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Energy Production Assessment of Solar Tower Based on the Study of the Mirror Shadowing and Blocking Effects

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Abstract Concentrated solar energy systems are one of the most important applications of solar energy, which will have a promising future in Jordan that because of Jordan has more than 300 sunny days with a high rate of solar radiation. In this research, the phenomenon of blocking and shadowing of mirrors in the solar field and their effect on the production of energy from the solar tower was examined and found that the mirrors far from the solar tower are affected in these phenomena significantly unlike the nearest mirrors.

Keywords Concentrated Solar Energy, Solar Tower, Blocking and Shadowing

1. Introduction

The problem of energy and its sources is one of the most important factors affected on the progress and prosperity of the world. Especially if we know that the traditional energy sources are on the way to the end and the need is urgent to find ways to use traditional sources in very effective ways to achieve the greatest benefit from them and also we must start searching for new energy sources. Renewable energy stands out as an ideal solution to this problem as renewable energy sources are widely available in various parts of the world. Solar energy is one of the most important renewable sources and is the main engine for the rest of renewable energy sources. With regard to Jordan, we find that it has been blessed with a huge amount of solar energy sufficient to meet the needs of energy because Jordan receives more than 300 sunny days throughout the year with a very bright solar radiation rate compared to neighboring countries and countries of the world [1-15]. In this context, there is an urgent need to support investment in the renewable energy sector in various countries of the world and in Jordan in particular because investment in this sector is still very low and there is a lacks in the supporting from different sectors inside the Jordan [4, 12, 16-20].

The availability of alternative energy sources is not enough to take the advantage of achieving the goal of disposal of traditional energy sources, but it is desirable that technology is available to assist in the optimization of renewable energy sources. Renewable energy is a promising candidate to replace the traditional energy for that we should be mentioned that there are many ways to exploit the solar energy which is the direct way through photovoltaic cells, which convert solar energy through radiation Pick-up on photovoltaic cells into electrical energy, as well as indirect method available is to convert solar energy by get the benefit through using the usual falling of the solar radiation and convert it to heating the water to produce steam and makes it triggers various turbines to generate electricity as a by-final of this process [5-10, 20-35].

Concentrated solar energy is one of the most important means to exploit solar energy in the process of power generation, which are similar to the other methods of exploitation of solar energy which suffering from a set of constraints and obstacles to optimizing the use of them [36-45]. Hence the need for research and investigation to solve the problems faced by this technology is essential from this point we find researchers from all over the world is carrying out studies and researches, such as Saad Alrwashdeh, who discussed the effect of the height of the solar tower on its energy production. He found that the higher the solar tower, the greater the energy generated. Another study of him is about the effect of the arrangement of mirrors in the field of solar tower and he found that the mirrors in the northern side of the earth has the ability to generate more energy than the mirrors that are arranged in the south. many researchers in the world try to solve the various problems for this type of technology to exploit renewable energy and in particular concentrated solar power [8, 12, 13, 15, 46-51].

The solar radiation reflected from the mirrors to the receiver in the top of the solar tower is the most important factors affected the process of production of energy from the solar tower from here, the need to install and arrange the mirrors correctly is an important factor aide to increase

energy production [7, 52-57]. In this research the phenomenon of blocking and shadowing of the mirrors on each other and its impact on the production of energy is studied through the use of 3D-Energy simulation program in Amman, the capital of Jordan.

2. Introductory to Solar Calculation

The mechanism of information collection and design of concentrated solar systems is a complex subject. It must be treated with great care. The design begins by collecting information about the area in which the solar system is to be built, and then analyzing these data and calculating the amounts of solar radiation, especially the amount of solar radiation falling with a tilt angle which are available and which used in the process of producing and utilizing the energy [58-64].

According to the logical design sequence, the design of the solar systems depends on taking into account the worst day in solar radiation, which is the 10th of December in Amman Jordan follows the process of site selected, the calculation of solar radiation falling daily, monthly and annual and then choose the optimal arrangement of the solar system Finally design ends by calculating the amount of energy Resulting

3. Result and Discussion

It is possible to calculate the solar radiation by knowing the amount of solar radiation falling on the unit area and measured in W/m^2. Figure 1 shows the mechanism of work for this study through the simulation 3D-Energy which is used it is clear through the figure the solar tower and a field of mirrors consisting of eight mirrors used to study the effect of the mirrors blocking on each other and the impact of the mirrors shadow on each other.

