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MEASUREMENT OF GLOBAL SOLAR RADIATION IN KOTA KINABALU MALAYSIA

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ABSTRACT

This paper presents the global solar radiation in University Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia (6.0367°N, 116.1186°E) over period of one year from 2013 to 2014 using LI-200 pyronometer data logger set. Daily and monthly average global solar radiation values were calculated from 10 minutes average recorded values. Daily maximum global solar radiation were 1056.10 W/m^2 was recorded on August 18, 2013 while the highest daily average global solar radiation of 495.90 W/m^2 was recorded on August 28, 2013. Global solar radiation of Kota Kinabalu were compared to other cities in Malaysia. From the data collected we can see that Kota Kinabalu receive ample global solar radiation and has a very strong potential for solar energy development.

Keywords: photovoltaic, global solar radiation, solar energy, pyronometer, kota kinabalu, Malaysia.

INTRODUCTION

Kota Kinabalu city receive stable amount of solar radiation throughout the country. Kota Kinabalu has the opportunity to utilize this bounty of natural energy effectively. Accurate information on the intensity of solar radiation at a given location is of essential to the development of solar energy-based projects (Islam, 2008). Quantifying solar irradiance that reaches the ground is necessary for many fields of application such as solar energy measurement, agriculture or modeling feeding (World Meterological Organization, 2008). Energy is essential to economic and social development and improved quality of life of human being. Solar energy is being seriously considered for satisfying a significant part of energy demand in Malaysia, as is in the world. Since there is more and more concern on energy conservation and environmental protection, interest has been increasingly focused on the use of solar energy (Muzathik, 2010). Solar radiation which arrives to earth surface for every year is 160 times the world's proven fossil fuels reserves (Ultanir, 1996). The radiation absorption by the ozone layer affects substantially the ultraviolet (UV) interval, while the water vapour attenuates some bounds in the near-infrared (Piedehierro, 2013). In addition to absorption, the scattering by air molecules, clouds and aerosols also contributes largely to the extinction of solar radiation (Piedehierro, 2013). However, sometimes radiation reaching the Earth's surface can be higher in magnitude compared with its corresponding ideal cloud-free sky (Cede, 2002), (Pfister, 2003), (Parisi and Downs, 2004), (Sabburg and Calbó, 2009), (de Miguel, 2011). These events are called radiation enhancements, being able to produce surface solar levels higher than their extraterrestrial value (Piacentini, 2003, 2011), (Antón, 2011). It is easy to say that solar energy is the main, biggest and most important energy resource while the other energy resource are the form of solar energy (Teke, 2014). Solar energy as a clean energy source and one kind of renewable energy is abundant in Malaysia (Muzathik, 2010). Solar energy in the form of PV is already very popular in countries such as the United State, Germany and Japan (Makrides, 2010). Output energy of photovoltaic modules is being estimated by using meteorological data (Teke, 2014). Global tilted irradiance data is needed to estimate output energy of PV modules (Yoshida, 2013) or calculation of diffuse radiation reaching photovoltaic system is essential for simulation of photovoltaic systems (Deb Mondol, 2008). An accurate knowledge of the solar radiation data at a particular geographical location is of vital importance for the development of solar energy devices and for estimates of their performance (Duffie and Beckman, 2006). However it is not possible to measure global solar radiation in many areas due to cost, maintenance and calibration requirements of the measuring equipment whereas sunshine duration is extensively measured in almost all meteorological stations for long period (Teke, 2014). In this respect, the importance of solar radiation data for design and efficient operation of solar energy systems has been acknowledged. A global study has been made on the global solar radiation models available including the study carried out on estimation of the monthly average daily global solar radiation on horizontal surface (Bakirci, 2009). In this study, solar radiation were measured for a one complete year.

