An Investigation into the Utilisation of Energy Saving Lamps in Residential Buildings−A Case Study of Lagos Nigeria

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***Abstract*—Electric energy providers all over the world are continually promoting energy efficiency among consumers. An activity that influences everyone is limiting the use of traditional incandescent lamps by replacing them with energy-saving lamps (ESLs). This study assessed the current level of ESLs household acceptance and identified ways to increase the awareness among users. Samples for this study were collected from Ikeja and Mushin districts in Lagos state. The research was carried out by surveying 200 residential houses with a questionnaire administered in the two districts using a random sampling survey technique. The data obtained from these two populations were subjected to analysis to determine the interpenetration level of ESL. The results showed that ESLs, though widely used in Ikeja, had not sufficiently replaced incandescent and tube fluorescent lamps. In Mushin, the incandescent lamp was still practically in use in homes more than tube fluorescent lamps and ESLs.**

***Index Terms*--CFL, fluorescent lamp, energy efficiency and utilisation, incandescent lamp, LED lamp.**

I. INTRODUCTION

The use of artificial lighting is on the rise worldwide and the usage is quite varied among different people of the world. The demand for electric-based lighting is growing in developing countries making the hitherto common situation whereby much of the population use fuel based-lighting to be gradually fading out. Electric lighting consumes about 19% of the world total electricity use [1]. The total power generated in Nigeria is still grossly insufficient for the population and the lion share of the meagre power is consumed by households more than industrial and commercial centres [2]. Residential sector account for 67% of energy consumption [3]-[5] and a large amount of this goes to lighting.

As improvements in energy-efficient lighting are achieved, the socio-economic growth in developing countries in the long run improves. Changes in technologies, in customers' consumption behaviour and lifestyle, have definite impacts on global energy consumption and invariably on the environment. Therefore, efforts at saving energy in lighting, and the various methods employable in achieving this goal should be embarked on at different levels (State, region, town, enterprise) and by multinational organizations.

Electric energy is the most important form of energy for socio-economic growth Lagos State utilizes the largest percentage of the power generated in Nigeria [6] yet there is much more energy wastage in the state.. The State at present consumes upwards of 50% of all electricity produced within Nigeria, but still, have low per capita consumption in comparison to other similar cities. All parts of Nigeria suffered inadequate electricity proportionately, but the Lagos scenario is worst because the State contains almost 60 per cent of the country's industries and consumes about one-half of the total electric power generated [7]. Given the perennial energy insufficiency, Lagos would have been doing much better if measures at energy conservation are being taken. This state has more residents and they widely use the traditional incandescent lamps. Apart from the incandescent lamps being a source of energy wastage, they do not last and this adds to energy cost when replaced. An average household dedicates about 5% of its energy budget to lighting [8]. Thus, switching to energy-efficient lighting is one of the fastest ways to cut energy bills.

The incandescent lamp has been phased out in many parts of the world. Despite this phasing out and subsequent replacement with CFL and LED lamps around the world, it has been discovered that the incandescent lamps appeared to be very much in use in the Nigeria residential areas. There is the need to investigate how much of this lamp is in use and how far has it been replaced with energy-saving lamps (ESLs) in Nigeria. Thus the objective of this study is to investigate the level of penetration and acceptability of ESLs in Lagos State and by extension Nigeria as a country. It is aimed to find out how residential areas adopt the use of the ESLs such as CFL and LED in replacement to all other lamps such as incandescent, and the magnetic ballast tube fluorescent lamps in Ikeja and Mushin residential areas of Lagos State.

Ikeja city is situated in Ikeja Local Government Area of Lagos State, Nigeria and is the capital of the state. It is one of

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the most developed metropolitan urban areas of the state. The city also plays host to several industrial estates both light and heavy industries. The sample for the study was taken from the residential areas of the city. Mushin town, on the other hand, is situated in the mainland of the state and is predominantly rural in setting. The town is largely residential and plays host to vast commercial and industrial activities. The local government is one of the most populous in the State. Samples were also obtained from the Mushin residential areas for this study.

There are several factors that influence homeowners' investment into the usage of ESL and energy efficiency generally. Such factor identified in the literature include homeowners awareness level regarding energy efficiency [9],[10], age of the building [11], energy cost [12], household income and economic motivation [13]-[17] behavioural pattern [18],[19] and environmental factors [20],[21]. Many of these factors play a significant effect on the usage of ESL lamps in Nigeria and especially Lagos. This study, however, focuses on how much usage of these modern lamps has been embraced given the several conditions that influence their usage.

