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Energy Audit and Utilization in Nigerian Colleges of Education: A Case Study of Waka-Biu

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Abstract

Energy cost and utilization are crucial for colleges of education because they drive financial savings, promote sustainability, and provide a practical learning environment for future educators. This study investigates energy audit and utilization in college of education Waka-Biu. The objective of this research work to carried out energy audit and utilization in college of education Waka-Biu and provides measures to reduce excess energy consumption and to minimize cost of electricity. The annual consumption data of two energy carriers (Electrical and AGO) for a period of 3 years (2021-2023) were obtained from YEDC and Diesel Consumption files from planning and maintenances unit of works department of the college. The finding reveals that office Area lighting consumes more energy which operates ranging from 6-12hours. The total annual energy consumption which is estimated to 319311.52KWh. Energy Use index in 2023 has the highest annual consumption rate which is estimated to N55, 749,026.64. This is as a results of increase in energy tariff and also new structures (Buildings) which increase the energy demand in the institution. The total amount of energy cost form the year 2021- 2023 is ₦119503137.77 while for the means of the power source (diesel power plant) stand at ₦6111728.91respectively. Relevant authority should improve building efficiency by upgrading buildings with better insulation, energy-efficient windows, and replace old lighting with LED bulbs, School management should iinvolve stakeholders and seek partnerships with energy providers and government support to improve overall energy performance.

Keywords: Audit, Cost, Energy, Electricity, Utility

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Introduction

Energy is one of the most fundamental elements for world's growth, is used for operating machine, lighting homes/cities, means of power for transport, musical or television and other home appliances. Energy is a necessity for human survival in the universe and plays important roles for economic advancement and technological development of any country (Oyedepo, 2019). The demand for electricity is increasing day by day with growth in population as well as increase in industries. In view of the crucial energy situation, it is necessary to find alternative sources of generating electric power (Olatunji *et al.,* 2018).

Energy consumption is expected to increase by up to 27% and greenhouse gas emissions have to be reduced by 40% by 2030. These are some of the goals for fossil-fuel-based economy to a more efficient low-carbon economy in 2050 (Reddy, 2011 and Sieminski, 2014). Moreover, energy usage for operating academic and administrative activities in the colleges most be improve in order to have smooth operational system to the colleges since its population (Students, Staff and others doing businesses in the university) is always increasing. The energy consumption by end users (lighting, space cooling and heating, electronics devices) are the major consumptions in the colleges. Energy audit of the university buildings will lead to reduce energy consumption, operating costs, lesser lighting fixture replacements and reduction in accumulated heat generated by them, thereby leading to parts of the drive towards mitigating greenhouse gas emissions and making buildings more environmentally friendly.

Tertiary education buildings are a significant subset of the building sector in Nigeria, as they host many students, staff, and researchers who engage in various academic and administrative activities that require energy. Tertiary education buildings include lecture halls, laboratories, libraries, offices, hostels, cafeterias, sports facilities, and other ancillary structures. These buildings have different energy needs and consumption patterns depending on their functions, design, equipment, occupancy, and operation (Chen *et al.,* 2021). Tertiary education buildings also play a crucial role in promoting sustainable energy management through education, research, innovation, and demonstration.

The need to conserve energy as part of measure to combat electricity crisis in Nigeria is vividly captured in the word of Oyedepo (2012) when he stated that: In Nigeria today, a lot of energy is wasted because industries, power companies, offices and households use more energy than is actually necessary to fulfill their needs. The reason is because they use old and inefficient equipment and production processes; buildings are poorly designed; and because of bad practices or habits. With energy efficiency practices and products, the nation can save over 50% of the present energy consumed in the country.

One way to help limit energy consumption is through energy saving. One important issue of energy consumption is energy wastage in the institution which leads to an increased cost of electricity. For instance, if appliances that are not currently in use are switched on, then electricity that could be put to other use is wasted. Energy saved is energy generated (Ekpenyong, 2010). The problems from power crisis in Nigeria have been observed to be the stumbling block to national development (Obadote, 2009). In a bid to enlighten people about the need to do away with the wastage; the government has tentatively mandated the Nigerian Electricity Regulatory Commission to promote Demand Side Management (DSM) in the country, pending the establishment of a substantive institution to carry out the responsibility. Other measures and policies include energy management systems, insulating materials, energy efficiency lighting.

