International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Investigation Of Monthly Peak Sun Hours For Proper Load Management In Awka, Anambra State, Nigeria.

G E Orizu[1], R A Akwolu[2], E K Oparaku[2], P O Isi[1], V M Igba[3,2], & E E Uzochukwu[1]

[1]Department of Physics and Industrial Physics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.
[2]Department of Physics and Astronomy, University of Nigeria, Nsukka, Enugu State, Nigeria.
[3]Department of Software Engineering, Baba-Ahmed University Kano, Kano State, Nigeria.

Abstract - The investigation of monthly peak sun hours for PV installation and energy management was carried out, and our findings and results highlighted the importance of peak sun hours for solar energy production in Awka, Anambra state, Nigeria. Our investigation revealed an average annual peak sun hours of 5.3, ranging from 11 AM to 3 PM. This suggested an optimal utilization of a PV system in this area within this period. The monthly peak sun hours indicated the least value in the months of December and January, suggesting less load utilization these months. The investigation also revealed a broader range of hours for heavy load usage in the months of March, April, May, August, September, and October. For proper system sizing, the annual peak sun hours of 5.3 is recommended, suggesting the use of solar radiation values from 11 AM to 3 PM for battery sizing. Our investigation also revealed the solar noon day of the months of January to August to be closer to 1 PM than it is to 12 noon. On the other hand, the solar noon days for the months of September to December are closer to 12 noon than it is to 1 PM.

Keywords: Solar radiation, peak sun hours, Awka, load management.

INTRODUCTION

Solar power generation is the most promising alternative to fossil fuels in achieving sustainable energy use to meet our daily energy needs with little or no environmental impact, reducing greenhouse gas emissions. A steady growth in the use of solar power generation in meeting our daily energy needs is attributed to an increasing efficiency of the panel, that comes with a decline in the cost of production [1]. The recent increase in energy demand and the inability of a standalone photovoltaic system to withstand this increase as a result of steady load increase in the building have led to load shedding and an energy crisis in those buildings, due to inefficient load management. The energy needed in the building is sometimes supplemented with the use of a hybrid system [2], which eventually resulted in an additional cost. Some underdeveloped countries like Pakistan and Nigeria have been experiencing a shortfall in energy supply, with Pakistan having the worst energy supply in 2021 [2]. An effort to stabilize power supply via renewable energy has been on for over a decade, and is still ongoing, using micro-hybrid, wind, solar, and biomass for improved socioeconomic and environmental activities [3][4].

The challenges associated with the use of a solar PV system to overcome our energy problem are the high cost of installation and manufacturing of these solar PV systems [5]. Overcoming these problems required proper sizing and load management. The alignment of energy consumption with the hours of maximum solar irradiance helps in reducing the inefficiency and extra cost associated with the energy storage [1]. Megantoro et al. [6] reported that a lower value of peak sun hours will result in a more number of PV panels and battery capacity for installation. The installation of an energy management system (EMS) in a building, intending to increase efficiency by reducing waste and energy consumption, comes with an extra cost that will eventually add to the payback period. The knowledge of energy consumed in a building and the variation of solar radiation in the area is essential in PV system design and management for proper planning to reduce energy wastage [7].

https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Megantoro et al. [6] define a peak sun hour as one hour during which the average solar irradiance is 1000 watts per square meter. It signifies the hours with an abundance of sunlight; solar panels are most likely to get this amount of sunlight when orientated straight towards the sun during its zenith at midday. The quantity of 1000 W/m² during one hour corresponds precisely to the standard sunshine intensity utilised for testing and rating solar panels in laboratory settings [8]. The sun does not shine all day at peak sunlight hours. Instead, the intensity of sunlight reaching the panels continuously varies based on the time of day and weather. In most cases, the sunlight is expected to be less than 500 W/m^2 during the early mornings and late afternoon hours, whereas during midday, a bright sunny day may receive more than 1000W/m² [9]. The notion of peak sun hour was created to allow us to precisely measure the quantity of irradiance (sunlight) that will strike solar panels placed in a specific area. This enables us to calculate the estimated energy production for a specific solar system installed at the location. The knowledge of peak sun hours helps to estimate the number of PV panels required for installation using a simple deterministic method for quick sizing [10].

