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Investigation of Electrical Energy Use Efficiency of Students' Hostel in Gidan Kwano Campus of Federal University of Technology, Minna

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Abstract: *This paper presents the result of an electrical energy audit conducted at the students' hostels of the Federal University of Technology Minna, Niger State, Nigeria. The aim was to ascertain the electrical energy consumption pattern, calculate the amount of electrical energy consumed, spot areas of waste and find measures to curb such waste. A walk-through audit and investigation through questionnaire and oral interviews was used to gather required data. SPSS and Microsoft Excel software packages were used to analyze the data. Electric cooking element ranked top in energy consuming loads, followed by lighting and fan loads. This was due to the use of unregulated hot plates and poor user habits in the hostels. Electricity bill was estimated based on the connected load. Possible energy saving options were highlighted, resulting in a 38% savings on electricity bill.*

Keywords: *Energy audit, Diversity factor, Duty cycle, Consumption pattern, Energy saving, SPSS.*

1. INTRODUCTION

"Engineering is the science of economy and conservation of energy stored up by nature for the use of man. It is the business of engineering to utilize this energy to the best advantage, so that there may be the least possible waste" (Willard, 1908). Energy for obvious reasons is regarded as the prime mover of any economy, and the engine of growth around which all sectors of the economy revolve. Thus it becomes imperative that its development, management, and improvement must have predetermined plans and strategies that are capable of driving the economy towards a sure path of sustainable development (Aderemi, *et al.,* 2009). In general, energy efficiency in Nigeria is very poor both in domestic and commercial usage (Awah and Okoro, 2010). Electrical energy utilization in Nigeria is far from being efficient (Otegbulu, 2011). A lot of energy is wasted in Nigeria because households, public and private offices and industries use more energy than is actually necessary to fulfill their needs (CREDC, 2009). Most Nigerians are unconscious of the energy they waste. Often, many people use wrong appliance for carrying out certain activities. An example is in using electricity for heating which wastes about 80% of the input energy (Awah and Okoro, 2010). The energy crises of 1973 gave birth to energy audit. Since then, interest in energy audits has increased as a result of growing understanding of human impact upon global warming and climate change (Akpama *et al*, 2009). Energy used to heat and cool homes, as well as the electricity used for lighting and appliances, contributes to 20% of greenhouse gas emissions that cause global warming (Anonymous, 2008).

An energy audit can be defined as an analysis of building or equipment, which identifies how and where that building or equipment can reduce energy consumption and save energy costs. Energy audit attempts to balance the total input of energy with its use (Suresh, 2009). Energy audits are meant to determine the energy consumption of an industry or organization at different process lines with a view to generate energy improvement options, to prevent energy wastage, to estimate the cost of energy improvement, calculate payback and evaluate the various options (Okoro *et al*, 2008). Energy Audit is an effective energy management tool. By identifying and implementing the means to achieve energy efficiency and savings, not only can energy savings be achieved, but also equipment/system services life can be extended and indoor quality could be improved. All these mean savings in money and possibly improve productivity. Based on the principle of "The less energy is consumed, the less fossil fuels will be burnt", both the buildings and the power generation companies will generate relatively less pollutants and by-products. Therefore, all parties concerned contribute to conserve the environment and to enhance sustainable development

Energy audits have been conducted in various commercial and residential buildings, plants, government offices and in tertiary institutions. In 2001, an investigation on the end-use efficiency of electrical energy by households in Lagos Metropolis, Nigeria, revealed that the cause of waste of energy resulted from two factors (Otegbulu, 2011);

a) The use of inefficient technologies or equipment
b) Behavioral pattern of consumers.

In Aalto University, Finland, an interactive web-based guide for energy consumption efficiency was built, using data from a carried out survey. The application combined the ability to calculate energy consumption as well as give advice on energy saving measures. It operates on a feedback technique where inputs from the user were used to generate a yearly electric energy consumption audit and personalized saving potential advices (Zenebe, 2010).

