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Analyzing of Global Solar Radiation over Baghdad

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Abstract: ***Solar radiation in Baghdad City was investigated over a span of one year at the Renewable Energy and Environment Research Center (REERC) in Baghdad city to comply with the increasing demand of the renewable energy sources and the wide use of their applications. In this study, the analyzing of Global Solar Radiation (GSR) data measured on a horizontal surface was done. The data collected and presented in this work were based on the hourly and the daily values. The Results found that the total of daily average GSR incident on a horizontal surface reached to about 194 MJ/m^2, distributed on the months from January to December. The results also showed that the maximum radiation is received in July (23.5 MJ/m^2) and the minimum radiation is received in December (7.5 MJ/m^2). Calculations of clearness index values were found to be in the range of 0.43-0.57 indicating that most of the months exceed the rates of 50%, which refers to a clear and sunny weather.***

Keywords: Global solar radiation, clearness index, Baghdad solar radiation, horizontal surface, climate change

1. Introduction

When solar radiation penetrates the atmosphere of the Earth, several physical operations will occur between the solar beam and the atmospheric particles which attenuate the solar radiation by means of absorption and scattering. Radiation that has been scattered one or several times is called the diffuse radiation. The remaining unabsorbed and un-scattered radiation is called the direct radiation. The total downward solar radiation from the hemisphere incident upon a horizontal surface is called the global radiation [1].

GSR is the most important component to be studied to explore the amount of solar energy incident on a specific location. GSR at a specific location is defined as the sum of direct and diffuse radiations reaching that location from sunrise to sunset. Solar radiation is required for many applications, such as agriculture, hydrology and meteorology. It is also a critical parameter for the design and performance of the solar energy systems [2]. The spectrum of solar radiation covers a wide range; from x-rays to radio waves. Solar energy applications are utilizing solar radiation with a spectral range of about 300-4000 nm. Measurements in this range are the most common. The extraterrestrial solar spectrum at the mean Sun-Earth distance can be calculated by the following formula [3]:

$$H_{o=}\ H_{SC}[1+0.034221cos(2\pi d365)+ 0.00128sin2\pi d365+0.00719cos(22\pi d365 \quad (1)$$

where: H_0 is the daily extraterrestrial radiation on a horizontal surface, and H_{sc} is the solar constant. This equation is necessary for the calibration of the solar instrumentation. The relation between the total global radiation on a horizontal surface (G) with the direct beam (B) and the diffuse radiation (D) can be written as in the following equation [3]:

$$G = Bcos(z) + D = Bsin(h) + D \quad (2)$$

where: *(z)* is the incident angle called the solar zenith angle, *(h)* is the complement of solar elevation. For tilted surfaces, equation (2) needs to be rewritten as:

$$G = Bcos(\theta) + R_dD + R \quad (3)$$

where: θ is the incidence angle normal to the tilted surface, R_d is the conversion factor, and R, is the radiation reflected from the ground to the tilted surface.

Global radiation reaching the earth's surface is the sum of two components: astronomical and meteorological. The meteorological (so-called stochastic component) is expressed by introducing the clearness index (K_T) which is defined as the ratio of the measured horizontal radiation (H) to the extraterrestrial radiation on a horizontal surface (H_o) as presented in equation (4) [4]. The low value of K_T refers to a very cloudy day, while the high value is referring to the clear and sunny day. Clearness can also be affected by the elliptic shape of the Earth by a factor of ±3.3%.

$$\overline{K}_T = \frac{\overline{H}}{\overline{H}_0} \quad (4)$$

Several studies on GSR at different locations in the middle east region are found in literature [5], [6], [7]. However, a very little literature is available on Iraq [8], [9]. Our previous investigation presented about 20 years ago [8] at the same location of the current study showed that the daily total amounts of GSR were 214 MJ/m^2, where a pyronometer was used to measure the GSR in the previous study. In fact, measured solar radiation data in Iraq are poorly covered. Therefore, it is imperative to achieve such measurements at various locations in Iraq and in different periods of times to determine the amount of solar energy delivered at each location and at different periods of time, especially since the noticeable climate changes worldwide. In addition, the extraordinary high temperatures in Iraq require and motivate a closer look at the atmospheric parameters. In this study, GRS was measured and analyzed on a horizontal surface in Baghdad City. The data collected and presented in this work were based on hourly and daily values. Clearness index is also calculated in this study to determine the feasibility of the use of PV systems in Baghdad.

2. Instrumentation and Data Analysis

A solar radiation sensor from Davis Instrument Corporation was used to measure the GSR. The sensor range is 300-1100 nm. The sensor was calibrated against a secondary standard

which is calibrated periodically against an Eppley Precision Spectral Pyranometer in natural daylight. The sensor was installed on the top of building at a height 3m from ground to ensure there is no adjacent shading or obstructed trees. Figure (1) illustrates a photograph of the installed sensor.

Figure 1: The solar radiation sensor used in this research.