Julius & Balogun, in 2022 [11] studied the distribution of solar radiation in Nigeria and confirmed that the far north experiences greater Peak Sun Hours than the colder months in comparison with regions in the west or southern part of the country. This is because places near the equator receive more direct sunshine. Peak Sun Hour is determined primarily by weather conditions. States in the north, where climate conditions allow for numerous cloud-free days, have a higher Peak Sun Hour than other locations, mostly in the south [12]. Awka, the Anambra state capital, is located halfway between the commercial city of Onitsha and the coal city of Enugu, approximately 40 km east of Onitsha. It is located between the latitudes of 6.2151^{o}N and the longitude of 7.0764^{o} E [13]. The city housing the Anambra state seat of power is rapidly increasing in population and energy demand. These demands contribute heavily to polluting our environment.

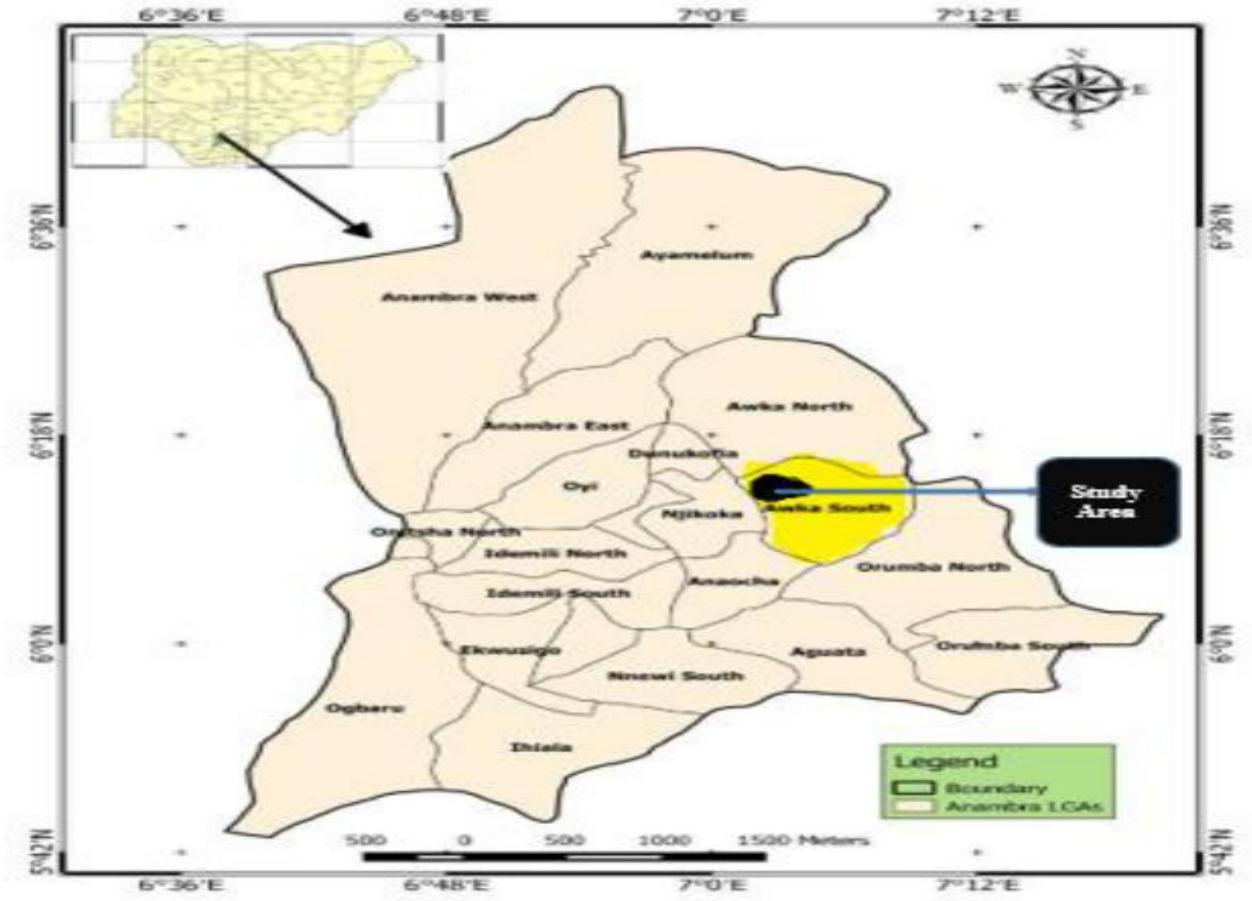


Figure 1. Map of the study area, Awka South L.G.A., in the map of Anambra State as a whole [14].

https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

The use of a solar photovoltaic system in overcoming this challenge poses its own challenge of inadequate solar radiation throughout the day. The low value of peak sun hours in this region will result in a higher cost of installation, due to the use of more PV panels and a storage system to maintain a steady power supply. A study investigating the peak sun hours in this region will be a guide for energy usage and load shedding. Our study is aimed at determining the peak sun hours in Awka, the capital of Anambra state, for proper load shedding. The investigation will go a long way toward reducing PV system failures in the region, promoting the installation of PV systems as an alternative to grid supply, and subsequently reducing air pollution associated with the use of fossil fuels.

