International Journal of Electrical, Electronic and Communication Sciences
ISSN: 2517-9438
Vol:5, No:4, 2011

Potential of Solar Energy in Zarqa Region

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***Abstract*—**The purpose of this work is to present the potential of solar energy in Zarqa region. The solar radiation along year 2009 was obtained from Pyranometer which measures the global radiation over horizontal surfaces. Solar data in several different forms, over period of 5 minutes, hour-by-hour, daily and monthly data radiation have been presented. Briefly, the yearly global solar radiation in Zarqa is 7297.5 MJ/m^2 (2027 kWh/m^2) and the average annual solar radiation per day is 20 MJ/m^2 (5.5 Kwh/m^2). More specifically, the average annual solar radiation per day is 12.9 MJ/m^2 (3.57 Kwh/m^2) in winter and 25 MJ/m^2 (7 Kwh/m^2) in summer.

***Keywords*—**Solar Energy, Pyranometer, Zarqa Region

I. Introduction

JORDAN lies between Latitude 28^{o}4'-33^{o}30' N and between Longitude 35 ^{o} -39 ^{o} E. The total area of Jordan is about 89,206 Km^2, around 90% of which is desert and rural areas. The population of Jordan was about 5.7 million in 2007 with growth rate of about 3.4%. Almost 90 per cent of the population lives in the north-west of Jordan, situated in areas which together constitute about 10% of the county's total land area. Jordan like other developing countries in general has to meet the energy challenges for achieving the requirements of the government strategy for a comprehensive and sustainable social and economic development. The lack of commercial energy resources in Jordan and dependence on crude oil and oil products imports, high population growth rate, an expected continuous high energy consumption growth rate of about (3% / year) and (6%) for the electricity consumption, all these yearly costs make the energy bill a big burden on the national economy. Part of the solution to this problem is to utilize Jordan's renewable energy resources like solar energy. According to the energy sector's strategy of Jordan, it is planned that the renewable energy contribution will reach 3% of the overall energy mixture until the year 2015 [1].

Several studies have been showed that the solar energy is promising in Jordan [2, 3, 4]. Jordan is one of the sun belt countries according to the international classification since the average annual solar radiation per day is (3.8) Kwh/m^2 in winter to more than (8) Kwh/m^2 in summer. The yearly global solar radiation in Jordan ranges from (1700) kWh/m^2 in Jordan Valley to more than (2250) kWh/m^2 for Hill area which facilitates building investment projects utilizing solar energy for the generation of electricity [5, 6].

Zarqa city lies at latitude of 32 5' N and longitude of 36 7' E with elevation of 555 m. Unfortunately, there are no solar data available in Zarqa region despite of 50% of industrial facilities lie within its zone in addition to energy-producing facilities such as the Jordan petroleum refinery and Al-Hussein thermal station. Mapping of solar energy along the year is essential for the utilization solar energy applications. This includes photovoltaic applications, thermal- solar systems, solar desalination and passive solar architecture. Moreover, availability of solar data may be encouraging the existing energy units to seek alternatives such as combined solar-thermal energy or hybrid system. The main objective of this current paper is to make the solar energy data in Zarqa area available for people interested in this area and to measure and assess the characteristics of the solar radiation in this area.

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II. Data Collection

The solar radiation data along a year 2009 was measured using Pyranometer which measures the global radiation on horizontal surfaces. It is mounted on the roof of the engineering college in Hashemite University. It contains carefully calibrated thermoelectric elements fitted under a glass cover, which is open to the whole vault of the sky. A voltage proportional to the total incident light energy is produced and then recorded electronically. Pyranometer measurements are recorded simply as total energy incident on the horizontal surface (beam plus diffuse). Data are recorded every 5 min and then averaged on hourly, daily, and monthly basis. The sensor is photodiode detector, the spectral response from 0.4 to 1.1 microns, the sensivity is 100 mV/1000 W/m^2, and the accuracy is ±5%.

III. Results and Discussion

The objective of present measurement is to introduce four types of solar radiation data. These are irradiance G (W/ m^2), hourly radiation I (MJ/ m^2), daily radiation H (MJ/ m^2), and monthly average daily radiation $\overline{H}$ (MJ/ m^2). The irradiance G data were recorded as shown in Fig. 1 for May 10;2009 as an example on some sample data. Values for G were recorded by integrated over period of 5 minutes.Fig.2 shows hourly radiation I on a horizontal surface versus 24 hours for March 10; 2009 as an instant. The hourly radiation I at a specific an hour is calculated by averaging the irradiance values at that hour. Daily total radiation H on a horizontal surface for all months of 2009 are shown in Fig.3a to Fig.3I . The data are recorded by summing the total hourly radiation over the day.Monthly average daily radiation $\overline{H}$ for each month of 2009 are shown in Fig. 4. This is done by averaging the daily total radiation for each month. Figure 5 shows the total daily radiation and this is done by summing all days for each month. If one takes the summation for all months then the total radiation will be 7297.5 MJ/m^2 for whole year (2009).

