Optimistic / Normal / Pessimistic Limits of Global Solar Radiation in Urban Armidale NSW, Australia

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Abstract:-The most common data for describing the local solar climate is through what is called Typical Meteorological Year data (TMY). Typical solar radiation data is very important for the calculations of many solar applications. In this study, typical solar radiation years for Armidale town in New South Wales in Australia are generated from the daily global solar radiation data measured for 23 years, utilising the Finkelstein-Schafer statistical method. The study outcome provides optimistic, normal and pessimistic expected global solar radiation in Armidale all over the year based on previous studies conducted based on meteorological historical measured data in Armidale's Airport Weather Automatic Weather Station. Such outcome presents a handy database of global solar radiation to be utilised by solar energy's specialists for detailed calculations and/or ordinary persons for initial assessment of solar energy in Armidale.

Keywords: - Armidale NSW, solar radiation, test meteorological year, test reference yea

I. INTRODUCTION

The most common data for describing the local solar climate is through what is called Typical Meteorological Year data (TMY). To determine TMY data, various meteorological measurements are made at hourly intervals over a number of years to build up a picture of the local climate. A simple average of the yearly data underestimates the amount of variability, so the month that is most representative of the location is selected. For each month, the average radiation over the whole measurement period is determined, together with the average radiation in each month during the measurement period. The data for the month that has the average radiation most closely equal to the monthly average over the whole measurement period is then chosen as the TMY data for that month. This process is then repeated for each month in the year. The months are added together to give a full year of hourly samples. There is no strict standard for TMY data so the user must adjust the data to suit the application. Considerable care must be taken with sample periods. Solar radiation data is a crucial parameter for the prediction of long-term performance of solar energy generation systems. As well, it is a key input in modelling and designing of solar energy applications. Thus, a need for a reliable source of solar radiation data has to be readily available for particular settlement locations.

The need for a one-year representative daily meteorological data led to the development of methodologies known as the Typical Meteorological Year (TMY), alternatively called Test Reference Year (TRY) [1]. TMY or TRY is a representative data that consists of the month selected from the individual years and concatenated to form a complete year. However, A TMY is not necessarily a good indicator of conditions over the next year or even the next five years. Rather, TMY represents conditions judged to be typical over a long period of time [2]. Typical weather year data sets can be generated for several climatic variables such as temperature, humidity, wind speed, etc. or only for solar radiation. Various trials have been made to generate such weather databases for different areas around the world [1, 3, 4, 5, 6, 7, 8, 9, 10&11].

A TMY for Armidale has been developed [12]. But it didn't consider cloudy days in Armidale since the calculation procedure of TMY doesn't incorporate that.

It is important to define the clear days and the cloudy days as follows:

Mean number of clear days is the average number of clear days in a calendar month or year, calculated over the period of record. This statistic is derived from cloud cover observations, which are measured in oktas (eighths). The sky is visually inspected to produce an estimate of the number of eighths of the dome of the sky covered by cloud. A completely clear sky is recorded as zero okta, while a totally overcast sky is 8 oktas. The presence of any trace of cloud in an otherwise blue sky is recorded as 1 okta, and similarly any trace of blue on an otherwise cloudy sky is recorded as 7 oktas. A clear day is recorded when the mean of the 9 am and 3 pm cloud observations is less than or equal to 2 oktas. This definition has changed slightly over time. Prior to this, a clear day was defined as having less than or equal to 2.5 oktas averaged over the 9 am and 3 pm observations [13].

On the other hand, the mean number of cloudy days is the average number of cloudy days in a calendar month or year, calculated over the period of record. This statistic is derived from cloud cover observations, which are measured in oktas (eighths). The sky is visually inspected to produce an estimate of the number of eighths of the dome of the sky covered by cloud. A completely clear sky is recorded as zero okta, while a totally overcast sky is 8 oktas. The presence of any trace of cloud in an otherwise blue sky is recorded as 1 okta, and similarly any trace of blue on an otherwise cloudy sky is recorded as 7 oktas. A cloudy day is recorded when the mean of the 9 am and 3 pm cloud observations is greater than or equal to 6 oktas. This definition has changed slightly over time. Prior to this, a cloudy day was defined as having greater than or equal to 5.5 oktas averaged over the 9 am and 3 pm observations [13].

