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Factors Influencing the Usage of Compact Fluorescent Lamps in Existing Residential Buildings in Lagos, Nigeria

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ABSTRACT: Nigeria as a developing nation is facing increasing demand for electricity especially in the residential areas. The use of compact fluorescent lamps (CFLs) is one of the several measures towards reducing the demand. However, in Nigeria, the use of CFLs is low. The present study was designed to investigate some factors responsible for the low usage of CFLs in Lagos, Nigeria. Questionnaires were administered by hand on 984 households, selected through systematic random sampling techniques from 5 local government areas in Lagos State. The first building along the major street in each of the local government was selected randomly and every tenth building constituted the sample. A household head was surveyed in each of the building selected, and was asked to rate some factors that might have influenced the usage of CFLs. The data generated from the questionnaire were analysed using ranking method. The findings show that inability to measure the saving benefits of CFLs on electricity bills, lack of affordability and high initial cost of acquisition and installation were the most important factors which influence the use of the CFLs. The study concludes by providing some recommendations on how to achieve sustainable energy management in the Lagos and beyond through more efficient residential house lighting.

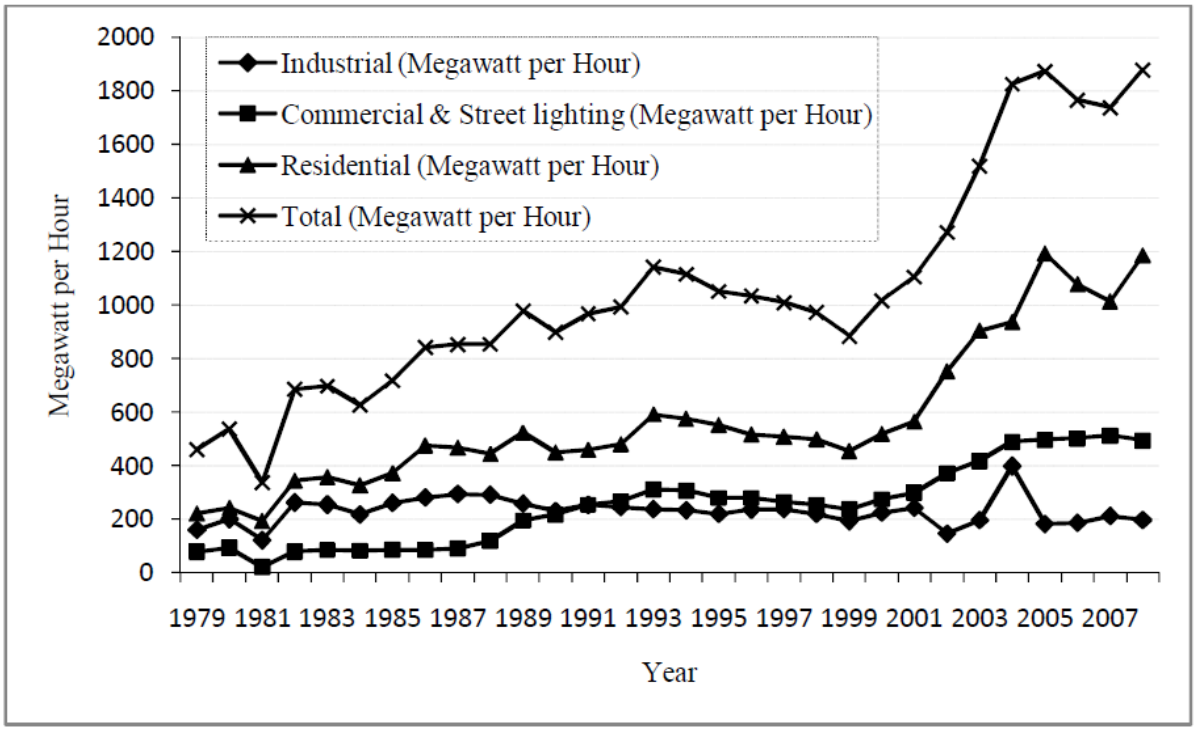
Keywords: Electricity; Energy usage; Energy Efficiency; Incandescent Bulbs; Compact Fluorescent Lamps
JEL Classification: Q

1. Introduction

In spite of the slow growth in economic activities in recent years, the demand for electricity in Nigeria has continued to increase (Ibitoye and Adenikinju, 2007; Subair and Oke, 2008; Akinlo, 2009; Adaramola and Oyewola, 2011). Nigeria has electricity peak demand of 2,000 GWH of electricity per day (United Nation Development Programme, 2010). Of this electricity demand, residential buildings consume the highest Megawatt per hour of electricity than industrial and commercial buildings (Central Bank of Nigeria, 2009). Electricity Consumption Pattern in Nigeria for 1979-2007 period in given in figure 1.