MATERIAL AND METHODS

Material

The most important material needed for this research is eight years (2018-2025) of hourly solar radiation data collected from the Nigeria Meteorological Agency (NiMet), Abuja. An origin Lab software and Excel were also utilized.

Methods

The hourly, monthly and yearly mean solar radiation was obtained and analyzed using descriptive statistics like mean, charts and range. The hourly mean solar radiation from 6 AM to 6 PM was obtained for each hour of the day in a month using the eight-year average solar radiation. The yearly average was first computed, from which the daily average was obtained. The daily average data was used to generate a chart using OriginLab software. The generated charts were used to investigate the peak sun hours for each month of the year. The results were used to investigate the trend in the monthly peak sun hours in Awka by generating graphs representing the monthly peak sun hours against the months. The annual peak sun hours of the region were calculated using Excel software. This was done to facilitate an easier comparison of Peak Sun Hours from one month to another. The average peak sun hours for each month of the year are obtained and tabulated.

RESULTS AND DISCURSION

Table 1 and the graphs below show the results for the mean daily solar insolation for every month of the year from 2018-2025 from 6 AM to 6 PM. The average radiation for each month of the year

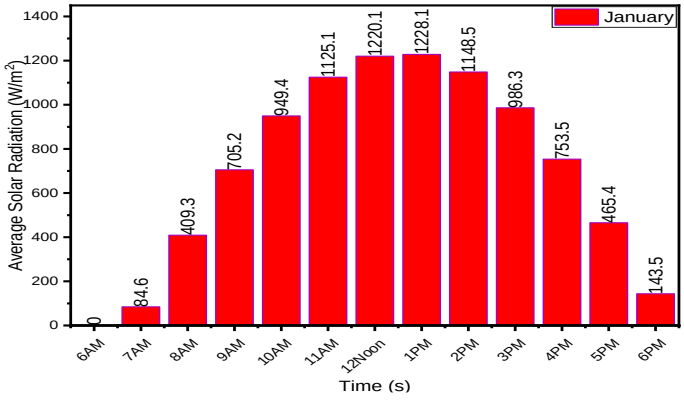
Table 1: The average solar radiation from 6 am to 6 pm at an interval of one hour for each month in the year (2017-

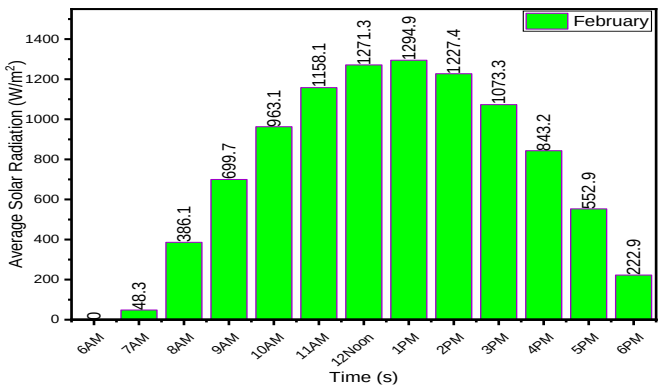
2025)