A TMY for Armidale considering the effect of cloudy days has been developed [14].

The main aim of this study is to provide a database's estimate of optimistic/normal/pessimistic solar radiation data for Armidale NSW, Australia based on TMY produced at earlier studies [12 & 14].

II. DATA AND LOCATION

The daily global solar radiations recorded during the period 1980–2012 are utilized to generate the typical solar radiation data. In Australia, meteorological observations are recorded by the Australian Bureau of Meteorology (BOM) weather stations are widely spreader in lots of cities and towns around Australia. In this study, the global solar radiation data recorded by Armidale Airport Weather Automatic Station and published on the BOM's website where it was collected. The missing and invalid measurements account for approximately 0.01% of the whole database of global solar radiation; those were replaced with the values of preceding or subsequent days by interpolation. During the calculations process, any year found with more than ten days in any month observations not available was excluded. "Table 1" provides geographical information for Armidale town and the periods of the relevant global solar radiation data.

Table 1 Geographical and solar radiation database information of Armidale NSW, Australia

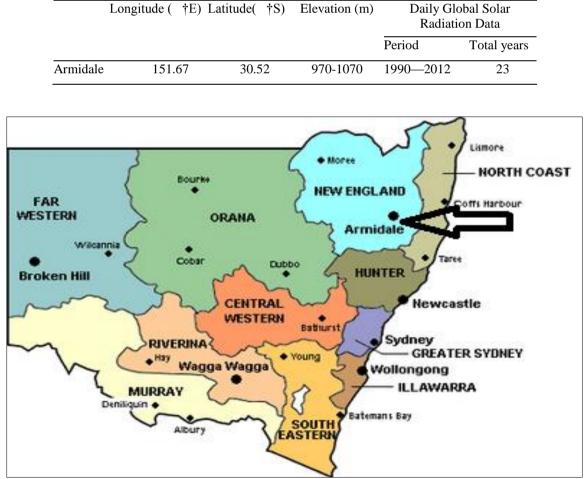


Figure1 Armidale NSW, Australia location

III. METHODOLOGY

Finkelstein-Schafer (FS) statistics [15] is a nonparametric statistical method, known as common methodology for generating typical weather data [1, 2, 3, 4, 5, 8, 9, 10 &12]. In this study, FS methodology is used for generating the typical solar radiation year. According to FS statistics [15], if a number, n, of observations of a variable X are available and have been sorted into an increasing order X1, X2,...,Xn, the cumulative frequency distribution function (CDF) of this variable is given by a function Sn(X), which is defined in equation (1).

$$S_n(X) = \begin{cases} 0 & For \ X < X_1 \\ \frac{(K-0.5)}{n} & For \ X_k < X < X_{K+1}(1) \\ 1 & For & X > X_n \end{cases}$$

where k is rank order number. The FS by which comparison between the long-term CDF of each month and the CDF for each individual year of the month was done is given in equation (2).

$$FS = \left(\frac{1}{N}\right) \sum_{i=1}^{n} \delta_{i(2)}$$

where i is the absolute difference between the long-term CDF of the month and one-year CDF for the same month at Xi (i = 1, 2, n), n being the number of daily readings of the month. di and F(Xi) are expressed with the following equations (3 &4).

$$\delta_i = max \left[\left| F(X_I) - \frac{(i-1)}{n} \right|, \left| F(X_i) - \frac{i}{n} \right| \right] (3)$$
$$F(X_i) = 1 - \exp\left(-\frac{X_i}{\bar{X}} \right) (4)$$

where Xi is an order sample value in a set of n observations sorted in an increasing order and X is the sample average.

Finally, the representative year for each month of the data set was determined on the basis that the representative year is that of the smallest value of FS as in equation (5).

$$TRY = MIN(FS) = MIN(\delta_i)$$
(5)

IV. GENERATION OF OPTIMISTIC/NORMAL/PESSMITIC TYPICAL SOLAR RADIATION'S LIMITS

Applying the above methodology for all the months in the database, a typical Test Reference Year (TRY) for daily global solar radiation data was formed for Armidale [12], as well a TRY considering the effect of cloudy days has been generated [14].

