

# Solar Radiation Measurement in Aksum City of Ethiopia

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**Abstract**— At the present level, the measurement of global solar radiation at ground surface in Aksum, Ethiopia (14.7 N and 38.43 E) is vital for the development of projects associated to solar energy. In this paper, the solar radiation data is measured on daily basis and being accounted for three months. The ground based measurements were taken from the Aksum university site. The graphs clearly indicate the variation of global radiation on a day and month basis. The data measurements were taken by a pyranometer and the monthly average radiation of summer month of March was found to be 1062 W/m<sup>2</sup>.

**Key words:** Solar Radiation, Aksum University, Global Radiation, Pyranometer

## I. INTRODUCTION

Solar energy utilisation is the fast growing technology in the renewable energy arena. It is purely essential to measure the solar radiation at the point of implementation of any solar based projects in the region [1]. Ethiopia is blessed with the year round sun shine. In order to have eco sustainability the solar data and the related projects are the vital source for eco-friendly energy utilisation. The global solar data was measure using a pyranometer. Data are fundamental input for the solar energy applications such as photovoltaic, solar thermal systems and passive solar design [2]. Automatic solar radiation monitoring stations can be set up across the country [3]. High quality solar radiation impinging on a horizontal plane at ground level are analysed [4]. The global radiation data is very promising for the calculation of efficiency of a solar flat plate collector [5].

## II. SOLAR RADIATION MEASUREMENTS

The global radiation data is measured by a pyrano meter (TM-206 solar power meter) which is hand held meter. The

instrument had the options of measuring the global radiation both in W/m<sup>2</sup> and BTU.



Fig. 1: Tm-206 Solar Power Meter (Pyranometer)

At the initial stage, the solar data was taken on hourly basis starting from 6 a.m. to 6 p.m. The average high occurs between 12 noon and 1 p.m. Hence the data measurements were taken at mid sun 12 noon to 1 pm everyday so that the maximum radiation could be noted down. The site in the university was selected such that the shadowing effect due to obstructions is almost nil or very minimal.

## III. RESULTS & DISCUSSION

### A. Hourly Variation of Global Radiation

The hourly variation of global radiation were the basic data for the analysis. Table 1 represents the solar data obtained from 6 am to 6 pm on the shown dates:

Date	6 am	7am	8 am	9 am	10 am	11 am	12 noon	1pm	2 pm	3 pm	4 pm	5 pm	6 pm
01.11.17	0	0	25	204	400	560	651	681	640	532	372	153	20
02.11.17	0	0	53	240	418	548	623	622	570	451	285	91	0
03.11.17	0	0	77	288	499	657	758	785	763	653	492	290	44

Table 1: Hourly Distribution of Solar Radiation

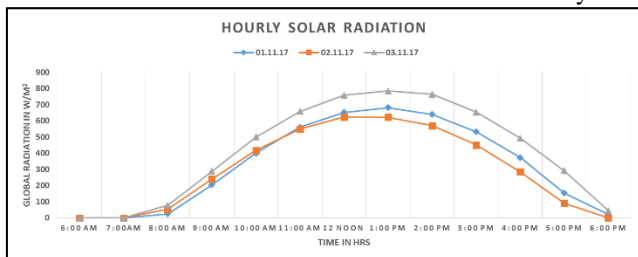


Fig. 2: Hourly Distribution of Solar Radiation

In the early morning session the sunshine is almost nil and as the day progresses, the radiation intensity increases slowly from 25 W/h to 681 W/h on November 1 and gradually

the reduction in intensity happens. At the end of the day at 6 pm the radiation again reaches the very minimum of zero. In the three days, the radiation intensity was higher on November 3. It was found that the day's high global radiation is to occur between 12 noon and 1 pm. The graph clearly depicts the curvy pattern of variation in radiation distribution.

### B. Daily Variation of Radiation

The daily variation of radiation was observed for a period of three months to predict the change in radiation according to the season.

The distribution is shown in the following table.

