American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-02, Issue-10, pp-271-275
www.ajer.org

Research Paper Open Access

Assessment of energy use pattern in residential buildings of Kano and Kaduna Northern Nigeria

Yohanna Irimiya, Iortyer A. Humphery, Ierve I. Aondover,
[1] ECWA, Goodnews Katsit, P.O.Box 432. Kafanchan,Kaduna,Nigeria
[2] Mechanical Engineering Department Federal University of Agriculture,Makurdi, 2373, Nigeria,
[3] Works and Housing Department,Buruku Local Government Council, Buruku, Nigeria,

***Abstract:* -** The energy consumption end use of some selected residential buildings in Kaduna and Kano in the Northern part of Nigeria was studied by comparing their energy consumption pattern. The energy usage and intensities of the buildings as-built (Coventional) and when retrofitted with green features were studied and the impact of the green retrofits documented. An Analysis of Variance (ANOVA) was conducted at 0.05% which indicates a significant difference in the Energy consumption between the Conventional and Green features in the six study areas. From the study, the annual energy intensity of Kaduna for conventional buildings is 25.24 kwh/m^2. With the introduction of green appliances, a drastic reduction in the buildings annual energy consumption was recorded which stood at 20.57 kwh/m^2 representing about 18.26% reduction in annual energy consumption which indicates a significant energy saving. In Kano VAC consumed the highest energy 12.49 kwh/m^2 of the total consumption of all end-users. When replaced with energy efficient appliances the consumption dropped to 7.95 kwh/m^2 representing 34.14% reduction. The use of energy efficient appliances is recommended.

***Keywords:* -** *Energy use, Residential Buildings, Northern Nigeria*

I. INTRODUCTION

Energy consumption all over the world is growing annually at an alarming rate. It's on this note that electricity utilities in many developing nations need to adopt the energy policy that encourages the efficient usage of limited electricity supply. This has been a grievous issue in many nations (Nigeria inclusive). In line with the recently held conference on Earth summit at Rio, it's believed that for energy to be made available to all, the developing nations need to reconsider their respective energy efficiency policy and strategies. This becomes necessary looking at the critical situation with respect to the energy consumption pattern in most of these nations which has left much to be desired [1].

According to [2] and [3] in collaboration with [4], the world consumes about 7,500Mtoe of energy every year. While primary energy consumption will grow by almost 50% from 2005 to 2030, the shares of different energy sources are not expected to change significantly in the near future. Also, according to [5], about 30-40% of all the primary energy is used in buildings worldwide. While in high and middle-income countries this is mostly achieved from the use of fossil fuels and biomass. This shows that, in the near future, more fossil fuels will be used to meet the energy demands of many nations. [3], also estimated that buildings account for about 30-40% of the word's energy consumption which is equivalent to 2,500 Mtoe every year. It is, therefore, an established fact that the building sector is responsible for a large share of the word's total energy consumption.

Energy consumption patterns in the world today shows that Nigeria and indeed African countries have the lowest rates of consumption. Nevertheless, Nigeria suffers from an inadequate supply of usable energy due to the rapidly increasing demand, which is typical of a developing economy. Paradoxically, the country is potentially endowed with sustainable energy resources. Nigeria is rich in conventional energy resources, which include oil, national gas, lignite, and coal. It is also well endowed with renewable energy sources such as wood, solar, hydropower, and wind [6].

The patterns of energy usage in Nigeria's economy can be divided into industrial, transport, commercial, agricultural, and household sectors [7]. The household sector accounts for the largest share of energy usage in the country - about 65%. The major energy-consuming activities in Nigeria's households are cooking, lighting, and use of electrical appliances. Cooking accounts for a staggering 91% of household energy consumption, lighting uses up to 6%, and the remaining 3% can be attributed to the use of basic electrical appliances such as televisions and pressing irons [8]

Energy consumed by households includes electricity, gas, diesel, kerosene, inverters, candles, lanterns etc. However, consumption is dominated by electricity. The enormity of Nigeria's energy problem creates a greater need for energy efficiency practice to be adopted by residential households as electricity demand in Nigeria far outstrips the supply which is epileptic in nature [9]. Energy efficiency has become the key driver for sustainable development. If we use energy more efficiently it will lead to saving of personal income and reduce the need for more power stations in the country [10], [11]. In the last few years more stringent environmental laws and souring energy prices has increased the need for household to react and participate in energy reduction and housing sustainability [12].

