Evaluation of Operational Energy Pattern and Performance of Senate Office Buildings of Federal Universities in of North-Central Nigeria

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Across the world, buildings are now the subject of research; this situation is not unrelated to the detrimental effects of this industry's massive energy use on the climate. In this regard, ensuring building products are energy efficient has become standard practice in majority of industrialized countries, while emerging nations are falling behind in pursuit of this admirable goal. This investigation was driven by the lack of energy standards, the overall dearth of energy data, and the open-ended nature of operational energy end-uses distribution and performance evaluation in Nigeria. Hence, this study evaluates operational energy consumption pattern and performance assessment of senate office buildings in Federal Universities in North-Central region of Nigeria. Simple energy audit was conducted which covers energy consumption and energy management regimen using energy survey form in the absence of monthly energy bills. Results revealed that energy supply to these buildings is on average of 37.3% to 63.7% from national grid and generators respectively. Energy end-uses consumption pattern showed similar trend to global reports as established by earlier studies. The results also established the dominance of cooling loads, accounting for not less than 40% of annual energy being in the tropical climate. This is an indication that cooling loads is an avenue where significant energy saving can be achieved. EUI of 176.82KWh/m^2/yr was derived as performance benchmark. The value is far above global best practises, this implies that these buildings were not energy efficient. Thus, it is imperative to ensure regular energy audit as none of the building has been audited before and ensure that significant buildings are sub-metered particularly senate office buildings for effective monitoring while general refurbishment towards efficient use of energy should be encouraged.

Keywords: Energy audit, Energy benchmarks, Energy consumption, Energy end-uses, Energy Use Index, Senate buildings

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INTRODUCTION

One of the main issues facing the twenty-first century is environmental sustainability, which calls for worldwide cooperation to address (Bazazzadeh *et al.*, 2018; Bazazzadeh *et al*., 2020). This threat has been linked to the world's population growth and the rapidly rising energy demand required to maintain comfortable living conditions (Rai, 2004; Coglianese, 2022). The majority of the energy used by buildings and the activities that go along with them comes from fossil fuels with greenhouse gases (GHG) as major by-products associated with global warming (ECN, 2015; Bazazzadeh *et al*., 2020) and cumulatively the dreaded case of climate change (Kasozi & Tutesigensi, 2007; Perez-Lombard *et al.*, 2008). In this regard, increasing building energy efficiency has been demonstrated to be essential to mitigating the effects of climate change through energy performance monitoring, which also has a built-in economic benefit (IEA, 2021; IEA, 2022). Energy performance evaluation exposes poor performing buildings when their performance index is compared to existing benchmarks. Also, a pointer to areas where efficiency strategies could be applied for better performance.

It was discovered that the building industry used, on average, between 30% and 45% of the world's energy supply, with the operating phase accounting for the majority of consumption (Asimakopoulus *et al.*, 2012; UNDP, 2010). In the meantime, it has been determined that the building type that uses the most energy during operation stage is non-domestic structures, especially office buildings. Office buildings are becoming a primary focus for energy reduction globally as a result of this accomplishment (Sadrzadehrafiei *et al.*, 2012; DEEC, 2013; Chung & Rhee, 2014). Universities, on the other hand, are expected to report their energy use and ensure efficiency as key cooperative responsibilities after the European Commission Joint Research Centre (ECJRC, 2012) classified them as high energy consuming organizations with at least 30% dedicated to office spaces (Sapri & Muhammad, 2010). In a similar vein, Adekunle *et al*. (2008) emphasized the necessity of monitoring and regulating energy use in Nigerian institutions due to the restricted supply in order to fulfill the goals of community development, teaching, and research. United Kingdom (UK) had developed a method for evaluating energy performance of tertiary institution buildings which involved segregation of various buildings into space types (BRECSU, 1997).

The shortcoming of the methodology is that assessment is based on the performance of group of buildings; individual building is not given attention to. Most developed countries set energy benchmarks for different building categories in a timely manner in response to the construction sector's energy reduction, but most developing countries, including Nigeria, are falling short of this admirable goal (Janda, 2009; Iwaro & Mwasha, 2010).

