ELECTRICAL LOAD STUDY AND DETERMINATION OF THE PREVAILING LOAD FACTOR FOR FEDERAL UNIVERSITY WUKARI, TARABA STATE, NIGERIA

Supported by tetfund TERTIARY EDUCATION TRUST FUND

Cookey Iyen[1]*, Daniel Tsokwa[1], Benedict Ayomanor[2], Osimiri Olisa Leonard[1], Simon Jaafaru [3], and Bunmi Akeredolu Jacob[1]

[1]Department of Pure and Applied Physics, Federal University Wukari, Taraba State, Nigeria
[2]Department of Science Laboratory Technology, Federal Polytechnic Nasarawa, Nigeria
[3]Shedda Science and Technology Complex (SHESTCO), Gwagwalada, Abuja, Nigeria
*Corresponding author: iyen@fuwukari.edu.ng

Received: November 29, 2020 **Accepted:** May 18, 2021

Abstract: Load study and energy management is a vital key for the study of electricity demand and supply and as such there is every need for such a study to be conducted especially in a school community such as Federal University Wukari where there is continuous increase in population and buildings which directly affects the demand for electricity. In this research, data was obtained from the school's electrical power generating sets at intervals of 2 h daily for a period of 15 days and statistical toolswere used to determine the electricity consumption characteristics of the university community. The result shows that the school community has its daily peak electricity demand at about 2:00pm daily, the school has its weekly peak electricity demand on Wednesdays and the prevailing load factor for the school was found to be 0.7. It was concluded that the current power supply scheme is satisfactory; however, recommendation was made that the school needs to look into the area of renewable energy by providing solar cells dedicated to lightings and fan sub circuits in the school. Also, better distribution of academic activities that are dependent on electricity will help enhance the load factor and reduce the risk of overloading the school generators at any particular time.

Keywords: Electricity, energy management, load, load factor, renewable energy

Introduction

Today, Electricity has become critical to human life, it has allowed us to achieve way more than what nature and evolution had restricted us to. But in our world, that is constantly in metamorphosis and growing exponentially, electricity demand continues to change which makes supply not to be equitably distributed to all as it should be. One of the reasons for this could be socio economic geographic conditions added to consumer behavior towards electricity (Matam *et al.,* 2014). The electric load in electricity distribution varies with time and place, and the power production and distribution system must respond to the consumers load demand at any time. Therefore, modern electricity distribution utilities need accurate load data for distribution network planning and load management. The load information mostly needed is how a consumer or group of consumers consume electric energy at different hours of the day, different days of the week and seasons of the year and what their share of utility total load is and how loads of different consumers aggregate in different location of a distribution network (Zhang *et al.,* 2009).

The mission of electric power supply departments is to service the consumers' need of electric energy at optimal costs. The most important thing characterizing the service is the load supplied to consumers. Other factors are reliability, number and length of outages, the quality of voltage and mechanical and electro-technical security of installation (Fintan, 2013). There is a continuous need to improve the knowledge of loads in electricity power system by collecting and analyzing more load information then developing better application utilizing all the new information available. The durability of transformers and generators can be estimated when the load at the transformer or generator is known.

Load with regards to electricity may refer to electricity consumption of an entire household, a city block, or all the customers within a certain region (Von, 2016); Katz *et al.,* (2002) defined load as an externally given quantity, a variable beyond control, in a completely unselfconscious manner., From a physical perspective, we would think of loads in terms of the electrical characteristics of individual devices (Zhang *et al.,* 2009).. The term demand thus refers to a physical quantity of power, not energy. Serving that instantaneous demand under diverse circumstances is the central challenge in designing and operating power systems, and the one that calls for the majority of investment and effort (Meier, 2004). The hourly fluctuation of domestic loads results from the combined effect of consumer available and activity level (Capasso *et al.,* 1994). A lot of researchers have worked on load study and development of hybrid systems (Adika & Wang 2014; Chen *et.al.,* 1996; Hanmandlu & Chauhan, 2011).