In most Nigerian homes, it is evident that energy efficiency is not factored in the choice of household appliances and electrical fittings. It could therefore be argued that electrical energy utilization in Nigeria is far from being efficient as in most homes; filament bulbs of wattages ranging from 40 watts to 120 watts per hour are still used.

The energy crises the country is facing coupled with population and infrastructural growth and the unrelenting rise of energy prices have stimulated research interest towards finding ways of alleviating or eliminating the unnecessary use of energy. Limited literatures on energy use in residential buildings have been reported:

[13], studied the monthly electric energy consumption of a total of 17 housing units at king Fahd University of petroleum and minerals, Dhahran, Saudi Arabia over a period of about five years. They found the annual average total electric energy consumption for 4.3.2 and 1 bedroom housing units to be 193, 208, 217 and 224 kwh/m^2 respectively. They reported that on average, the air – conditioning energy accounted for about 73% of the total energy consumed in the studied housing units. In another study, which compared energy consumption patterns of low – energy buildings to conventional buildings in Malaysia. The aim of this study is compare the impact of green buildings on efficient energy utilization in Nigeria. The objectives:

1. To identity the green features that can be retrofitted into buildings to enhance energy efficiency and conservation;
2. To highlight several dividends accruable from green buildings;

The importance of this work will among other things include, Identifying energy-saving measures (i.e. green retrofits) in buildings adaptable to the climate of our region, which will help in maximizing the total energy need of the nation; Provide a comprehensive database for identifying and quantifying projected benefits from investment in green building projects.

II. MATERIALS AND METHODS

2.1 Materials

The materials used are the Surveyor tape, Engineering Compass, the single phase *Lanvis* Analogue electric Meter.

2.2 The study area

Kano state is the second largest industrialized State in Nigeria. It is the centre of commerce and economy in Northern Nigeria. It lies between latitudes 12^0 23' and 9^0 33' north and longitudes 9^0 29' and 7^0 43' east. It has a population of 9, 383,682 in 2006. The estimated total land area is 20, 760 square kilometers. It has 44 local government areas. Kaduna State is a State in central Northern Nigeria,. Its capital is Kaduna. It has coordinates 10^0 27'N 7^0 45' and an area of 46,053km^2. It ranks between 3rd out of the 36 States and has a population 6,066.552 in 2006.

2.3 Data collection

The required data for the work were identified and classified as electrical energy-dependent appliances. The appliances were sub-categorized into ventilation and air-conditioning (VAC), lighting, cooking, food preservation, water heating, electronic and laundry. In order to determine the energy consumption of the selected buildings, parameters of household appliances such as energy rating, number of units consumed, hours of operation and the cost were collated as the primary data. Other parameters included the size of building and building orientations. Summary of the parameters is presented in Table 1. The buildings investigated were 3 bed room flats.

Table 1: Summary Data of Buildings

Building	Location	Type	Area (m^2)	Orientation
Kaduna 1	Afaka, Mando	3-Bedroom	137.5	S75E
Kaduna 2	Ungwan Rimi	3-bedroom	72	S40E
Kaduna 3	NAF BASE	3-Bedroom	160	S30W
Kano 1	AKTH, KANO	3-Bedroom	168	N50E
Kano 2	AKTH, KANO	3-Bed room	168	N50E
Kano 3	Sallari, Kano	3-Bed room	162	East

2.4 Experimental procedure

A data collection form was designed for easy documentation of all the parameters collected from various buildings. The data measured included the size of the building in square meters, the orientation of the buildings and of the windows. The duration, in hours, of the building access to power supply from Power Holding Company of Nigeria (PHCN) was also recorded. The orientations of some of the buildings investigated shade them away from the direct incidence and impact of sunlight when the sun is at its peak. The buildings enjoy power supply from PHCN for 7-18 hours per day on the average. The buildings' household devices depended largely on electricity for their operation.

The physical characteristics (orientations and locations) of the green building were taken to be the same with their conventional counterparts. However, the conventional buildings were retrofitted with green products, which varied from one building to the other depending on the power consumption of the appliance incorporated into the buildings. Some of the green devices retrofitted into the building were lighting, cooking, cooling, ventilation, and electronic devices. These are energy-efficient household appliances such as compact fluorescent lamps, improved fridges, electric fans, air conditioners, and deep freezers. Each of these appliances was connected to an electric power recording meter (Single phase *Lanvis* Analogue Meter) through which the energy consumption of the appliance was observed and recorded. The Conventional Appliances were each connected to a recording meter. The readings were collected for a period of six months after which the buildings were retrofitted with more energy-efficient appliances and readings collected for another period of six months, making one year, the energy intensity was determined from the floor area of building and the energy consumption of each appliance.