The test reference years with minimum FS for monthly mean global solar radiation for Armidale are given in "Table 2". Which shows that, although the big picture that Armidale has a high potential of solar energy, still there are considerable differences of potentiality in through the months due to the fact that Armidale's winter season (June, July and August) is relatively cloudy. "Table 2", the minimum and maximum values of monthly mean of the daily global solar radiation on a horizontal surface (ITRY) in Armidale, the minimum is 10.41 MJ/m2 day in June and the maximum is 25.80 MJ/m2 day in December.

For comparing purpose, both "Table 2" and "Table 3" were created, analysing both lead to clear fact that considering cloudy days have dramatic inverse effect on the traditional totally dry TYR. In March, the CTYR presents 69% of the totally dry TYR which is the largest share. On the other hand, the lowest share of 45% in February of the average monthly solar radiation. Additionally the lowest cloudy average monthly solar radiation is in June of 170.8 MJ/m² compared with 314.1 MJ/m² totally dry radiation in June also, while the highest cloudy average monthly is in Jan of 492.1 MJ/m² compared with the 804.4 MJ/m² totally dry radiation in December.

Apparently, Table 2" presents the optimistic values of global solar radiation all over the year in Armidale, on the

other hand, "Table 3" shows the pessimistic values of global solar radiation yearly. Considering the totally and partially cloudy days, normal values of global solar radiation are calculated for Armidale. Tables 4, 5 & 6 depicts the typical optimistic, normal and pessimistic global solar radiation in Armidale.

						Australia						
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	29.4	18.1	19.1	18.8	13.5	10.8	10.0	14.5	16.4	20.5	22.3	24.6
2	27.0	22.5	21.8	18.9	12.6	10.6	10.4	14.2	16.3	19.4	22.9	25.0
3	27.2	23.2	21.1	17.8	13.9	9.00	11.2	13.6	16.1	19.3	23.4	26.0
4	26.1	26.1	22.0	19.0	13.0	10.7	10.0	13.2	17.5	20.9	23.1	25.7
5	23.2	25.5	19.8	16.8	12.0	10.9	12.0	13.3	15.8	21.2	21.3	25.4
6	23.2	23.5	21.3	19.5	14.7	11.6	11.2	14.3	18.7	19.9	22.3	23.8
7	26.6	21.5	19.4	18.8	14.5	9.70	10.8	13.7	17.0	21.4	24.1	26.1
8	25.1	23.2	20.3	16.4	12.8	10.3	10.7	14.9	17.0	21.6	22.0	26.8
9	24.9	23.2	19.5	16.2	13.4	10.6	9.60	14.9	15.7	22.3	23.2	24.8
10	26.4	24.1	21.0	17.4	12.9	10.7	11.2	15.4	18.7	21.5	24.7	22.7
11	26.4	24.3	21.4	16.3	12.8	10.1	11.4	15.1	18.3	22.4	24.2	24.7
12	26.7	21.4	20.2	16.5	12.6	11.6	10.3	15.2	18.4	22.8	25.3	26.3
13	26.1	22.4	21.0	16.4	12.5	9.80	9.90	15.7	20.4	23.7	24.4	28.3
14	25.6	20.2	21.1	14.9	12.7	10.2	10.2	15.6	19.7	21.9	26.9	25.8
15	25.7	19.7	21.9	16.7	12.9	10.5	11.6	15.6	19.3	23.2	23.8	25.2
16	26.6	20.3	21.9	15.7	12.2	10.5	12.4	14.3	19.7	23.6	22.5	27.0
17	25.1	23.9	19.3	15.4	11.5	11.2	12.1	14.4	19.2	22.5	21.3	28.3
18	25.1	22.2	20.7	16.2	11.1	10.6	10.7	14.0	19.7	23.0	21.5	26.0
19	22.1	21.8	20.9	15.2	12.4	9.50	12.2	14.6	20.0	21.8	25.5	27.1
20	28.4	22.8	20.5	15.4	12.4	9.90	12.4	13.9	19.9	23.6	24.2	26.8
21	27.3	23.4	19.8	16.2	11.3	10.6	12.4	15.5	19.9	22.9	21.3	28.1
22	25.0	21.3	17.8	15.7	11.9	10.6	12.2	14.3	21.2	24.3	24.2	26.4
23	23.5	23.2	18.8	16.2	12.2	10.4	12.7	12.8	21.8	24.4	23.7	27.9
24	25.6	23.3	20.3	14.6	12.0	11.1	11.6	16.1	20.2	21.3	25.6	24.3
25	20.8	19.0	19.5	14.6	12.2	11.0	10.8	16.8	21.5	22.9	25.3	26.2
26	25.4	21.5	17.8	14.9	11.9	10.3	9.60	16.2	20.5	20.0	26.3	26.3
27	25.2	21.5	19.4	13.7	12.2	9.80	11.4	15.5	21.5	21.3	26.1	19.8
28	27.2	25.5	17.9	13.1	11.7	10.6	11.7	15.3	21.6	26.9	26.5	26.2
29	26.8	18.3	18.5	15.1	11.4	11.2	13.6	14.9	22.1	25.5	25.7	28.3
30	27.4		15.8	14.9	11.5	9.70	13.3	14.0	23.7	21.3	26.0	26.1
31	22.8		18.7		11.0		12.8	15.9		22.6		28.4

