sapteka2019

by Turnitin .

Submission date: 06-May-2023 06:15PM (UTC+0800)
Submission ID: 2085829715
File name: sapteka2019.pdf (444.59K)
Word count: 1807
Character count: 9244

Modelling of Monthly Clear Sky Solar Irradiation on Horizontal Surface in Denpasar City

Anak Agung Ngurah Gde Sapteka
Electrical Department
Politeknik Negeri Bali
Denpasar, Indonesia
sapteka@pnb.ac.id

Anak Agung Ngurah Made Narottama
Electrical Department
Politeknik Negeri Bali
Denpasar, Indonesia
narottama@pnb.ac.id

Kadek Amerta Yasa
Electrical Department
Politeknik Negeri Bali
Denpasar, Indonesia
amerta.yasa@pnb.ac.id

Ponlakit Jariyatantiwait
Electronics and Telecommunication Department
Rajmangala University of Technology Phra Nakhon
Bangkok, Thailand
ponlakit.j@rmutp.ac.th

I Made Sajayasa
Electrical Department
Politeknik Negeri Bali
Denpasar, Bali
madesajayasa@pnb.ac.id

***Abstract*—This article discusses the monthly clear sky solar irradiation in Denpasar City from April to October, focusing the effect of June Solstice. The primary data of daily solar radiation on horizontal surface is taken using Lutron SPM-1116SDfrom 8 o'clock to 16 o'clock in minute basis. The data filtered using second order polynomial fitting. Only data th adjusted R-square more than 0.9 is included. If it is eded, the upper envelope signal processing is taken before cond order polynomial fitting.By integrating this data, we have daily solar irradiation data on horizontal surface in Watt hour per square meter and a precise model of monthly clear sky solar irradiation using third order polynomial.**

Keywords—modelling,solar irradiation,irradiance, horizontal surface,denpasar, bali

I. INTRODUCTION

The sun moves from position abov the equator on March 21 towards the June Solstice(23^0 26' 12.3" north of equator) on June 21. Furthermore, the movement of the rth's axis causes the movement of the sun to return to the equator on September 23 and is continued to reach the ecemberSolstice (23^0 26' 12.3" south of equator) on ecember 22. The position of the sun then returns to the uator on March 21. This regular movement causes peated solar irradiation every year at certain locations on e surface of the earth.In Surabaya, Indonesia, the monthly lar irradiation averageis 4.92 kWh/m^2 in 2008 [1]. In edan, Indonesia, the minimum and maximum estimations irradiance are 522.19 W/m^2 in December and671.69 W/m^2 August [2]. In Pontianak, Indonesia, solar irradiation reaches 7.71kWh/m^2 on March 10, reaching a minimum value of6.78 kWh/m^2, with possible local maximum of 7.62 Wh/m^2 on June 22 and reaching a maximum value of 671.69 W/m^2 in August [3]. Due to the variety in solar irradiation, there are several modelshave been studied about is subject such as: Genetic algorithms to optimize the rection and angle of installation of solar panels in Sabang, donesia [4];Solar energy potential in Indonesia using artificial neural networks (ANNs) method in Makassar[5]. he ANNs method is also used in the cities of Pekanbaru, ndung, Banjarmasin and Gorontalo [6].Meanwhile in kkarta, solar radiation modelling is based on the calculation mean bias error and root mean square error [7]. In this search we report about modelling of monthly clear sky solar radiation on horizontal surface in Denpasar City, Bali.

II. METHODOLOGY

We collect the data of solar irradiation at Denpasar City, ali, Indonesia. It is located at 8^{0}39' S, 115^{0}13' E. We use utron Solar Power Meter (SPM-1116SD) to collect the ily data in Watt/m^{2}on minute basis from April to October 2018 and 2019. The irradiation sensor of LutronSolar Power Meter SPM-1116SD is placed in a horizontal position as shown in Fig 1.

Fig. 1. Lutron SPM-1116SD.