According to Dineen and Gallachóir (2011), the residential areas offer significant opportunity for improved energy efficiency. Gujba et al., (2011) identified that the Nigeria Government has focused on the economic and technical viability within its own means to develop its energy plans and policies and has not seriously considered and incorporated environmental and social issues in its plans. Investing in energy efficiency measures would help to achieve sustainable energy management especially in residential buildings (Community Research and Development Centre, 2009; Adaramola and Oyewola, 2011).

Figure 1. Electricity Consumption Pattern in Nigeria (1979-2007).



Source: CBN, 2009

Compact fluorescent lamp (CFL) is a kind of energy efficient lamp which consumes much less of energy than incandescent bulbs (ILs). CFLs are simply miniature version of full-sized fluorescent. The usage of CFLs instead of incandescent bulbs (ILs) in residential areas offer significant measures through which Nigeria can achieve sustainable energy management in the residential areas. A considerable body of research exists on the technical benefits of retrofitting ILs with CFLs. For instance, Casillas and Kammen (2011) stipulated that the CFLs installation provided the most attractive financial investment, with an internal rate of return (IRR) of 528%. Bertoldi and Atanasiu (2006) also reported that the payback for switching from ILs to CFLs depends on the initial purchasing costs, the cost of electricity, and the rate of use. The authors opined that the evidence that the payback is typically less than a year is unambiguous to identify. Xing, Hewitt and Griffiths, (2011) opined that the replacement of inefficient lamps is usually the first choice for low carbon refurbishment due to the fact of a significant reduction in electricity usage with relatively cheaper means. Furthermore, CFLs consume 1/4th to 1/5th of the energy used by incandescent light bulbs to provide the same level of light (Kumar et al., 2003; IEA, 2006; Waide, 2006). CFLs now fit the sockets of incandescent bulbs, which is an improvement that reduces cost of installation. Furthermore, about 25% of energy consumed by CFLs is converted to visible light compared with just 5% for a conventional incandescent lamp (Xing, et al., 2011). CFLs also have much longer lifetimes with rated life spans of 5,000 to 25,000 hours compared to 1,000 hours on average for incandescent lamps (IEA, 2006).

Globally, incandescent lamps are estimated to have accounted for 970 TWh of final electricity consumption in 2005 and given rise to about 560 Mt of CO2 emissions (IEA, 2006). About 61% of this demand was in the residential sector with most of the rest in commercial and public buildings (IEA, 2006). In the hypothetical case that all these lamps were to be replaced by compact fluorescent lamps (CFLs), cumulatively this would reduce global net lighting costs by USD 1.3 trillion from 2008 to 2030, and avoid 6.4 GtCO2 emissions at negative abatement cost.

In Nigeria, saving potentials of retrofitting ILs with CFLs have been estimated, Community Research and Development Centre (CREDC, 2009) opined, if a particular household using 20 incandescent bulbs of 60W decides to replace them with energy saving bulbs of 20W, instead of spending 1200W/h (20 x 60W) for lighting, they will be spending 400 watts per hour (20 x 20W). Thus this saves approximately 67% of energy for lighting alone. On a larger scale, if Nigeria as a country phase out one million incandescent bulbs and replace them with energy saving bulbs, the

country will be saving about 40MW of electricity. This is enough to provide electricity to many communities in Nigeria. If each of the 36 states and the FCT replace one million incandescent bulbs each, we can save up to 1480MW of electricity. In another project feasibility report by Global Environment Facility (GEF, 2010) towards promoting energy efficiency in residential and public sector in Nigeria, it was estimated that the replacement of 1 million energy inefficient incandescent of 60W light bulbs with more efficient CFL 15W will result in direct greenhouse gas emission reductions during the project's implementation phase of 4 years, direct greenhouse gas emission reductions totalling 92,000 tCO2e will be achieved from the energy savings (184,000 tCO2e or 0.184 MtCO2e over the lifetime of CFL (8,000 hours).