However, because of the bulk-metering approach used, it is uncertain how much energy is utilized by each building in Nigerian universities. It is a well-known fact that there are generally insufficient building energy statistics in Nigeria as a result of insufficient empirical research on building energy use, particularly in universities. There are no local energy benchmarks and no effort has been made to determine the true energy end-use distribution for different building categories (Imaah, 2004; Fadamiro & Ogunsemi, 2004). After identifying these issues, the study examined the operational energy performance of Federal University senate buildings, which serve as the major administrative offices, in the hot and humid climate of North-Central Nigeria. Senate buildings are conventional office structures that are comparable in both design, construction and operations to any other public office buildings.

LITERATURE REVIEW

Global energy sources revealed that fossil fuel that has harmful greenhouse gasses has major by-product had been reported to account for largest supply of 79% of world energy while the renewable energy (clean energy) is just about 18% and 3% from Nuclear power source (Kumar *et al*, 2010). Globally, buildings and its related activities has been estimated to be consuming above 40% of overall energy supply (Madlener & Sunak, 2011). This is not unconnected to the fact that energy is an indispensable variable and a major determinant factor of socio-economic and quality of life globally (ASHRAE, 1990; Kousksou *et al*., 2014). This scenario is expected to continue with the dynamics of energy demand particularly countries with emerging economies in Africa, South America, South-east Asia and Middle East (IEA, 2014).

United Nations on Environmental Programme (UNEP, 2007) reported that built environment with other supporting activities accounted for about 40-45% of total energy demand in European countries. In United States of America and United Kingdom buildings consume approximately not less than 40% of total energy supply and accountable for nearly 40% of greenhouse gas emissions (Springer Science and Business Media, 2017). Equally, in China and India, energy consumption estimation values stood at minimum of 25%. In Nigeria, building sector was reported to have accounted for consuming about 40% of electricity supply from the national grid (Akinbami, 2010). Epileptic nature and the gross inadequacy of power supply is augmented by back-up generators (Adenikinju, 2005) This situation is responsible for why electricity supply to office buildings in Nigeria through back-up power is about 75% of the time energy is required (Batagarawa *et al*., 2011).

Mambo and Mustapha (2016) revealed that the average Nigerian building's energy use is not fixed. In order to comprehend the state and energy performance of a few office buildings in Abuja, Nigeria, Mua'zu (2012) looked at the operational energy consumption of those buildings. The resulting performance ranged from 13 KWh/m^2/yr to 134 KWh/m^2/yr while the common suppressed energy supply was blamed for this outcome. Additionally, Batagarawa (2013) looked into the possibility of using phase change material (PCM) on the building envelope in order to reduce energy use. The end-use distribution for lighting, equipment, and cooling was estimated to be 12%, 48%, and 40%, respectively.

Mua'zu (2015) derived typical performance baseline for 22 Abuja office buildings. The results of EUI varied from 90 KWh/m^2/yr to 134 KWh/m^2/yr, with 59%, 43%, 15%, and 4% values for cooling, equipment, lighting, and services, respectively. Similarly, Salihu *et al*. (2016) investigated the energy supply, demand, and consumption in Kaduna city's office buildings. According to the study, 51%, 35%, and 14% of the energy consumed was accounted for by equipment, lighting, and cooling loads. It was clear that none of these studies took place in a university environment.

The few studies had attempted to examine energy consumption in universities. Adekunle *et.al*. (2008) examined electricity consumption and demand in University of Lagos, Nigeria. The study revealed that space cooling and lighting are the major end-uses which accounted for 33% and 7% respectively. Also, Adebis*i et al*. (2019) x-rayed energy performance of selected administrative buildings in tertiary education. The study derived performance benchmark at 181.34KWh/m^2/a while the end-uses distribution for VAC, Lighting, Equipment and building services consumed 45.6%, 9.6%, 44.4% and 0.003% respectively. Other notable studies that had explored energy consumption of individual buildings in tertiary institutions included Colin and Christopher (2013) investigated the effect of users on the energy demand of five academic buildings at the University of Sheffield, UK. In the same vein, Mehreen and Sandhya (2014) looked at the energy consumption and occupancy of a multi-purpose academic building of Heriot-Watt (HW) University, Edinburgh, Scotland to understand the relationship between electrical energy and users' activities.