The last two figures show the gaussian distribution of the radiation where is the maximum in summer as expected

especially in June and July. In summary, the yearly global solar radiation in Zarqa is 7297.5 MJ/m^2 (2027 kWh/m^2) and the average annual solar radiation per day is 20 MJ/m^2 (5.5Kwh/m^2). More specifically, the average annual solar radiation per day is 12.9 MJ/m^2 (3.57Kwh/m^2) in winter and 25 MJ/m^2 (7Kwh/m^2) in summer.

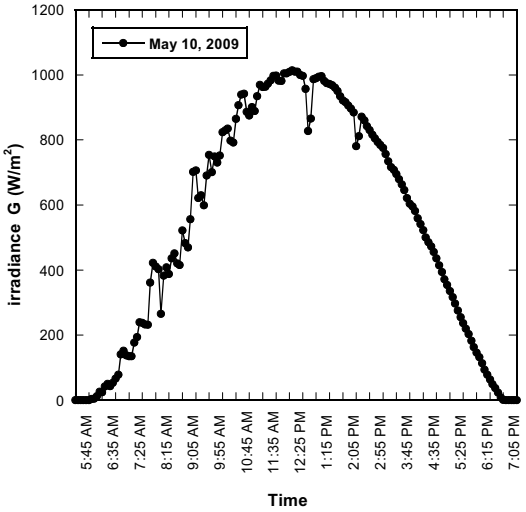

Fig. 1 Total irradiance on a horizontal surface vs time

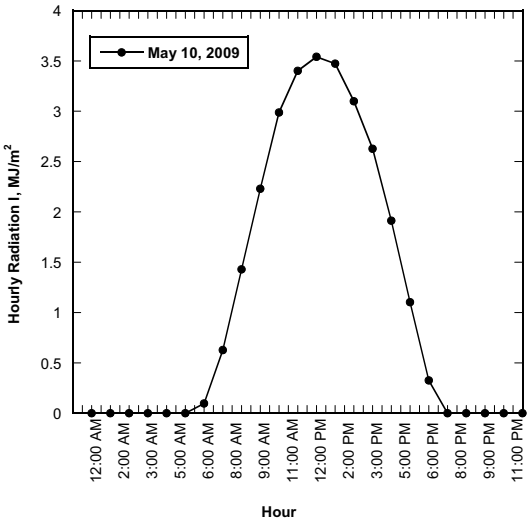

Fig.2 Hourly total radiation on a horizontal surface

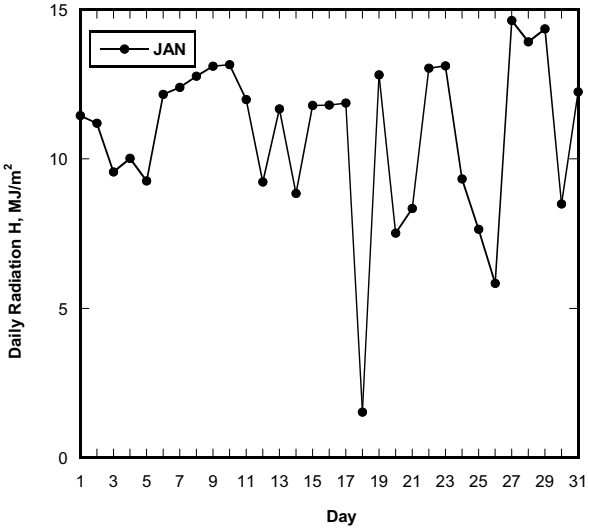

Fig.3a Daily total radiation on a horizontal surface: January

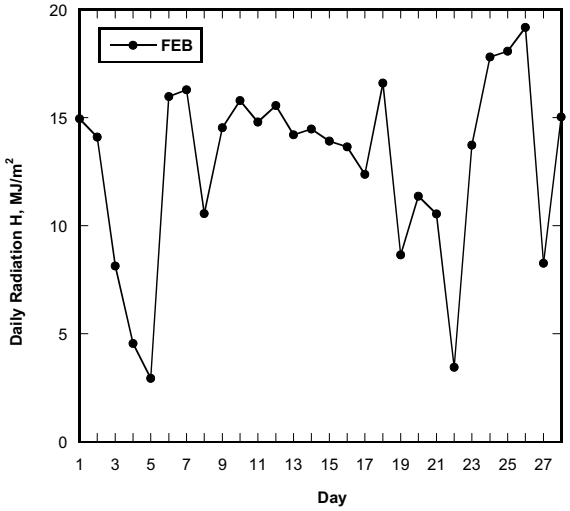