https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

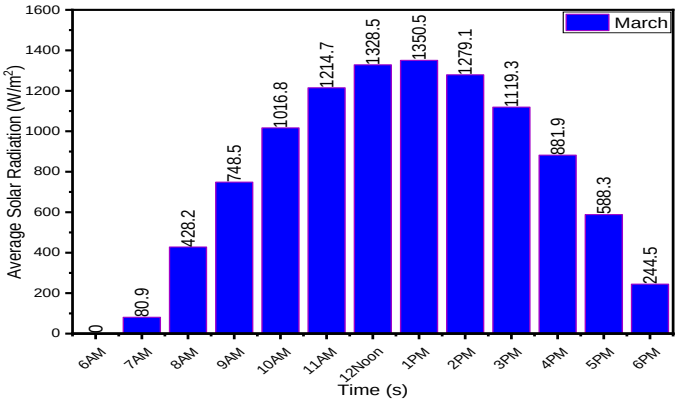
Time of the day	Hourly Average Solar Insolation (Wh/m^2)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
6 AM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 AM	84.6	48.3	80.9	159.0	223.6	207.2	174.4	171.7	203.9	229.3	198.2	140.6
8 AM	409.3	386.1	428.2	501.2	538.0	511.5	483.3	497.2	539.7	563.0	522.1	429.6
9 AM	705.2	699.7	748.5	811.7	819.9	785.8	764.2	792.5	840.2	857.8	808.3	730.6
10 AM	949.4	963.1	1016.8	1067.9	1049.4	955.8	996.8	1036.3	1084.2	1092.7	1036.2	960.9
11 AM	1125.1	1158.1	1214.7	1252.3	1210.6	1010.6	1165.3	1211.8	1254.8	1251.6	1190.1	1146.8
12 noon	1220.1	1271.3	1328.5	1352.1	1289.2	1170.5	1258.0	1307.1	1340.3	1323.6	1259.6	1224.0
1 PM	1228.1	1294.9	1350.5	1360.7	1291.6	1254.6	1268.6	1315.5	1334.9	1303.9	1240.0	1215.9
2 PM	1148.5	1227.4	1279.1	1277.4	1202.5	1257.1	1196.5	1236.6	1238.9	1193.7	1132.5	1125.3
3 PM	986.3	1073.3	1119.3	1107.8	1036.5	1022.3	1046.4	1075.7	1059.0	1000.7	944.5	953.9
4 PM	753.5	843.2	881.9	863.7	803.2	801.0	828.7	843.8	807.4	738.0	689.6	713.6
5 PM	465.4	552.9	588.3	561.8	518.7	529.9	558.3	407.8	501.3	423.7	383.3	420.9
6 PM	143.5	222.9	244.5	223.4	203.2	226.1	254.1	234.9	163.2	82.4	53.5	98.4