Statement of the Problems

Lack of adequate electricity supply from the national grid is a daily problem in Nigeria. College of education Waka-Biu suffers immensely from power interruption. Staff and students require electricity for lighting, fans, air conditioners and operation of laboratory equipment for knowledge and research purposes. As a result of these problems, the college is spending a lot of money in buying diesel (AGO) for use in generators in order to keep up with its energy demand, especially during examination period. Also, absence of effective electricity metering systems in the college , as several offices, laboratories and residential buildings in the campuses are not metered, leading to high tendency to waste energy and overestimated billing. Apart from the use of inefficient appliances and poor consumer behaviors, the college does not have programmes and policies to promote energy efficiency best practices and conservation. Hence based on the above problems there is need for the college management to audit its utilization and cost effectively manages it.

Objective of the Study

The objective of this research work were to:

i. Conduct an energy audit and utilization assessment in College of Education, Waka-Biu.
ii. Provides measures to reduce excess energy consumption and to minimize cost of electricity.

Literature Review

Load Characteristics of a Tertiary Institution

In tertiary institutions, such as college of education Waka-Biu environment, common loads can be grouped as lighting (lamp), heating ventilating and air conditioning (HVAC), and machine/laboratory equipment.

Lightings

During the installation of buildings, lighting is one of the most important sections which cannot be left out. Lightings consume 17 to 30 percent of energy in commercial buildings; it is also a primary source of heat gain. Energy can be considerably reduced by implementing energy efficient lighting system. Upgrading lighting system can also improve lighting quality. Lighting is useful in almost all aspects. Lighting is useful to human beings because it directly affects the comfort, mood, health and safety of people. Also lighting is the most visible building system, it affects the aesthesis and image of a building while aiding brightness. More so, lighting is useful to business because it aids productivity. In companies, lighting is important because it ensures the safety of workers by illuminating the working arena. Lighting is also useful to the environment because it aids security of the environment; for instance, security fittings will expose any hideout of burglars.

Heating Ventilating and Air Conditioning (HVAC)

Heating and cooling systems are the largest single consumers of energy in buildings. These systems condition the air within the building to improve the occupants' comfort. Heating and cooling systems consist mainly of chillers, boilers, cooling towers and pumps. The ventilating and air conditioning system used in the school are fans and air conditioners. Air conditioners use a chemical that easily convert from its gaseous state to its liquid state and then back again. Air conditioners have three main parts. They are the compressor, condenser and evaporator. The compressor and condenser are usually located on the outside portion of the air conditioner. The evaporator is located on the inside part of the air conditioner, sometimes as part of the furnace. The compressor squeezes the working fluid and increases its temperature and pressure and flows to condenser. The condenser changes its temperature by cooling it and converts it to liquid under high pressure. The liquid is then passed to the evaporator where it is being changed to gas and evaporates and extracts heat from the air around it. The advantage of heating, ventilating and air conditioning is that it increases comfort, mood and health.

Energy Consumption and Efficiency in Tertiary Education Buildings

Several studies have measured and analyzed the energy consumption and efficiency in tertiary education buildings in Nigeria and other countries. These studies have used various methods and tools, such as energy audits, surveys, interviews, questionnaires, metering, modeling, simulation. These studies have also focused on different types of buildings, such as lecture halls, laboratories, libraries, offices, hostels, cafeterias. The main findings and contributions of these studies are summarized below:

i. A study by Oyedepo *et al.,* (2019), audited a Nigerian university campus, finding it consumed 24 GWh in 2018. Residential buildings used 62%, and implementing energy-efficient measures could save up to 30%.

ii. A study by Alnaser *et al.,* (2020) evaluated Bahrain university buildings, noting 1,050 kWh/sqm/year consumption. Solar PV systems on roofs could meet demand, with a payback period of 5-7 years.

iii. A study by Oyedepo and Adaramola (2018) assessed a Nigerian polytechnic, finding it consumed 6 GWh in 2018. Wind and solar could cover 80%, costing $12 million with a $28 million net present value over 25 years.

iv. A study by Chen *et al.,* (2021) analyzed the energy consumption and carbon emissions of 14 university buildings in China using a bottom-up approach. The study revealed an annual average electricity consumption of 76 kWh per square meter, with lighting contributing 43%. Additionally, the average carbon emissions were 0.09 kg CO2e per square meter yearly, with electricity generation responsible for 97%.

