Effect of Average air Temperature and Relative Humidity on Global Radiation

M.Kesavan [1] & M.Senthilkumar[2]
1&2 Assistant professor, Department of mechanical engineering Annamalai university
Annamalai naar .608002.INDIA.

Abstract

This statistical data analysed was aimed of the found to relationships between global solar radiation, relative humidity and mean air temperatures of the Chennai City ,India.For the month of July-in this studied. The IMD data of minimum and maximum temperatures as well the relative humidity and MAT-LAB curve fitting tool was used. In this work observed that 'SGR'is affected by both air temperature and relative humidity .The solar global radiation directly proportional to the mean air temperature and relative humidity. Therefore the accurate knowledge used of solar global radiation at a developed area, rural and urban area is very useful for commissioning of power plant and other requirement for the peak load energy demand.

I. INTRODCTION

The earth and its atmosphere depend ultimately on the sun for its energy supply. The radiant energy from the sun covers the entire electromagnetic spectrum. The atmospheric interference restricts this spectrum to 290nm to 300nm which is called "Solar radiation" energy. From solar radiation can be derived by thermal conversion where in the heat generated due to irradiation is used to operate a system and by direct conversion into electrical energy. The accurate information of the solar radiation intensity at a given location is essential to the development of solar energy based projects and in the long term evaluation of the solar energy conversion systems performance [1]. This information is used in the design of a project. Furthermore monthly mean daily data are needed for the estimation of long term solar systems performances. Furthermore daily global solar radiation models required for engineering design and planning projects [2, 3]. Solar radiation which arrives to earth surface for every year is 160 times the world's proven fossil fuel and reserves [4]. A global study has been made on the global solar radiation models are available the study carried out an estimation of the monthly average daily global solar radiation on horizontal surface [5] among several empirical models which have been used to calculate global solar radiation the most commonly used parameters in sunshine hours [6].The empirical

models has been used to calculate global solar radiation are usually based on some factors as shown in table (1)[7]. Since the solar radiation reading the earth's surface depends upon climate condition of the place. A study of solar radiation under local climatic conditions of the place is necessary. This knowledge of local solar radiation is essential for the proper design of buildings energy systems, solar energy systems and a good evaluation of thermal environment within the buildings [8-11]. It is measured in terms of sunshine duration. One way of solving this is using appropriate correlations which are empirically established that can be used to estimate global solar radiation from more readily available metrological parameters such as sunshine hours. Several empirical models have been developed to calculate solar radiation from meteorological, geographical, climateological parameters such as relative humidity, ambient temperature, soil temperature, number of rainy days and evaporation [12-18]. In addition, other empirical models have been developed to calculate solar radiation from sunshine hours [19-22]. The most commonly used parameters for estimating global solar radiation are sunshine duration among various correlations. The modified variations of [23] model who proposed a linear relationship between the ratio of average daily global radiation to the corresponding value on a clear sky day and the ratio of average daily sunshine duration to the maximum possible sunshine duration and its derivatives have been widely used. Empirical models which have been used to calculate global radiation are usually on some factors as shown in table [1], [23]. The Solar radiation data computed based on measured metrological data computed data. The average daily global radiation on horizontal surface it, for a location is now possible of sunshine hours five different models have been selected from different previous studies for estimating daily global solar radiation. All models have been proposed for estimating for monthly mean daily global solar radiation, H-based on the Angstrom-Prescott model [24].

II. NEEDED FOR SOLAR RADIATION DATA

A whole array of application via, thermal conversion, photovoltaic conversion, photochemical

Classification	Parameter
Meteorological factors	Extraterrestrial solar radiation, sunshine duration, temperature, precipitation, relative humidity, effects of cloudiness, soil temperature, evaporation, reflection of the environs, etc.
Geometrical factors	Azimuth angle of the surface, tilt angle of the surface, sun elevation angle, sun azimuth angle.
Physical factors	Scattering of dust and other atmospheric constituents such as O_2, N_2, Co_2 and O
Geographical factors	Latitude, Longitude and elevation of the site
Astronomical factors	Solar constant, earth – sun distance, declination and hour angle

utilization, biomass conversion, passive solar lighting, heating of buildings, detoxication etc is becoming apparently viable and enhances the societies energy management planning and hence its efficient applications. The economics of these technologies depend on the efficiency of the utilizing processes. So that the operating costs are comparable if not cheaper. With the present day processes based on conventional fossilized energy utilization. Thus to design operating systems which will have the highest achievable efficiency under comparable costs. The reliable database on different aspects of solar radiation energy is essential. The more accurately the solar resources are known. The better becomes the system design the radiation energy available at a location changes throughout the day and year due to varying weather patterns by knowing the variability storage systems can be designed and used optimally. Solar radiation data also help determine the best geographic location for utilization as it will have a direct influence on the design of the systems. Photovoltaic and photochemical conversions need spectral distribution over space and time, location, climate and atmospheric conditions have strong influence on the spectral distribution of solar irradiance.Table 1: Classification of parameters used to calculate solar radiation (GSR)