Fig.3b Daily total radiation on a horizontal surface: February

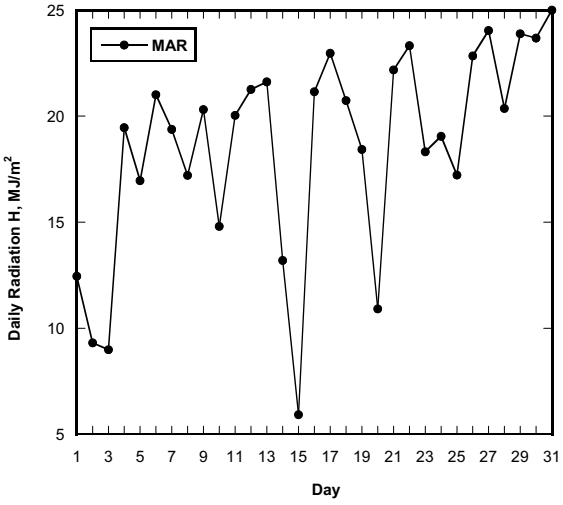

Fig.3c Daily total radiation on a horizontal surface: March

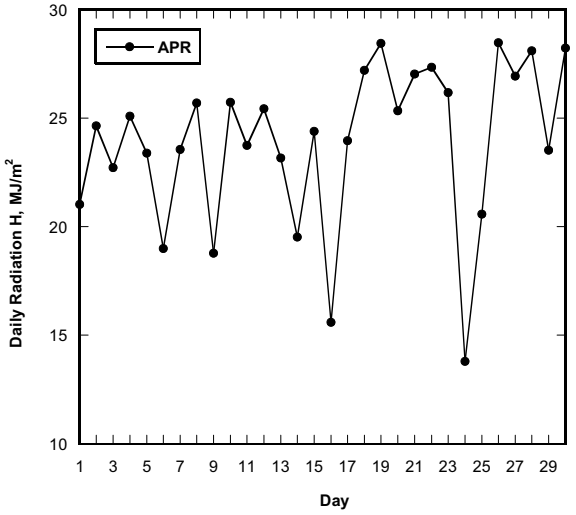

Fig.3d Daily total radiation on a horizontal surface: April

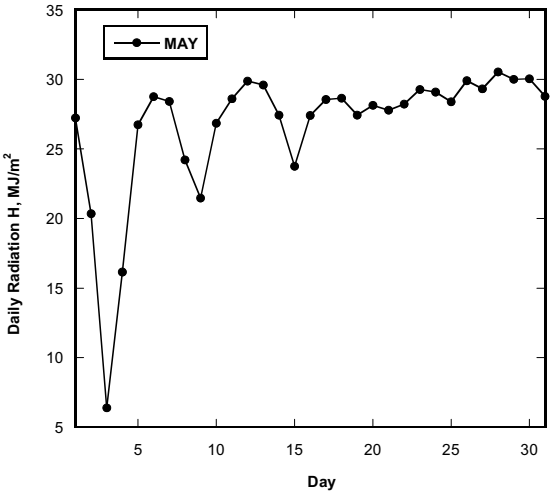

Fig.3e Daily total radiation on a horizontal surface: May

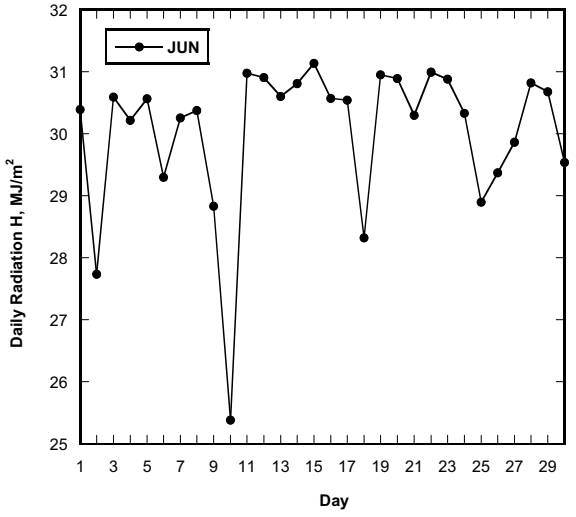

Fig.3f Daily total radiation on a horizontal surface: June

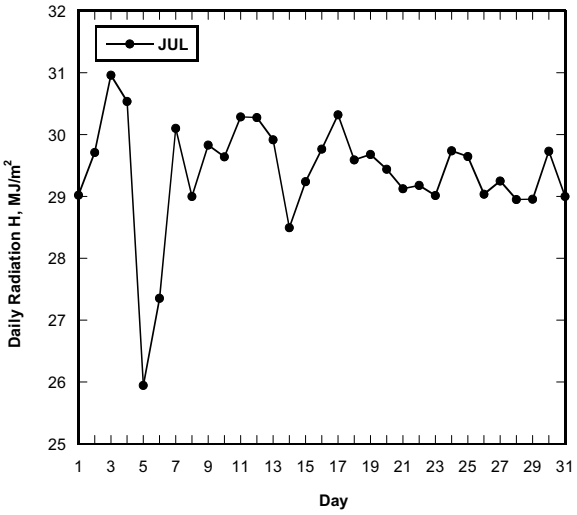

Fig.3g Daily total radiation on a horizontal surface: July

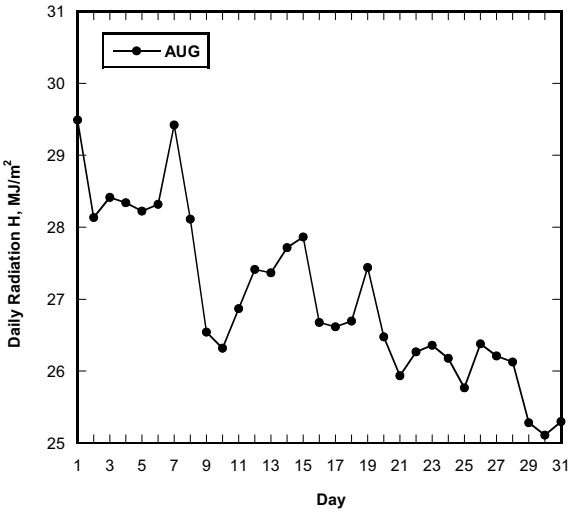

Fig.3h Daily total radiation on a horizontal surface: August

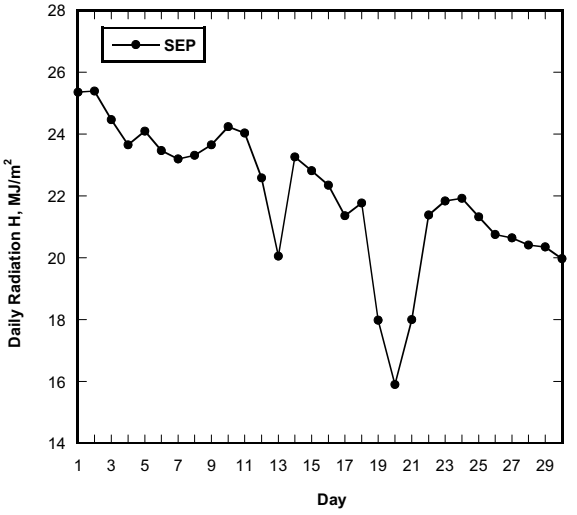