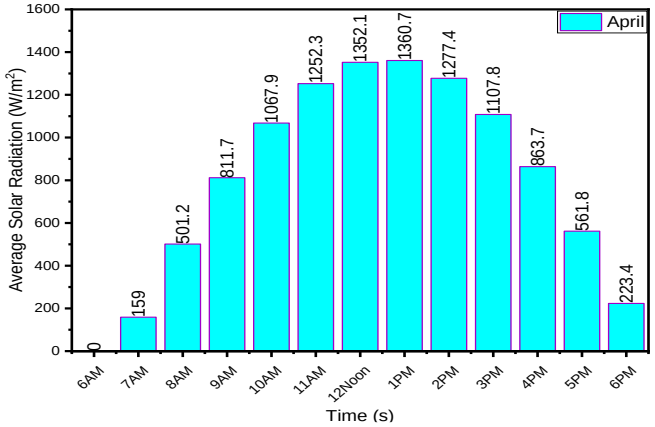


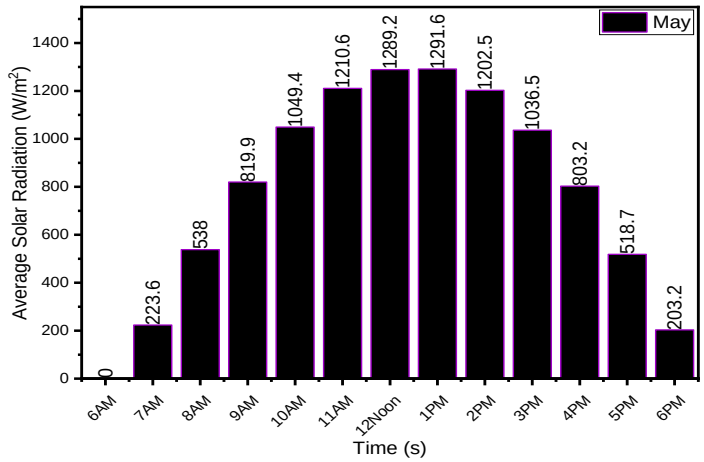


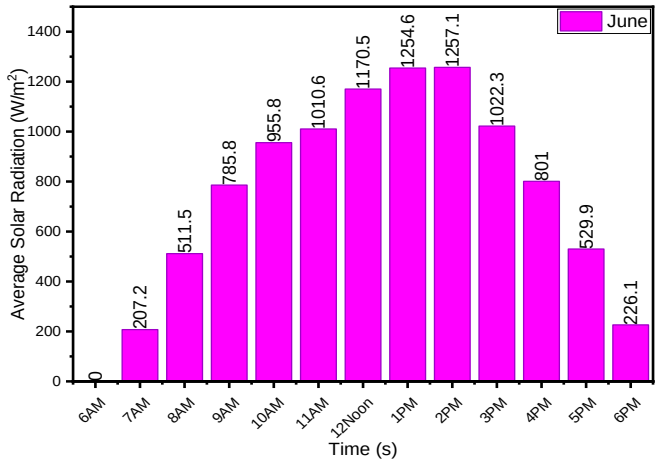
https://doi.org/10.5281/zenodo.20155793

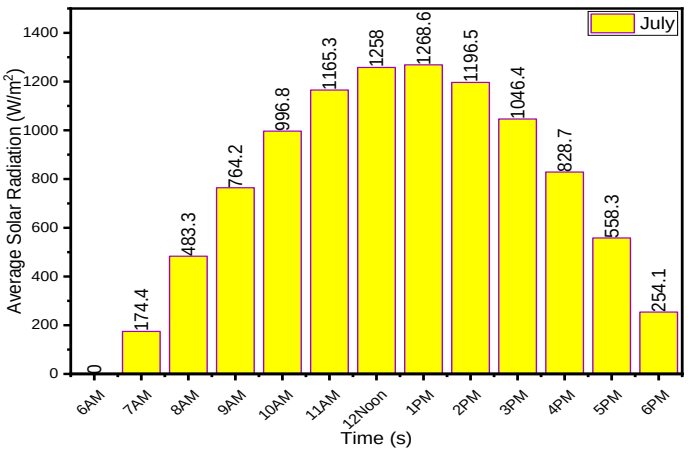
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

