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Solar radiation determination for solar energy applications; case study for two different sites in Egypt

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Abstract - *Solar energy is going to be a main substitute for fossil fuels in the coming years for i ts clean and renewable nature. Egypt has a very high potential of incident solar radiation that could be used efficiently as an alternate source of clean energy. The average annual solar radiation energy incident over Egypt varies from 5 to 9 kWh/m2/day. Several empirical models have been developed to calculate the solar radiation using various parameters. The daily average and monthly average global solar radiation are calculated from three important parameters through year 2012. The parameters are Temperature, Relative humidity and Extraterrestrial solar radiation at two different si tes in Egypt, Marsa-Matrouh (coastal area) and Qena (desert area). Multiple Linear Regression model was applied for calculations. The Comparison between the measured (Gm) and calculated (Gc) global solar radiation are analyzed for model verification.*

Key Words: Solar Radiation; Empirical Model; Solar Energy; Extraterrestrial Solar Radiation.

1.INTRODUCTION

As the world develops rapidly, the energy demand follows. Energy was, is and will remain the basic foundation which determines the stability of the economic development of any nation, Chow (2007). The resources of fossil fuels (oil, coal, gas) are not unlimited, and with the expected energy consumption for the future, these supplies will be emptied withinthe next generations. Therefore it is already now necessary to supplement and replace the fossil fuels with renewable energy sources. Solar energy is the most abundant renewable resource, Markvart, T. and Casta, L. (2003)

The solar radiation received by any surface on earth will varies in intensity and spectrum due to varying several factors including; geographical location, time of the day, season, local landscape and atmospheric parameters such as the cloud cover, the turbidity, the water vapour content, Temperature, Relative humidity and the zenith angle, Shimokawa R. et al. (1986), Nann S. and K. Emery (1992), Gonzalez M. C. and J. J. Carrol (1994) and Parreta A. et al. (1998).

Most solar energy applications such as the simulation of solar energy systems require, at the least, knowledge of the values of solar radiation on a surface.

In this paper, we discussed and calculate the solar radiation using various meteorological parameters. The parameters are Temperature, Relative humidity and Extraterrestrial solar radiation at two different sites in Egypt, Marsa-Matrouh (coastal area) and Qena (desert area). Multiple Linear Regression model was applied for calculations. The Comparison between the measured (Gm) and calculated (Gc) global solar radiation are analyzed for model verification.

2. Data collection and Methodology

The relevant data was provided by South valley university station at Qena, which is one of the stations guides of the Egyptian Meteorological authority. Solar radiation measurements are determined using CMP3 Kipp&Zonen pyranometer. The CMP3 is used in order to measure solar radiation with high quality blackened thermopile that provides a flat spectral response forthe full solar spectrum range.

We used Multiple Linear Regression model to calculate the global solar radiation from extraterrestrial solar radiation, temperature and relative humidity as follow.

$$G = a + b\,Go + c\,T + d\,RH \quad \text{………………..} \quad (1)$$

Where G, Go, T, and RH are respectively daily average horizontal global- and extraterrestrial-radiation, temperature, and relative humidity while a, b, c and d are empirical constants.

3. Results and discussion

Detailed analysis of the model is given using SPSS program and summarized in table 1 (a, b) for Mars-Matrouh and table 2 (c, d) for Qena.

According to this table, in view of the great value of correlation this formula can compute the daily average global solar radiation (G) with a good accuracy.

Model performance was assessed to compare the calculated and measured global solar radiation fromthe mean bias error (MBE), the mean absolute error (MAE) and the root mean square error (RMSE) also additional statistical parameters were used to assess model performance such as modeling index (d) and modeling efficiency (ME). According to the obtained results, a good agreement was observed between them as illustrated in the following table Mars Matrouh and Qena.

The above developed correlation (Eq. 1) is then employed to calculate the daily and monthly average global solar radiation (G) at the two sites. The calculated (Gc) and the measured (Gm) values of monthly average global solar radiation using this equation are illustrated in the following Figures for Mars Matrouh and for Qena respectively. From these figures one can conclude that there is a very strong correlation between the calculated and measured values of G (0.92 for Mars Matrouh and 0.97 for Qena).