Sule et al., (2011), also investigated savings potential of retrofitting ILs with CFLs from University of Ilorin Government Reserved Area (GRA) quarters and Lower Niger River Basin staff quarters. The authors hypothesized that "the energy consumption before the installation of CFLs is not significantly different from energy consumption after the installation of CFLs". Results show that there were significant differences between the energy consumption before and after installations of CFLs, and about 40 per cent reduction in electricity consumption was achieved through the use of CFLs in the residential households.

Despite the proven benefits, the usage of CFLs has been puzzling slow all over the world (Menanteau and Lefebvre, 2000; IEA, 2006). According to IEA (2006), ILs represents the most commonly sold lamps in the world. ILs dominates retail lamp sales especially in the residential sector in most countries. The author estimated that 13.2 billion ILs were sold in 2003 representing over 72% of the global lamp market by volume that year. In contrast, CFLs sales in 2003 are estimated at 1.1 billion units, representing approximately 6% of the global lighting market by volume; the low sales invariably translate to low usage of CFLs. It is therefore worrisome that despite the introduction of CFLs in the early 1980's, the improvement in its functionality and the associated benefits, the usage of CFLs is still low.

A variety of factors from different countries have been advanced to explain this phenomenon. For instance, the upfront cost of purchase and installing CFLs is a deterrent to household usage of CFLs (Gadgil and De Martino Jannuzzi, 1991; Balachandra and Shekar, 2001; Kumar et al., 2003). A city size is also an important factor, which has been reported in literature as a factor supporting low usage of CFLs. Sandahl et al., (2006) opined that large cities may have a greater array on retail outlets, making it easier for households to find and purchase CFLs. Large cities may also have been differentially targeted by electrical utilities with information campaigns on energy-saving bulbs, given decreased transaction costs of such campaigns in high density areas (Sandahl et al., 2006). Information and awareness constraints have often been cited as a significant barrier to adoption of CFLs (Kumar et al., 2003; Sathaye and Murtishaw, 2004). Income or affordability and lack of guarantee of performance and where to purchase CFLs were other factors considered by (Kumar et al., 2003). Other factors found in literature are as follows: problem of disposal due to mercury content of CFLs; proliferation of sub-standard CFLs and difficulty in measuring the economic advantages of the usage of CFLs (Community Research and Development Centre, 2009).

To the best of our knowledge, no published articles in the literature have investigated the factors influencing the low usage of CFLs in existing residential buildings in Lagos, Nigeria, which has the highest number of households as at 2007 with an estimate of 2,497, 419 million (National Bureau of Statistics, 2009) and most populated in Nigeria (Lagos State Government, 2006). This study therefore investigates these factors. It is hoped that the result will contribute to the understanding of how to increase the acceptability of the CFLs aimed at a sustainable energy usage the residential areas. The remainder of this paper is organised as follows. Section 2 provides a description of methodology. Section 3 provides the result. The concluding section 4 proffers recommendations.

2. Methodology

A survey of households was conducted during May to July, 2011 to investigate the factors influencing the usage of CFLs in residential areas of Lagos, Nigeria. Several factors influencing the usage of CFLs in residential areas were identified in literature (Kumar et al., 2003; Sathaye and Murtishaw, 2004; Community Research and Development Centre, 2009). These factors were then re-phrased and expanded into 7 statements based on the characteristics of the study area. These factors include: high initial cost, inability to measure benefits of CFLs, health hazard of CFLs because of its

mercury content, proliferation of inferior CFLs in the market, lack of awareness of CFLs, non-affordability and no guarantee from retailers in case of mal-function of CFLs.

The questionnaire was broadly divided into the following sections: Section A covers personal information about the respondent's sex, age, educational qualifications, income, etc. Section B covers information on the level of usage of CFLs by household and the factors influencing their usage of CFLs.