Table 2 Daily global solar radiation values obtained from Test Reference Year data for Armidale NSW, Australia

Extracted from [12]

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	29.4	1.1	5.2	18.8	0.2	10.8	6.5	14.5	16.4	2.5	22.3	2.9
2	3.9	1.6	2.8	18.9	12.6	4.4	10.4	14.2	3	2.4	22.9	9.1
3	27.2	7.1	7.6	17.8	13.9	4.1	11.2	13.6	16.1	19.3	1.5	10.8
4	7.5	3.1	7.2	19	5.6	4.8	10	2.7	17.5	4.2	1.4	25.7
5	7.4	3.9	19.8	0.7	12	10.9	12	13.3	15.8	21.2	1.8	25.4
6	23.2	7.1	21.3	7.3	14.7	2.5	6.7	14.3	18.7	0.5	10.4	6.4
7	26.6	4.5	19.4	18.8	14.5	2.5	10.8	9.1	17	1.7	7.7	0.3
8	25.1	3.4	20.3	16.4	12.8	10.3	2.9	2.4	3	21.6	8.7	26.8
9	24.9	11.5	1.9	6.7	4.9	1.6	3.2	9.6	1.4	22.3	23.2	9.6
10	26.4	24.1	21	17.4	12.9	0.2	2.3	15.4	2.5	21.5	24.7	22.7
11	26.4	4.9	21.4	2.9	2.6	10.1	2.7	3.6	2.8	22.4	24.2	2.3
12	26.7	5.5	20.2	16.5	4.1	11.6	2.8	15.2	5.1	22.8	7.6	2.4
13	26.1	2	21	7.9	1.6	3.2	9.9	5.2	2.2	23.7	3.8	11.1
14	5.4	6.1	12.6	14.9	12.7	2.4	3.4	15.6	19.7	21.9	3.4	7.1
15	4.7	2.1	21.9	6.9	2.8	2.2	0.5	15.6	2	4	23.8	10
16	7.8	2.2	21.9	1.1	3.8	3.7	0.8	14.3	4.9	4.3	22.5	27
17	3.8	7.6	6.1	6.1	1.9	3.8	12.1	3	5	22.5	3	5.6
18	1.9	22.2	7.2	16.2	1.4	1.3	3.3	1.3	4.1	2.2	6.7	3.6
19	4	2.1	20.9	15.2	12.4	3.5	1.5	14.6	2.9	4	25.5	27.1
20	28.4	22.8	20.5	15.4	12.4	9.9	4.3	3.6	1.9	23.6	2.7	26.8
21	27.3	7	1.6	16.2	3.5	10.6	4.6	15.5	19.9	22.9	2	28.1
22	25	0.4	17.8	3.2	1.4	3.1	3.1	4.4	21.2	24.3	2.8	10.3
23	1.2	23.2	18.8	2.9	12.2	10.4	12.7	3	21.8	4.5	3.7	27.9
24	25.6	23.3	20.3	14.6	4.9	11.1	5.9	5.4	1.9	1.9	25.6	24.3
25	6.2	3.3	8.1	14.6	2.5	11	2.8	6.6	21.5	22.9	10	3.6
26	6.7	21.5	4.5	4.9	1.7	2.9	0.5	4.2	20.5	4.5	0.3	7.4
27	25.2	21.5	8	4.4	2.4	9.8	0.9	2.5	21.5	21.3	26.1	4.4
28	27.2	25.5	4.9	2.9	11.7	3.9	2	2	21.6	26.9	26.5	26.2
29	1.6	18.3	18.5	6.1	2.9	2.5	2.4	4	22.1	25.5	25.7	28.3
30	2.5		3.5	3.3	11.5	1.7	13.3	7.6	23.7	2.3	26	10.7
31	6.8		18.7		11		12.8	1		22.6		28.4