Site and Instruments

Kota Kinabalu is the capital of the state of Sabah, located in East Malaysia. It also the capital of the West Coast division of Sabah (5.9714°N, 116.0953°E). The site of the measurement station was located at the University Malaysia Sabah, Kota Kinabalu (6.0367°N, 116.1186°E) about 12.5 km from Kota Kinabalu City. This study was carried out from 2013 till 2014 for a complete year. LI-200 pyronometer was used to measure the global solar radiation. Its accuracy is <±1%

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error over 360° at 45° elevation. Sensitivity typically 90µA per 1000 Wm^{-2} and its response time is 10µs. Global solar radiation measurements were recorded every 10 minute using a single data logger (Symphonie Data Retriever). Temperature dependence of LI-200 pyronometer is 0.15% per °C maximum. Operating temperature is -40 °C to 65 °C and has high stability photovoltaic detector.

Experiment Setup and Procedure

LI-200 pyronometer was placed in Faculty Science and Natural Resource, University Malaysia Sabah. Pyronometer were collected the data every 10 minute. Every month the data were clear from the memory card inside the NRG data logger and replaced with new memory card. From the raw data stored for every 10minute, the average and maximum hourly values were calculated. From the hourly data set, daily and monthly statistics were made for the solar radiation and temperature data.

RESULT AND DISCUSSIONS

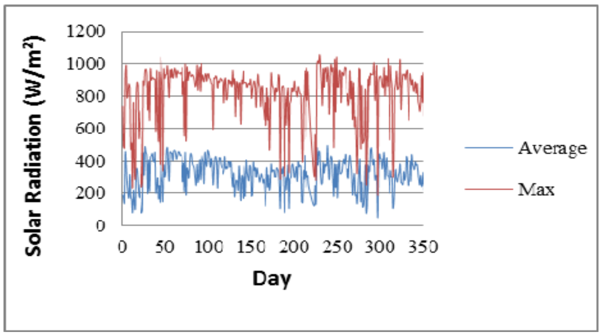

Figure-1. Daily average and daily peak of global solar radiation throughout the year 2013 and 2014 at the site research.

From the data it is clear that the daily average and maximum global solar radiation as well as temperature higher from August to November and lower May to July. Figure-1 describes the daily average and daily maximum global solar radiation for the end of 2013 and early 2014. The graphs show that the daily maximum global solar radiation of 1056.10 W/m² was recorded on August 18, 2013 while the highest daily average global solar radiation of 495.90 W/m² was recorded August 28, 2013.

Daily mean solar radiation values were high during periods of February to April and August to November. Average daily energy input for the whole year was 15.87 $MJ/m^2/day$ which agrees with the global solar map. Figure-1 also show downward excursions in Southwest monsoon, especially in March until July. These excursions might be due to rain and haze in March 2014 and June 2013.

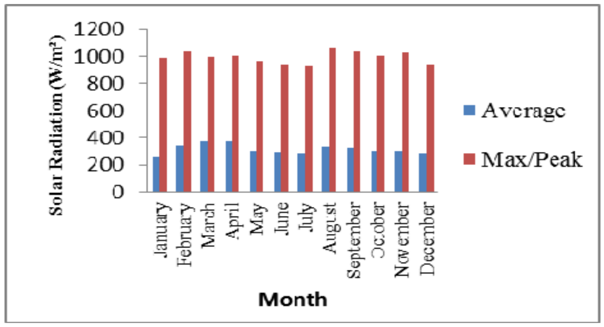

Figure-2. Monthly average and monthly peak daily total global solar radiation at the site research.

Daily average for each month and peak daily global solar radiation for complete years are shown in Figure-2. The month of April had the highest monthly average daily radiation of 378.76 W/m² but the month of August shows the highest daily peak in global solar radiation of 1056.10 W/m². January had the lowest monthly average daily solar radiation of 254.10 W/m².

Table-1. Monthly mean daily values of global solar radiation ($MJ/m^2/day$) for Kota Kinabalu and other cities. (Kamaruzzaman and Othman, 1992).