RESEARCH METHODOLOGY

Universities in Nigeria use bulk-metering systems for their building facilities; as a result, there is no information available on the energy use of specific buildings particularly senate office buildings. This scenario guided the exploratory approach used in this study, while case studies were selected via purposive sampling. This method allows for the examination of a phenomenon in its natural setting because it has been used previously for similar studies conducted worldwide (Francis, 2001; Ogbonna, 2008; Batagarawa, 2013, Adebisi *et al.*, 2022). The buildings investigated were the main administrative office buildings (senate buildings) of five (5) universities in North-Central Nigeria as illustrated in Plate 1 with acronyms CSB 1 to CBS 5.

Plate 1: Pictorial view of the buildings (Author, 2023)

The fieldwork exercise involved conducting simple walk-through energy audit using building energy survey form as a guide to collect energy consumption related data while information related to energy management regimen was collected using structured questionnaires self-administered to the facilities managers of the institutions studied. Performance assessment was evaluated using the most widely used energy performance index known as Energy Use Index (EUI). The results were presented using descriptive statistics. EUI ensures unbiased and accurate comparison of buildings of different sizes and was estimated by this mathematical expression:

$$\text{EUI } (\text{KWh/m}^2\text{/a}) = \frac{\text{Total annual energy consumption}}{\text{Total floor area of building}}$$

The Annual energy consumption estimation was carried out using mathematical model adopted from studies of similar characteristics (Batagarawa, 2013; Rosenberg, 2014; Adebisi, *et al.*, 2019). This is so because time and finances for on-site equipment measurements is beyond the scope of this study. The detail of the mathematical model is express as follows:

Qa = energy rating x quantity x duration of use (hours) ………equation (1)

Where Qa is the quantity of energy consumed by appliance; obtained from manufacturers/label/maintenance manual.

$QA = Qa_1 + Qa_2 + Qa_3 + Qa_n$……. equation (2)

Where QA = total energy consumed by appliance

Qa_1, $Qa_{2\ldots\ldots}$ Qa_n = different appliances. The same equation (2) is applied for Ventilation (QV), air conditioning (QC) and lighting (QL). Hence,

$QV = Qv_1 + Qv_2 + Qv_3 + \ldots Qv_n$……..equation (3)

$QC = Qc_1 + Qc_2 + Qc_2 + Qc_n$ ………...equation (4)

$QL = Ql_1 + Ql_2 + Ql_3 + Ql_n$…..........…...equation (5)

So total energy consumption (QT),

$QT=QA+QV+QC+QL$…………. equation (6)

Also, total energy supply (QS),

$QS = Q_P + Q_G$…………equation (7)

Where Q_P, energy from primary source, and Q_G energy from generator.

The annual energy consumption was further disaggregated into end-uses; Ventilation and Air-conditioning (VAC), lighting, equipment and building services in the absence of no heating load. The data was analysed using descriptive statistics that included tables and percentages. Consequently, a performance baseline was derived in terms of EUI. Meanwhile, in the absence of local benchmark in Nigeria, the result was compared with international benchmarks of Chartered Institute of

Building Service Engineers (CIBSE) in UK and South African Building Regulation SANS 10400-XA benchmarks for office buildings where climate sub-tropical is similar to Nigeria according to Köppen-Geiger global climate classification.

RESULTS AND DISCUSSION

All buildings got their primary energy source from the national grid while the daily shortage was augmented via alternative means. Co-incidentally, all the buildings had 500KVA stand-by diesel generators each to take care of the epileptic nature of power supply in the country. The supply of electricity to these buildings varied on a daily basis but averagely the daily supply of energy from the primary source ranging between minimum of four (4) hours and maximum of eight (8) hours of the daily working hours. Based on this premise, Figure 1 represented the average percentage ratio of primary to alternative energy supply on annual basis. Electricity from primary source was estimated and found to be averagely accounted for about 62.7% while back-up generator was responsible 37.3% of annual energy supply. This result was in contrary to outcome of energy use in similar office buildings outside academic environment where back-up consumption was reported to be up to 75% in Nigeria (Batagarawa, 2013). Consequently, location of buildings seems to be a significant factor on primary energy supply in Nigeria, this may account for lower back-up consumption. The implication of this is that tertiary institutions were seemed to be given preferential treatment in terms of energy supply from the national grid in order to meet the primary goal of teaching and learning.