The respondents were asked to rank how significant these factors influence their usage of CFLs based on a five point Likert Scale (1=Not significant, 2=Somewhat significant, 3=Fairly significant, 4=Significant and 5=Very significant). The five point likert scale was selected as it provides unambiguous results and has ease of use (Ekanayake and Ofori, 2004). Questionnaires were self-administered to households who were selected from five local governments out of the twenty in Lagos State. The selected local governments were: Shomolu, Kosofe, Mushin, Oshodi-Isolo and Lagos Mainland Local Governments. In each of the selected local governments, 300 questionnaires were administered to a head of household. In all, a total of 1,500 households were selected systematically through random technique. Having identified the major streets in the selected local government, the first building along the streets was chosen randomly and every tenth building constituted the sample. Out of the 1,500 households, 988 questionnaires were retrieved, while only 4 questionnaires were invalid due to error of partial completion, 984 valid questionnaires were therefore used for the analysis representing 66%.

In this study, the Cronbach's coefficient alpha was calculated to ascertain the reliability of the five-point scale which has been used in the survey. The reliability test measures the internal consistency among the factors influencing the usage of CFLs. The reliability test of the 7 factors was 0.8411 which is above 0.5, indicating that the five-point scale measurement was reliable at the 5 percent significance level. Kendall's Coefficient of Concordance of the sample data was also computed, which was useful to measure the agreement of household on their rankings of the factors influencing the low usage of CFLs in their homes. According to Yeung et al., (2007), a value of the Kendall's Coefficient of Concordance that is equal to 1 means that all the respondents' rank of the factors are similar, while a value of the Kendall's Coefficient of Concordance that is equal to 0 indicates that all the respondents' rank of the factors are totally differently.

After checking the reliability of the scale, the data collected were then analysed using SPSS 17.0 Package. The analyses were divided into two parts. Part one focused on the presentation of the characteristics of the household; frequency tables were used for these presentations. Part two focused on the factors influencing the usage of CFLs in existing residential areas of Lagos State; this was presented using the "mean score". To be able to quantify these, the authors used the following criteria based on a scale of 1-5:

1. if the mean score is less than or equal to 1.49, then household perceived the factors responsible for the low usage of CFLs as being "very insignificant";
2. if the mean score is between 1.50 and 2.49, then household perceived the factors responsible for the low usage of CFLs as being "insignificant";
3. if the mean score is between 2.50 and 3.49, then household perceived the factors responsible for the low usage of CFLs as being "average";
4. if the mean score is between 3.50 and 4.49, then household perceived the factors responsible for the low usage of CFLs as being "significant"; and
5. if the mean score is between 4.50 and 5, then household perceived the factors responsible for the low usage of CFLs as being "very significant"

3. Results and Discussions

3.1 Characteristics of the Respondents

Responses to questions on the characteristics of the respondents in terms of their gender, age, level of education and annual income are presented in Table 1. From the responses, it can be deduced that males' responses were greater than females within the study areas. Specifically 96.1% of the respondents were male and 3.9% females. This huge disparity is expected since the culture and tradition of the country place men households heads. In terms of the age, respondents in the age bracket of 51 years above dominated the sample. A total of 804 respondents fell within this group representing 81.7%. While 28 respondents fell within the less than 30 years group; 43 respondents fell

within the age bracket between 31 – 40 years representing 4.4% and 109 respondents fell within the age bracket between 41 – 50 years representing 11.1%. The results of the analysis on educational qualification of the respondents revealed that 9% of the respondents hold primary school certificate; 20.6% hold secondary school certificate; 22.0% OND/NCE; 41.6% hold HND/BSc and 6.8% hold MSc/PhD representing 6.8%. The analysis on the level of income of the households revealed that 12 of the households representing 1.2% of the total responses fell within the group of those earning below ₦100,000 per annum. A total of 102 respondents representing 10.4% fell within the income group of between ₦101,000 and ₦300,000, while 153 respondents representing 15.9% fell within the income group of between ₦301,000 and ₦500,000. Those earning between ₦501,000 and ₦700,000 were 408 respondents representing 41.5% of the entire responses. Earning between ₦701,000 and ₦1,000,000 were 219 household accounting for 22.3% of the entire responses. 63 household representing 6.4% were those earning between ₦1,010,000 and ₦3,000,000. Earning above ₦3,000,000 were 27 respondents representing 2.74% of the total responses. This result therefore confirmed there was a general low level income among household in the study areas. This is because, 309 households representing 31.4% were earning above ₦700,000 per annum.