In South Africa, the relationship between environmental awareness and electricity consumption behaviours amongst students in tertiary institutions was conducted in the Rhodes University residential system (Aletia *et al*, 2007). In India, an energy audit of the Indian Institute of Technology (IIT), Bombay campus was conducted with the support of some students from the Energy Science and Engineering Department (Chikku *et al*, 2008). Energy audits have also been conducted in some Universities in Nigeria, among which are University of Lagos (Adekunle *et al,* 2008), Cross River University of Technology, Calabar (Akpama *et al,* 2009), Michael Okpara University of Agriculture, Umudike (Awah and Okoro, 2010) and the University of Nigeria, Nsukka (Okoro *et al*, 2008).

The objectives of this investigation include the following:

- To ascertain the present electrical energy consumption pattern in the students' hostel of Federal University of Technology, Minna, Nigeria.
- To calculate the amount of electrical energy consumed in the hostel.
- To spot areas of waste and find out reason for such waste.
- To find feasible and low cost measures to curb the waste.

2. MATERIAL AND METHOD

The steps and procedures used in obtaining and analyzing the data include:

i. **Physical Inspection**: This includes the walk-through audit of the hostel facilities and observation of end-user habits of the students. This is important so as to get a clear picture of load consumption pattern.

ii. **Data Collection**: Data was collected by physical counting of lighting and fan points, socket outlets and some room was obtained for all the blocks of hostel buildings.

iii. **Questionnaire Structuring and Administration**: The questionnaire was structured to cover the following area; Respondents' awareness of energy conservation and its benefits, electrical energy consumption pattern in the hostel and the energy saving habits of the respondents. In administering the questionnaires, two sampling methods used are; Stratified sampling and Simple random sampling. The hostel population was divided into two major strata- the male and the female students. The questionnaire was then administered to each group using simple random sampling.

A total of four hundred and thirteen (413) questionnaires were distributed, covering well over thirty percent (30%) of the entire hostel population.

iv. **Data analysis**: Data gathered was analyzed using Statistical Package for Social Sciences (SPSS) and Microsoft Excel software packages.

2.1 Load Classification and Estimation

Based on end-use, the connected loads in the hostel were grouped into five classes namely;

i. Lighting and fan
ii. Water heating
iii. Cooking
iv. Refrigeration
v. Others

Electric usage is measured in Kilowatt-hours

$$(KWh) = P\ (KW) \times t\ (hr.) \quad (1)$$

In estimating the electricity consumption, the following load reducing factors were used.

- ***Diversity factor:*** This *is* the probability that a particular piece of appliance will come on at the time of the facility's peak load (Barnley, 2012).
- ***Duty cycle:*** This is a ratio of the operating time of an appliance to the total time the electrical appliances in the hostel. The average usage time was also noted. The number of rooms and students in each appliance is on. It is usually applied for appliances with thermostats which do not actually consume energy for the whole 'ON' period. For example, the best estimate of the duty cycle for all properly working refrigerators seems to be fifty percent (50%) (Cavallo, 2000).

2.2. Description of Case Study (Hostel Blocks)

The students' hostel in the main campus comprises of eight (8) blocks, (blocks A to G and the Shehu Aliyu hostel). Blocks A and B are male hostels while the others are female hostels. Table 1 gives a full description of the various blocks in the hostel.

Table 1: Description of Students' Hostel

BLOCK	DESCRIPTION	TYPE OF HOSTEL	NO. OF ROOM	STUDENTS PER ROOM	STUDENTS PER BLOCK
A	Two storey building	Male	83	4	332
B	Two storey building	Male	83	4	332
C	Self-contained flats	Female	14	6	84
D	Self-contained flats	Female	14	6	84
E	Self-contained flats	Female	14	6	84
F	Self-contained flats	Female	14	6	84
G	Self-contained flats	Female	14	6	84
SHEHU ALIYU	A storey building	Female	70	3	210
Total no. of students					1,294

3. RESULTS

The results obtained are presented in Table 2, Table 3, Fig.1, Fig. 2, Fig. 3, Fig.4, Fig.5, Fig. 6, Fig. 7, Fig 8, Fig. 9, and Fig.10