 Table 3 Daily global solar radiation values (MJ/m²day) obtained from Cloudy Test Reference Year (CTRY) data for Armidale NSW, Australia

Extracted from [14]

	January			February				March		April		
Day	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes
1	29.4	29.4	29.4	18.1	9.6	1.1	19.1	12.1 5	5.2	18.8	18. 8	18.8
2	27	15.45	3.9	22.5	12.0 5	1.6	21.8	12.3	2.8	18.9	18. 9	18.9
3	27.2	27.2	27.2	23.2	15.1 5	7.1	21.1	14.3 5	7.6	17.8	17. 8	17.8
4	26.1	16.8	7.5	26.1	14.6	3.1	22	14.6	7.2	19	19	19
5	23.2	15.3	7.4	25.5	14.7	3.9	19.8	19.8	19.8	16.8	0.7	0.7
6	23.2	23.2	23.2	23.5	15.3	7.1	21.3	21.3	21.3	19.5	7.3	7.3
7	26.6	26.6	26.6	21.5	13	4.5	19.4	19.4	19.4	18.8	18. 8	18.8
8	25.1	25.1	25.1	23.2	13.3	3.4	20.3	20.3	20.3	16.4	16. 4	16.4
9	24.9	24.9	24.9	23.2	17.3 5	11.5	19.5	10.7	1.9	16.2	6.7	6.7
10	26.4	26.4	26.4	24.1	24.1	24.1	21	21	21	17.4	17. 4	17.4
11	26.4	26.4	26.4	24.3	14.6	4.9	21.4	21.4	21.4	16.3	2.9	2.9
12	26.7	26.7	26.7	21.4	13.4 5	5.5	20.2	20.2	20.2	16.5	16. 5	16.5
13	26.1	26.1	26.1	22.4	12.2	2	21	21	21	16.4	7.9	7.9
14	25.6	15.5	5.4	20.2	13.1 5	6.1	21.1	16.8 5	12.6	14.9	14. 9	14.9
15	25.7	15.2	4.7	19.7	10.9	2.1	21.9	21.9	21.9	16.7	6.9	6.9
16	26.6	17.2	7.8	20.3	11.2 5	2.2	21.9	21.9	21.9	15.7	1.1	1.1
17	25.1	14.45	3.8	23.9	15.7 5	7.6	19.3	12.7	6.1	15.4	6.1	6.1
18	25.1	13.5	1.9	22.2	22.2	22.2	20.7	13.9 5	7.2	16.2	16. 2	16.2
19	22.1	13.05	4	21.8	11.9 5	2.1	20.9	20.9	20.9	15.2	15. 2	15.2
20	28.4	28.4	28.4	22.8	22.8	22.8	20.5	20.5	20.5	15.4	15. 4	15.4
21	27.3	27.3	27.3	23.4	15.2	7	19.8	10.7	1.6	16.2	16. 2	16.2
22	25	25	25	21.3	10.8 5	0.4	17.8	17.8	17.8	15.7	3.2	3.2
23	23.5	12.35	1.2	23.2	23.2	23.2	18.8	18.8	18.8	16.2	2.9	2.9
24	25.6	25.6	25.6	23.3	23.3	23.3	20.3	20.3	20.3	14.6	14. 6	14.6
25	20.8	13.5	6.2	19	11.1 5	3.3	19.5	13.8	8.1	14.6	14. 6	14.6
26	25.4	16.05	6.7	21.5	21.5	21.5	17.8	11.1 5	4.5	14.9	4.9	4.9
27	25.2	25.2	25.2	21.5	21.5	21.5	19.4	13.7	8	13.7	4.4	4.4
28	27.2	27.2	27.2	25.5	25.5	25.5	17.9	11.4	4.9	13.1	2.9	2.9
29	26.8	14.2	1.6	18.3	18.3	18.3	18.5	18.5	18.5	15.1	6.1	6.1
30	27.4	14.95	2.5				15.8	9.65	3.5	14.9	3.3	3.3
31	22.8	14.8	6.8				18.7	18.7	18.7			