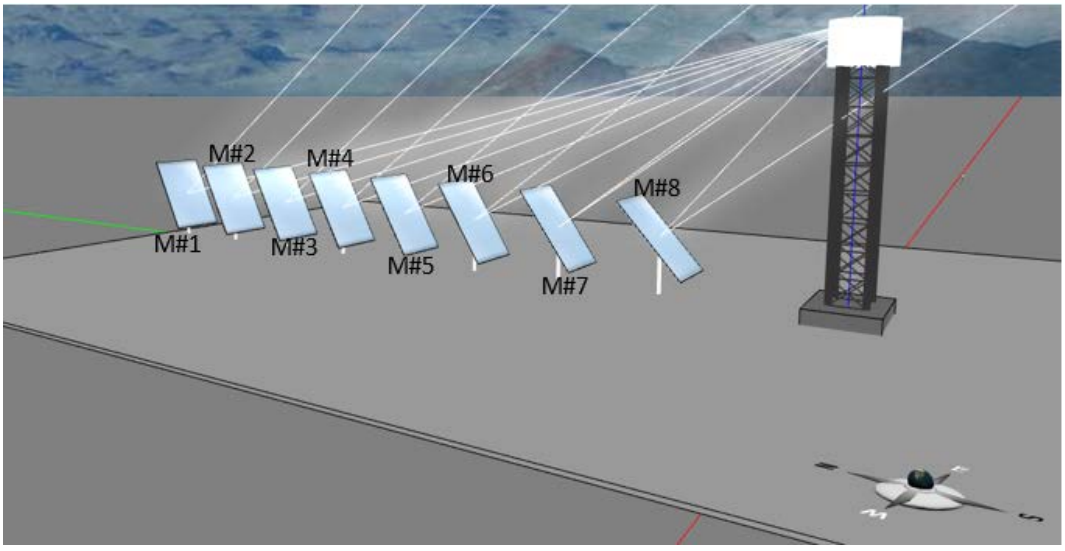

Figure 1. Solar power tower and the mirror fields

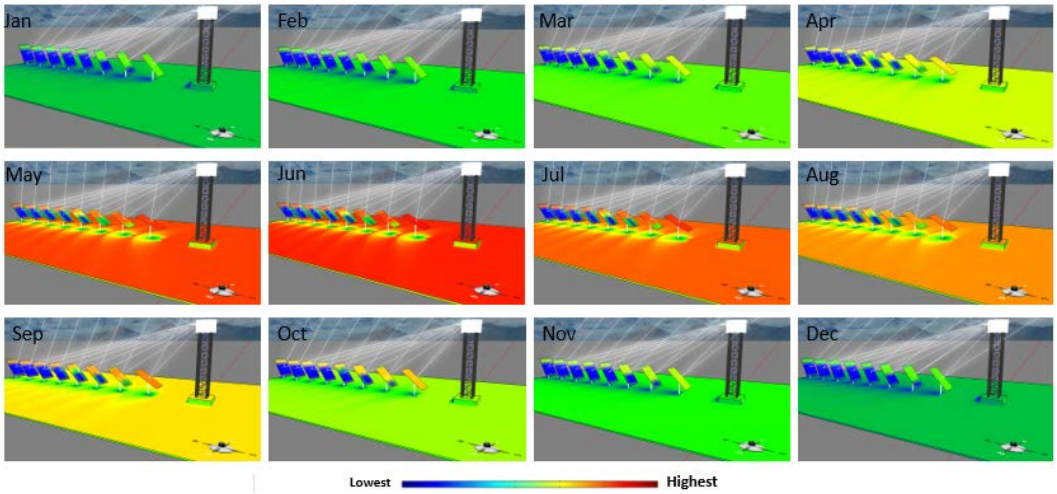

Figure 2. Simulation result of each month through the year

Figure 2 shows the results of the 3D-Energy simulation program used in this study during the tenth day of each month throughout the year. As is clear, the results show that the largest quantities of energy production were during the months between May and September and the rest of the months of the year is the worst in the production of energy. Based on the figure. 2 it is clear that the mirrors in the field do not work at full capacity, where it can be noted that a large part exceeds 75% of some mirrors, especially the far away from the solar tower does not have any impact in the production of power as it is blocked by other mirrors. Thus, the solar radiation will not reflect toward the receiver on the top of the solar tower as well it is also clear that the mirrors shadow has a limited effect on the ability of mirrors to reflect the solar radiation and thus reduce the power output.

