EVALUATION OF ELECTRICAL ENERGY CONSUMPTION PATTERN ON RESIDENTIAL BUILDINGS IN ZARIA, KADUNA STATE, NIGERIA

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Abstract: More than one-third of the electricity generated in the world is being consumed in the residential sector. This study aims to assess electrical energy consumption in three different building with minimum of 20 hrs supply. The study adopts case study approach and the instrument use in conducting the research are quantitative which include checklist and measurement, and the results were analyzed using descriptive method. The study reveals that heating load plug load lighting and cooling load were categorized respectively have energy consuming activities the study area. However, heating as a result of cooking activities was measured to be the highest with an average vale of 5033 kWh which represent 55% of the annual consumption. While plug loads were found to be 5 times more than the lighting and cooling loads. The Case Study Building 3 (CSB3) recoded the lowest annual energy consumption by an amount of 76.44 kWh/m^2 per person followed by the CSB1 with 80.02 kWh/m^2 per person, while CSB2 comes with the highest energy consumption of 88.40 kWh/m^2 per person. In conclusion, heating system and plug load were observed to have high consumption in all the CSB with an average usage of 5 to 7 hrs per day. The study recommends raising energy efficiency awareness campaign, mandatory use of prepaid meter, implementation of energy efficiency policy and changing attitude of end users toward efficient purchase and use of energy should be encouraged.

Keywords: Building performance, Energy Consumption, Greenhouse Gas Emission, Residential Building

1. INTRODUCTION

Today Energy is as an integral part of life, it comes at a fiscal price but more than that it comes at environmental cost too. Anthony and Biobele (2020). The Use of energy is increasing exponentially, with buildings responsible for consuming considerable amount. However, buildings consume around one-third of total primary energy resources, making it a prime target for the application of energy efficiency measures. Globally residential building energy consumption stood at 30% to 40% thus making the built environment responsible for a large portion of the world total energy consumption (IEA,2002 and Paone, 2018). Based on usage, household energy includes fuel wood, dung, agricultural residues, charcoal, kerosene, Liquefied Petroleum Gas (LPG) and electricity, but the most widely use is electricity (Adamu, 2020). According to Adetooto (2020) 80% of total energy consumed in Nigeria goes to residential building and the dominant form of energy used in residential buildings is electricity The use of this energy in buildings has increased in recent years as a result of population growth and increase in information technology (Samuel, Esther & Richard, 2016). Growing world energy consumption is putting increasing pressure on environmental pollution and global warming. However, on other to avoid climate change and by keeping the average temperature below 2^0C as agreed during the Paris Climate Conference

(COP21), energy consumption and Green House Gas (GHG) emissions must be reduced in all economic sectors. Thus, efficient use of energy will save the available energy resources for the next generations. ‘’The connection between the increased CO_2 released to the atmosphere and the use of energy is another motive to render a more efficient energy usage, and lower the total energy demand’’ (Mohammed, 2020). Sani (2021) reported that a lot of energy is been wasted in most residential buildings in Nigeria because households use more energy than necessary to fulfill their needs. This trend can partly be offset by considerable improvement in building energy conservation through materials used in building, insulation, day lighting design enhancement and effective energy management practice (Hinge, 2004). Oyedepo (2012) maintained that energy management improvement in building is one of the most cost-effective ways to meet energy challenges. This study is aimed at evaluating energy consumption pattern in residential buildings with a view of mitigating Green House Gas emission.

1.2 LITERATURE REVIEW

Authors Name	Title	Year
Adamu et al	Household Energy Consumption in Nigeria: A Review on the Applicability of the Energy Ladder Model	2020
Mohamed et al	Energy Consumption in Residential Buildings: Comparison Between three Different Building Styles	2020
Maria del P et al	Global Changes in Residential Energy Consumption	2018
Hussaini and Amal	A Comparative study for the Traditional and Modern house in terms of Thermal Comfort and Energy Consumption in umm Qais City, Jordan	2019
Anthony and Biobele	Energy Management in Residential Buildings: A Case Study of Golf housing estate, Trans-Amadi, Port Harcourt	2020
Malgorzata et al	Energy Performance for Residential Building Comparison Between Theoretical Method and Real Measurements	2018