Proposed energy conservation measures include switching to LED lamps, installing dimming and occupancy sensors, and optimizing electrical equipment operation and maintenance. The study estimated that these measures could reduce the electricity consumption and carbon emissions of the buildings by up to 30% (Tong *et al.,* 2020). A study by Oyedepo *et al.,* (2018) assessed the energy efficiency and renewable energy potential of a Nigerian college of education campus using a hybrid optimization model. The study found that the campus consumed about 4GWh of electricity in 2018, with hostels accounting for 48% of this consumption. The study also found that the campus had a high potential for solar and wind energy, which could provide up to 85% of its electricity needs if solar PV systems and wind turbines were installed on the campus. The study calculated that the optimal configuration of solar and wind systems for the campus would cost about $9 million and would have a net present value of $21 million over a 25-year period (Oyedepo *et al.,* 2018).

Energy Consumption in Buildings

Several studies investigated the energy consumption in buildings in general. For example, Meng *et al.,* (2021) used an algorithm-centric method to analyze energy use in big buildings. They used a smart automated meter to collect data on consumption characteristics which included energy use, temperature, and lighting intensity. The data was processed using Apache Kafka and Spark Streaming modules. However, the concept was impractical for occupied buildings due to data transfer issues and obstructive infrastructure.

Himeur *et al.,* (2023) considered big data analytics using AI in buildings to consider several tasks such as energy anomaly detection in residential and office buildings and energy. A study by Sodenkamp *et al.,* (2017) that focused on the

use of smart meters showed that 9 out of 11 energy efficiency-related equipment in households could be identified with an accuracy of 70% and the aggregation of hourly reading gave high prediction quality.

Materials and Methods

The Study Site and Its Geographical Location

The study area is college of education Waka-Biu is situated in Biu, Borno state, Nigeria. Its geographical coordinates are $10^{0}38^{'}0^{''}$ North, $12^{o}12^{'}0^{''}$ East.

The following materials were used in this study:

i. Multimeter
ii. Watt meter
iii. Megohmeter
iv. Electricity bills file: The annual consumption figures of Electricity in kWh for a period of 3 years (2021-2023) were extracted from YEDC Electricity Consumption files.
v. AGO consumption file: The annual consumption figures of AGO in liters for a period of 3 years (2021-2023) were extracted from AGO (Diesel) Consumption files.

Energy Consumption Pattern for Energy Carriers.

The annual consumption data of two energy carriers (Electrical and AGO) for a period of 3 years (2021-2023) were obtained from YEDC and Diesel Consumption files from planning and maintenances unit of works department of the college.

Energy Demand in College of Education Waka-Biu

Using the installed generating plants and appliances installed in the different offices, lecture Halls, Laboratories and Student hostels is presented in tables 1. Figure 2 reveals that office Area lighting consumes more energy which operates ranging from 6-12hours. The total annual energy consumption which is estimated to **319311.52KWh.** Table 3 indicates that the Energy Use index in 2023 has the highest annual consumption rate which is estimated to **₦55, 749,026.64**. This is as a results of increase in energy tariff and also new structures (Buildings) which increase the energy demand in the institution

From Table 1, the total annual energy consumption for the buildings in college of education Waka-Biu indicated that area and office lighting has the highest consumption of 319311.52KWh followed by space cooling (Air Conditions), Ventilation Fans and others (electrical devices that plugs into the buildings). Figure 1 shows the annual aggregate amount of energy consumed by each section of the Buildings in the college. The results reveals the appliances with the highest energy consumption. The data were collected considering the LED light, fan, PC Lap-top and PC computer Desktop, printer, A.C and other instruments. It is obvious from the table that, the Lightning and Space Cooling consumed the most. The total required energy peak energy is 900126.84KWh per annum from the data generated.