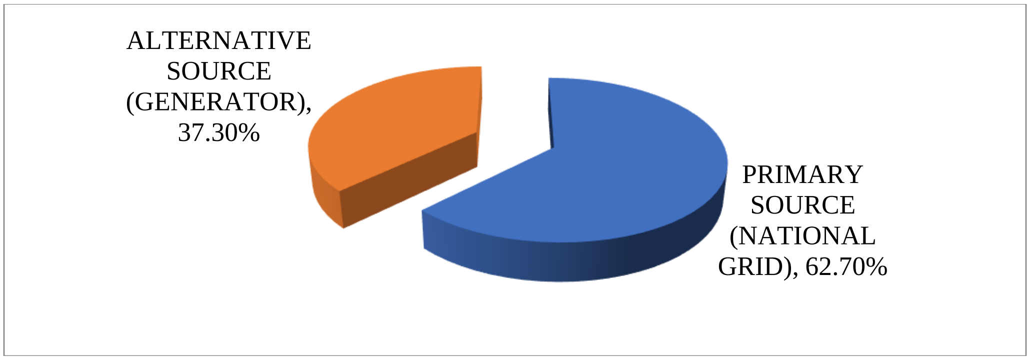

Figure 1: Cumulative annual percentage ratio of energy supply to the buildings

The annual energy consumption was disaggregated into end-uses. The values obtained affords the opportunity of determining the sources of considerable energy demand where savings can be significant. Therefore, the results of disaggregation into various end-uses for all the five buildings audited as presented in Table 1. The outcomes revealed that aggregately VAC, Lighting, equipment and building services consumed 42.1%, 10.54%, 44.03% and 0.003% of the annual energy consumption respectively.

Table 1: Disaggregation of annual energy into end-uses

Case study building	VAC (KWh)	Lighting (KWh)	Equipment (KWh)	Building services (KWh)
CSB 1	358,189.37	79,294.20	330,358.42	20.35
CBS 2	913,264.67	194,324.03	835,593.33	58.29
CSB 3	411,078.05	84,949.62	447,475.46	39.06
CSB 4	185,870.13	60,407.79	217,932.73	46.99
CSB 5	201,928.85	86,005.79	217,621.49	15.19
Cumulative % average	42.17%	10.54%	44.03%	0.003%

The results implied that VAC (cooling load) as a weather induced load contributed to more than 40% of energy use in this category of office buildings. These outcomes had validated and re-affirmed the dominance of cooling loads as equally submitted by global reports on similar office building and earlier studies on office buildings in Nigeria (Batagarawa, 2013; Mua'zu, 2015; Salihu *et al*., 2016; Adebisi *et al*., 2019). This is an indication that cooling loads is an avenue where significant energy saving can be achieved. The annual energy consumption, the energy use index as well as the derived cumulative baseline performance is presented in Table 2.

Table 2: Annual Energy Consumption and Energy Use Index

Case study building	Annual energy consumption (KWh)	EUI (KWh/m$^{2/}$a)
CSB 1	767,862.34	164.74
CBS 2	1,943,240.32	306.53
CSB 3	976,432.44	155.18
CSB 4	464,675.33	117.87
CSB 5	506,214.22	139.78
Derived Cumulative Performance baseline	176.82 KWh/m$^{2/}$a	

The EUI obtained from this study is far above good and typical best practice benchmarks of 128KWh//m^2/yr when compared to CIBSE (UK) benchmark (CIBSE, 2016). This may be owing to the difference in climatic conditions under which the CIBSE benchmarks was based unlike warm climate experienced in tropical zone like Nigeria as well as gap in technological advancements between the countries. Therefore, CIBSE benchmarks may not be adoptable for office buildings in Nigeria. Notwithstanding, comparing the result with South African Building Regulation SANS 10400-XA benchmarks established in 2011 where the weather is similar to Nigeria, but technology is a bit more advanced compared to Nigeria. The benchmarks stated that EUI under 130KWh/m^2 /yr, between 130-210KWh//m^2 /yr, 210-320KWh//m^2 /a were established for best, good and typical practices respectively while any case of EUI more than 320KWh//m^2/yr was categorised as poor performing office building. The derived performance value fell within good practice when compare with South Africa benchmarks. Nevertheless, The EUI fell within the same range when compared to earlier studies on office buildings conducted in Nigeria (Batagarawa, 2013; Mua'zu, 2015). The implication of this result is that there is need for building owners and managers to ensure proper monitoring of energy use embrace building refurbishment towards improving efficient use of energy.