The daily data is collected every minute from 08.00 to 6.00 local time. By integrating this data, we have solar radiation data in Wh/m^2. Then the data is fitted using cond order polynomial fit. Only data with adjusted R-uare more than 0.9 is included. If it is needed, the upper velope signal processing is taken before second order olynomial fitting. So that only the data on sunny days will processed further to be monthly data. Furthermore, the monthly data is fitted to obtain the appropriate mathematical model.

III. RESULT AND DISCUSSION

A. Solar Irradiation Data

Data collection begins on April 2018 in Denpasar City. n that month, the average sun declination at 4.51^0 and the erage sun elevation at 71.70^0.On April 18, 2018, it has aximum irradiance value of 1036 W/m^2, as shown in Fig.2. n May 2018, the average sun declination at 18.86^0 and the erage sun elevation at 62.49^0. The maximum irradiance vel onMay 6, 2018 is870 W/m^2, lower than April as shown Fig. 3. On June 2018, the sun is approaching June Solstice, the maximum irradiance level has value of 867 W/m^{2}on June 6, 2018, which is lower than May as shown in Fig. 4.On June, the average sun declination at 23.06^0 and the average

978-1-7281-4160-2/19/$31.00 ©2019 IEEE

sun elevation at 58.29^0. The irradiance level still decreases on July although the sun has already moved to the equator. As shown in Fig. 5, the maximum irradiance on July 20, 2018 is 830 W/m^2. The increase of irradiance level begins on August. On August 15, 2018, the maximum irradiance level is 959 W/m^2, as shown in Fig. 6.The average sun declination at 13.61^0 and the average sun elevation at 67.74^0. On September, the sun is approaching equator. The average sun declination at 2.83^0 and the average sun elevation at 78.52^0. On September 30, 2018, the maximum irradiance level is 976 W/m^2, as shown in Fig. 7. On October, the average sun declination at -8.76^0 and the average sun elevation at 87.16^0. The sun is right above Denpasar at noon on October 15, 2018. As shown in Fig. 8, the maximum irradiance level is 1001 W/m^2 on October 3, 2018.

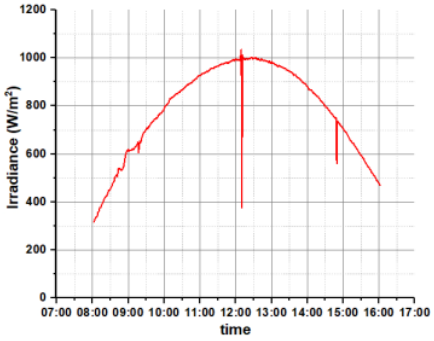

Fig. 2. Irradiance on April 18, 2018.

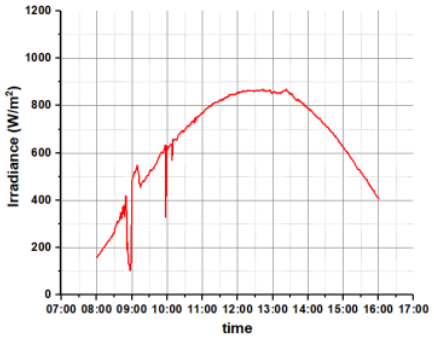

Fig. 3. Irradiance on May 6, 2018.

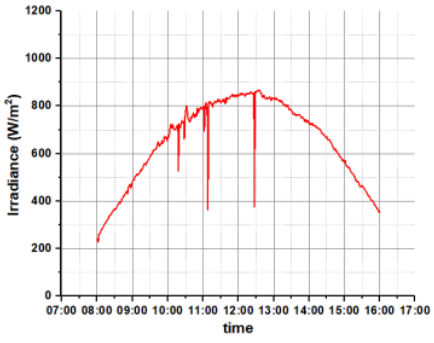

Fig. 4. Irradiance on June 6, 2019.