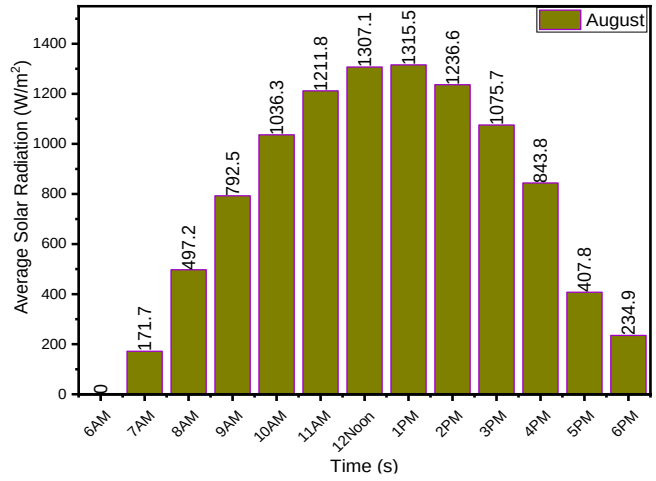


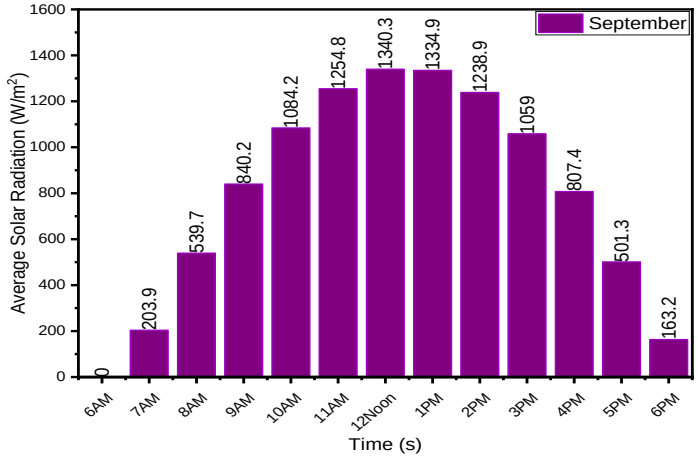


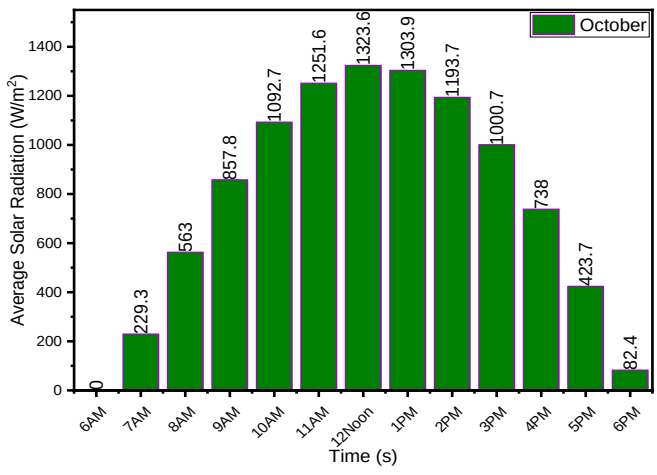












https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

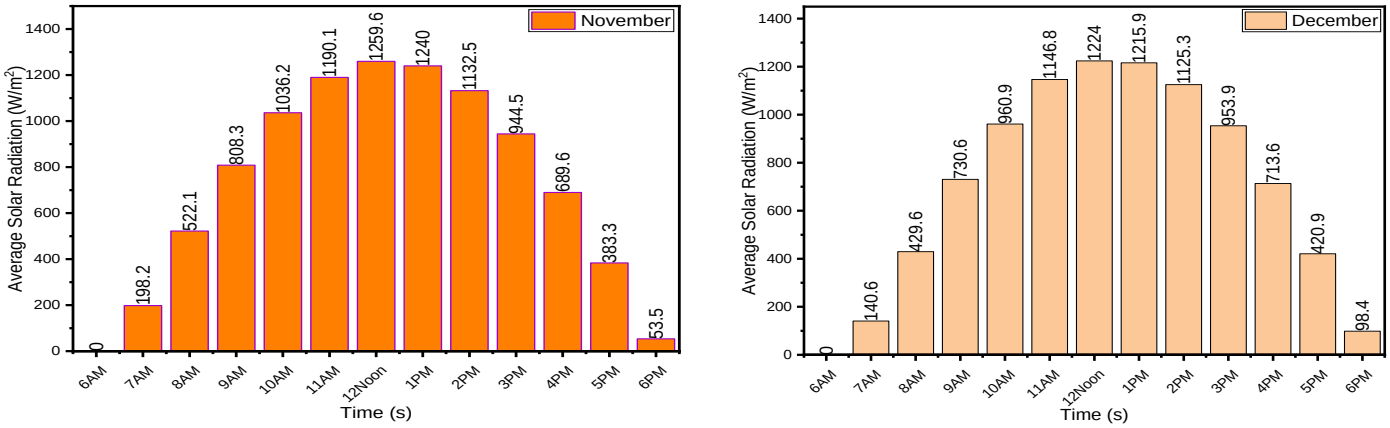


Figure 2. The Chart plot of 8 years average solar radiation in Awka, Anambra state, Nigeria, at one-hour intervals from 6 AM to 7 PM, for the determination of solar midday for proper load management.

The plotted solar radiation (Figure 2) showed variations over time in the average solar radiation received in Awka across all months. The plot indicated a steady increase from 6 AM to 1 PM in the average solar radiation received in the month of January, and a decrease from 1 PM to 6 PM. The average solar radiation received in this month of January has its peak at 1 PM, indicating noonday. The estimated peak sun hour using the January chart in Figure 2 indicated that January has a peak sun hour of 4, corresponding to the number of hours with solar radiation equal to or above 1000 W/m^2. The implication is that the energy required for sizing of the PV panel using the energy received in January is collected between 11 AM and 2 PM. The chart plot of February solar insolation indicated that the month has a peak sun hour of 5, ranging from 11 AM to 3 PM. The chart has its highest peak at 1 PM, indicating the solar noon day fail around that period. The required solar radiation for system sizing in the month of February is to be collected between 11 AM and 2 PM, just like that of January. The peak sun hours for the months of March, April, May, June, July, August, September, October, November, and December are 6, 6, 6, 5, 5, 6, 6, 6, 5, and 4, respectively. The values correspond to the number of bars in the chart, with solar insolation equal to or above 1000 Wm^{-2}. Our results from the plotted chart revealed that the peak sun hours for the months of March, April, and May ranges from 10 AM to 3 PM, while that for the months of June and July ranges from 11 AM to 3 PM. On the other hand, the peak sun hours for the months of August, September, and October range from 10 AM to 3 PM. The month of November has its peak sun hours from 10 AM to 2 PM, while that of December is between 11 AM and 2 PM. For proper system sizing, the energy required is to be collected within this range, ensuring that panels receive enough energy to power the loads. The annual average value of peak sun hours is 5.3. A lesser value of peak sun hours means an increase in the number of PV panels required for installation.

