A SURVEY OF HOUSEHOLDS ELECTRICITY CONSUMPTION OF END-USE APPLIANCES IN NIGERIA

E. Uyigue, J. Yapp, B. Lebof and M. Odele

United Nations Development Programme, Plot 617/618, Diplomatic Zone, CBD District Abuja, Nigeria,
etiosa.uyigue@undp.org; etiosa.uyigue@gmail.com

ABSTRACT

A study was conducted to determine the electrical energy consumption of selected end-use appliances in residential houses in Nigeria. The end-use monitoring study was undertaken in the Federal Capital Territory, Abuja to assess the current level of energy efficiency of lighting appliances, refrigerators and air conditioners. A total of 35 households were monitored. The households were selected at random based on their income status. Data logger devices such as serial watt meters, *Multivoies* (watt meter with six pliers), lamp meters and temperature sensors were used to measure energy consumptions and energy related parameters for a period of 30 day from each household. Data obtained showed that electricity supply was available for 63% of the monitoring period and power outage accounts for 37% of the period. A total of 51% of the houses had air conditioners installed in them with an average power consumption of 1387kWh/annum. A total of 37% of the houses had fridge-freezers cooling systems with an average energy consumption of 698kWh/annum. Deep freezers were found in 46% of the households; the average energy consumption of deep freezers was 756kWh/annum. The average annual consumption of fridges was 420kWh/annum. The study revealed that power supply to the houses was unstable. Air conditioners were the most used appliances in most of the houses monitored and had the highest annual consumption. The average annual electricity consumption in Nigeria households is much higher than those in European countries where a similar study was conducted.

Keywords: Electricity, Energy, Efficiency, Consumption, Lighting

1.0 INTRODUCTION

With a population of well over 160 million people, only about 40% of Nigerians have access to electricity. In places where there is access to electricity (mainly in the urban areas), consumers of electricity suffer from frequent power outages which last for several hours. The survey conducted in three large cities in Nigeria – Abuja, Lagos and Benin City[1] revealed that over 80% of those interviewed do not get electricity supply for up to 24 hours a day as shown in Fig. 1. The grid-generated electricity is inadequate for the population; as at August 2012, the peak generation was 4,477.7MW[2]. The inadequate and unstable supply of electricity in Nigeria have forced a large portion of the industry, businesses and households to rely on diesel and petrol generators as primary or back-up source of electricity. Moreover, a large part of the energy generated is wasted from the use of inefficient appliances and wasteful human behaviour.

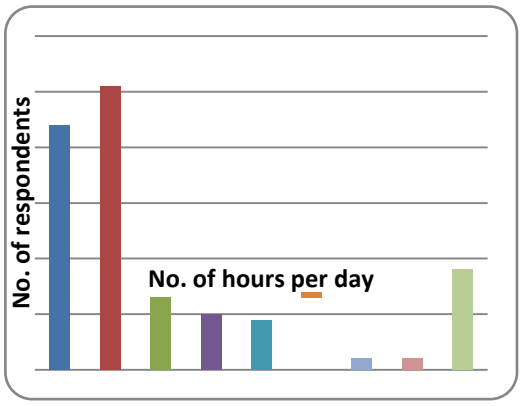

Fig. 1: The number of hours respondents get electricity per day [1]

Wielet al [3] reported that energy consumption contributes to about 25% to 30% of energy-related CO_2 emission, accounting for 26% of all anthropogenic CO_2 emission and 14% of global net contribution to climate change from greenhouse gases. Similarly, Price et al[4] reported that the use of energy in human activities related to buildings, including the use of appliances, equipment and lighting accounts for 42% of total energy consumption (including the use of biomass) and 36% of total energy related CO_2 emissions. The study further reported that the industrialized countries consume half of this energy, while the remainder is consumed by the rest of the world. CLASP[5] asserted that improving energy efficiency in the residential, commercial and building sectors will help to save money, reduce pollution and improve the indoor environment of homes and productivity in commercial buildings.