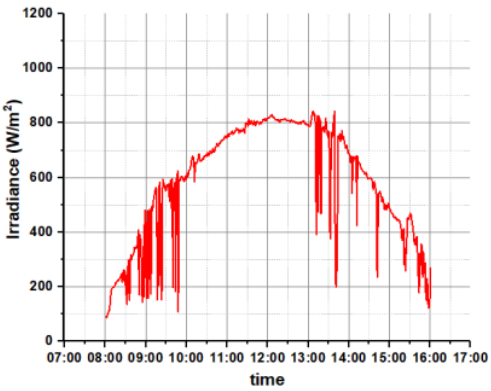

Fig. 5. Irradiance on July 20, 2018.

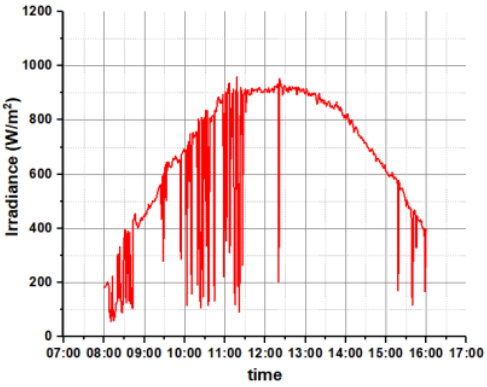

Fig 6. Irradiance on August 15, 2018.

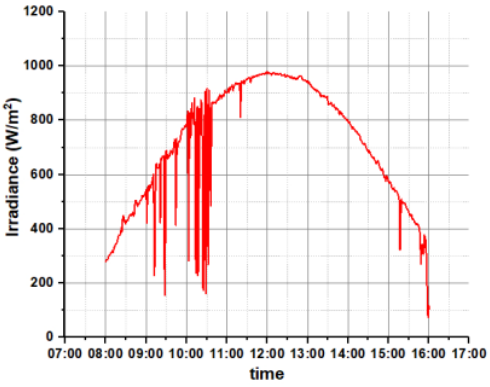

Fig. 7. Irradiance on September 30, 2018.

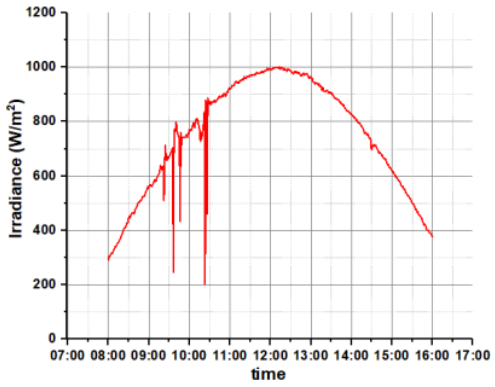

Fig. 8. Irradiance onOctober 3,2018.

TABLE I. SOLAR IRRADIATION STATISTIC

Month	No. of Days	Mean (Wh/m²)	Min (Wh/m²)	Max (Wh/m²)
April	12	6179.64	5618.78	6747.23
May	16	5200.46	4645.23	5762.80
June	4	5112.32	4636.14	5289.44
July	8	4992.19	4306.95	5316.54
August	6	5391.75	5066.41	5717.09
September	4	6009.49	5919.93	6071.98
October	7	6066.65	5810.86	6334.49

By integrating the daily irradiance data, the mean, minimum, median and maximum values of daily solar irradiation can be determined as shown in Table I. Number of days in Table I shows the amount of sunny days in a certain month which is calculated statistically in Denpasar City, Bali.

B. Modelling

The movement of the sun towards JuneSolstice fromMarch 21 to June 21 causes reduction of solar irradiation on horizontal surface in Denpasar. Mean, minimum and maximum values of solar irradiation are still decreasing until July even though the sun has moved towards the equator. This phenomenon is consistent with the results obtained in other locations as stated in [6]. Mean, minimum and maximum values of solar irradiation are increasing from August to October.