Based on this, the total amount of energy cost form the year 2021- 2023 is ₦119503137.77. While for the means of the power source (diesel power plant) stand at ₦6111728.91respectively. Student use of personal electronics (laptops, chargers, study lamps) and inefficient use of appliances contribute significantly to overall energy consumption. Simple actions like switching off lights and appliances when not in use can reduces energy consumptions in the college. The condition of the energy balance which is the condition of heat exchange between the building and its surrounding is also analyzed. Data generated during the research work for the energy audit are useful for understanding the energy distribution and utilization of the polytechnic. The diesel generating power plant was used to power only the administrative block of the college.

Conclusion and Recommendation

The college buildings needs a maximum of 900126.84KWh of electricity per annum. On the scale of ₦64.07 per kWh for MD- BAND B electricity tariff classification of which College of Education Waka-Biu is under by virtue of its location which by implication it made to enjoy from 16-20 hours of power supply per day. Based on this the total amount of running all these appliances is ₦57,671,126.64 per annum. This indeed is a huge sum compared with the numerous appliances within the institution. The diesel fuel power plant which only supply the provost Office, Bursary Department, Registry Department, ICT, Library and school of education as a substitute during power blackout. The epileptic supply of electricity supply of the area has affected negatively the performances of both staff and students of the institution. The said amount of money is enough to install a solar system technology that is environmentally friendly, no noise pollution and less mainatainace cost compared to the source of energy with as much as needed energy to enhance optimum performances and discharge of duties.

Based on the findings, the following recommendations were made:

1. Relevant authority should improve building efficiency by upgrading buildings with better insulation, energy-efficient windows, and replace old lighting with LED bulbs

2. school management should Promote energy-conscious behaviour by educate students and staff on the importance of saving energy by turning off lights and appliances when not in use, and using energy-saving settings on devices.
3. School management should iinvolve stakeholders and seek partnerships with energy providers and government support to improve overall energy performance

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References

Adekeye, T., Oyebanji, J. A., Abidakun, A. O., and Agberegha, O. L. (2018). Towards a Sustainable Electricity Supply in Nigeria: The Role of Decentralized Renewable Energy System. European Journal of Sustainable Development Research, 2(4). https://doi.org/10.20897/ejosdr/3908

Alnaser, W. E., and Alnaser, N. W. (2020). The Impact of the Rise of Using Solar Energy in GCC Countries (pp. 167–183). https://doi.org/10.1007/978-3-03018488-9_13

Chen, S., Zhang, G., Xia, X., Chen, Y., Setunge, S., and Shi, L. (2021). The impacts of occupant behavior on building energy consumption: A review. Sustainable Energy Technologies and Assessments, 45, 101212. https://doi.org/10.1016/j.seta.2021.101212

Ekpenyong, O. N; "Energy Efficiency and Labelling" Paper presented at One-Day Workshop on Energy Efficiency and Labels held at Sheraton Hotel and Towers, Abuja, 3rd August, 2010

Himeur, Y., Elnour, M., Fadli, F., Meskin, N., Petri, I., Rezgui, Y., Bensaali, F., Amira, A. (2023), AI-big data analytics for building automation and management systems: A survey, actual challenges and future perspectives. Artificial Intelligence Review, 56(6), 4929-5021.

Meng, B., Ji, X., Hu, G. (2021), Research on energy consumption analysis system of large buildings based on big data monitoring. IOP Conference Series: Earth and Environmental Science, 651(2), 022045.

Olatunji, O., Akinlabi, S., Oluseyi, A., Abioye, A., Ishola, F., Peter, M., and Madushele, N. (2018). *Electric power crisis in Nigeria: A strategic call for change of focus to renewable sources*. IOP Conf. Series: Materials Science and Engineering, vol. 413, the 2nd International Conference on Engineering for Sustainable world, 9-13 July, 2018. doi:10.1088/1757-899X/413/1/012053

Oyedepo, S. O., Babalola, O. P., Nwanya *et al.*, (2018). Towards a Sustainable Electricity Supply in Nigeria: The Role of Decentralized Renewable Energy System. European Journal of Sustainable Development Research, 2(4). https://doi.org/10.20897/ejosdr/3908

Oyedepo, S., et al. (2019b). Energy audit and efficiency measures in a Nigerian university campus. Energy Reports, 15(4), 289-305.