II. LITERATURE REVIEW

The first practical commercial electric lamp was developed and tested in 1879. That lamp used a voltage of about 110 V and that became the first commercially available incandescent lamp. It was constructed of a wire filament placed in glass bulb heated by electricity causing it to glow and give off light. The lamp works in so much similar way as an electrical heater and thus more than 90 percent of the energy produced by incandescent lights is heat, not light [22],[23] and such light bulbs convert less than 5% of the energy they use into visible light with standard light bulbs averaging about 2.2%.

A replacement to the incandescent lamps was made by the production of the tube (magnetic ballast) fluorescent. The parent to this type of lamps was invented in the late 1890s by Peter Cooper Hewitt [24]. In 1980, Philips introduced its model with an integral magnetic ballast. This was a screw-in lamp that used a folded T4 tube, stable tri-color phosphors, and a mercury amalgam. It was the first successful screw-in replacement for an incandescent lamp. In 1985, the first CFL to include electronic ballast was produced [25].

The typical luminous efficacy of CFL lamps is 60 to 72 lm/W giving around 9 to 11% efficiency while normal domestic incandescent lamps have an efficacy of 13 to 18 lm/W giving about 1.9 to 2.6% efficiency [22]. The efficiencies of various artificial lamps are shown in Fig. 1 where it is seen that the incandescent lamp has the least efficiency and LED the highest. However, despite how much desirable the CFL is in saving a large amount of energy, it has its attendant harmful effects to the environment. These effects include toxic element, toxic fumes, fire hazard, and health hazard [26]. To combat such harmful effect to health and the environment and still obtain far higher energy savings, LED

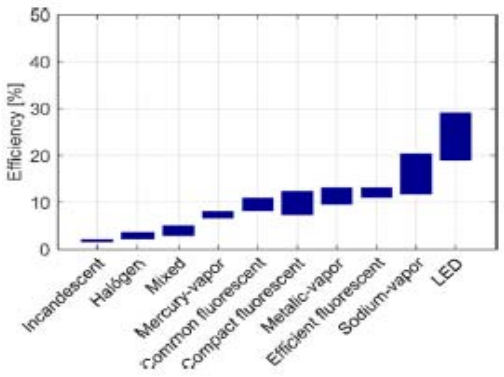

Fig. 1: Comparative efficiency of various lamp efficiency [27]

lamps have been developed. The various lamps considered in the study are shown in use in Fig. 2.

The first LED was independently created by Oleg Vladimirovich Losev in the mid-1920s although his research was ignored at that time. In 1962, Nick Holonyak Jr. developed the first practical visible-spectrum LED [28]. By 1990, LEDs of one lumen output were available. In 1993, the first high-brightness blue LED created was created by Shuji Nakamura. This was followed in 1996 by the development of Phosphor White LEDs, which combined a blue or ultraviolet LED with a phosphor coating that produced white light. By 2005, output levels of 100 lumens were possible. White light LEDs became available in various shades. LEDs began competing with conventional light sources and fixtures in general illumination applications. LED light output has improved by 35%/year, while the cost has dropped by 20%/year. It does not produce infrared, (IR) radiation and no ultraviolet, (UV) rays. The lamp is mercury-free and can operate in cold environments while withstanding impact and vibrations [29]. Thus LED holds the key to safe, energy-efficient lighting in the future.

Given in Table 1 is the comparison of the various lamps considered in terms of their efficiency and energy consumption while Table 2 shows the typical lifespan and cost for each considered lamp. As can be observed from Table 2, the CFL has a lifespan ten times that of the incandescent, so apart from saving more energy, it also saves more money in the long run although its capital cost is about 10 times that of the incandescent lamp and the LED is far better than that.

III. METHODOLOGY

To realise the objective, of this research, a survey of 100 randomly selected houses each in the two chosen locations of Ikeja and Mushin of Lagos State was carried out using stratified random sampling. Ikeja and Mushin areas were chosen to have an urban area and a rural area represented in the study community. The choice of Ikeja and Mushin also ensured that two different LGAs in the State were covered in the study.

Fig. 2: Various lamps considered for the study shown in use

Table 1: Electrical power equivalents for different lamps [30]

Minimum light output (lumens)	**Electrical power consumption (W)**		
	Incandescent	**Compact fluorescent**	**LED**
450	40	9–11	6–8
800	60	13–15	9–12
1100	75	18–20	13–16
1600	100	23–28	15–22
2400	150	30–52	24–28
3100	200	49–75	30
4000	300	75–100	38

Table 2: Lifespan and cost for the lamps considered

Lamp Type	**Cost (₦)**	**Lifespan (hr)**
Incandescent	100	1,000
Fluorescent	1,200	15,000
CFL	1,000	10,000
LED	1,200	30,000

A questionnaire was developed and self-administered, with a 100% response rate, to obtain information from an adult resident in each of the 200 sampled households of Ikeja and Mushin. The primary data was collected through pen and paper by directly interacting with each respondent in their home. A survey of 100 households in each of Ikeja and Mushin was thus carried out.