Table 4 Optimistic/Normal/Pessimistic Daily global solar radiation values for Armidale NSW, Australia for January, February, March and April

	-	May		June				July		August		
Day	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes
1	13.5	0.2	0.2	10.8	10.8	10.8	10	6.5	6.5	14.5	14.5	14.5
2	12.6	12.6	12.6	10.6	4.4	4.4	10.4	10.4	10.4	14.2	14.2	14.2
3	13.9	13.9	13.9	9	4.1	4.1	11.2	11.2	11.2	13.6	13.6	13.6
4	13	5.6	5.6	10.7	4.8	4.8	10	10	10	13.2	2.7	2.7
5	12	12	12	10.9	10.9	10.9	12	12	12	13.3	13.3	13.3
6	14.7	14.7	14.7	11.6	2.5	2.5	11.2	6.7	6.7	14.3	14.3	14.3
7	14.5	14.5	14.5	9.7	2.5	2.5	10.8	10.8	10.8	13.7	9.1	9.1
8	12.8	12.8	12.8	10.3	10.3	10.3	10.7	2.9	2.9	14.9	2.4	2.4
9	13.4	4.9	4.9	10.6	1.6	1.6	9.6	3.2	3.2	14.9	9.6	9.6
10	12.9	12.9	12.9	10.7	0.2	0.2	11.2	2.3	2.3	15.4	15.4	15.4
11	12.8	2.6	2.6	10.1	10.1	10.1	11.4	2.7	2.7	15.1	3.6	3.6
12	12.6	4.1	4.1	11.6	11.6	11.6	10.3	2.8	2.8	15.2	15.2	15.2
13	12.5	1.6	1.6	9.8	3.2	3.2	9.9	9.9	9.9	15.7	5.2	5.2
14	12.7	12.7	12.7	10.2	2.4	2.4	10.2	3.4	3.4	15.6	15.6	15.6
15	12.9	2.8	2.8	10.5	2.2	2.2	11.6	0.5	0.5	15.6	15.6	15.6
16	12.2	3.8	3.8	10.5	3.7	3.7	12.4	0.8	0.8	14.3	14.3	14.3
17	11.5	1.9	1.9	11.2	3.8	3.8	12.1	12.1	12.1	14.4	3	3
18	11.1	1.4	1.4	10.6	1.3	1.3	10.7	3.3	3.3	14	1.3	1.3
19	12.4	12.4	12.4	9.5	3.5	3.5	12.2	1.5	1.5	14.6	14.6	14.6
20	12.4	12.4	12.4	9.9	9.9	9.9	12.4	4.3	4.3	13.9	3.6	3.6
21	11.3	3.5	3.5	10.6	10.6	10.6	12.4	4.6	4.6	15.5	15.5	15.5
22	11.9	1.4	1.4	10.6	3.1	3.1	12.2	3.1	3.1	14.3	4.4	4.4
23	12.2	12.2	12.2	10.4	10.4	10.4	12.7	12.7	12.7	12.8	3	3
24	12	4.9	4.9	11.1	11.1	11.1	11.6	5.9	5.9	16.1	5.4	5.4
25	12.2	2.5	2.5	11	11	11	10.8	2.8	2.8	16.8	6.6	6.6
26	11.9	1.7	1.7	10.3	2.9	2.9	9.6	0.5	0.5	16.2	4.2	4.2
27	12.2	2.4	2.4	9.8	9.8	9.8	11.4	0.9	0.9	15.5	2.5	2.5
28	11.7	11.7	11.7	10.6	3.9	3.9	11.7	2	2	15.3	2	2
29	11.4	2.9	2.9	11.2	2.5	2.5	13.6	2.4	2.4	14.9	4	4
30	11.5	11.5	11.5	9.7	1.7	1.7	13.3	13.3	13.3	14	7.6	7.6
31	11	11	11				12.8	12.8	12.8	15.9	1	1