According to the data in Table I, we propose a 3rd order polynomial equation to determine daily solar irradiation on horizontal surface in Denpasar City from April to October as stated in Eq. 1. In this equation, the value of y represents daily solar irradiation in Watt hour per square meter (Wh/m²), meanwhile x represents the month number. The values of intercept, B1, B2 and B3 are written in Table II. The fitness level of this equation is shown Adjusted R-Square value of 0.91 as shown in Fig. 9.

$$y = \text{Intercept} + \text{B1} \times x + \text{B2} \times x^2 + \text{B3} \times x^3 \quad (1)$$

TABLE II. FITNESS OF THIRD ORDER POLYNOMIALEQUATION

Statistic	Value
Number of Points	7
Degrees of Freedom	3
Residual Sum of Squares	63805.11
R-Square(COD)	0.95
Adj. R-Square	0.91
Intercept	20210.28
B1	-6241.70
B2	816.92
B3	-33.37

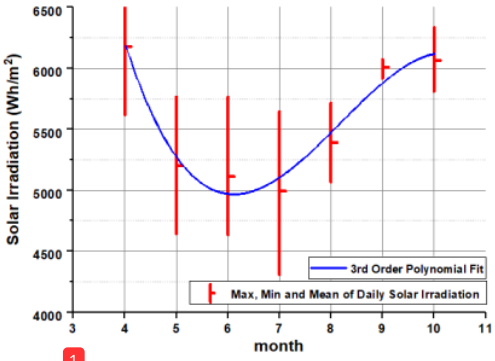

Fig. 9. 3rd order polynomial fit of solar irradiation.

Compared to other models [4-7], this equation does not require other parameters such as temperature, humidity and so forth. As shownin Fig.9,the Equation (1) can predictmonthly clear sky solar irradiation on horizontal surface in Denpasar City from April to September.

IV. CONCLUSION

In this research, we recommend a mathematical model using 3rd order polynomial to calculate monthly clear sky solar irradiation on horizontal surface in Denpasar City from April to October as stated in Eq. 1. This equation is statistically fit with adjusted R-square value 0.91.

ACKNOWLEDGMENT

We would like to thank to the Center of Research and Community Service (P3M) Politeknik Negeri Bali for funding this research.

REFERENCES

[1] E. Tarigan, "Evaluation of the solar energy potential for photovoltaic system in Surabaya," Proceeding of the 2015 International Conference on Technology, Information, Management, Engineering and Environment, pp. 275-278, 2010.

[2] H. Alam et al., "Output characteristics of photovoltaic module in Medan based on estimated solar irradiance using Hargreaves method for application assessment of transformerless photovoltaic inverter," International Conference on Advanced Science, Engineering and Technology (ICASET), pp. 1-8, 2016.

[3] A. Rosario, "Calculating the solar energy of a flat plate collector," Undergraduate Journal of Mathematical Modeling: One + Two, vol. 6, iss. 1, pp. 1-14, 2014.

[4] A. Yassir, U. Zamzami, K. Fauzan, T. Hasannuddin, and Subhan, "Optimization of tilt angle for photovoltaic: case study Sabang-Indonesia," IOP Conf. Ser.: Mater. Sci. Eng., vol. 536, pp. 1-7, 2019.

[5] M. Rumbayan and K. Nagasaka, "Solar irradiation estimation with neural network method using meteorological data in Indonesia," International Journal of Technology, vol. 2, pp. 110-120, 2012.

[6] A. Prastawa, R. Dalimi, and A. Rezavidi, "Single hidden layer artificial neural network technique for solar energy potential prediction in Indonesia," ISESCO Journal of Science and Technology, vol. 10, pp. 2-9, 2014.

[7] M. A. Budiyanto and Nasruddin, "Study on the estimation of solar radiation", 3rd International Conference on Power Generation Systems and Renewable Energy Technologies (PGSRET), pp. 5-8, 2017.

sapteka2019

ORIGINALITY REPORT

93%	22%	92%	14%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Anak Agung Ngurah Gde Sapteka, Anak Agung Ngurah Made Narottama, Kadek Amerta Yasa, Ponlakit Jariyatantiwait, I Made Sajayasa. "Modelling of Monthly Clear Sky Solar Irradiation on Horizontal Surface in Denpasar City", 2019 International Conference on Electrical, Electronics and Information Engineering (ICEEIE), 2019 Publication	87%
2	Submitted to University of Anbar Student Paper	4%
3	Submitted to Universitas Mulawarman Student Paper	2%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		