Table 2: Consumption of electricity in each block per month in kWh

Block	Lighting and fan	Water heating	Cooking	Refrigeration	Others	Total load consumption
A	2,391.81	1,867.50	7,128	63.84	1,299.60	12,750.75
B	2,391.81	1,867.50	7,128	57.12	1,394.64	12,839.07
C	756.735	360	792	176.4	316	2,401.14
D	756.735	360	792	201.6	505	2,615.34
E	756.735	360	792	100.8	316	2,325.54
F	756.735	360	792	189.84	316	2,414.58
G	756.735	360	792	290.04	505	2,703.78
Shehu Aliyu	1,869.32	1,575	950.4	403.2	896.94	5,694.86
Total	10,437	7,110	19,166	1,483	5,549	43,745

Table 3: Electricity bill per month for the hostel

Load classification	Consumption Per Month (KWh)
Lighting & Fan	10,437
Water Heating	7,110
Cooking	19,166
Refrigerators	1,483
Others	5,549
Total KWh per Month	43,745
Monthly Bill at ₦11:20K per KWh	₦489,942:12K

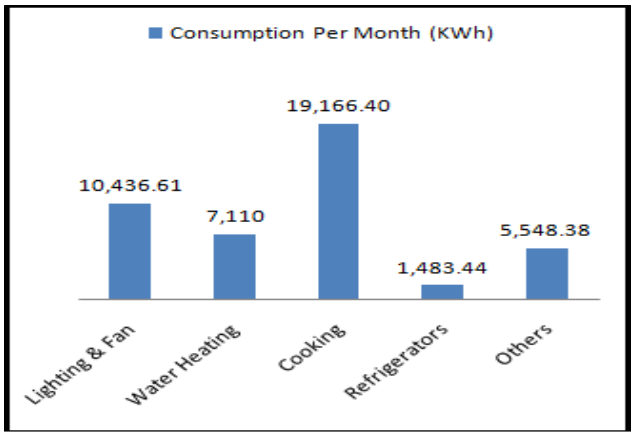

Fig. 1: Electricity consumption per month

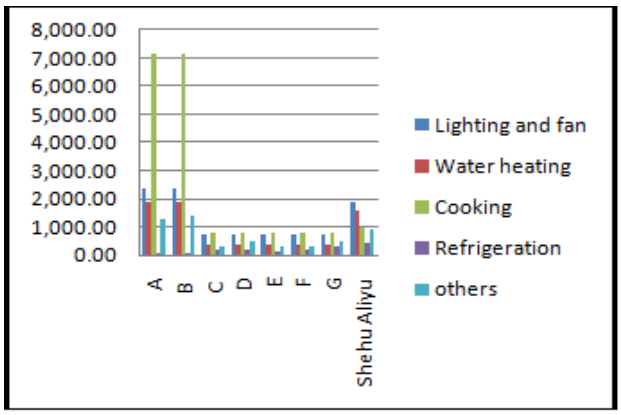

Fig. 2: Consumption in KWh per month of each block for the five classes of load

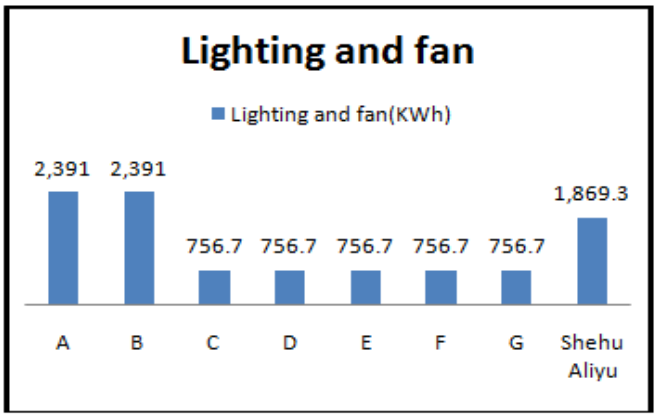

Fig. 3: Lighting and Fan Consumption for Each Block

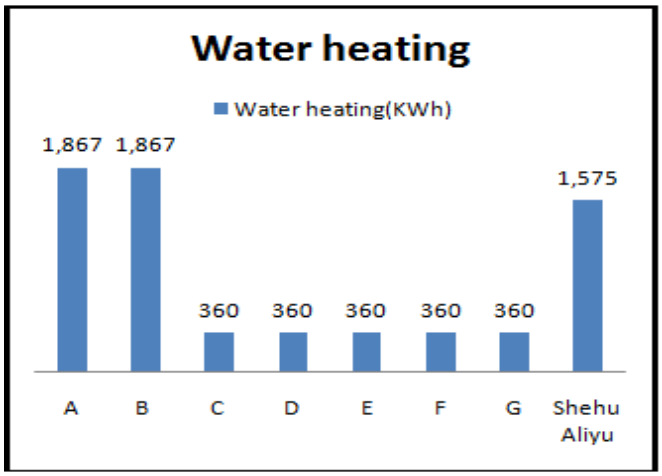

Fig. 4: Consumption for heating water in each block

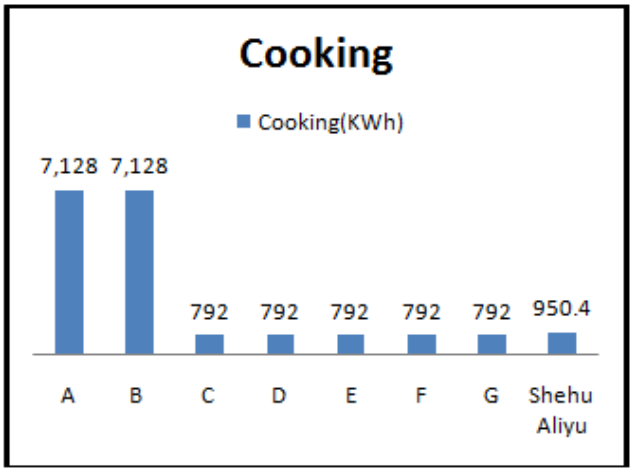

Fig. 5: Consumption for cooking in each block