DAY	NOVEMBER'17	DECEMBER'17	JANUARY'18	FEBRUARY'18	MARCH'18
01	666	558	561	822	1053
02	623	553	549	835	1090

03	771	396	399	744	1058
04	720	716	718	905	1061
05	823	811	817	962	1077
06	800	794	797	946	1064
07	730	720	725	912	1068
08	705	700	703	898	1062
09	742	737	740	915	1059
10	826	821	824	969	1083
11	801	796	799	930	1031
12	805	801	803	930	1026
13	756	240	498	790	1051
14	766	702	734	927	1090
15	243	542	393	740	1057
16	146	290	218	654	1059
17	330	335	333	694	1025
18	344	303	324	692	1030
19	245	275	260	686	1082
20	230	300	265	677	1058
21	255	277	266	679	1061
22	301	340	321	709	1067
23	308	380	344	719	1063
24	400	410	405	756	1076
25	342	200	271	681	1060
26	323	415	369	729	1058
27	371	450	411	766	1091
28	220	222	221	652	1052
29	238	250	244	----	1069
30	157	381	269	----	1094
31	-----	392	196	----	1102

Table 2: Daily Distribution of Solar Radiation

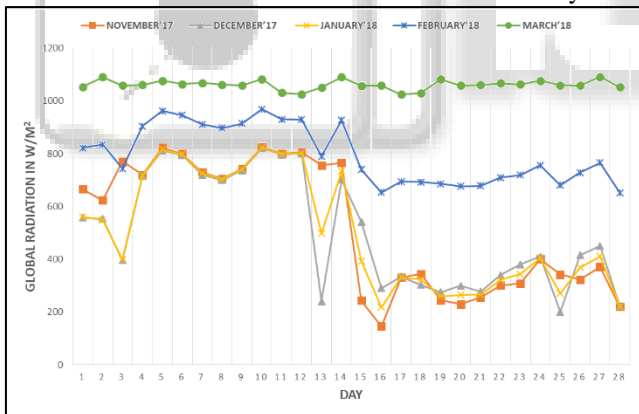


Fig. 3: Daily Distribution of Solar Radiation

The monthly distribution of global radiation is shown in the figure 3. The distribution is found to be in a random fashion. The November'17 month recorded an average radiation of 499.5 W/m<sup>2</sup> and in the December'17 month the average radiation of 487.32 W/m<sup>2</sup> was recorded and the corresponding value of average radiation of 471.27 W/m<sup>2</sup> was recorded in the month of January'18. The transition from the summer to winter which is noted as a seasonal variation was found to be a cause for the less value of global radiation. On the notable area of the graph, during a sunny day, the high value of global radiation of 826 W/m<sup>2</sup> was recorded on the 10<sup>th</sup> day of November'17 and the minimum value of global radiation of 157 W/m<sup>2</sup> was observed on 30<sup>th</sup> day of the same month on November'17. The consecutive months of December'17 and January'18

recorded less value of radiation when compared with the month of November'17. The winter season that prevails in most of the parts of Ethiopia and in particular about Aksum city, the less value of radiation was recorded. The cloudy days and the cool winds of the winter season were found to be the cause of this least radiation. However, the radiation was seem to have a tremendous improvement in the months of February and March. The winter season gets over in the month of January and the seasonal change of winter to summer started too early in the mid of February. Hence, the global radiation increased. In particular about March month, the global radiation was observed to be above 1000 W/m<sup>2</sup> and the maximum value was recorded on March 31 about 1102 W/m<sup>2</sup>.

#### IV. CONCLUSION

A detailed investigation of the variability of solar radiation can be proven useful towards more efficient and sustainable design of renewable resources systems [6]. A comprehensive knowledge of available solar energy amount in a specific location is crucial for the successful development for solar energy policies and investment [7]. The data can be used for the pumping application, irrigation, village water supplies [8]. It becomes a difficulty to express the solar radiation in cloudy and complicated weather conditions [9]. The hourly variation infers that the peak global radiation was found to be occurring between the time periods of 12 noon to 1 pm. The daily variation of global radiation infers that the low amounts of radiation in the range of 100 -500 W/m<sup>2</sup> was recorded on

few days of November '17 and December '17 and the maximum of 500 -800 W/m<sup>2</sup> was recorded in the few days of January '18 and February '18. However, when the seasonal change of winter to summer recorded ample radiation in the months of March '18 and a maximum global radiation of 1102 W/m<sup>2</sup> was recorded on day of March 31, 2018. This five month radiation data would surely give a clear insight about the global radiation falling on the earth surface in Aksum city. This would also pave the way for implementation of various projects in the Aksum university campus and also in the city.

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