Promoting energy efficiency best practices is particularly relevant for the Nigeria power sector. This has the potential to reduce electricity demand and free more power which can be made available for more Nigerians. With support of the UNDP and the Global Environment Facility, the Energy Commission of Nigeria (ECN) and the National Centre for Energy Efficiency and Conservation (NCEEC) inaugurated a programme[6] to promote energy efficiency best practices in Nigeria. Part of the objectives of the Programme was to put in place a minimum energy performance standards (MEPS) for end-use appliances and introduce energy labels. Before MEPS are developed, it is imperative to understand the base line energy consumption and the level of efficiency of existing appliances. MEPS are mandatory standards and are done in a manner that they balance technical possibility with economic viability and the competitive forces within a particular market.

The objective of the study was to assess the current level of energy efficiency of selected appliances (lighting, refrigerators and air conditioners) used in Nigeria. The study also monitored the total household electricity usage. This paper therefore will give the preliminary report of the end-use energy monitoring study which was conducted in the six geopolitical zones of Nigeria. It will also share the progress made so far as well as share the success stories and lessons learnt. The study is on-going, thus the paper will present the report of the study that was conducted in the Federal Capital Territory, Abuja. (Fig. 2) the report of the study that was conducted in the Federal Capital Territory, Abuja. (Fig. 2)

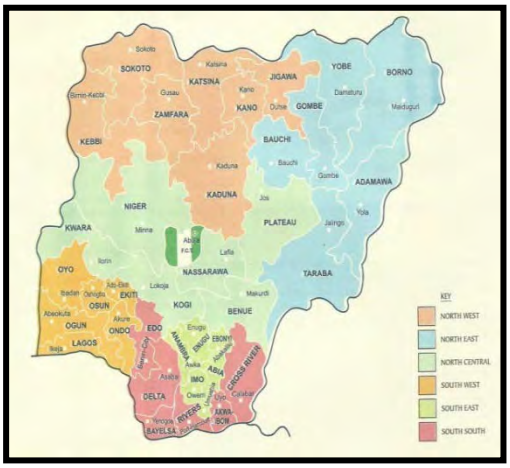

Fig. 2: Map of Nigeria showing the six geopolical zones and the Federal Capital Territory, Abuja

2.0 METHODOLOGY

Energy data were collected from Abuja, the Federal Capital Territory of Nigeria. A total of 35 households were monitored during the study. The criteria for choosing households include the size of the family and the socio-economic status such as the income level. The Study Team collected data using different electronic data logger devices for a period of 30 days from each house. Data logger devices are

small devices used to measure regular interval the electric consumption of different appliances. Three different data logger devices were used for monitoring during the study. They include *Serial Wattmeter,* which was designed to measure the active energy and voltage for single-phase appliances with power level lower than 2.6 kW.

The device was placed between the standard socket-outlet (design to accommodate voltage from 0-250 V) and the plug of the appliance to be measured. The serial wattmeter is entirely autonomous and can be left to monitor anyappliance for several months according to the frequency of the selected data memory - memory can record data for up to 13 months. At the end of the measurement period, the data recorded were read using the Oscar software which transferredthe data to a computer for analysis. One serial watt meterwas used per appliance. The serial wattmeterswere used to collect data from refrigerators and some lighting appliances.

Multivoies Meteris a device designed for the measurement of a large number of channels of power consumption and energies from electrical switch boxes. It includes a din rail mounted concentrator to measure voltages and supplied power to the system, and several modules equipped with current sensors. The memory of the Multivoies can collect data for up to 4 months. If recording is required for more than 4 months, the device can be reset to collect more data. The Multivoies system can interface with Personal Data Assistant (PDA) using infrared communication or low power radio (Bluetooth). The Multivoies meter helped to collect the total consumption from the household, energy consumption from air conditioners and lighting equipment that were not connected to wall socket. The average voltage per ten minutes was recorded with the multivoie system to detect the periods with and without power supply.