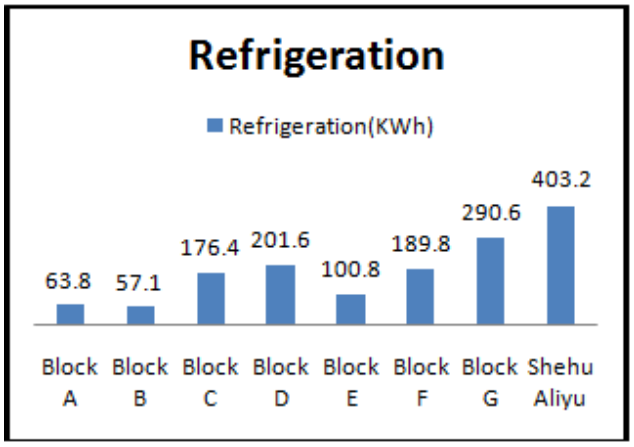

Fig.6: Consumption by refrigerators in each block

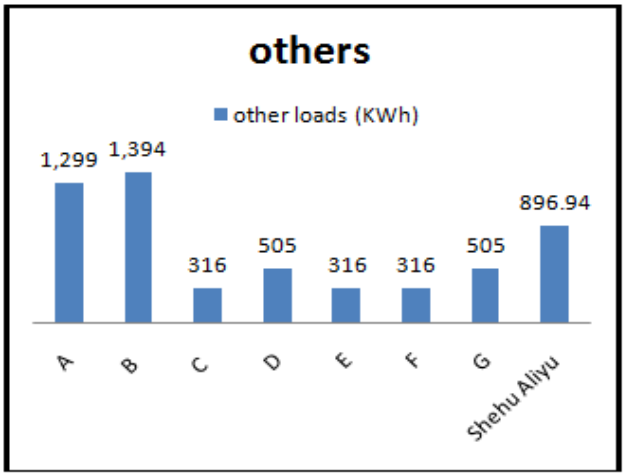

Fig. 7: Consumption by other appliances in each block

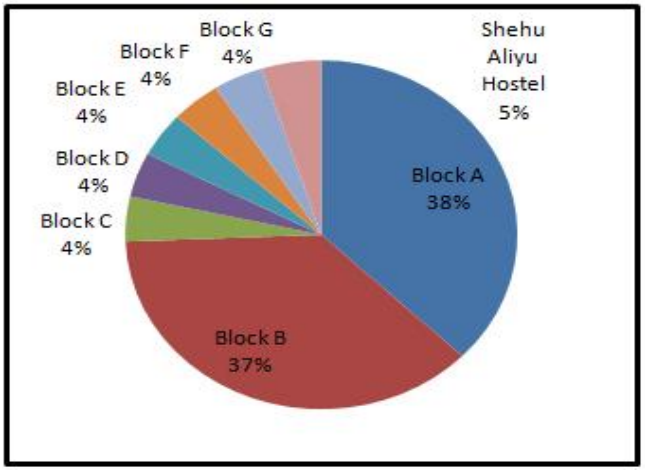

Fig. 8: Contributions of each block to the energy used for cooking in the hostel

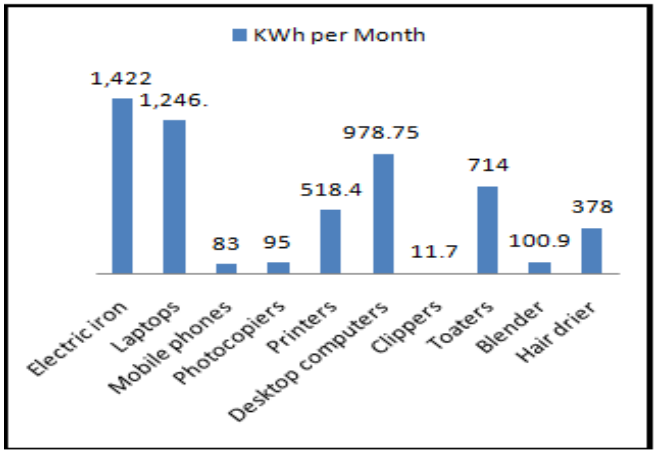

Fig. 9: Electricity consumption by other appliances

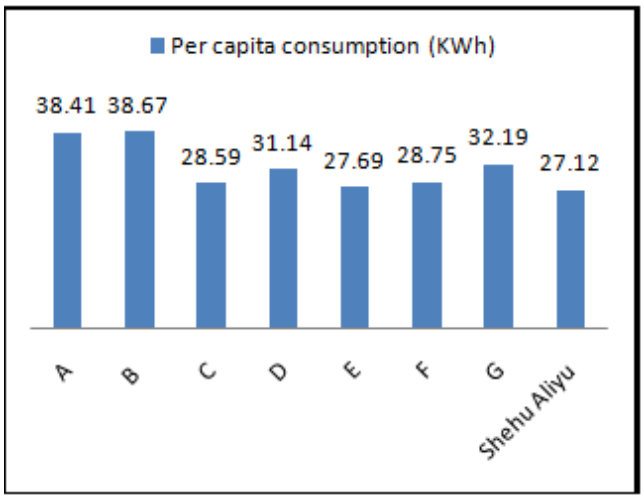

Fig. 10: Per capita consumption for each hostel block

4. DISCUSSION

The chart in fig. 1 shows that a large percentage of electricity consumed in the hostel is used for cooking, followed by that used for lighting and fan. From fig. 2, it is evident that the male hostels (blocks A and B) consume more energy than the female hostels especially for cooking. The other results are discussed under the following heading.

4.1 Lighting and fan

It is a credit to the hostel managers that most of the bulbs are Compact Fluorescent Lamp (CFLs) hence much energy savings as regards the type of lamps. However, response from the questionnaires administered and a walk-through audit of the hostel shows that external light bulbs are left on during the day and students leave light bulbs in their rooms on even when they are out for lectures. The questionnaire shows that 82% of respondents agree that light bulbs are left on during the day. If lighting and fans in the rooms are put off when they are not needed and external light bulbs put on only at night, it will reduce the 'ON' hours of light bulbs to an average of 7hours

from 10hours daily, leading to about 30% savings in energy consumed for lighting and fan.

4.2 Water heating

From fig. 4, we can see that blocks A and B use more electrical energy for water heating than other blocks. This is majorly due to the large numbers of the occupant in the blocks.

4.3 Cooking

This is the activity that consumes the most amount of electricity in the hostels. Figure 8 show the contributions of each block to this total amount. It can be seen from this figure that blocks A and B, which are both male hostels, have the highest percentage. From a walk-through inspection of the hostel, it was observed that the male students use more unregulated hot plates than the regulated ones. The unregulated hot plates have a duty cycle of one (1), and hence keep draining current even when the element is red-hot. This leads to waste of a lot of electrical energy and subsequent damages of cables and socket outlets. Using only regulated hot plates will greatly reduce the energy used for cooking from 19,166.4(kWh) to 5,702.4(kWh), resulting in a saving of 13,464kWh.