2.0 METHODOLOGY

The survey was conducted in Madachi, Zaria local government Area of Kaduna state Nigeria. The population of the study are single household residential buildings in the study area. A total of 100 single household residential building were identified and divided into three clusters, in each cluster one single household was selected using purposive technique. However, from each selected single household building, numbers of functioning and frequently used electric appliances were identified and related data that influences energy demand and consumption was also collected using checklist. These data include site orientation, floor area, lighting and hot water use profile. DT201 Digital clam meter was used to measure energy consumption of some selected higher energy consuming appliances while LX- 1330B digital light meter was used

to determine both natural and artificial light intensity of the study area. The data was presented and analysed using tables and descriptive statistic

2.1 Case Study

In this study, three different residential buildings with minimum of 20hr power supply in Madachi, Zaria local government area were selected. Each building is well defined by satisfying the following requirements

a) Band A (minimum of 20hrs supply per day)
b) One year energy bill of power consumption
c) Single household residential type
d) Level of income must be grade 12above or its equivalent.

The selected case study buildings were coded as case study building 1, 2 and 3 respectively (CSB1, CSB2 and CSB3) which largely represents the residential building within the area. The three buildings identified have a similar structure and accessory components, such as roofs, floors, doors, and windows.

4.0 DISCUSSION OF MAJOR FINDINGS

Table 1 Specification of the three buildings

Description	CSB 1	CSB 2	CSB 3
Building type	Bungalow	Bungalow	Bungalow
Location	Zaria	Zaria	Zaria
Latitude	11.09	11.09	11.09
Year of construction	2019	2018	2022
Orientation	N/S	N/S	S/W
Number of occupant's	5	7	5
No of equipment per house	11	15	12
Floor area per sq.m	98.28	97.65	93.4
Mode of energy supply	Estimated bill	Estimated bill	Estimated bill
Window to wall ratio %	8.5	5.14	7.35

Source, 2023

Table 2.0: Disaggregation of Energy consumption for the case studies buildings.

End-use	CSB 1 (kwh)	CSB 2 (kwh)	CSB 3 (kwh)	Average (kwh)	%
Lighting	500	1172	414	695	8
Plug load	519	2000	510	1010	11
Heating	4200	5060	5838	5033	55
Cooling	756	450	378	528	6

Source, 2023

Table 2.0 reveals the load categories for the case study buildings. The heating equipment consumes the highest amount of electric energy in the building while less is cooling

load with an average consumption of 528kwh which represent 6%. Demand and consumption pattern of the study area revels that heating was observed and measured to have the highest consumption of 4200 for CSB1 5060kwh for CSB2 and 5838 for CSB3 respectively. However, the average consumption for the three-case study building were 5033kwh taken 56% out of the total energy consumption follow by plug load with 11% and lighting system with 8% these indicate that the occupant exhibits the habits of energy conservation when not using plug load and lighting system. Space cooling represents only a fraction with 6% for the three buildings. Furthermore, based on a twenty hours (20hrs) daily availability of electricity (KEDCO, 2022). Table 2.0 compares the average of the measured electricity consumption with the Licensed Electrical Contractors Association of Nigeria and Kaduna Electricity Distribution Company (LECAN and KEDCO) standards. The three building were categorized as high energy consuming buildings.

Table 3.0 Consumption for each Building per Square Meter Per End-User

Load	**CSB 1**	**CSB 2**	**CSB 3**	**Average**
Area(m^2)	**98.285**	**97.657**	**93.45**	
End-user				
Kwh	7865	8640	7140	7882
Kwh/m^2	80.02	88.48	76.44	81.65
Kwh/p	1573	1234	1428	1412
Kwh/m^2/p	16	13	15	15

Source, 2023

Table 3 reveals the total consumption, consumption per meter square, and consumption per meter square per person in the study area. It also shows their average consumption values. The obtained results in the three case study buildings have been compared with the values of consumption in the United States where the energy consumption per square meter 143.5 kWh/m^2 (Shabunko et al.,) which is higher than the presented values in table 3. This difference can be as a result of user behavior, characteristic of building envelops and policy.

5.0 Conclusions

Based on the findings from the study, heating system and plug load were observed to have high consumption with an average usage of 5 to 7 hours per day. For the three buildings, the maximum power load occurred in the morning and evening. Also, the three-case study building exhibit similar consumption per square area and per square area/person with an average consumption of 81.65kwh/m^2 and 15kwh/m^2/p respectively. The study recommends that raising energy efficiency awareness campaign, mandatory use of prepaid meter, implementation of

energy efficiency policy and changing attitude of end user toward efficient purchase and use to energy should be encourageD.

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