Electronic thermometers were installed in all the houses monitored to provide information on the temperature changes during the time of measurement. The thermometer is an autonomous electronic data logger of reduced size provided with temperature sensor. It takes regular measurements and stores at interval between each measurement. The thermometer has a very broad range of measurements (-50°C to 120°C).The data were stored in a non volatile memory of strong capacity (64kb) allowing a recording going up to 65,000 measurements (1 byte per data, for an autonomy of approximately 1 year and 3 months for recordings with the step of 10 minutes).

There were several challenges encountered during the entire monitoring period. The electrical connections in many of the houses that were selected to collect data were faulty; there were cases where the neutral terminal of some houses had a measureable amount of voltage. Where such anomalies existed, the data logger devices could not be used. This problem resulted in lengthening the time to collect data as the Project Team spent more time to look for houses where the electrical connection were properly done. Furthermore, the illegal practice of bypassing meters was found in some of the houses that were selected for the study. In such houses, it was difficult to use the data logger devices especially the Multivoies Meter. Many of the data logger devices were damaged during the monitoring period. Several reasons might have been responsible for this; voltage fluctuation and the use of generators during the period of power outage.

There were many cases of errors between the configuration, installation and the dismantling of data logger devices. Hence, about 20% of the data logger devices were unusable. Moreover, the distribution boards found in many of the houses were complex. There were no labels on the different circuits in the

distribution board; as a result, the Project Team had to check manually all fuses to trace the line to any appliance. In some cases it was quite difficult to fully identify all appliances connected to a specific electrical circuit. Finally, there was the problems due to security, religious and traditional practices. In many of the houses, the Project Team was not given full access to every part of the house during installation of the data logger devices and as a result, it was difficult to fully measure the consumption of all the appliances. The power outages had influence on the report when calculating the average annual consumption of an appliance that is switched off for half of the time because there was no power supply will certainly consume less energy as the appliance with a stable electricity supply.

3.0 RESULT OF STUDY

The study revealed that the power supply to the houses was unstable, thus they do not receive continuous supply of electricity. Fig 3 shows the percentage of power access and power outage. On the average, electricity supply was available for 63% of the monitoring period and power outages accounted for 37% of the period.

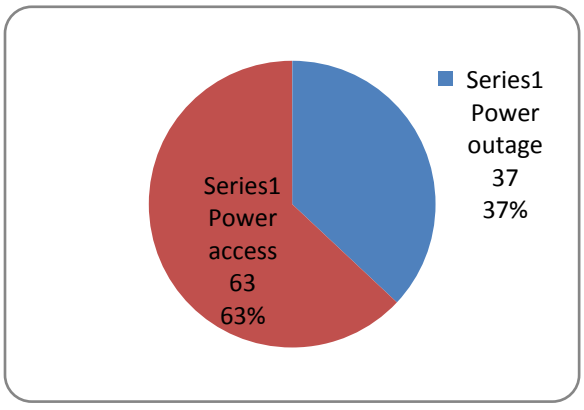

Fig. 3: Power access and power outage in Abuja

51% of the households in Abuja had air conditioners installed in them. Fig. 4 shows the highest energy consuming air conditioner was 3307 kWh/annum while the lowest was approximately 92 kWh/annum which give anaverage of 1387 kWh/annum.