Load factor enables the school to know its electrical power consumption profile based on hours of the day as well as day of the weak. Load factor is generally used to obtain the ratio between average demand and maximum demand. This implies that it is a measure of uniformity or variance in electricity use. In an ideal condition, the value of load factor is 1 or 100% (Deepak, 2014). The load factor spans between the interval 0 to 1. Load factors that are less than 0.5 are considered unsuitable while if the load factor is closer to 1 it implies that the load factor and load distribution for the school is satisfactory. The knowledge of the load factor enables the management to plan their time table and activities correctly such that high electrical power dependent activities are not clustered together on the same day thereby overworking the school's power source on certain days while other days are characterized by very low power consumption which underutilizes the school power source which makes it uneconomical to run the generators. Maintaining a load balance makes it just perfect on all days of the week while ensuring that the school's generating sets are not overworked on certain days. The formular for load factor is given by equation 1:

Electrical load factor

$$E_{LF} = \frac{1}{\mathrm{D}_{max}} \left(\frac{1}{n}\sum_{i-1}^{m} D_i\right) \quad (1)$$

Where: $D_{\max}$ is the maximum electrical power demand during the period under study; D_i is the individual power demand recorded in 2 h interval during the period under study; n is the sample size

Materials and Methods

The power consumption data used in this project were taken directly from the school generators. The load drawn from the central generators were obtained by taking thepower readings in kVA every two hours from the display on the generator for a period of two weeks. The time of day with average maximum power demand and value of the average maximum demand were computed. Also, the day of week with the average maximum demand and the value of the maximum demand were also computed. From the data, the load factor was computed. Tables 1 to 3 show the data obtained from school central generating sets in a 2 h interval for a period of 15 days

Computation of Load Factor was obtained by using equation (1):

$$\text{Load factor} = \frac{\frac{1}{120}*(65513)}{779} = \frac{545.94}{779} = 0.7 \quad (2)$$

Table 1: Electrical power drawn on a two hour interval from day 1 to 6

Time	DAY 1 (WED.) Total Power (kVA)	DAY 2 (THUR.) Total Power (kVA)	DAY 3 (FRI.) Total Power (kVA)	DAY 4 (SAT.) Total Power (kVA)	DAY 5 (SUN.) Total Power (kVA)	DAY 6 (MON.) Total Power (kVA)
08:00am	582	588	589	386	371	582
10:00am	691	661	702	437	341	696
12:00pm	735	737	749	428	415	735
02:00pm	754	749	755	436	429	779
04:00pm	611	619	636	486	452	626
06:00pm	466	470	465	446	432	475
08:00pm	483	460	446	405	471	468
10:00pm	435	438	437	413	438	434
Total	**4757**	**4722**	**4779**	**3437**	**3349**	**4795**
Average	594.625	590.25	597.375	429.625	418.625	599.375

Table 2: Electrical power drawn on a two hour interval from day 7 to 12

Time	DAY 7 (TUE.) Total Power (kVA)	DAY 8 (WED.) Total Power (kVA)	DAY 9 (THU.) Total Power (kVA)	DAY 10 (FRI.) Total Power (kVA)	DAY 11 (SAT.) Total Power (kVA)	DAY 12 (SUN.) Total Power (kVA)
08:00am	582	561	587	604	458	362
10:00am	691	691	683	679	433	351
12:00pm	735	735	735	725	437	400
02:00pm	754	770	757	751	445	367
04:00pm	611	618	607	618	425	369
06:00pm	465	460	459	461	405	406
08:00pm	480	485	470	420	431	442
10:00pm	435	426	432	414	410	400
Total	**4753**	**4746**	**4730**	**4672**	**3444**	**3097**
Average	594.125	716.125	591.25	584	430.5	387.125

Table 3: Electrical power drawn on a two hour interval from day 13 to 15

Time	DAY 13 (MON.) Total Power (kVA)	DAY 14 (TUE.) Total Power (kVA)	DAY 15 (WED.) Total Power (kVA)
08:00am	574	584	584
10:00am	653	641	710
12:00pm	725	735	735
02:00pm	752	744	782
04:00pm	641	622	635
06:00pm	476	475	449
08:00pm	458	470	497
10:00pm	430	434	426
Total	**4709**	**4705**	**4818**
Average	588.625	588.125	602.25

Results and Discussion

The results of the computations are as represented in Figs. 1 and 2 From Fig. 1 it can be deduced that the average peak electricity demand during time of day was found to be 668.27 kVA which occurs at 02:00pm. The average peak demand during day of week was found to be 655.37 kVA which occurs on Wednesday while the minimum demand during time of day was found to be 426.8 kVA which occurs at 10:00pm. Also, the minimum demand during day of the week was found to be 402.875 kVA which occurs on Friday.