Table -1: Statistical parameters of daily average global solar radiation (G) for equation 1 at Mars-Matrouh.

Model Summary

Model	R	R Square	Adjusted R Square	F	Sig.
1	.818	.670	.667	205.862	.000

(a)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1159.357	389.149		2.979	.003
	Go	0.525	0.042	0.802	12.554	.000
	T	3.693	14.900	0.015	0.248	.804
	RH	-3.157-	7.300	-.015-	-.432-	.666

(b)

Table 2: Statistical parameters of daily average global solar radiation (G) for equation 1 at Qena.

Model Summary

Model	R	R Square	Adjusted R Square	F	Sig.
1	.969	.940	.939	1596.051	.000

(a)

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-688.023-	304.419		-2.260-	0.024
	Go	0.807	0.025	1.033	31.904	.000
	T	-17.437-	6.057	-.082-	-2.879-	.004
	RH	-0.466-	2.216	-.006-	-.210-	.834

(b)

Table 3: Statistical parameters of daily average global solar radiation (G) at Mars Matrouh for equation 1.

Statistical error	
correlation	0.92
MBE%	-5.71
RMSE%	19.54
MAE%	8.13
ME	-1.72
d	0.56

Table 4: Statistical parameters of daily average global solar radiation (G) at Qena for equation 1.

Statistical error	
correlation	0.97
MBE%	0.29
RMSE%	2.44
MAE%	1.73
ME	0.97
d	0.99

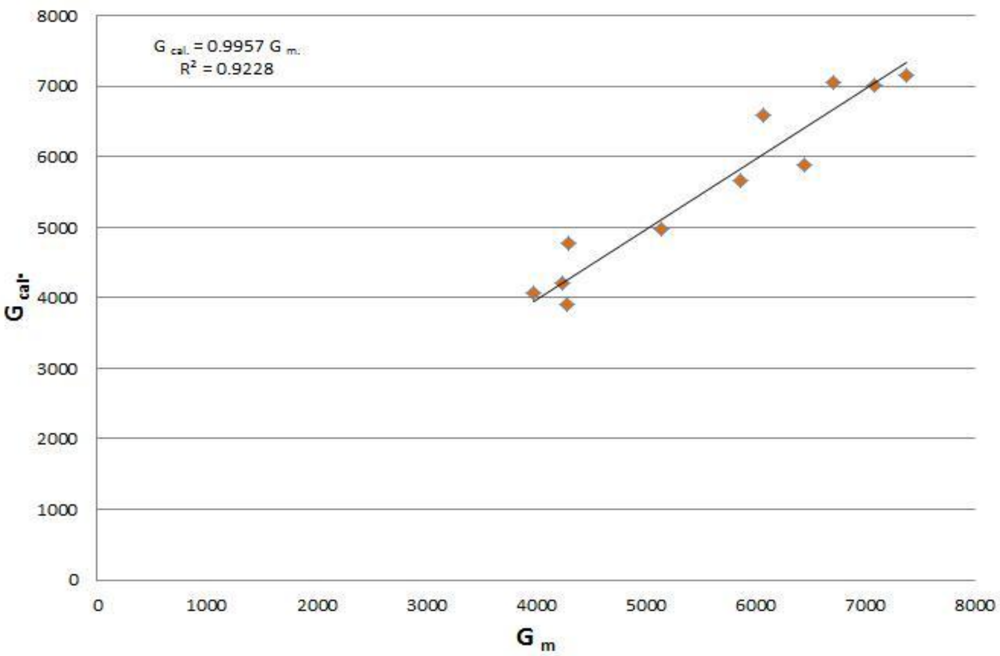

Fig. 2: Comparison between measured (Gm) and calculated (Gc) global solar radiation values for monthly average data through the study period at Mars Matrouh.