Model no	Regression Equation	Model Type
1	$H/H_o = a + b(s/S_o)$	Linear
2	$H/H_o = a + b(s/S_o) + c(s/S_o)^2$	Quadratic
3	$H/H_o = a + b(s/S_o) + c(s/S_o)^2$	Cubic
4	$H/H_o = a + b\log(s/S_o)$	Logarithmic
5	$H/H_o = a + b\exp(s/S_o)$	Exponential

III. CALCULATION PROCEDURE

Many different models have been found in the literature such as linear, quadratic, cubic, logarithmic, exponential regressing model to estimate on a horizontal surface from observed sunshine duration and calculate extraterrestrial radiation and maximum possible sunshine duration. In this study model have been investigated and validity of this model has been made. The Angstrom Prescott model [24] that examines the linear correlation between clearness index (H/H_0) and sunshine duration ratio (S/S_0) is most commonly used model. The equation used in this model is,

$$H/H_0 = a + b(S/S_0) \ldots (1)$$

Where H is monthly average daily global radiation on a horizontal surface,
H_0 is a extraterrestrial radiation on a horizontal surface
S is a monthly average daily sunshine duration
S_0 is a monthly average maximum possible daily sunshine duration and
a, b are Angstrom coefficient (also called regression coefficient)

The quadratic model is proposed by Akinolgu and Ecevit .et.al [25] and the related equation is
$$H/H_0 = a + b(S/S_0) + C(S/S_0)^2 \ (2)$$
The cubic model is proposed by Bahel et .al [26]. And the related equation is
$$H/H_0 = a + b(S/S_0) + C(S/S_0)^2 + d(S/S_0) \ldots (3)$$
The logarithmic model is proposed by D.B Ampratoumandet.al [27] and the related equations is
$$H/H_0 = a + b\log(S/S_0) \ldots (4)$$
The exponential model is proposed by J. Almorex et.al [28] and related equation is
$$H/H_0 = a + b\exp(S/S_0) \ldots (5)$$
The monthly average daily extraterrestrial radiation on a horizontal surface can be calculated by following equation [29]:
$$H_0 = 24 * 3600/\pi * I_{sc} * \left(1 + 0.003 \cos \frac{360*n}{365}\right)(6)$$
$$\left(\cos \varnothing \cos \delta \sin \omega_s + \frac{\pi \omega_s}{180} \sin \pi \sin\delta\right)$$

Where I_c is the solar constant (1367 W/m^2), Ø is the latitude of the location , δ is the sun declination and ω_s is the sunset hour angel for a given month and D or N is the no of days of the year starting from 1st of January.

Declination sunset hour angel and day length can be computed by the following equation [30, 31]

$$\delta = 23.45 \sin\left(360 + \frac{284+d}{365}\right)..(7)$$
$$\omega_s = \cos^{-1}(-\tan Ø \tan \delta) \ldots..(8)$$
$$S_{0} = 2/15\,\omega_s \quad \cdots \quad (9)$$

Further five different models have been selected from different previous studies for estimating daily global solar radiation. All models having proposed for estimating the monthly mean daily global radiation. H based on the Angstrom Prescott model, extraterrestrial radiation on a horizontal surface sin daily period where calculated numerically for each month using declination angle, latitude and sunset hour angel from the calculation procedure using the equation [32-34]. Then we develop equation to estimate H/H$_0$ for each month by applying regression analyze to the parameter S/S$_0$ based on the model equation, five model equation for each month where formed. The values of monthly average of daily solar radiation estimated for each month. The corresponding measure value where compared with the estimated values using the above five models for each month.(linear, quadratic, cubic, log and power).