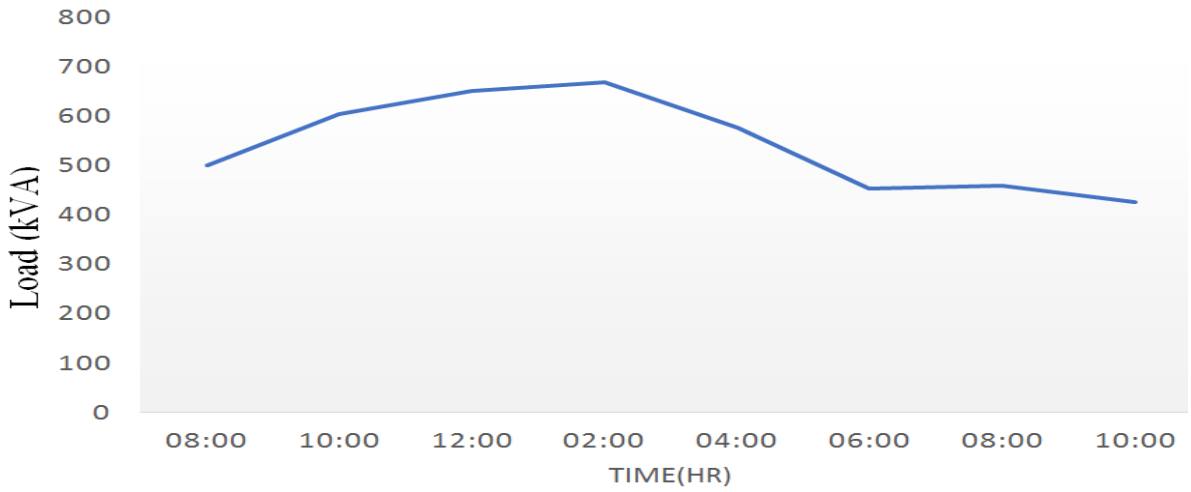

Fig. 1: Graph for average load consumption at two-hour interval for 15 days

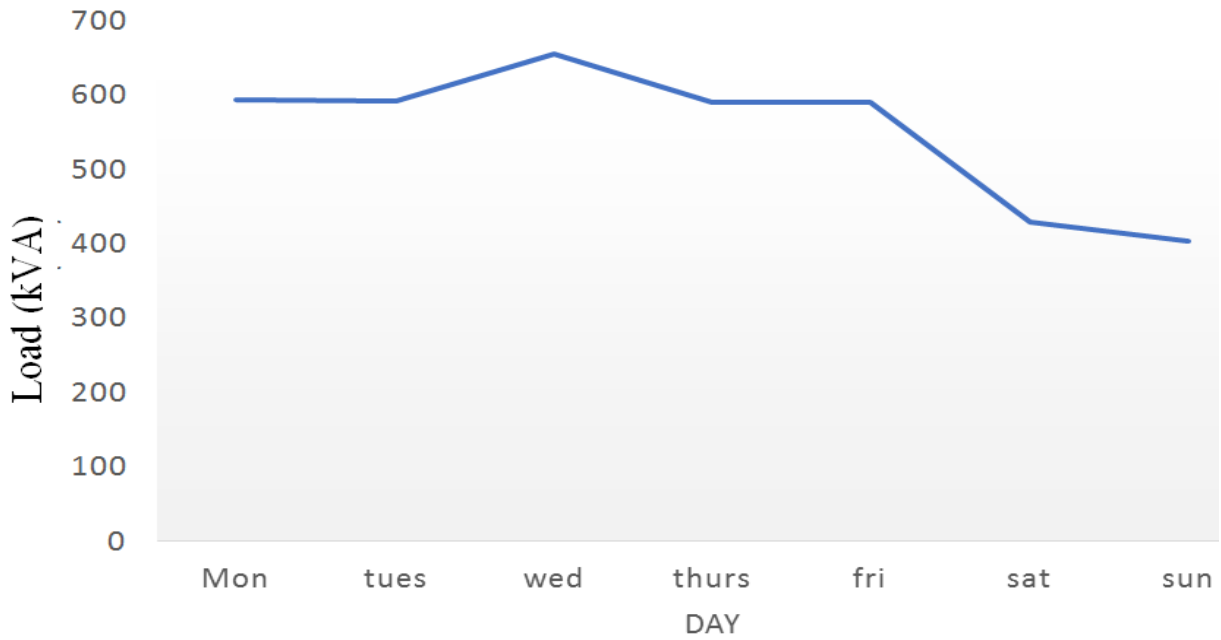

Fig. 2: Graph for average load consumption based on day of week

The prevalent load factor for the school was found to be 0.7. Since the load factor measures the uniformity or variance in electricity demand distribution and supply (Deepak, 2014), a load factor of 0.7 shows that the loads are relatively evenly distributed across the days of the week. However, there is room for improvement.

Conclusion

The result of the load study shows that the current power scheme in Federal University Wukari is satisfactory. It is however recommended that the school needs to look into the area of renewable energy by providing solar cells dedicated to lightings and fan sub-circuits in the school. Also, better distribution of academic activities that are dependent on electricity will help enhance the load factor and reduce the risk of overloading the school generators at any time.

Acknowledgement

The authors wish to acknowledge the Department of Works and Physical Planning of the Federal University Wukari for allowing them access to relevant data for the project.

Conflict of Interest

The authors declare that there is no conflict of interest related to this work.

References

Adika CO & Wang L 2014. Autonomous Appliance Scheduling for Household Energy Management. *IEEE Transactions on Smart Grid*, 5(2): 673-682.

Capasso A, Grattieri W, Lamedica R & Prudenzi A 1994. A bottom-up approach to residential load modeling. *IEEE Transactions on Power Systems*, 9: 957-964.