Table 5 Optimistic/Normal/Pessimistic Daily global solar radiation values for Armidale NSW, Australia for May, June, July and August

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	Se	ptember		October			No	ovember		December			
Day	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes	Opt	Nor	Pes	
1	16.4	16.4	16.4	20.5	2.5	2.5	22.3	22.3	22.3	24.6	13.75	2.9	
2	16.3	3	3	19.4	2.4	2.4	22.9	22.9	22.9	25	17.05	9.1	
3	16.1	16.1	16.1	19.3	19.3	19.3	23.4	1.5	1.5	26	18.4	10.8	
4	17.5	17.5	17.5	20.9	4.2	4.2	23.1	1.4	1.4	25.7	25.7	25.7	
5	15.8	15.8	15.8	21.2	21.2	21.2	21.3	1.8	1.8	25.4	25.4	25.4	
6	18.7	18.7	18.7	19.9	0.5	0.5	22.3	10.4	10.4	23.8	15.1	6.4	
7	17	17	17	21.4	1.7	1.7	24.1	7.7	7.7	26.1	13.2	0.3	
8	17	3	3	21.6	21.6	21.6	22	8.7	8.7	26.8	26.8	26.8	
9	15.7	1.4	1.4	22.3	22.3	22.3	23.2	23.2	23.2	24.8	17.2	9.6	
10	18.7	2.5	2.5	21.5	21.5	21.5	24.7	24.7	24.7	22.7	22.7	22.7	
11	18.3	2.8	2.8	22.4	22.4	22.4	24.2	24.2	24.2	24.7	13.5	2.3	
12	18.4	5.1	5.1	22.8	22.8	22.8	25.3	7.6	7.6	26.3	14.35	2.4	
13	20.4	2.2	2.2	23.7	23.7	23.7	24.4	3.8	3.8	28.3	19.7	11.1	
14	19.7	19.7	19.7	21.9	21.9	21.9	26.9	3.4	3.4	25.8	16.45	7.1	
15	19.3	2	2	23.2	4	4	23.8	23.8	23.8	25.2	17.6	10	
16	19.7	4.9	4.9	23.6	4.3	4.3	22.5	22.5	22.5	27	27	27	
17	19.2	5	5	22.5	22.5	22.5	21.3	3	3	28.3	16.95	5.6	
18	19.7	4.1	4.1	23	2.2	2.2	21.5	6.7	6.7	26	14.8	3.6	
19	20	2.9	2.9	21.8	4	4	25.5	25.5	25.5	27.1	27.1	27.1	
20	19.9	1.9	1.9	23.6	23.6	23.6	24.2	2.7	2.7	26.8	26.8	26.8	
21	19.9	19.9	19.9	22.9	22.9	22.9	21.3	2	2	28.1	28.1	28.1	
22	21.2	21.2	21.2	24.3	24.3	24.3	24.2	2.8	2.8	26.4	18.35	10.3	
23	21.8	21.8	21.8	24.4	4.5	4.5	23.7	3.7	3.7	27.9	27.9	27.9	
24	20.2	1.9	1.9	21.3	1.9	1.9	25.6	25.6	25.6	24.3	24.3	24.3	
25	21.5	21.5	21.5	22.9	22.9	22.9	25.3	10	10	26.2	14.9	3.6	
26	20.5	20.5	20.5	20	4.5	4.5	26.3	0.3	0.3	26.3	16.85	7.4	
27	21.5	21.5	21.5	21.3	21.3	21.3	26.1	26.1	26.1	19.8	12.1	4.4	
28	21.6	21.6	21.6	26.9	26.9	26.9	26.5	26.5	26.5	26.2	26.2	26.2	
29	22.1	22.1	22.1	25.5	25.5	25.5	25.7	25.7	25.7	28.3	28.3	28.3	
30	23.7	23.7	23.7	21.3	2.3	2.3	26	26	26	26.1	18.4	10.7	
31				22.6	22.6	22.6				28.4	28.4	28.4	