Months	Kota Kinabalu	Kuching	Kota Bharu	Senai	Bayan Lepas	Kuala Lumpur	Petaling Jaya	Bandar Baru Bangi
Jan	12.66	12.02	16.26	15.08	19.1	15.44	15.28	13.17
Feb	17.46	13.35	17.72	20.05	19.56	16.89	16.99	15.99
Mar	18.92	15.39	19.72	16.8	20.06	17.26	15.71	14.85
April	19.32	13.07	19.74	17.1	18.98	17.71	16.68	16.07
May	15.29	13.42	18.23	15.79	17.51	16.13	15.83	15.84
June	15.08	16.28	17.1	16.06	17.34	15.91	15.96	15.48
July	14.68	16.57	17.17	14.92	17.27	15.87	15.88	16.76
Aug	16.60	15.14	17.42	15.16	16.79	15.9	15.99	14.49
Sept	16.50	15.79	18.12	15.63	16.66	16.03	16.08	14.38
Oct	14.58	15.23	17.09	15.43	16.29	15.82	16.23	14.19
Nov	15.25	14.92	13.28	15.3	17.03	14.36	14.67	12.28
Dec	14.15	12.56	12.15	15.9	17.59	14.53	14.54	12.66
Annual Average	15.87	14.48	17	16.1	17.85	15.99	15.82	14.68

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In Table-1 and Figure-3 respectively, the monthly mean daily values of global solar radiation of Kota Kinabalu (from our data) and other cities (Kuching, Kota Bharu, Senai, Bayan Lepas, Kuala Lumpur, Petaling Jaya & Bandar Baru Bangi) of Malaysia (Kamaruzzaman and Othman, 1992) are compared. It is clear that the monthly average global solar radiation over the course of the year 2013 and 2014 is 15.87 MJ/m^2/day. The higher for Kota Kinabalu in April 2014, 19.32 MJ/m^2/day. Annual average for Bayan Lepas and Kota Bharu were 17.85 MJ/m^2/day and 17.00 MJ/m^2/day respectively.

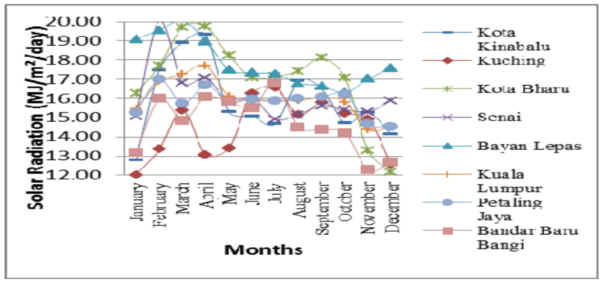

Figure-3. Monthly mean daily values of global solar radiation for Kota Kinabalu and other cities.

Table-2. Daily global solar radiation values (MJ/m^2/day) obtained from average reference year data for Kota Kinabalu.