Oyedepo, S.O. (2012): Energy Efficiency and Conservation Measure: Tools for Sustainable Energy Development in Nigeria. International Journal of Energy Engineering (IJEE) Vol.2, Issue 3

Reddy (2011). "Applied data analysis and modeling for energy engineers and scientists". New York: Springer; 2011.

Sieminsk. A. "International energy outlook". In Proceedings of the Deloitte Oil and Gas Conference, Houston, TX, USA, 18 November 2014; Energy Information Administration (EIA): Washington, DC, USA, 2014

Sodenkamp, M., Kozlovskiy, I., Hopf, K., Staake, T. (2017), Smart Meter Data Analytics for Enhanced Energy Efficiency in the Residential Sector. 13th International Conference on Wirtschaftsinformatik. P1235-1249

Tong, W., *et al.*, (2020). Energy conservation measures in Chinese university buildings. Energy and Buildings, 18(2), 187-202.

Figures

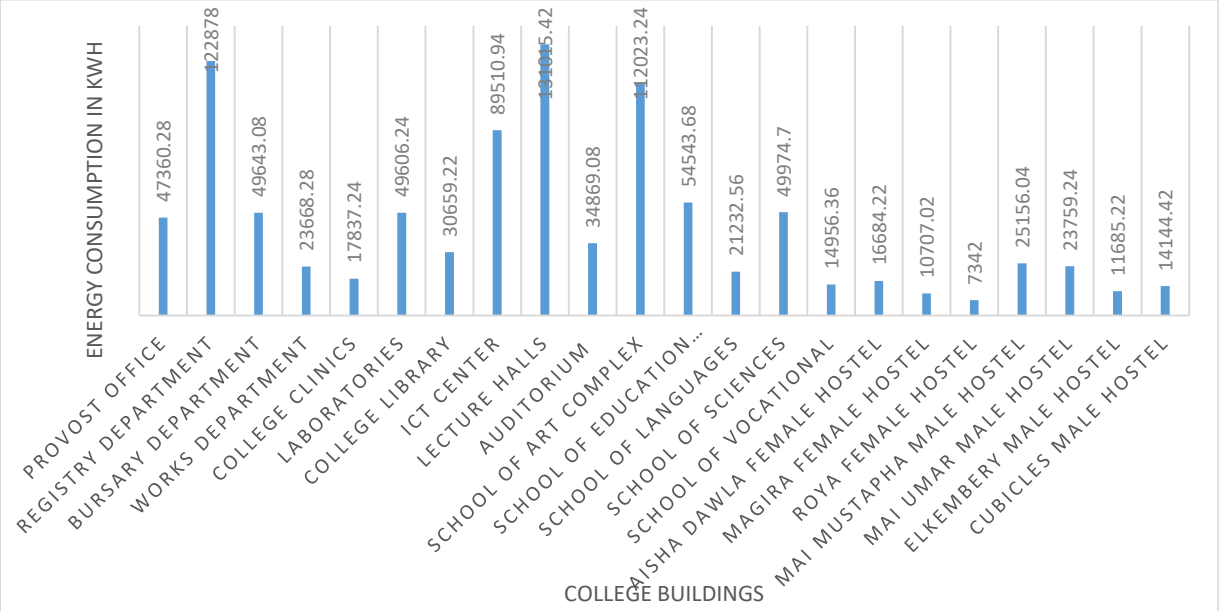

Figure 1: Annual Energy Peak Demand by the end users

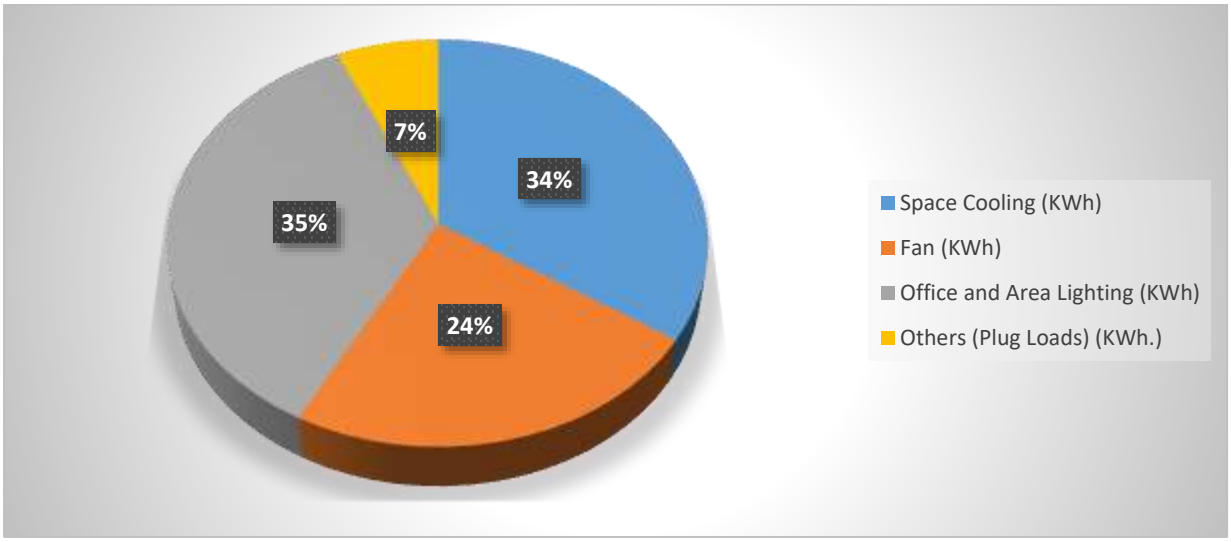

Figure 2: Percentage Consumption of the end users

Table 1: Annual Energy Consumption Pattern in the College

S/N	Name of Building	Space Cooling (Kw)	Fan (KW)	Office and Area Lighting (KW)	Others (Plug Loads) (KW.)	Total (KW)
1	Provost Office	4955.97	636.93	595.68	436.18	6624.76
2	Registry Department	11300	1418	2649	463	15830
3	Bursary Department	4901.56	503.70	664.30	349	6418.56
4	Works Department	1633.74	394.2	1240.27	47	3315.21
5	College Clinics	1225.31	284.7	754.82	48	2312.83
6	Laboratories	--	4789.32	1385.54	1631	7805.86
7	College Library	1009.54	2335.76	897	231.89	