Table 6 Optimistic/Normal/Pessimistic Daily global solar radiation values for Armidale NSW, Australia for September, October, November and December

V. CONCLUSION

Typical solar radiation data is very important for calculations concerning many solar energy generation systems and for building energy calculation modelling and analysis. In this study, optimistic, normal and pessimistic typical global solar radiation for each day of the year is estimated based on TRY(s) developed for Armidale NSW, Australia using 23 years' meteorological measured data. The daily global solar radiation on a horizontal surface for the region is presented throughout the year in a tabular form.

Such typical database is highly recommended to be considered by investigators of solar photovoltaic (PV) systems in Armidale, such database provides realistic and reliable data, no overestimating or undervaluation.

It is suggested that user of this database to use normal values when initially evaluation the solar photovoltaic power in Armidale, on the other hand, it is suggested to consider optimistic values in summer months, pessimistic values in winter months and normal values for the rest of the year for further thorough evaluation of solar PV systems by either PV specialist of ordinary persons.

REFERENCES

- A. Argiriou, S. Lykoudis, S. Kontoyiannidis, C.A. Balaras, D. Asimakopoulos, M. Petrakis, and P.Kassomenos. Comparison of methodologies for TMY generation using 20 years data for Athens, Greece. *Solar Energy* 66(1), 1999, 33–45.
- [2] W. Marion and K. Urban. User's Manual for TMY2s. National Renewable Energy Laboratory, Colorado, USA, 1995.
- [3] H. Bulut. Generation of typical solar radiation data for Istanbul, Turkey. *International Journal of Energy Research* 27(9), 2003, 847–855.
- [4] H. Bulut. Typical Solar Radiation Year for South-eastern Anatolia. *Renewable Energy* 29(9), 2004, 1477–1488.
- [5] R.L. Fagbenle. Generation of a test reference year for Ibadan, Nigeria. *Energy Conversion and Management* 30(1), 1995, 61–63.
- [6] J.C. Lam, S.C.M. Hui, and A.L.S. Chan. A statistical approach to the development of a typical meteorological year for Hong Kong. *Architectural Science Review* 39(4), 1996, 201–209.
- [7] A. Miguel, and J. Bilbao. Test reference year generation from meteorological and simulated solar radiation data. *Solar Energy* 78(6), 2005, 695–703.
- [8] M. Petrakis, H.D. Kambezidis, S. Lykoudis, A.D. Adamopoulos, P. Kassomenos, I.M. Michaelides, S.A. Kalogirou, G. Roditis, I. Chrysis, and A. Hadjigianni. Generation of a typical meteorological year for Nicosia, Cyprus. Renewable Energy: 13(3), 1998, 381–388.
- [9] S.A.M. Said and H.M. Kadry. Generation of representative weather-year data for Saudi Arabia. *Applied Energy* 48(2), 1994, 131–136.
- [10] M.A.M. Shaltout and M.T.Y. Tadros. Typical solar radiation year for Egypt. *Renewable Energy* 4(4), 1994, 387–393.
- [11] G. Kalogirou, I. Roditis, II. Chrysis, and A. Hadjigianni. Generation of a typical meteorological year for Nicosia, Cyprus. *Renewable Energy*: 13(3), 1998, 381–388.
- [12] Y. Maklad. Generation of an Annual Typical Meteorological Solar Radiation for Armidale NSW Australia. *IOSR Journal of Engineering (IOSRJEN)*: 4(4), 2014, 41-45.
- [13] Australian Bureau of Meteorology. http://www.bom.gov.au/climate/cdo/about/definitionsother.shtml
- [14] Y. Maklad. The Effect of Cloudy Days on the Annual Typical Meteorological Solar Radiation for Armidale NSW, Australia. *IOSR Journal of Engineering (IOSRJEN)*: 4(8), 2014, 14-20.
- [15] J.M. Finkelstein and R.E. Schafer. Improved goodness of fit tests. *Biometrika* 58(3), 1971, 641–645.