Fig.3I Daily total radiation on a horizontal surface: Septemper

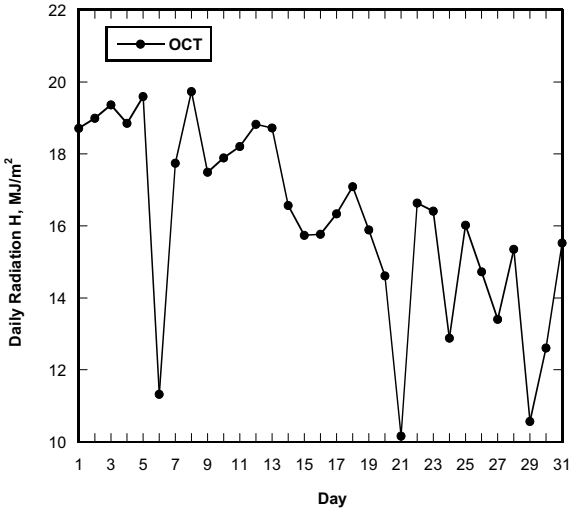

Fig.3I Daily total radiation on a horizontal surface: October

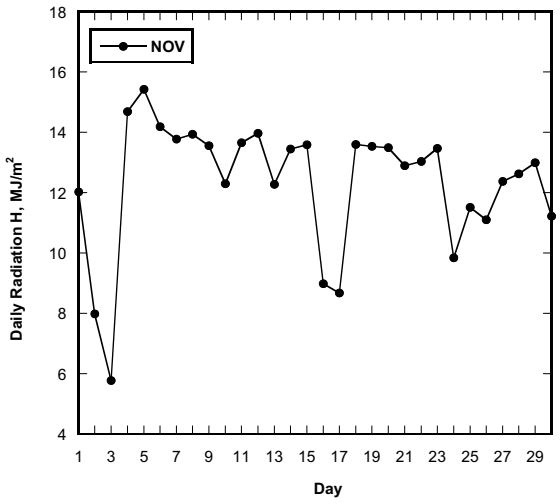

Fig.3j Daily total radiation on a horizontal surface: November

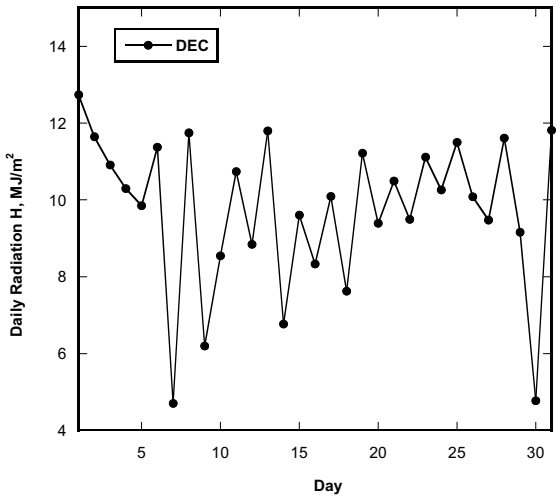

Fig.3K Daily total radiation on a horizontal surface: December

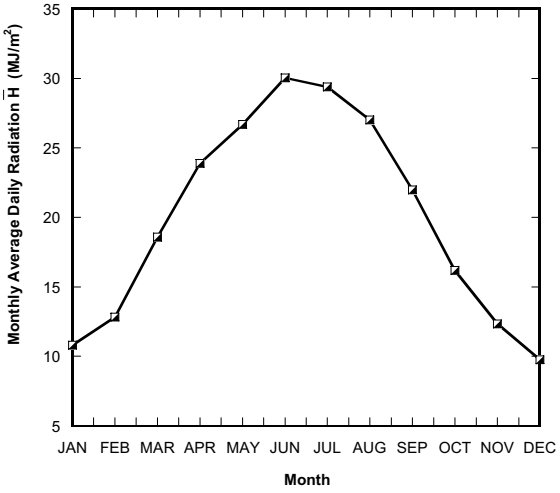

Fig.4 Monthly Average Daily total radiation on a horizontal surface

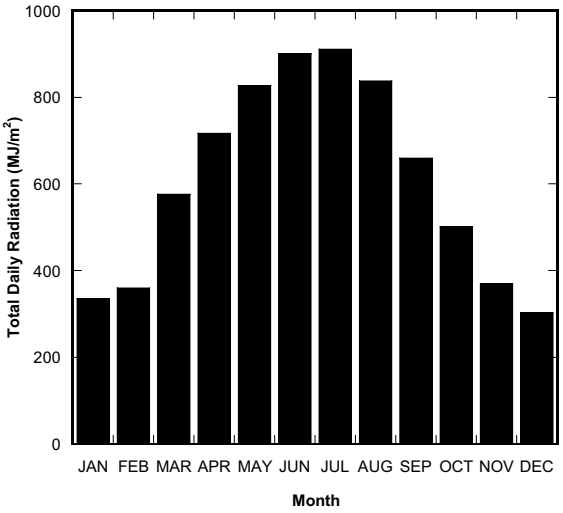

Fig.5 Total Daily Radiation on a horizontal surface

Since the measurements of total radiation (beam plus diffuse) were done on a horizontal surface, then measurements are required for direct and diffuse radiation. In addition, measurements of solar radiation on inclined planes are important in determining the input to solar collectors, PV cells, and passive heating and cooling systems. Beam and diffuse radiation and data for inclined surfaces including the reflected radiation can be deduced from the available data on a horizontal surface. This will be done and analyzed in near future work.

IV. Conclusions

We have presented useful solar data in Zarqa region in several different forms, hour-by-hour, daily and monthly data radiation. The yearly global solar radiation in Zarqa is found to be 7297.5 MJ/m^2 and the average annual solar radiation per day is 20 MJ/m^2. These values are promising in this region and indicating a high potential of solar energy.

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