8	ICT center	3267.48	1817.70	3052.86	4673.67	12811.71
9	Lecture Halls	------	6307.20	11605.54	54.65	17967.39
10	Auditorium	---	1357.80	3259.45	107.78	4725.03
11	School of Art Complex	2450.61	1883.40	1836.68	335.86	6506.55
12	School of Education Complex	3215	2156	1643.54	456.56	7471.10
13	School of Languages	983	453	1231	133.76	2800.76
14	School of Sciences	2651.89	2115.53	1735.66	363.52	6866.57
15	School of Vocational	875	342.84	679.77	76.86	1974.47
16	Aisha Dawla Female Hostel	--	1345	1017.73	78.73	2441.46
17	Magira Female Hostel	---	956	569.86	68.69	1594.55
18	Roya Female Hostel	--	569	455	48	1072
19	Mai Mustapha Male Hostel	---	1967.78	1567.66	134.68	3670.04
20	Mai Umar Male Hostel	---	1892	1455.91	126.66	3474.57
21	Elkembery Male Hostel	---	963	671	86.75	1693.75
22	Cubicles Male Hostel	---	1006.58	945.67	89.87	2042.1
Total		**38469.1**	**35495.44**	**39913.94**	**10014.98**	**123893.46**

Table 2: Energy Use index for the period of Three years from YEDC

Year/Session	Electricity Consumption KWh/Annum	Tariff Band	Tariff Rate(N)	Total Amount per Annum (₦)
2021	499741.73	Non-MD	50.02/KWh	24997081.33
2022	678875.98	Non-MD	57.09/KWh	38757029.70
2023	870126.84	Band B	64.07/KWh	55749026.64
Total	**2078744.55**			**119503137.77**

Table 3: Estimate of the Amount of Diesel Used from January 2021-December, 2023

Year/Session	Quantity of Diesel in Litres	Amount per Liter (₦)	Total Amount per Annum (₦)
2021	2376	289.37	687543.12
2022	1899	817.86	1553116.14
2023	3985	1126.69	4489859.65
Total	**8260**		**6111728.91**