It is clear from the Figure 3 that the mirrors far from the solar tower have a low ability in the reflecting of the solar radiation toward the receiver on the top of the solar tower because of the blocking and shadowing effects from the nearby mirrors that will cause a reduction in the contribution to the production of energy, conversely, the closest mirrors to the solar tower have the greatest ability to reflect the solar radiation toward the solar tower receiver and thus its contribution in the energy production will be more compared to the far mirrors. This is illustrated by the calculation of the energy generated through the mirrors in the worst days of the year in the solar radiation, which is the tenth of December, where the amount of energy produced by the furthest mirrors is 4.02 kWh and the amount of energy produced from the nearest mirrors is 16.2 kWh.

Based on the figure. 4, the amount of energy produced from the solar tower was calculated using eight mirrors arranged in front of the solar tower over the year. It was found that the furthest mirror is the least contributor to the production of energy. as the contribution of the furthest mirror to the production about 6 % of the total production. while the contribution of the closest mirror was about 26% of the total production.

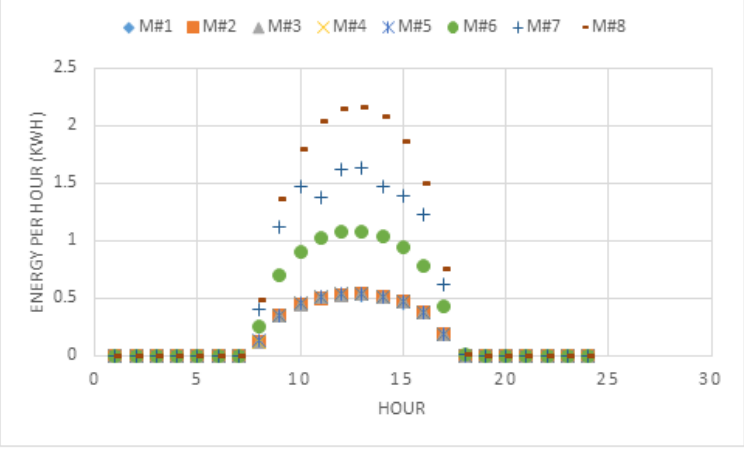

Figure 3. Energy output at 10th of December for the mirrors

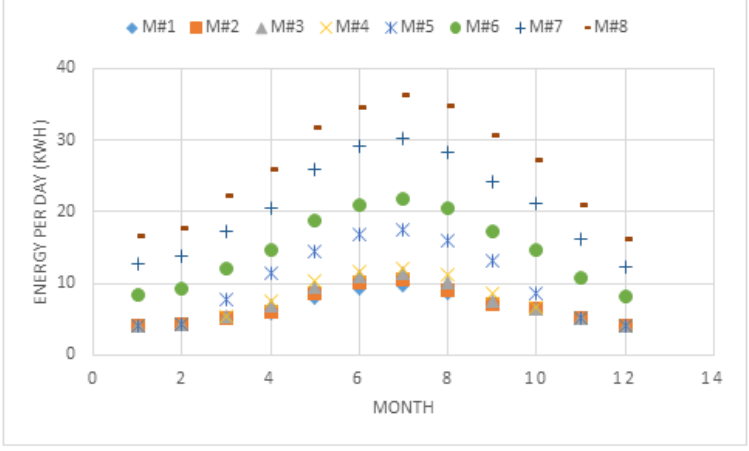

Figure 4. Energy output over the year of solar tower based on the effect of each mirror of the field

4. Conclusions

In this study, the amount of energy produced from a solar tower was calculated using eight mirrors arranged in front of a solar tower. The energy value produced by the solar tower during the worst day of the solar radiation which is December 10th, was 57 kWh and the amount of energy produced over the year was 1202 kWh.

The effect of the phenomenon of blocking and shadowing of the mirrors on each other was studied and it was found that this phenomenon has a significant impact on the production of energy, where the contribution rates of the mirrors in the production of energy varied according to distance from the solar tower and according to the order of mirrors in the first figure, the impact of mirrors was 6, 6.7, 7, 7.5, 10.3, 14.75, 20.9 and 26.2 respectively.

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