4.4 Refrigeration

This accounts for only 3% of the monthly electricity consumption. There are 55 refrigerators in the hostel and 51 of these are in the female hostel. Options for saving energy here lies mainly on the user habits, i.e ensuring the refrigerator door is tightly closed after use and putting it off when it is empty will help in saving energy.

4.5 Others

This is consumption by appliances not considered in the above four (4) classes. Figure 9 shows these appliances and their contributions to the total electricity consumption. Energy can be saved if students practice energy saving habits. These include:

i. Putting off appliances when not in use.
ii. Disconnecting laptops and phones from electricity supply when they are fully charged.
iii. Completely turning off appliances that will not be used for a long time, instead of leaving it on standby mode.

4.6 Per Capita Consumption

The energy consumption per student for a month in each hostel block is shown in figure 10. The male hostels have a higher per capita consumption. The average per capita consumption for all the hostel blocks is 31.57KWh per month.

4.7 Potential Savings

Savings from lighting and fan = 3,130.98KWh
Savings from cooking = 13,464KWh
Total KWh savings = 16,594.98KWh
Total savings cost = 16,594.98(KWh) x ₦11.20K = ₦185, 863.78K
Comparing this amount with the total monthly electricity bill of ₦489, 942.12K, this amounts to a 38% savings in electrical energy cost for the hostel.

Fig. 11 and 12 shows graphically the consumption in KWh and cost before and after energy saving measures are implemented.

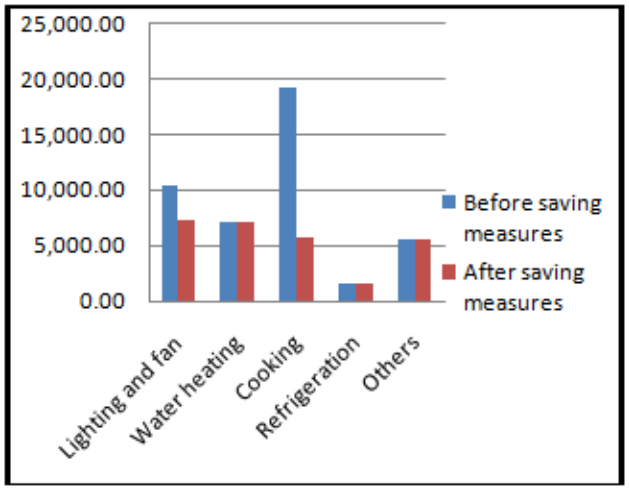

Fig. 11: Consumption in KWh before and after saving measures

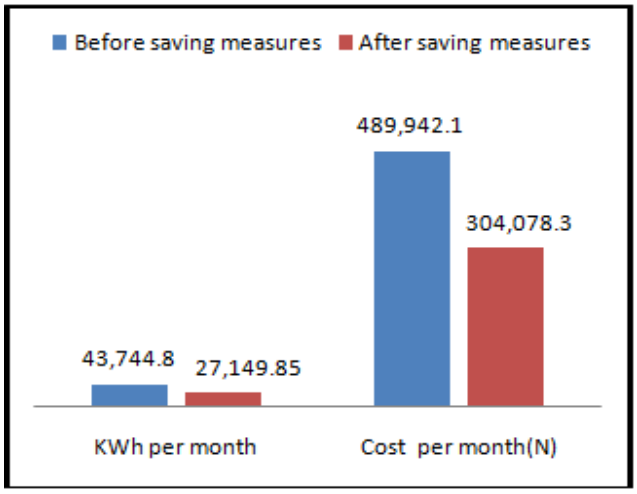

Fig. 12: Total consumption and cost before and after saving measures.

5. CONCLUSION

Electrical energy audit was conducted for the eight (8) blocks of students' hostel at the permanent site of the Federal University of Technology, Minna. Major classes of load were lighting and fan, cooking, refrigeration, water heating and others. Considerable amount of waste was discovered in both cooking and lighting and fan categories. Recommended savings measures results in about 38% savings on electricity bill, which amounts to ₦185, 863.78K per month.