The questionnaire was developed based on an informal survey from expert advice, interaction with consumers, and technical requirements. It is a well-structured questionnaire to elicit the required information from the respondent. The key questions included the numbers of bedrooms in an apartment, numbers of various lamps under study available in the apartment, the usage (installed and operating), and the average monthly electricity bill for each apartment.

The study was carried out on buildings using lighting units with incandescent lamps, tube fluorescent lamps, CFL and LED lamps. For this study, the CFLs and LEDs are regarded as ESLs, considered together and treated as one group of lamps while the magnetic ballast fluorescent lamp is referred to simply as fluorescent for the sake of analysis. Other electrical loads in the buildings were not considered and their possible effects on the lamps are ignored. The types of apartments popular in Nigeria were grouped into three for the study. They are 2-bedroom flat, 3-bedroom flat and those with 4 or more bedrooms flats including multiple room apartments locally referred to as *face-me-and-face-you* apartments. The data collected were analysed using descriptive statistics.

IV. Results

Table 3 and 4 give the frequency of the type of apartments encountered in the survey in Ikeja and Mushin respectively. The tables show that there are very good mix of the three types of apartments. Tables 5 and 6 provide a summary of the total number of bulbs used in all the apartments in Ikeja and Mushin respectively.

Figs. 3 and 4 give the percentage of the lamp usage in Ikeja and Mushin sampled apartments respectively. As seen in Fig. 3, that ESL has wide acceptance in Ikeja with a total of 63 % recorded. Also, the ballast fluorescent type of lamp registered up to 10% of the total bulbs use and the incandescent lamps accounted for the remaining 27 %. It is observed (Fig. 3) that for Mushin, the ESL accounted for 36 % of all lamps use, the ballast fluorescent and the incandescent lamp accounted for 16 % and 48 % respectively of all lamps usage.

V. Discussion of Results

The ESL lamp is gradually getting acceptance in the study area of Ikeja as many households now utilize it. As seen in Fig. 3, 63% of all lamps used were ESLs. However, incandescent and ballast fluorescent lamps are still very much in use (a total of 37 %). The ballast fluorescent is prone to

flickering when operated under low voltage thus resulting in gradual burnout of the lamp. The starter device (starting switch) incorporated in the fluorescent lamp over time gets weak and also often contributes to non-starting of the fluorescent lamp. When many of these non-starting fluorescent lamps are put on, the ballast coil remained connected to power and consumes up to 8 % of the power rating for the lamp. Thus, the fluorescent lamp remains one major source of energy wastage. Additionally, the ballast fluorescent lamp takes more power than CFL for the same lumen output. In the study area of Ikeja, the fluorescent lamp constituted 10% of all lamps in use. That portion of all lamps used can be effectively replaced with ESLs to achieve a further reduction in energy wastage.

Table 3: Frequency table of Participants in Ikeja Lagos

Participants	Frequency	Percent	Cumulative Percent
2 Bedrooms	25	25	25
3 Bedrooms	54	54	79
4 Bedrooms+	21	21	100
Total	100		

Table 4: Frequency table of Participants in Mushin Lagos

Participants	Frequency	Percent	Cumulative Percent
2 Bedrooms	40	40	40
3 Bedrooms	36	36	76
4 Bedrooms+	24	24	100
Total	100		

More importantly, the incandescent lamp still constituted a whopping 27% of all lamps used in Ikeja sampled residences. The lamp is still very much available to householders and although Ikeja is a more metropolitan area than Mushin, the households still use this huge percentage. The other concern about the incandescent lamp is that it comes in very high power ratings from 40 W up to 200 W. Householders use all the various power ratings to obtain a varying level of illumination. This is partly due to the cheap cost of the lamps and partly due to ignorance on the part of consumers. If all households in the sampled households in Ikeja replace all the incandescent lamps with ESLs, there can be up to 21.6 % (80% of 27 %) further saving in energy used.