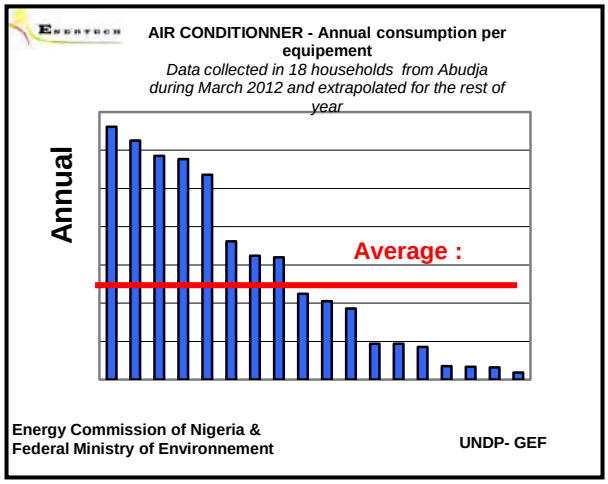

Fig 4: Annual consumption of air conditioners monitored in Abuja

Many of the houses monitored have one or more of the following appliances – fridge-Freezer (having both a fridge and freezer compartment), Fridge (only fridge compartment) and freezer (having only freezer compartment). A total of 37% of the households had fridge-freezer cooling systems. The average annual consumption for fridge-freezer was 698 KWh/annum; the highest consumption was 1,230 KWh/annum while the lowest was 427 KWh/annum. (Fig. 5)

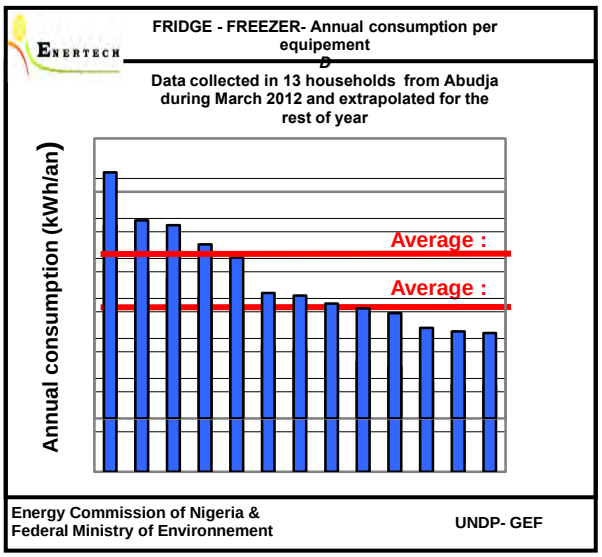

Fig. 5: Annual consumption of fridge-freezer monitored in Abuja

Freezers (popularly called deep freezers) were found in 45% of the households. The average annual consumption for freezers was 756 KWh/annum, the highest consumption was approximately1318 KWh/annum, while the lowest was 212.50 KWh/annum. (Fig. 6)

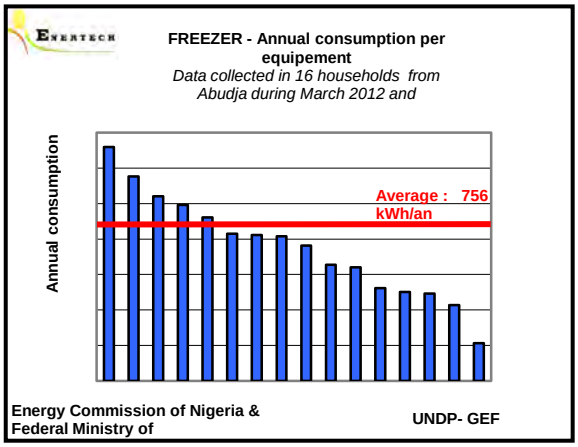

Fig. 6: Annual consumption of freezers monitored in Abuja

Sixteen (16) fridges were monitored during the study and the average annual consumption was 420 KWh/annum; the highest reading was 941 KWh/annum and the lowest was 125 KWh/annum. (Fig. 7)