2.5 Data Analysis

Monthly consumption for each type of appliance and the percentage breakdown of total consumption were analysed descriptive statistics on Microsoft Exec 2007. The Energy Intensity (EI), which determines the ratio of the energy consumed in kWh to the floor area of building in square meter, was calculated using equation 1. A computer application software (micro soft Excel) was employed in the preparation, interpretation and analysis of the collated data. Analysis of variance (ANOVA) was carried out on the energy intensity data of the conventional and green buildings using sigma Plot 11.0 software version in order to determine if there are significant differences between their means.

$$Energy\ Intensity = \frac{Total\ Energy\ Consumption}{Floor\ Area} \quad (1)$$

III. RESULTS

3.1 Analysis of variance for the conventional and energy efficient appliances for the study area

Then data was subjected to analysis of variance at 5% to test for significant differences. The Anova test shows that, there was significant difference at 95% for the seven appliances (rows) indicating that there was a difference in the energy intensity between the conventional and the energy efficient buildings appliances. The Anova test shows no significant difference at 95% for the study areas (columns), implying that the study was standardized. The mean values for the entire study was then considered for analysis.

Table 2: ANOVA for conventional and energy efficient appliances for the study area

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	175.5414	5	35.10827	4.080773	0.007598	2.602987
Columns	24.99242	5	4.998484	0.580994	0.714171	2.602987
Error	215.0834	25	8.603338			
Total	415.6172	35				

$H_{o:}\ F \leq Fcrit.$ $\propto = 0.05$
$H_{a:}F \geq Fcrit.$

3.2 Energy end use in the study area

Table 3 shows the breakdown of energy consumptions by the various energy end-users in Kaduna. From the Table 3, energy intensities of VAC, lighting, cooking, preservation, water heating, electronic and laundry devices were 4.16kwh/m^2, 5.08 kwh/m^2, 10.19 kwh/m^2, 3.47 kwh /m^2, 0.53 kwh /m^2, 1.09 kwh /m^2, 0.71 kwh /m^2while consumption for the retrofitted building was 3.4 kwh /m^2, 3.16 kwh /m^2, 9.36 kwh /m^2, 2.63 kwh /m^2, 0.48 kwh /m^2, 0.88 kwh /m^2 and 0.65 kwh /m^2 representing 16 %, 32%, 8.39%, 24.25%, 9.43%, 14.93%, 8.45%, reduction respectively of the total energy consumption of the conventional buildings in Kaduna. The least energy was consumed by water heating with 0.53 kwh/m^2 representing 9.43 % savings of the overall energy consumption while the highest was consumed by cooking, 10.19 kwh/m^2. The annual energy intensity of Kaduna for conventional buildings is 25.24 kwh/m^2. With the introduction of green appliances, a drastic reduction in the buildings annual energy consumption was recorded which stood at 20.57 kwh/m^2 representing about 18.26% reduction in annual energy consumption which indicates a significant energy saving.
Energy consumptions pattern in Kano for both conventional and efficient appliances is presented in Table 4. VAC consumed the highest energy 12.49 kwh/m^2 of the total consumption of all end-users. When replaced with energy efficient appliances the consumption dropped to 7.95 kwh/m^2 representing 34.14% reduction. Details of energy consumption in kWh/m^2 in Kano are as shown in Table 4.
Fig. 1 shows the overall energy intensity for the entire study. Lighting and VAC has the highest annual consumption (42.19 kwh/m^2 and 15.92 kwh/m^2) followed by preservation and cooking (3.97 kwh/m^2 and 3.87 kwh/m^2) electronic, laundry and water heating have the lowest consumption of (1.24 kwh/m^2, 0.06 kwh/m^2 and 0.05 kwh/m^2).

Table 3: Energy consumption and savings for conventional and energy efficient buildings in Kaduna

Usage	Conventional kw/m_2	Energy Efficient kw/m^2	Energy savings kw/m^2	Energy savings (%)
VAC	4.16	3.4	0.76	16
Lighting	5.08	3.16	1.85	32
Cooking	10.19	9.36	0.83	8.39
Preservation	3.47	2.63	0.84	24.25
Water heating	0.53	0.48	0.05	9.43
Electronic	1.09	0.88	0.21	14.93
Laundry	0.71	0.65	0.06	8.45
Total	**25.23**	**20.56**	**4.6**	**113.45**

Table 4: Energy consumption and savings for conventional and energy efficient buildings in Kano