IV. RESULT AND DISCUSSION

The relationship between global solar radiations, relative humidity and mean air temperature of the study area was determined using the data of minimum and maximum temperature obtained from archive of weather online and a Microsoft excel tool, and the results is presented in Table 2. Hargreaves –Samanni model of global solar radiation was used for the prediction of the global solar radiation using the maximum and minimum temperature data for the month of June, 2016. Mean temperature was gotten from the maximum and minimum data already acquired and the relative humidity for the month of June, 2016 was obtained from the same achieve of weather online limited. From Table 2, it was observed that, the mean air temperature (Tav) has effect on the global solar radiation(Rs) to some extent. The comparison between the two quantities shows the positive correlation coefficient of 0.460648 (46.06%), implying that the two quantities would increase and decrease in the same way, but not in all the values due to the correlation coefficient value that is below average, i.e. 50%. Okonkwo&Nwokoye (2014), reported that, global solar

radiation was highest in the month of November, while the lowest value was recorded in August. This is attributed to the highest and lowest values of clearness index obtained for these months respectively. Also, from Table 2, it was observed that relative humidity has effects on global solar radiation to some extent. The comparison between the two quantities shows a negative correlation of -0.47686 (-47.69%), implying that when one quantity is increasing, the other will be decreasing and vice versa, though not in all the

1.Table Calculated global solar radiation for July month

DATE	T_{MIN} c	T_{MAX} c	T_{AV}	RH (%)	SGR(Kwh) Measured	SGR(Kwh) calculated
182	26.8	37.5	32.1	31	22.42	20.5
183	23.7	35.2	29.4	40	23.42	21.4
184	27.7	30.6	29.1	55	23.47	22.3
185	28.9	36.6	32.7	39	21.71	20.2
186	28.1	33.8	30.9	56	23.95	21.3
187	28.9	39.7	34.3	46	22.14	20.5
188	26.7	33.2	29.9	66	23.84	21.8
189	27.6	32.1	29.8	65	24.14	22.3
190	27.6	32.5	30.0	61	18.10	16.5
191	28.9	35.3	32.1	47	21.39	19.5
192	28.3	36.8	32.5	40	24.17	22.4
193	25.1	35.6	30.3	44	23.84	21.9
194	26.8	33.8	30.3	49	24.01	21.1
195	26.6	30.8	28.7	47	24.01	21.2
196	28.7	32.3	30.5	67	23.42	20.1
197	28.7	33.3	31.0	52	16.74	14.2
198	28.0	34.0	31.0	42	06.50	04.5
199	28.8	35.8	32.3	52	11.91	09.2
200	29.8	36.8	33.3	40	18.67	16.5
201	28.9	35.0	31.9	36	16.94	14.5
202	28.5	33.2	30.8	41	22.48	20.3
203	27.4	34.4	30.9	46	22.20	20.2
204	28.5	36.8	32.6	43	15.79	13.2
205	30.0	33.6	31.8	36	10.95	08.5
206	29.8	34.0	31.9	37	14.49	12.3
207	29.0	34.3	31.6	48	18.95	16.3
208	29.8	34.9	32.3	45	17.70	15.4
209	29.0	36.0	32.5	41	18.64	16.5
210	29.2	36,0	32.6	36	15.48	13.4
211	29.1	36.8	32.9	37	14.17	12.2
212	28.8	34.9	31.8	35	16.18	14.6

values due to the correlation value that is below average, i.e. 50%. According to Fatayi (2013), cloud cover and relative humidity are higher in wet than in dry season, meaning more rainfall between the months of May and October, with low surface temperature, high relative humidity and low cloud cover.The effects of mean air temperature and relative humidity on global solar radiation is shown Figures 2 and 3 respectively. But relative humidity has more impacts on global solar radiation than mean air temperature. This is also displayed in figure 4, in which the trend of change of global solar radiation and relative humidity are very close when compared to the graph of mean temperature.

V. RECOMMENDATION

It has been concluded that global solar radiation is affected by both mean air temperature and relative humidity using Hargreave-Samanni model with the minimum and maximum temperature data for rainy season (June), as obtained from achieve of weather online limited from their website, similar method should be employed using the data (relative humidity, maximum and minimum temperature) for dry season.

VI. MATERIALS AND METHOD

A. Materials

The materials used for this work are the data of minimum and maximum temperature as well as the relative humidity of Ikeja, Nigeria, for June

2016obtained from the achieve of weather online limited, and the Microsoft excel software. The **Table 2: Calculated global solar radiation for July month**

studyarea is Ikeja, the capital of Lagos state, Nigeria. Lagos state is located in the South-Western Nigeria. The study location is within latitude and longitude 6.4N and 3.35E respectively. Because water is the most topographical feature of Lagos state, water and wetlands cover 40% of the total land area in the state (Albert *et al.*(2006)). Lagos state is bounded from the North and East by Ogun state, West by the Republic of Benin, and South by the Atlantic Ocean. It has two seasons; rainy and dry seasons due to its tropical savanna climate. The rainy season is from April to September, but the intense rain is from April to July, and the dry season is from October to March. It has an average temperature of 27^0 c.