As portrayed in Fig. 4, ESL (CFL and LED) have not penetrated the Mushin sampled residences as much. Incandescent lamp (48 %) still took the lead in lamps used followed by ESL having 36 % while fluorescent lamps constituted only 16 %. That gave a total of 64 % of non-ESL lamps usage. It means that non-ESL use was still the order of the day in the Mushin area. This is expected for a rural area such as Mushin. Compared to Ikeja residences, more households use the fluorescent and the incandescent lamps in Mushin. This high usage of incandescent lamps in Mushin can be attributed to low income of the majority of residents as is revealed in the type of houses they live in. Furthermore, a lack of awareness of the Mushin residents can be a contributory factor. This is subject to further studies to establish possible causes. If all households in the sampled households in Mushin replace all the incandescent lamps with ESLs, there can be up to 38.4 % (80% of 48 %) further saving in energy used. Replacement of all fluorescent lamps with CFLs or LED lamps will also go a long way as they constituted a whole 16 % of all lamps used. This result can be useful in policy making and energy planning.

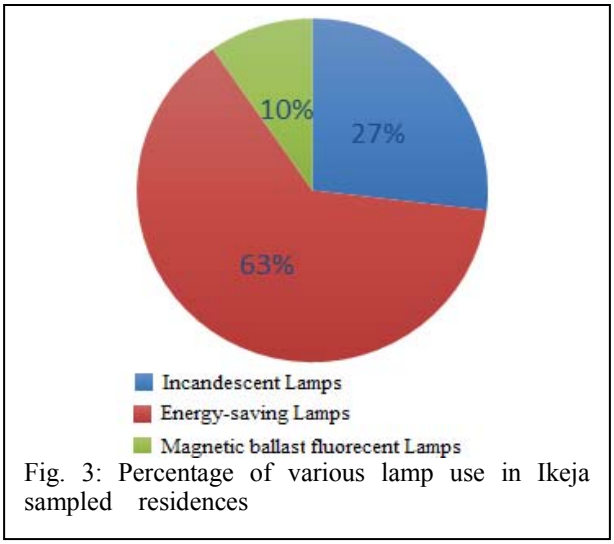

Fig. 3: Percentage of various lamp use in Ikeja sampled residences

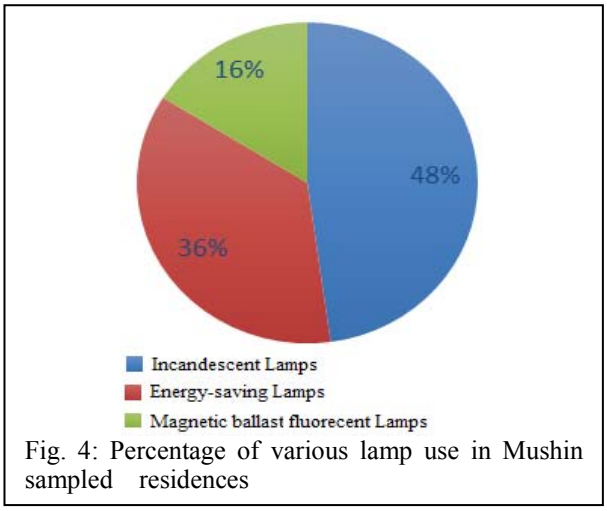

Fig. 4: Percentage of various lamp use in Mushin sampled residences

VI. CONCLUSIONS

This study showed that ESLs, though widely used in Ikeja, had not sufficiently replaced incandescent and fluorescent lamps in the area while in the district of Mushin, the incandescent lamp was still practically in use in homes more than fluorescent lamps and ESLs. The ESLs can produce the same amount of light (lumens) as a traditional incandescent lamp while using significantly less energy. Thus, when the traditional incandescent lamps are replaced with the energy-savers, the consumer pays less to get the same amount of light. But there appears to be lack of necessary awareness in this

regard. The ESLs also last significantly longer than traditional incandescent lamps, so there is no need to replace them as often and will keep saving into the future. Switching to energy-saving bulbs will reduce the growth of Nigeria's energy demand and avoid carbon emissions at the same time helping consumers to save more in the long run.

To achieve this goal, an awareness campaign should be embarked upon by necessary government agencies to educate energy consumers in the sample areas and by extension, the Nigeria residential sector. Further, there should be a governmental policy proscribing the importation and manufacture of the energy-wasting lamps (ballast fluorescent and incandescent lamps). The developed countries have done this to phase out such wastage of energy from such avoidable means. Nigeria can take a cue from them. The government should also give necessary incentives to the manufacturers of ESL and LED lamps to establish their plants in Nigeria. This will reduce the cost of the devices and encourage more buyers to invest in them.

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