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	9.63	10.67	23.31	14.15	17.89	9.62	16.93	21.9	21.75	7.1	22.65	18
2	8.82	21.47	23.49	19.73	18.54	19.74	12.06	11.63	20.33	10.11	14.33	20.13
3	7.09	21.72	22.68	21.94	17.9	17.3	5.46	17.02	13.99	3.5	18.87	13.72
4	22.68	22.52	20.66	21.03	20.12	18.29	17.69	14.92	9.24	20.61	21.14	22.04
5	18.97	20.21	21.87	19.88	20.15	15.15	16.38	15.69	19.36	7.57	15.71	19.35
6	13.1	19.97	23.02	19.84	18.37	18.1	18.49	11.25	11.77	13.55	15.65	18.49
7	8.5	22.65	23.02	22.69	20	16.51	14.88	16.88	19.19	5.84	13.45	17.6
8	8.58	10.29	21.92	19.73	15.25	15.19	4.23	21.41	8.66	6.13	10.21	20.03
9	16.02	12.43	21.75	18.7	11.99	13.43	12.68	4.56	18.24	10.03	17.21	18.89
10	8.79	14.86	22.67	23.46	16.66	15.19	15.33	13.8	20.49	19.01	15.21	19.22
11	8.18	8.31	20.08	22.93	9.07	16.36	11.01	18.42	16.28	4.15	15.37	16.99
12	4.09	12.44	13.55	21.28	12.47	14.65	15	6.21	16.36	6.68	5.61	14.19
13	10.94	7.55	19.64	18.29	14.14	13.11	18.73	12.43	17.02	19.08	6.99	12.58
14	7.06	21.98	10.59	21.03	13.59	14.28	5.4	6.96	19.72	9.98	13.32	15.89
15	5.27	16.49	22.88	19.19	11.04	10.5	14.49	23.98	20.77	18.54	17.73	12.15
16	17.99	12.59	9.52	12.56	18.77	6.18	14.81	18.93	19.29	14.55	14.29	12.94
17	17.97	7.59	18.07	17.11	13.78	11.77	18.87	23.14	18.69	21.88	13.49	16.72
18	14.21	18.89	17.32	21.13	7.83	18.3	19.38	23.14	20.13	24.27	15.72	9.36
19	9.69	15.28	14.62	21.59	15.81	11.84	17.28	16.65	14.95	21.06	16.78	16.68
20	8.76	16.47	19.63	19.48	14.99	16	14.83	12.78	17.88	19	19.32	14.62
21	12.72	23.26	22.5	11.58	8.54	10.99	16.75	13.39	14.54	20.56	13.29	12.97
22	6.2	24.41	21.92	19.22	18.54	12.55	18.43	19.82	20	14.18	13.19	19.95
23	4.03	19.04	19.29	21.21	16.36	19.3	13.65	16.54	21.98	15.89	13.65	13.39
24	4.97	19.05	18.74	21.16	9.18	16.92	19.98	19.32	19.59	15.85	17.03	2.07
25	22.59	23.08	17.78	19.23	20.28	17.51	18.45	18.56	16.19	2.56	14.03	24.43
26	15.86	22.68	14.34	18.14	17.07	17.51	19.06	18.71	9.53	18.01	15.77	5.26
27	24.47	22.63	12.63	18.03	15.38	15.15	18.58	18.76	13.58	22.35	21.6	4.88
28	22.87	20.31	19.25	16.24	13.97	15.11	7.52	24.99	16.31	20.98	20.4	5.17
29	22.0		13.45	17.37	18.94	18.17	7.18	18.12	9.37	20.9	12.49	4.56
30	9.96		15.73	21.61	18.28	17.72	17.2	14.23	9.83	17.79	12.93	2.09
31	20.51		20.65		9.22		14.49	20.55		20.39		14.37
Monthly Average	12.66	17.46	18.92	19.32	15.29	15.08	14.68	16.60	16.50	14.58	15.25	14.15

By using all the months' data in the database, the average reference year for daily global solar radiation data was developed for Kota Kinabalu state of Malaysia. Table-2 gives the average reference year for monthly mean global solar radiation for the location considered in this study. Minimum and maximum values of monthly average of daily global solar radiation are 12.66 MJ/m^2/day in January and 19.32 MJ/m^2/day in April respectively with annual average value of 15.92 MJ/m^2/day. The highest daily average maximum and minimum global solar radiation were 24.47 MJ/m^2/day on January 27, 2014 and 2.07 MJ/m^2/day on December 24, 2013 respectively.

CONCLUSIONS

In this study, global solar radiation were measured to get a better view of the solar energy potential in Kota Kinabalu. The total global solar radiation of Kota Kinabalu throughout the year in comparison to other cities in Malaysia indicates a strong potential for utilizing solar energy among other state in Malaysia. It is expected that these average solar radiation years will be useful to the designer of solar energy systems. Daily average global solar radiation data show that the month of April had the highest monthly average of radiation of 378.76 W/m^2 and month of August shows the highest daily peak in global solar radiation of 1056.10 W/m^2. Average daily energy input for the whole year was 15.87 MJ/m^2/day.

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