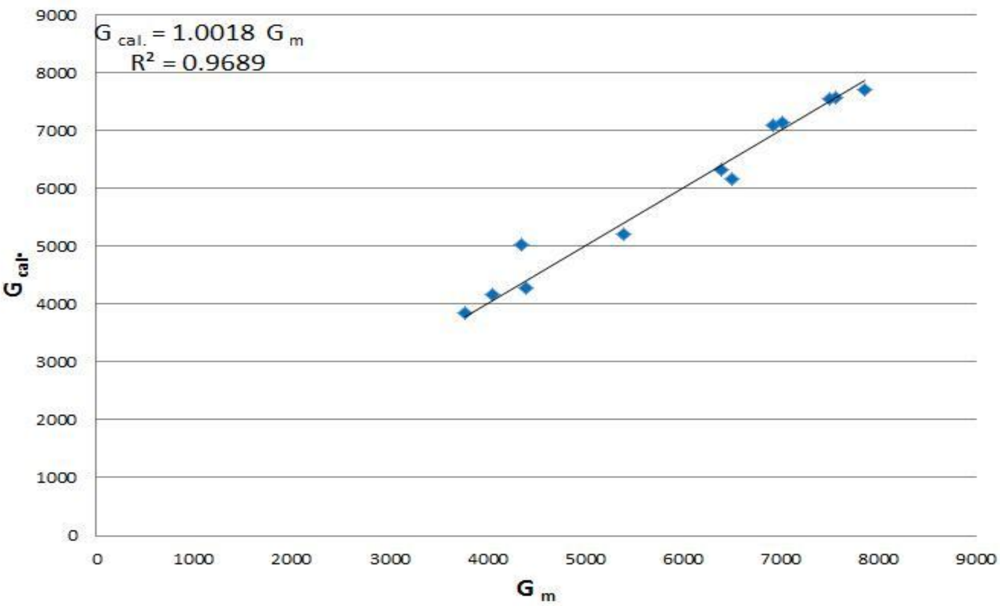

Fig. 3: Comparison between measured (Gm) and calculated (Gc) global solar radiation values for monthly average data through the study period at Qena.

3. CONCLUSIONS

Solar radiation data are required by solar engineers, architects, agriculturists and hydrologists for many applications such as solar heating, cooking, drying and interior illumination of buildings. Since there is a very low spatial density of meteorological stations equipped for radiation observations, the models become alternative. In order to achieve this, several empirical models have been developed to predict the solar radiation all over the world. These models developed to estimate solar radiation components using available weather parameters such as temperature, cloud cover, sunshine duration, relative humidity…etc.

In this study we used multiple Linear Regression model to estimate global solar radiation from temperature, extraterrestrial radiation and humidity through the year 2012at three different sites in Egypt. These sites represents different geographical sites, Marsa-Matrouh that represent a coastal area , Qena that represent an urban area and Helwan that represent a desert area.

REFERENCES

Chow , T.T., Performance evaluation of photovoltaic – thermosyphon system for subtropical climate application, Solar Energy, 81, 2007, pp. 123–130.

Markvart, T., & Casta, ñer, L. (Eds.), Practical handbook of photovoltaics Fundamentals and applications. Oxford, UK: Elsevier, 2003.

Shimo kawa R., Y. Miyake, Y. Nakanishi, Y. Kuwano and Y. Hamakawa, Effect of at mospheric parameters on solar cell performance under global irrad iance, Solar Cells, 19, 1986, pp. 59-72.

Nann S. and K. Emery, "Spectral effects on PV-device rating," Solar Energy Materials and Solar Cells , 1992, vol. 27, no. 3, pp. 189–216.

Gon zalez M. C. and J. J.Carrol, "So lar Cells Efficiency Variations with Vary ing Atmospheric Conditions," Solar Energy, Vo l. 53, No. 5, 1994, pp. 395-402.

Parreta A., A. Sarno and L. R. M. Vicari, "Effects of solar irradiation conditions on the outdoor performance of photovoltaic modules", Optics Commun ications, 1998, 153, pp. 153.