The following recommendations are hereby made based on the findings of this study.

i. Awareness on energy saving habits and their benefits should be created, through mediums such as the hostel notice board, the Student Union Government (SUG) and the University's FM radio station can be used to pass this information.

ii. Inefficient appliances such as electric hot plate that are not allowed in the hostel should be listed in the hostel rules and regulations and given to students before they are admitted into the hostel.

iii. The external lighting should be controlled automatically using light sensing devices such that they are off in the day time and on at night.

iv. The university should set up an energy audit committee with representatives in each hostel. These representatives should ensure energy saving habits for areas such as common room, kitchen, toilet and bathroom. These representatives could be among the porters or security personnel so as to avoid any cost in hiring new staffs.

v. The University's metering system should be decentralized to enable effective monitoring of consumption pattern for each block of building in the school.

vi. As a preventive measure, the University management should ensure that architectural designs for future structures take full advantage of natural daylight. This will eliminate the need for interior lighting during the day.

vii. Electrical energy audit should be conducted for other parts of the institution to uncover areas of waste and potential savings.

REFERENCES

Aderemi, A. O, Ilori, M. O, Aderemi, H. O. and Akinbami J. F. K (2009). Assessment of electrical energy use efficiency in Nigeria food industry. African Journal of Food Science Vol. 3(8), pp. 206-216

Adekunle, O. A., Olatunde, D., Sunday, A. O., Akinwale B. A. and Allen, O. A. (2008). A Survey on the Energy Consumption and Demand in a Tertiary Institution. Maejo International Journal of Science and Technology, **2**(02): 331-344.

Aletia, R., Fatema, M., Mongiwa, M., Natalie, K. and Zukiswa, K. (2007). An investigation of the consumption of electrical energy in the Rhodes University residential system. Environmental Science Journal, **302**(2007): 1-20.

Akpama, E.J., Okoro, O.I. and Chikuni, E. (2009): Energy Audit/Assessment in the Cross River University of Technology, Calabar, Nigeria. Proceedings of Domestic Use of Energy Conference, Cross River University of Technology, Calabar, 2009, pp.131-135.

Akinbami, J. and Lawal, A. (2009). Opportunities and Challenges to Electrical Energy Conservation and CO2 Emissions Reduction in Nigeria's Building Sector. Fifth Urban Research Symposium 2009, Nigeria, p. 11.

Awah, C. C. and Okoro, O. I. (2010). Energy Audit at Michael Opkara University of Agriculture, Umudike (MOUAU): A Need for an Energy Efficiency Programme.

Barnley L. C.: Load Reduction Factors, http:/www.ise.ufl.edu/diversity.doc, retrieved on 18th August, 2012.

Cavallo, J. (2000): Targeting Refrigerators for Repair or Replacement, ACEEE's Summer Study on Energy Efficiency in Buildings.

Chikku, A., Mel, G., Victor, J. and Sharath, D. (2008). Energy Audit of IIT-Bombay Campus. 1st Year M.Tech Students of the Department of Energy Science and Engineering, IIT-Bombay, India.

CREDC (2009). Energy Efficiency Survey in Nigeria, Community Research Development Centre, Benin City.

Department of Planning & Development (2008): Do-It-Yourself Energy Audit Manual. City of Seattle Printing Office.

European Commission (2005). The European Green building programme Energy audit guidelines Version 1, Directorate-General JRC Institute for environment and sustainability Renewable energies unit.

Otegbulu, C. A. (2011). Energy Efficient Practice: A Focus on Residential Households. Department of Estate Management, University of Lagos.

Okafor, E.E. (2008): Development Crisis of Power Supply and Implications for Industrial Sector in Nigeria. Stud Tribes Tribals, **6**(2): 83-92.

Okoro, O.I., Chikuni, E. and Oluseyi, P.O. (2008). Introducing an Energy Efficiency Awareness Programme at the University of Nigeria, Nsukka (UNN), Industrial & commercial use of energy conference 2008, pp 99-103.

Suresh, K. K. S(2009). Electrical Energy Conservation & Auditing in Plant Electrical Distribution System. Department of Electrical Engineering R.E.C Calicut.

Zenebe, M. D. (2010). Interactive Web-Based Guideline for the Efficiency of Household Electric Power Consumption. Aalto University.