CONCLUSION

In Nigeria, general paucity of energy data and unavailability of energy benchmarks for any building category has shown an unresponsive attitude to building energy monitoring. This is also evident has none of the buildings has been audited before despite been in existence for many years. The peculiar nature of bulk-metering system in universities has make estimation of individual building energy demand unknown. Although, these buildings enjoy more energy supply from the national grid in comparison to similar office building outside university environment owing to the peculiarity of the organisation where constant energy is needed for effective teaching and learning. Furthermore, disaggregation of energy into end-uses was found to be in line with what is obtainable in tropical climate globally, where cooling load dominates and a potential avenue where tangible saving could be achieved. Meanwhile, performance evaluation shown that these buildings are energy inefficient. Therefore, it is recommended that building facilities managers of these universities should embrace regular energy audit and ensure that significant buildings are sub-metered for effective monitoring while general refurbishment towards efficient use of energy should be encouraged.

REFERENCES

Adebisi, G.O., Olagunju, R.E., Akande, O.K. & Akanmu, W.P. (2019). Energy Performance of Selected Administrative Buildings in Tertiary Education Institutions in Niger State, Nigeria, *Environmental Technology & Science Journal*, 10 (1), 16-27. https://etsj.futminna.edu.ng/

Adebisi, G.O., Olagunju, R.E., Akande, O.K. & Akanmu, W.P (2022). Evaluation of energy Performance of Main Administrative Office Buildings of universities in North-Central Nigeria. Proceedings of 5th International conference of Contemporary Affairs in architecture and Urbanism, Alanya HEP University, Turkey, 11th – 13th May 2022. DOI: 10.38027/ICCAUA2022EN0120.

Adekunle, O.A., Olatunde, D., Sunday A.O., Akinwale, B.A. & Allen, O.A. (2008). A survey on the energy consumption and demand in a tertiary institution, *Maejo International Journal of Science and Technology*, 2(2), 331-344. www.mijst.mju.ac.th

Adenikinju, A. (2005). Analysis of the cost of infrastructure failures in a developing economy: The case of the electricity sector in Nigeria.

AERC Research paper 148.African Economic Research Consortium, Nairobi https://www.africaportal.org/documents/5651/RP148.pdf .

Akinbami, J.F.K. &Lawal, A. (2009). Opportunities and challenges to electrical energy conservation and CO2 emissions reduction in Nigeria's building sector. *Paper presented at the 5th Urban Research Symposium:* Cities and climate change.http://siteresources.worldbank.org/

America Society of Heating, Air-conditioning, Refrigeration Engineers (1990). ASHARE Position Statements, *ASHARE Journal*, 32, 52. https://www.ashrae.org/file%20library/about/mission%20and%20vision/ashrae%20and%20industry%20history/archives/ashrae-archives.pdf

Asimakopoulos, D.A., Santamouris, M., Farrou, I., Laskari, M., Saliari, M., Zanis, G., Giannakidis, G., Tigas, K., Kapsomenakis, J., Douvis, C., Zerefos, S.C., Antonakaki, T. & Giannakopoulos, C. (2012). Modelling the energy demand projection of the building sector in Greece in the 21st century. *Energy and Building* (49) 488–498, https://www.doi:10.1016/j.enbuild.2012.02.043

Batagarawa, A., Hamza, N. & Dudek, S.J. (2011). Disaggregating primary Electricity consumption for Office Buildings in Nigeria, *Proceedings of Building Simulation, 12th Conference of International Building Performance Simulation Association, Sydney, 14-16 November.*Sydney, 1033-1040. http://www.ibpsa.org/proceedings/BS2011/P_1379.pdf

Batagarawa, A. (2013). Assessing the Thermal Performance of Phase Change Materials in Composite Hot Humid/Hot Dry Climate: An Examination of Office Buildings in Abuja Nigeria, Unpublished PhD Thesis, School of Architecture, Planning and Landscape, Newcastle University, UK. https://theses.ncl.ac.uk/dspace/bitstream/10443/2146/1/Batagarawa,%20A.%2013.pdf

Bazazzadeh, H., Ghomeshi, M. & Hashemi, S. (2018). Requirements for comprehensive management of industrial heritage sites and landscapes, *Proceedings of International Conference on Conservation of 20th Century Heritage from Architecture to Landscape*, Univeristy of Tehran, Iran. June 2019, 167-180.