For proper installation of a PV system, the system is sized using solar radiation collected at the site, averaged over the year's peak sun hours. For proper load management, heavy loads are expected to be utilized during the peak sun hours window. Channeling of loads with high power-consuming capacity to this period will help reduce the financial cost incurred with the use of battery storage. Our observation indicated that different months in the year have various peak sun hours. As a result, the load usage for each month of the year will vary.

Table 2. The estimated peak sun hours for each month of the year.

S/N	Month	Peak Sun Hours
1	January	4
2	February	5
3	March	6
4	April	6
5	May	6
6	June	5
7	July	5
8	August	6
9	September	6
10	October	6
11	November	5
12	December	4

https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

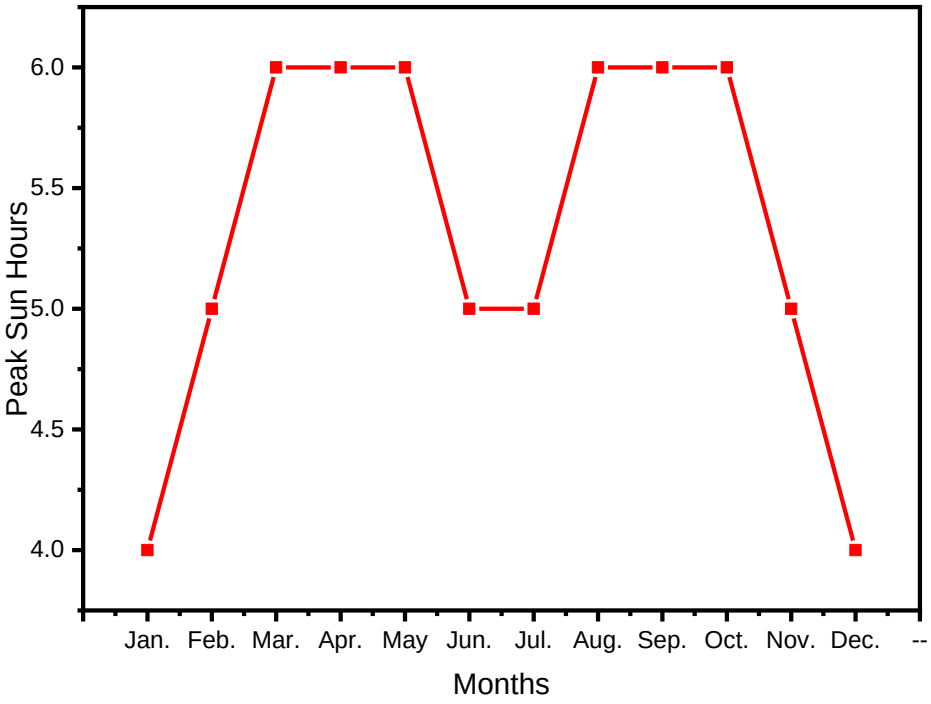


Figure 3. The Peak Sun Hours against each month of the year

The plot of peak sun hours over the months in a year indicates that January and December have the least peak sun hours. Possibly due to the shorter day period experienced during this period. The value increases from 4 in January to 5 in February and 6 in the month of March. The plot indicated a steady value of peak sun hours between the months of March and May before decreasing to 5 in the month of June. The value increases again after the month of July to 6 and becomes constant at that till the month of October, before experiencing a sharp decrease to 4 in the month of December through the month of November with 5 peak sun hours.

CONCLUSION

The installation of a PV system required proper sizing to avoid system failure and unnecessary wastage. A proper load management is also essential to maintain a steady power supply all day and to reduce the extra cost incurred with the use of a large battery storage system. In Nigeria, despite the incremental advancement and recognition of the benefits of solar energy, a significant proportion of the population remains unable to accurately assess the solar energy potential in their home areas and the optimal methods for harnessing it. The identification of Peak Sun Hours will reveal the optimal periods of maximum solar insolation for the region, while also facilitating the effective utilization of solar appliances and the storage of electrical energy during these hours. The study will also go a long way, helping out in the range of daily solar radiation that will be utilized in PV system sizing. Nigeria is progressively advancing in the adoption of solar energy, with a modest but encouraging integration of solar systems among its populace.

RECOMMENDATION

We recommend further research to determine the peak sun hours in other states in Nigeria for proper management of a PV system.