Usage	Conventional kw/m^2	Energy efficient kw/m^2	Energy savings kw/m^2	Energy savings %
VAC	12.49	7.95	4.48	34.14
Lighting	3.92	2.48	1.44	40.16
Cooking	1.78	1.77	0.01	1.5
Preservation	1.49	1.01	0.48	21.32
Total	19.69	13.21	6.41	97.12

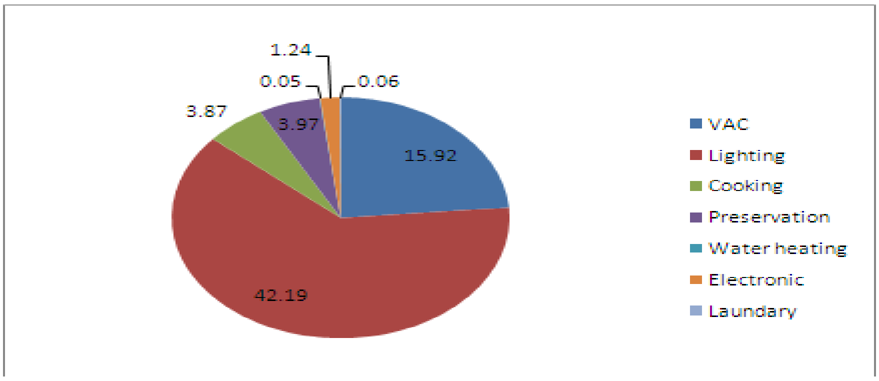

Figure 1: Overall energy intensities of conventional and energy efficient buildings in the study areas

IV. CONCLUSIONS AND RECOMMENDATIONS

The study has shows that overall energy intensity for the entire study was Lighting and VAC has the highest annual consumption (42.19 kwh/m^2 and 15.92 kwh/m^2) followed by preservation and cooking (3.97 kwh/m^2 and 3.87 kwh/m^2) electronic, laundry and water heating have the lowest consumption of (1.24 kwh/m^2, 0.06 kwh/m^2 and 0.05 kwh/m^2).

It can therefore, be concluded that green buildings impacts positively on energy consumptions in residential buildings in Nigeria. This is evident in the low energy consumptions recorded in the green buildings compared to those of the conventional buildings. Hence, the contribution of this research finding will bring about considerable energy savings in conventional buildings in Nigeria. Energy consumptions of residential building in Nigeria should be adequately monitored and data collected on monthly basis. This would give exact representation of residential buildings energy consumptions.

REFERENCES

[1] www.punchng.com/feature/power-talkback/case-for-energy-efficient-appliances/

[2] IEA, World Energy outlook, 5-7, 2002

[3] IEA, Key World Energy Statistics, 25-30, 2005

[4] Energy Information Administration, E1A. World Energy Overview, 1993-2003. Energy information Administration Washington DC 2005 http://www.eia.doe.govr/emeu/overview/htm/.

[5] UNEP, Buildings and Climate Change Status, Challenges and opportunities'' United Nations Environmental programme, 2007

[6] Okafor ECN, Joe-Uzuegbu CKA, Challenges To Development Of Renewable Energy For Electric Power Sector In Nigeria. International Journal Of Academic Research 2(2):211- 216, 2010

[7] Energy Commission of Nigeria (ECN) National Energy Policy. Federal Republic of Nigeria,Abuja. 2003

[8] Energy Commission of Nigeria (ECN), Renewable Energy Master Plan. 2005

[9] Sule, B.F., Ajao, R.K., Ajimotokan, A.H. and Garba, M.K. Compact Fluorescent Lamps and Electricity Consumption Trend in Residential Buildings in Ilorin, Nigeria, International Journal of Energy sector Management,5 (2): 162-168, 2011, Emerald Group Publishing Limited, UK

[10] Otegbulu, A.C. Economics of Green Design and Environmental Sustainability, Journal of Sustainable Development,. 4(2); 240-248, 2011, Canadian

[11] CREDC, Energy Efficiency Survey in Nigeria, *Community Research Development Centre (CREDC)* Benin City, 2009

[12] Eves, C. and Kippen, S. (2010) Public Awareness of Green and Energy Efficient Residential Property: An empirical survey based on data from New-Zealand, Property Management, 28(3), 193-208 2010, Emerald Group Publishing Limited, UK

[13] Elhadidy, M.A and Manzoor-ul-Haq, A.AElectric energy consumption in selected resident ion buildings at King Fahd University of petroleum and Minerals, Dhahran, Saudi Arabia, 2011