Bazazzadeh, H., Nadolny,A., Attarian, K. & Ali Najar, B.S. (2020). Promoting Sustainable Development of Cultural Assets by Improving Users' Perception through Space Configuration; Case Study: The Industrial Heritage Site. *Sustainability.* 12(12) 5109.

Building Research Energy Conservation Support Unit [BRECSU] (1997). ECG 54: Energy Efficiency in Further and Higher Education: Cost-Effective Low Energy Buildings. London. Retrieved from https://www.thenbs.com/PublicationIndex/documents?Pub=BRECSU. (accessed May, 2022)

Chung, H.M. & Rhee, K.E. (2014). Potential opportunities for energy conservation in existing buildings on university campus: a field survey in Korea, Energy and Building, 78, 176–182.Doi: 10.1016/j.enbuild.2014.04.018.

CIBSE (2016) Guide A. Norfolk: Chartered Institute of Building Service Engineers.https://www.buildup.eu/en/free-tags/cibse-chartered-institution-building-services-engineers.

Coglianese, C. (2022). Solving climate risk requires normative change. Environmental, Social Governance (ESG) Initiative, University of Pennsylvania. Retrieved from https://riskcenter.wharton.upenn.edu/climate-risk-solutions-2/solving-climate-changerequires-normative-change-2/ (Accessed June 2023)

Colin, G.W & Christopher, R.J. (2013). User Perceptions of Energy Consumption in University buildings: University of Sheffield Case Study. *Journal of Sustainability Education*, 5. Retrieved from http://www.jsedimensions.org/(accessed February, 2021)

Department of Energy & Climate Change [DEEC] (2013). Digest of United Kingdom Energy Statistics, *National statistics publication*, London. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/279523/DUKES_2013_published_version.pdf

European Commission Joint Research Centre (ECJRC). (2012). http://re.jrc.ec.europa.eu/energyefficiency/html/standby initiative data centers.htm.

Energy Commission of Nigeria (2015) The Nigeria energy sector-GIZ. http://www.energy.gov.ng/

Fadamiro, J.A. & Ogunsemi, D.R. (2004). The Impact of Construction Activities on the Quality of the Environment. *The Journal of the Nigerian Institute of Architects*, 4(2), 417-431. http://www.internationaljournalcorner.com/index.php/ijird_ojs/article/view/164902

Francis, M. (2001). A case study method for landscape architecture. *Landscape Journal*, 20(1), 15-29, doi: 10.3368/lj.20.1.15.

Imaah, N.O. (2004). Sustainable construction: the dilemma of high-rise buildings in a developing country such as Nigeria. In-house Publishing. http://www.irb.fraunhofer.de/

International Energy Agency (2014). Energy in Buildings and Communities Program Shining Examples of Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation (Annex 56). Retrieved from http://iea-annex56.org/Groups/GroupItemID6/Brochure%20shining%20examples.pdf(accessed May, 2022).

International Energy Agency (2021). Tracking buildings 2021. Retrieved from: https://www.iea.org/reports/tracking-buildings-2021. (accessed May 2023)

International Energy Agency (2022). Empowering people to act: how awareness and behaviour campaigns can enable citizens to save energy during and beyond today's energy crisis. Retrieved from https://www.iea.org/ (accessed March 2023)

Iwaro, J. & Mwasha, A. (2010). A review of Building energy regulation and Policy for Energy Conservation in developing countries, *Energy Policy*, 38(12), 7744-7755, https://www.doi: 10.1016/j.enpol.2010.08.027

Janda, K.B. (2009). Worldwide Status of Energy Standards for Buildings: A 2009 Update. *Proceedings of the ECEEE Summer Study*,La Colle Sur Loup, France, June, 1-6. ps://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2009/Panel_2/2.299/

Kasozi, P. & Tutesigensi, A. (2007). A Framework for appraising Construction Project Using carbon footprint, *Paper Presented at the 23rd Annual Association of Researchers in construction Management (ARCOM) Conference*,841-850, September 3-5, Belfast, UK. https://www.tib.eu/en/search/id/TIBKAT%3A1002890942/

Kumar, A., Kumar, K., Kaushik, K., Sharma, S. & Mishra, S. (2010). Renewable energy in India: Current status and future potentials, *Renewable andsustainable Energy Review*, 14 (8), 2434-2442. https://doi.org/10.1016/j.rser.2010.04.003