B. Methods

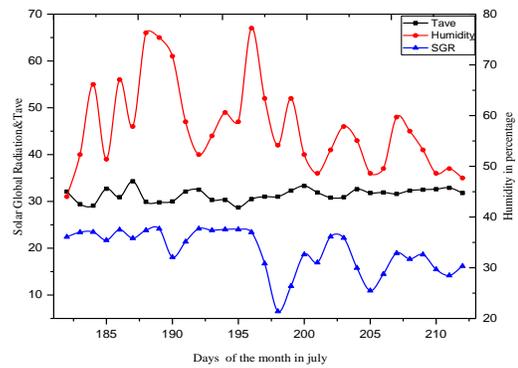From the studies [6,7], the predominant factors that have

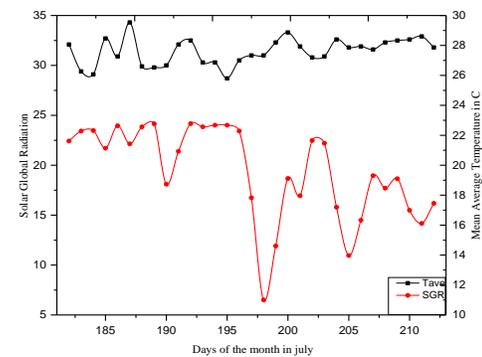**Fig. 3: Graph of mean air temperature, relative humidity and global solar radiation**

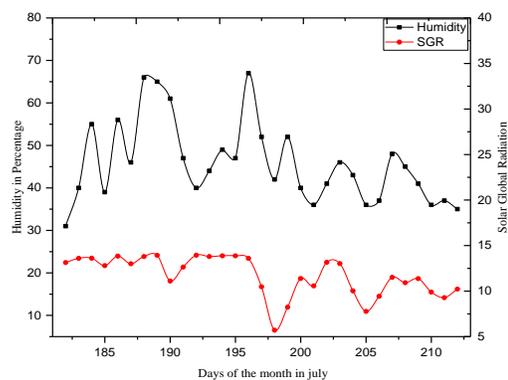**Fig 1: Graph of relative humidity and global solar radiation**

Fig 2: Graph of mean air temperature and relative humidity

DATE	T_{MIN}	T_{MAX}	T_{AV}	RH (%)
182	26.8	37.5	32.1	31
183	23.7	35.2	29.4	40
184	27.7	30.6	29.1	55
185	28.9	36.6	32.7	39

186	28.1	33.8	30.9	56
187	28.9	39.7	34.3	46
188	26.7	33.2	29.9	66
189	27.6	32.1	29.8	65
190	27.6	32.5	30.0	61
191	28.9	35.3	32.1	47
192	28.3	36.8	32.5	40
193	25.1	35.6	30.3	44
194	26.8	33.8	30.3	49
195	26.6	30.8	28.7	47
196	28.7	32.3	30.5	67
197	28.7	33.3	31.0	52
198	28.0	34.0	31.0	42
199	28.8	35.8	32.3	52
200	29.8	36.8	33.3	40
201	28.9	35.0	31.9	36
202	28.5	33.2	30.8	41
203	27.4	34.4	30.9	46
204	28.5	36.8	32.6	43
205	30.0	33.6	31.8	36
206	29.8	34.0	31.9	37
207	29.0	34.3	31.6	48
208	29.8	34.9	32.3	45
209	29.0	36.0	32.5	41
210	29.2	36.0	32.6	36
211	29.1	36.8	32.9	37
212	28.8	34.9	31.8	35

Table 2: Relative humidity, minimum and maximum air temperatures for July month

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Fig. 4: Map of chennai showing the study area

VII. CONCLUSION

In this statistical analyzed, the relationship between the global solar radiation ,mean air temperature and relative humidity of Chennai city , India were analyzed for the month of July .it can be strongly recommended that global solar radiation is affected by the both   relative humidity and mean air temperature as given by the correlation results. However, the mean air shows that solar global radiation increases with increase in mean temperature at same global solar radiation. Increase with decreases in relative humidity and the results shows high relative humidity is associated with low global solar radiation and low relative humidity is associated with high global solar radiations. Also high average temperature is associated with high global solar radiation and low average temperature is also associated with low global solar radiation.it have been concluded relative humidity and mean air temperature have effects on solar global radiation of a study area. The above study revealed that of relative humidity more conquer than that of mean air temperature.

Nomenclature

a-d   empirical constants

I_{sc} solar constant

H   daily global solar radiation on horizontal surface (MJ/m^2)

H_0 daily extraterrestrial radiation on horizontal surface (MJ/m^2)

n   number of day of year starting from first of January

S   sunshine duration (h)

R   coefficient of determination

S_0 day length

Greek letters

s   sunset hour angle

∂ Solar declination

Ø   Latitude of site

σ Standard deviation

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