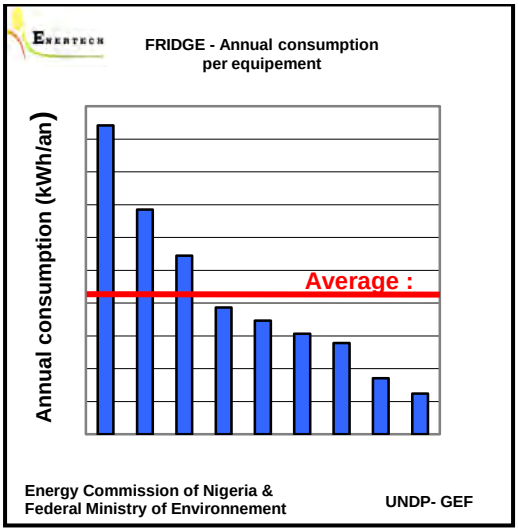

Fig 7: Annual consumption of fridges monitor in Abuja, Nigeria

4.0 DISCUSSION

The study in the Nigeria Federal Capital Territory revealed that the energy consumption of appliances is very high compared to countries where energy efficiency measures have been put in place. Similar studies have been carried out in many countries in Europe. These countries include France, Sweden and England. Compared to these countries in Europe, the average annual consumption of fridges, fridge-freezers and freezers in Nigeria is the highest. The lowest consumption of energy was recorded in England.

Table 1: Average annual consumption for Nigeria and European countries

	Annual consumption per equipment (kWh/an)		
Country	**Fridge**	**Fridge-freezer**	**Freezer**
FRANCE 2007	253	460	556
SWEDEN 2007	225	469	470
ENGLAND 2011	162	427	344.5
NIGERIA 2012	**420**	**698**	**756**

Table 1 also revealed that the average annual consumption for cool appliances in European countries decreases with time. From the study conducted in France in 2007, the average annual consumption of fridge, fridge-freezer and freezer was 253, 460 and 556 Kwh/annum respectively. The study conducted in England in 2011 (about four years after the study in France) reveal a considerable fall in the annual energy consumption of domestic cold appliances. This may be as a result of several energy efficiency measures such as standard and label which have been introduced in many European countries. From the study in France and the study in England, there was 36%, 7% and 38% decrease in average annual consumption for fridges, fridge-freezer and freezer respectively.

The preliminary study in Abuja,Nigeria compared to the study in England revealed that the average annual consumption recorded in the current study are significantly higher than that recorded in England. For instance, the study revealed that the average annual energy consumption for fridge, fridge-freezer and freezer for Nigeria was 61%, 39% and 54% respectively higher compared to England. This calls for the need to embark on energy efficiency programmes in Nigeria. This further justifies the objective of the on-going Nigeria Energy Efficiency Programme, on the need to introduce measures to promote energy efficiency in end-use appliances.

5.0 CONCLUSION

When compared to other countries where similar studies have been done, the average annual energy consumption of cold appliances in Nigeria is the highest. This implies that the energy efficiency of cold appliances inNigeria is low compared to those of these countries. The results of this study further justify the need to put in place energy efficiency measures to reduce electricity demand of the end users. The use of regulatory instruments such as mandatory minimum energy performance standards (MEPS) can help to improve the energy efficiency of cold appliances. Since MEPS have to be developed empirically, the result from this study will provide the required information to the relevant agent of government to set up the appropriate energy performance benchmark suitable for cold appliances in the Nigeria market.

APPRECIATION

The authors of this paper extend their gratitude to the Global Environment Facility (GEF) and the UNDP Nigeria Country Office for providing the financial support to embark on this study. The technical support of the Energy Commission of Nigeria and the National Centre for Energy Efficiency and Conservation is highly appreciated.

REFERENCES

[1] CREDC 2009. *Energy efficiency survey in Nigeria: a guide for developing policy and legislation*. A publication of Community Research and Development Centre.www.credcent.org

[2] Daily Times, August 15th, 2012

[3] Wiel, S., Martin N., Levine M., Price L. and J. Sathaye 1998. *The role of building energy efficiency in Managing atmospheric carbon dioxide*. Environmental Science Policy. 1:28-29

[4] Price, L., S. De la Rue du Can, E. Worrell, and J. Sinton. 2005. Sectoral Trends in Global Energy Use and Greenhouse Gas Emissions. Berkeley, CA, Lawrence National Laboratory, LBNL – 56144.

[5] CLASP (2005). Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment and Lighting (2nd Edition). A publication of the Collaborative Labelling and Appliance Standard Programme, Washington D.C., USA

[6] UNDP/GEF 2011. *Promoting energy efficiency in residential and public sector in Nigeria*. Project Document.www.thegef.org