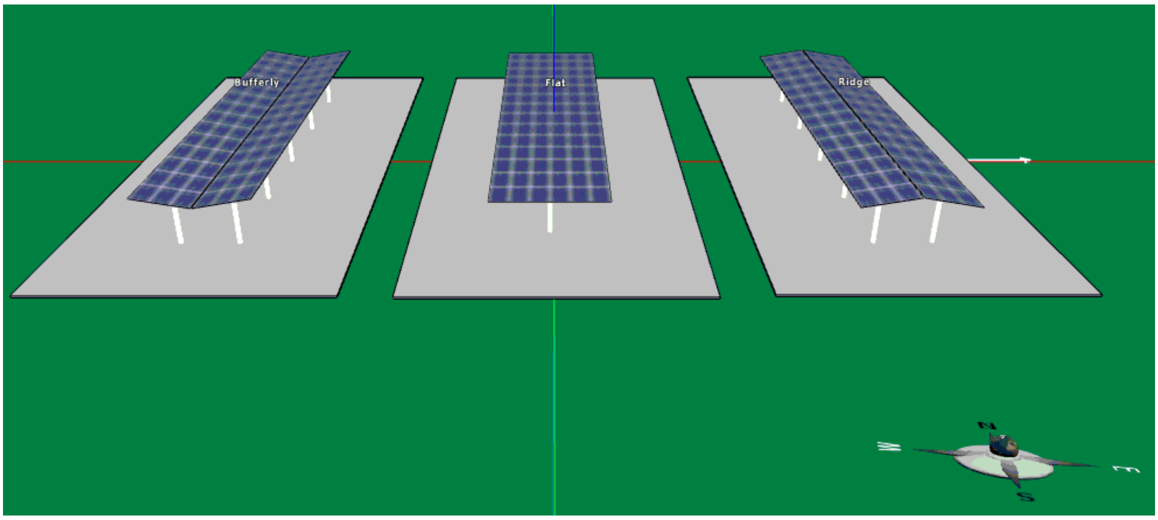

Figure 2. The selected canopy form factors of the Energy-3D simulation

Figure. 3 illustrated the simulation result of the three selected canopy form factors after it runs over the 10th of each month over the year. The maximum production over the year was between May and September. While, the lowest was in January, February, November and December.

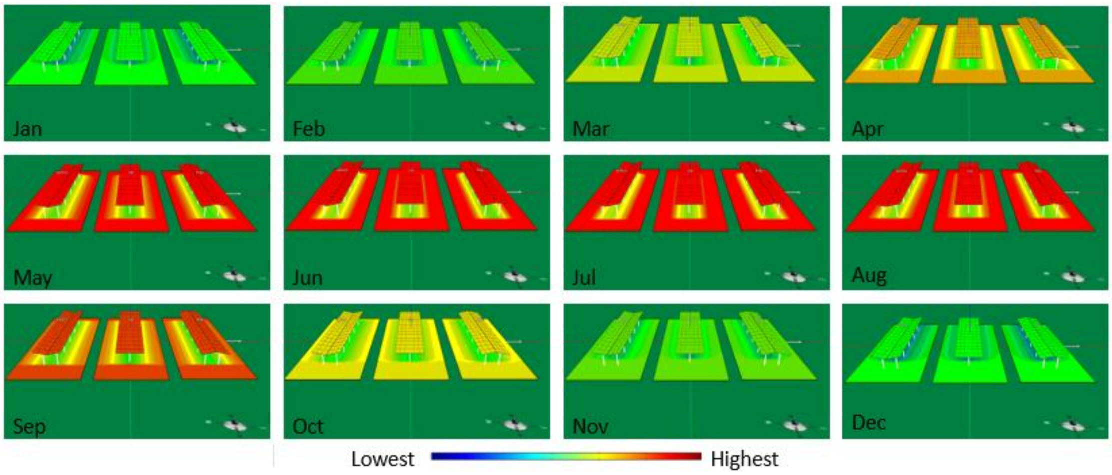

Figure 3. Result of the simulation over each months of the year

The energy output from the PV panel depends on the size, the efficiency and the received sunlight that the panel gets. Figure. 4 presents the energy output from the solar PV racks with the different canopy form factors during the 10th of December as it is the worst solar day during the year for the selected location which is Amman-Jordan. It is clear that: The maximum energy production was for the PV racks with the flat canopy form factor with an energy production of 51.53 kwh. While, the production of the system with the Bufferly and Ridge canopy form factors approximately same with energy production of 48 kWh.