Chen CS, Hwang JC, Tzena YM, Huang CW & Cho MY 1996. Determination of customer load characteristics by load survey system at Taipower. *IEEE Transactions on Power Delivery*. 11(3): 1430-1436.

Depak SD 2014. Electrical Load Profile analysis and peak load assessment using clustering technique. *IEEE PES General Meeting/Conference & Exhibition*, pp. 180-186.

Fintan M 2013. Characterizing Domestic Electricity Demand for Customer Load Profile Segmentation. *Doctoral Thesis, Dublin Institute of Technology*, pp. 15-20doi:10.21427/D7PK7X.

Hanmandlu M & Chauhan B 2011. Load forecasting using hybrid models. *IEEE Transactions on Power Systems*, 26(1): 20-29.

Katz G, Steven N, Neal E, Michael S, Steve G & Anibal T 2002. Energy-Efficient Motor Systems: *A Handbook on Technology, Program and Policy Opportunities*, Second Edition. American Council for an Energy-Efficient Economy Washington, DC, pp. 100-105.

Matam M, Prashant S, Abhilash M & Guarav SP 2014. Consumer behaviour towards electricity- A field study. *4th Int. Conf. on Advan. in Energy Res. ICAER. Energy Procedia*, 54: 541-548.

Meier A, Lin J, Liu J & Li T 2004. Standby power use in Chinese homes. *Energy and Buildings*, 36(12): 1211-1216. DOI:10.1016/j.enbuild.2003.

Von AM 2006. Electric Power Systems: A Conceptual Introduction. *John Wiley &Sons, Inc., Hoboken, New Jersey*, p. 250.

Zhang, J., Yufang, L., and Pan L. (2009). "Short-term Electricity load Forecasting based on ICA and LSSVM. *Int. Conf. on Comput. Intell. and Software Engr.*, pp. 1-4.