GSR was measured and collected in the Renewable Energy and Environment Research Center (REERC) located in Baghdad with the coordinates (Latitude 32.33˚N and Longitude 44.45˚E) during the period Jan. 2016 to Dec. 2016. Hourly and daily data were recorded using Davis Vantage Pro.2 instrument and analyzed to show the variation and intensity of the incident global solar radiation on a horizontal earth surface. The annual accumulated measured data for the daily total amounts of GSR were recorded in a period of 345 days (20 days' data are missing due to maintenance) and reached to the monthly average of daily total 194 MJ/m^2 which is considered a noticeable difference compared to the total value of our previous study published in 1998 [8]. This difference could be attributed to the direct impact of the weather attenuated factors; (aerosols, dust, pollutants) and/or due to the difference in accuracy between the measuring devices (pyronometer versus silicon cell). The maximum amount of GSR was recorded in June and July, while the minimum was recorded in December and January. Figure (2-a) shows the annual variation of the measured GSR on a horizontal surface. The average values of monthly total solar radiation were calculated for the same data and illustrated in Figure (2-b).

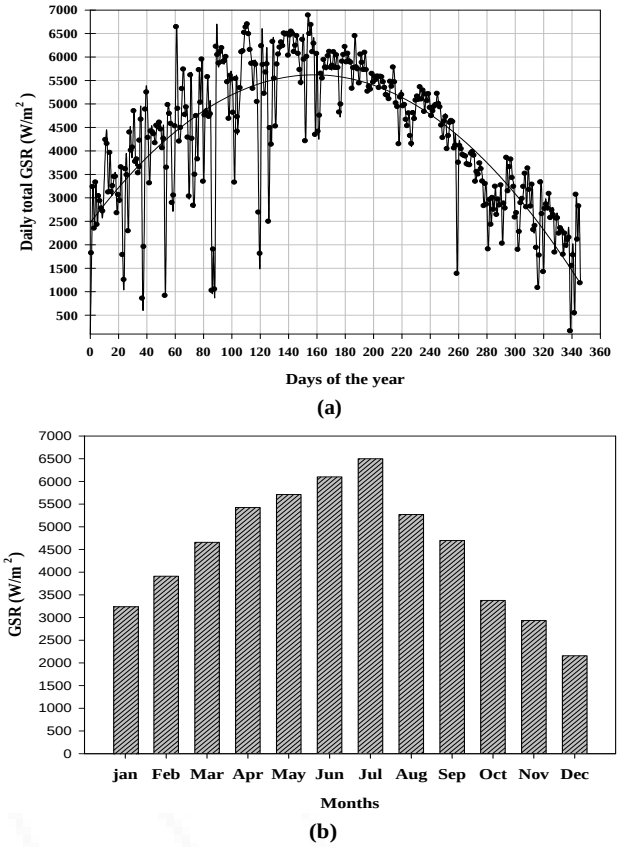

Figure 2:.Measurements of daily total GSR (a), and monthly average GSR (b)

Figure (3) demonstrates the distribution of the hourly measurements of global solar radiation from January to December. It can be seen from the figure that the peak of the intensity of radiation lays around 11:00am-13:00pm duration of day time in the summer months from June to August.

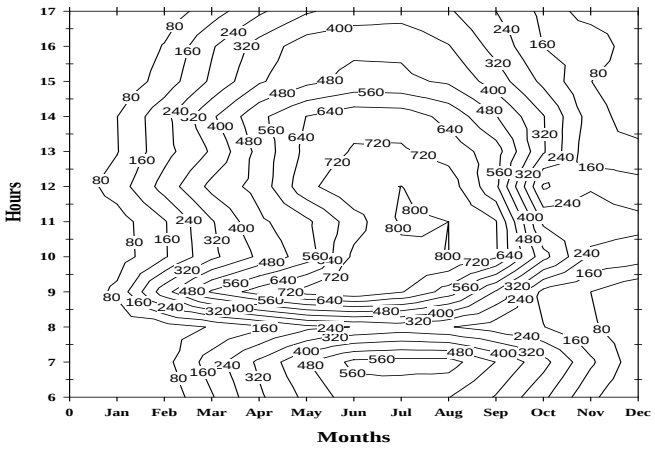

Figure 3: Distribution of the hourly Measured GSR

The monthly clearness index values (K_T), is calculated for Baghdad City. The theoretically extraterrestrial solar radiation data are obtained from (Waleed and Shaimaa 2011). The monthly clearness index values are varying between 0.43 and 0.57 as shown in Figure (4). By comparing this result with our previous results of the exact location in 1998 (with K_T varied between 0.48 and 0.66) [8], it can be deduced that Baghdad weather is less clear nowadays than it was 20 years ago. This can be ascribed to the climate change associated with the global warming and other natural factors. Dust and other pollutants directly affect the clearness.