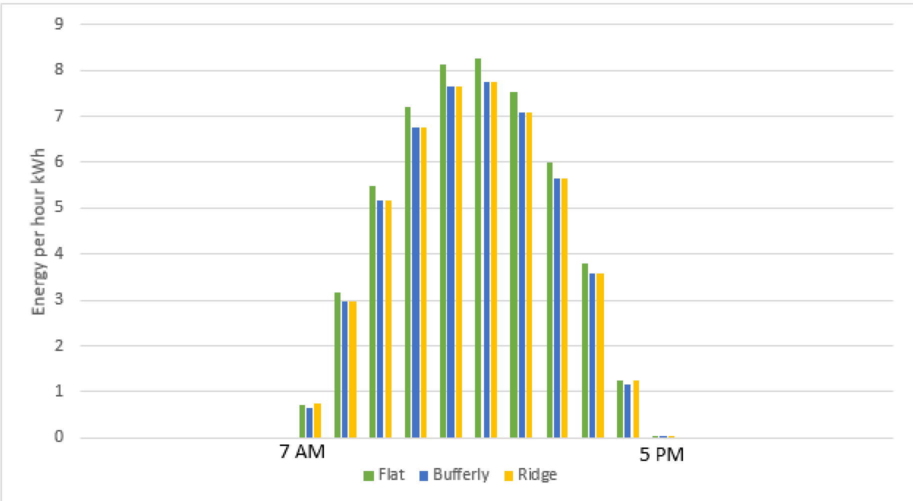

Figure 4. Production of the energy at 10th of December for the PV racks with different canopy form factors

Figure. 5 presents the energy production from the PV rackes with different canopy form factors at Amman-Jordan over the year in kWh. The maximum energy output over the year was for the system with a flat canopy form factor with an energy output of 40467 kWh/year. The bufferly and ridge canopy form factors have approximately the same energy output with a value of 38000 kWh/year.

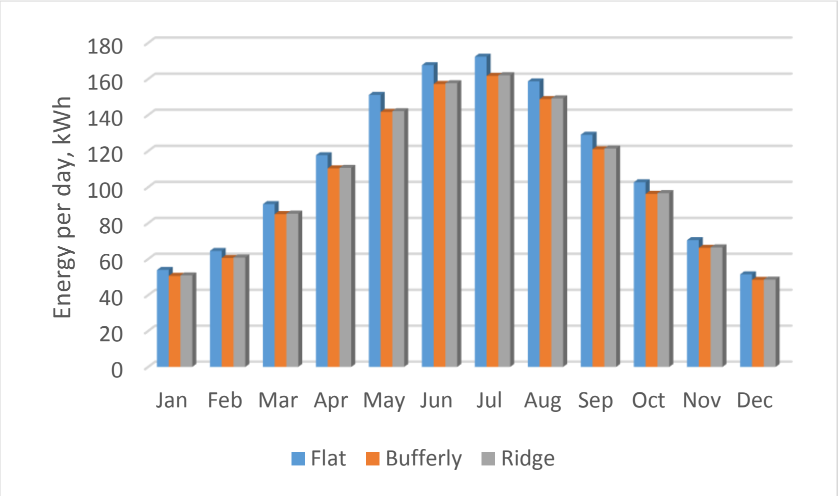

Figure 5. Energy output during the year for the PV racks with different canopy form factors

5. CONCLUSION

The production of the PV racks is studied with Appling different canopy form factors: The flat, the bufferly and the ridge canopy form factors. It is found from the result of the simulation that. The maximum energy output for the PV racks was for the PV racks with the flat canopy form factor, with an energy production of 40467 kWh/year. while the minimum output of energy was 39000 kWh/year for the PV racks with bufferly and ridge canopy form factors.

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