ACKNOWLEDGMENT

The authors are grateful to the Nigerian Meteorological Agency (NIMET) Head Office Station at the Federal Capital Territory, Abuja, for the provision of the data that was used for this research work.

REFERENCE

[1] M. Heydari, A. Heydari, and M. Amini, “Energy Consumption, Solar Power Generation, and Energy Management: A Comprehensive Review,” *World Eng. Appl. Sci. J.*, vol. 11, no. 02, pp. 196–202, 2023.

[2] F. Rashid, A. Gilany, S. Rasheed, H. Nisar, A. Raza, and M. Hasnat, “Load Management System with Integration of Renewable Energy

https://doi.org/10.5281/zenodo.20155793

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Resources," *Int. J. Integr. Eng.*, vol. 13, no. 6, pp. 339–348, 2021, doi: 10.30880/ijie.2021.13.06.030.

[3] T. F. Sanni *et al.*, "Renewable Energy Towards a Sustainable Power Supply in the Nigerian Power Industry: Covenant University as a Case Study," *Int. J. Mech. Eng. Technol.*, vol. 10, no. 3, p. 754, 2019.

[4] K. K. Jaiswal *et al.*, "Renewable and sustainable clean energy development and impact on social, economic, and environmental health," *Energy Nexus*, vol. 7, no. April, p. 100118, 2022, doi: 10.1016/j.nexus.2022.100118.

[5] M. Mustafa and M. O. F. Malik, "Factors Hindering Solar Photovoltaic System Implementation in Buildings and Infrastructure Projects: Analysis through a Multiple Linear Regression Model and Rule-Based Decision Support System," *Buildings*, vol. 13, no. 7, 2023, doi: 10.3390/buildings13071786.

[6] P. Megantoro, M. A. Syahbani, I. H. Sukmawan, S. D. Perkasa, and P. Vigneshwaran, "Effect of peak sun hour on energy productivity of solar photovoltaic power system," *Bull. Electr. Eng. Informatics*, vol. 11, no. 5, pp. 2442–2449, 2022, doi: 10.11591/eei.v11i5.3962.

[7] N. Waleed, R. K. Antar, and A. A. Abdullah Al-Karakchi, "Solar Power Load Energy Management System– A Review," *AIP Conf. Proc.*, vol. 2862, no. 1, 2023, doi: 10.1063/5.0171732.

[8] D. Agar and J. Korppi-Tommola, "Standard testing of photovoltaic modules for use in renewable energy education," *Lumat Int. J. Math, Sci. Technol. Educ.*, vol. 3, no. 5, pp. 693–701, 2015, doi: 10.31129/lumat.v3i5.1013.

[9] A. M. Noman, Z. A. Haidar, A. S. Aljumah, S. Z. Almutairi, and M. H. Alqahtani, "Forecasting the Distortion in Solar Radiation during Midday Hours by Analyzing Solar Radiation during Early Morning Hours," *Appl. Sci.*, vol. 13, no. 10, 2023, doi: 10.3390/app13106049.

[10] D. F. Al Riza and S. I. U. H. Gilani, "Standalone photovoltaic system sizing using peak sun hour method and evaluation by TRNSYS simulation," *Int. J. Renew. Energy Res.*, vol. 4, no. 1, pp. 109–114, 2014.

[11] K. A. Julius and R. A. Balogun, "Characteristics and Distribution of Some Radiation Parameters over Nigeria," *Eur. J. Environ. Earth Sci.*, vol. 3, no. 4, pp. 32–40, 2022, doi: 10.24018/ejgeo.2022.3.4.255.

[12] M. Jaafar, "Solar Energy Potentials of Some Selected Locations in Northeastern Nigeria," *Asian J. Res. Rev. Phys.*, vol. 6, no. 1, pp. 21–30, 2022, doi: 10.9734/ajr2p/2022/v6i130175.

[13] E. J. Emengini, C. P. Igwe, and K. Idhoko, "Development of Real Estate Decision Support System for Awka , Anambra State , Nigeria," *Int. J. Sci. Adv. Technol.*, vol. 4, no. 8, pp. 2–5, 2014.

[14] U. Omoja, B. N. Okpalaku, U. Uchechukwu, and T. N. Obiekezie, "Variability of Rainfall in Awka , Anambra State Nigeria," *J. Appl. Phys.*, vol. 13, no. 4, pp. 50–56, 2021, doi: 10.9790/4861-1304015056.

https://doi.org/10.5281/zenodo.20155793