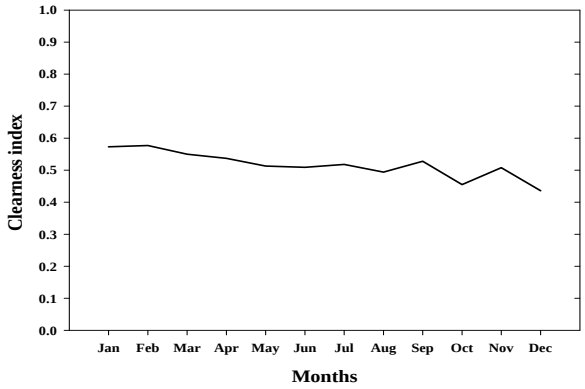

Figure 4: Monthly clearness index factor

Solar energy applications often demand the availability of GSR amounts in any site of experiments, specifically knowing the yearly average of radiation amount which represents the optimum measured value of GSR that is needed for the calculations of the systems design. This annual average is found to be 4496 W/m^2. Values more or less than the annual average radiation are shown in Figure (5). These values are also useful for PV design calculations and it can provide information about the maximum and minimum power gain for solar applications.

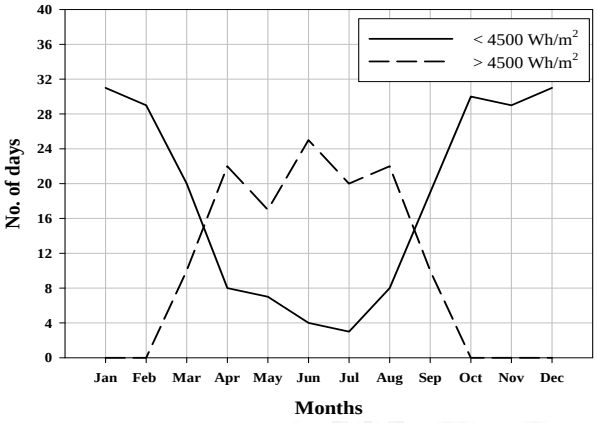

Figure 5: No. of accumulated days referring to the average value of GSR

3. Results and Discussion

The distribution of the incident solar radiation on the horizontal earth's surface is non-uniform due to the changes in the atmospheric conditions and sunshine duration which depends on the incident angle of radiation during the day and the year. It is important to have an idea about the behavior of received solar radiation for the calculations and design in solar applications, GSR amounts can be divided over the year as follows: (40% in summer, 24% in autumn, 20% in spring, and 16% in winter). Clearness index factor that range between 0.43-0.57 indicate that the weather in Baghdad is mostly clear during the year, which shows that there is a good potential of utilizing solar power applications.

4. Conclusions

The availability of GSR at the ground is significantly variable due to the dependence on the meteorological conditions and the changes in declination angle of the sun path throughout the year that needs to be measured continuously and periodically. Data should be analyzed annually, especially in clear and sunny weather regions that can provide more chances to utilization of solar applications. The present work appeared to give a validity to achieve solar systems due to the availability of solar radiation amounts over Baghdad City which have a high amount of incident solar radiation on a horizontal surface.

References

[1] J. E. Hay, "Calculating solar radiation for horizontal surfaces—I. Theoretically based approaches," *Renew. Energy*, vol. 3, no. 4, pp. 357–364, 1993.
[2] M. Despotovic, V. Nedic, D. Despotovic, and S. Cvetanovic, "Review and statistical analysis of different global solar radiation sunshine models," *Renew. Sustain. Energy Rev.*, vol. 52, pp. 1869–1880, 2015.
[3] V. Badescu, *Modeling Solar Radiation at the Earth's Surface*, vol. 53, no. 9. Springer, 2008.
[4] G. Vijayakumar, M. Kummert, S. A. Klein, and W. A. Beckman, "Analysis of short-term solar radiation data," *Sol. Energy*, vol. 79, no. 5, pp. 495–504, 2005.
[5] B. Y. H. Liu and R. C. Jordan, "The interrelationship and characteristic distribution of direct, diffuse and total solar radiation," *Sol. Energy*, vol. 4, no. 3, pp. 1–19, 1960.
[6] I. Etier, A. Al, and M. Ababne, "Analysis of Solar Radiation in Jordan," *Jordan J. Mech. Ind. Eng.*, vol. 4, no. 6, pp. 733–738, 2010.
[7] A. N. Çelik, "Analysis of Ankara's exposure to solar radiation: Evaluation of distributional parameters using long-term hourly measured global solar radiation data," *Turkish J. Eng. Environ. Sci.*, vol. 30, no. 2, pp. 115–126, 2006.
[8] M. Al-Riahi and A. Al-Kayssi, "Some comments on time variation in solar radiation over Baghdad, Iraq," *Renew. Energy*, vol. 14, no. 1, pp. 479–484, 1998.
[9] I. Waleed and H. Shimaa, "Study of Spatial Variation of Total Solar Radiation Falling on Horizontal Surface in Iraq," *Al-Rafidain Sci. J.*, vol. 22, no. 4, pp. 119–134, 2011.