Kousksou, T., Bruel, P., Jamil, A., El Rhafiki, T. & Zeraouli, Y. (2014). Energy Storage: Perspective and Challenges, Solar Energy Matter, *Solar Cell* 120, 59-80. https://www.doi:10.1016/j.solmat.2013.08.015

Madlener, R. & Sunak, Y. (2011). Impacts of urbanization on urban structures and energy demand: What can we learn for urban energy planning and urbanization management? *Sustainable Cities and Society*, 1(1), 45-53 https://www.sciencedirect.com/science/article/abs/pii/S221067071000007/
(accessed February, 2022)

Sapri, M. & Muhammad, S. (2010). Monitoring Energy Performance in Higher Education Buildings for Sustainable Campus, *Malaysia Journal of Real Estate,* 5(1), 18-25. http://eprints.utm.my/id/eprint/38002/1/MaimunahSapri2010_MonitoringEnergyPerformanceinHigherEducation.pdf

Mambo, A.D., & Mustapha, Z. (2016). Modelling the Energy Profile of Typical Building in Nigeria: A case study of Sokoto, Osogbo and Minna, *Proceeding of School of Environmental Technology International Conference (SETIC 2016*), Federal University of Technology Minna, Nigeria, 10th -12th May 2016. https://setic.futminna.edu.ng/index.php/en/component/users/?view=reset&Itemid=101

Mehreen, S.G. & Sandhya, P. (2014). Understanding the Energy Consumption and Occupancy of Multi-Purpose Academic Building. *Energy & Building* 87 (155-168). Retrieved from www.elsevier.com/locate/enbuild (accessed February, 2022)

Mu'azu, A.I. (2012). Scenario of Energy Consumption of Office Buildings in Abuja, Nigeria, *international journal of Science and Advanced technology*, 2 (9), 2221-8386.http://www.ijsat.com

Mu'azu, A.I. & Louis, G. (2015). Design of Sustainable office buildings in Nigeria.https://www.academia.edu/11357912/Design_of_sustainable_office_buildings_in_Nigeria.

Ogbonna, A.C. (2008). An integrated assessment of domestic energy demand and use for energy planning in sub Saharan Africa; the case of Jos, Nigeria, Unpublished PhD Thesis, School of the Built Environment, Heriot Watt University, UK. https://www.ros-test.hw.ac.uk/handle/10399/2186?show=full

Perez-Lombard, L., Ortiz, J. & Pout, C. (2008). A review on buildings energy Consumption information, *Energy and Buildings, 40*(3), 394-398. https://doi.org/10.1016/j.enbuild.2007.03.007

Rai, G.D. (2004). Non-Conventional Energy Sources. Khanna Publishers, Delhi.http://www.amazon.in/Non-conventional-Energy-Sources-G-D-Rai/dp/8174090738

Rosenberg, E. (2014). Calculation method for electricity end-use for residential lighting. *Energy*. Elsevier, 66(C), 295-304. DOI: 10.1016/j.energy.2013.12.049

Sadrzadehrafiei, S., Sopian, K., Mat, S., Lim, C., Hashim, H.S. & Zaharim, A. (2012). Enhancing energy efficiency in office buildings in a tropical climate, Malaysia, *International journal of energy and environment.6* (2), 209. http://www.naun.org/main/NAUN/energyenvironment/17-726.pdf

Salihu, M.M., Ejeh, D. & Hassan, O.S. (2016). Walkthrough Energy Audit Exercise on Office Buildings of Kaduna Central Business District Nigeria, *School of Environmental Technology International Conference (SETIC 2016*), Federal University of Technology Minna, 10th -12th May 2016. https://setic.futminna.edu.ng/index.php/en/component/users/?view=reset&Itemid=101

Springer Science and Business Media, (2017). https://link.springer.com/ (accessed February, 2022)

United Nations Environment Programme (UNEP) (2007). Buildings and Climate Chang Status, Challenges and Opportunities ed.: UNEP publications. http://hdl.handle.net/20.500.11822/7783

United Nations Development Programme (UNDP) (2010). Promoting Energy Efficiency in Buildings: Lessons from international Experience. http://www.ng.undp.org/content/nigeria/en/