Table 1. Characteristics of Households

Descriptions		
Gender	**Frequency**	**Percentage**
Male	946	96.1
Female	38	3.9
Total	**984**	**100**
Age		
< 30	28	2.8
Between 31-40	43	4.4
Between 41-50	109	11.1
>51	804	81.7
Total	**984**	**100**
Educational Level		
Primary School Certificate	89	9.0
Secondary School Certificate	203	20.6
OND/NCE	216	22.0
HND/BSc	409	41.6
MSc and above	67	6.8
Total	**984**	**100**
Income		
< N100,000	12	1.2
Between N101,000 – N300,000	102	10.4
Between N301,000 – N500,000	153	15.5
Between N501,000 – N700,000	408	41.5
Between N701,000 – N1,000,000	219	22.3
Between N1,010,000 – N3,000,000	63	6.4
> N3,000,000	27	2.7
Total	**984**	**100**

3.2 Usage of CFLs

Results to the question that focused on investigating the usage of CFLs among the respondents are presented in Table 2. This result confirmed the low usage of CFLs in the study areas. It is observed from Table 2 that only 9.6% of them had bought or used CFLs in all spaces requiring lighting in their homes, while 90.4% did not. The factors responsible for this, among those who did not use CFLs were investigated in the next section.

Table 2. Usage of CFLs

Usage of CFLs	Frequency	Percent
Yes	94	9.6
No	781	90.4
Total	**984**	**100**

3.3 Factors Responsible for Household' Low Usage of CFLs

This section investigates the factors responsible for the low usage of CFLs in the study areas. The means and standard deviations of the 7 factors influencing the low-level usage of CFLs in existing residential areas in Lagos State are shown in Table 3 below. The computed mean score revealed that inability to measure the saving benefits of CFLs on electricity bills was ranked 1st with a mean score of 4.76. This result is 'very significant' based on the scale adopted in this study. The result could be attributed to the apparent inefficient metering system by Power Holding Company of Nigeria (PHCN) (the organisation that is responsible for power generation and distribution in Nigeria). The use of prepaid meters, which was recently introduced by PHCN can help achieve accurate billings. However, this has not been widely distributed in many parts of Nigeria. In many homes, the meters installed by PHCN are no longer functioning. PHCN therefore results to the use of estimated bill, this practice further makes it difficult for households to measure the benefits of CFLs. In 2nd position was affordability with a mean score of 4.69. This is also 'very significant' based on the study mean classifications. This result was also expected; about 70.8% of Nigerians live below the international poverty line of $1 per day (United Nations Development Program, 2007). The cost of ILs is averagely ₦40 for 60 watts, while inferior CFLs are in the range of ₦100 to ₦150 for 15 watts and standard 60 watts CFLs are in the range of ₦1,000 to ₦1,500. Thus, many households are not able to afford the cost of purchase and installation of good quality or standard CFLs. Ranked 3rd was high initial cost of acquisition and installation of CFLs with a mean score of 4.51. This is also 'very significant'. This result could be attributed to the apparent lack of CFLs manufacturing companies in Nigeria. The country therefore heavily relies on importation to meet her housing lighting needs. Cost of shipment, insurance and import duties paid on CFLs importation could be further causing high cost of acquisition. In 4th position was proliferation of inferior or sub-standard CFLs in the market with a mean a score of 4.21. The result is 'significant' based on the classification of the mean score rating adopted for the study. The outcome of the study could be attributed to the fact that some Nigerian businessmen import inferior CFLs from countries like China, Indonesia, and India into the Nigerian market. They capitalise on the apparent weak laws and regulations governing importation of products into Nigeria. Standard Organisation of Nigeria (SON), the organisation that is responsible for ensuring products are of quality standards is therefore underperforming. Furthermore, Nigeria regional boarders are porous and become avenues for massive smuggling of inferior CFLs into the country. This implies that CFLs in the market would not last long, making household preferring to continue using the ILs instead of CFLs. Awareness of CFLs was ranked 5th with a mean score of 3.59. This result is 'fairly significant'. In 6th was no guarantee of the performance from CFLs retailers with a mean score of 1.67. This result is 'insignificant' based on the mean classification adopted for the study. This factor is contrary to the findings of Kumar et al., (2003), they found guarantee to be a major deterrent in the purchase of CFLs among all income groups sampled in Indian. Ranked 7th was health hazard associated with CFLs due to presence of mercury content with a mean score of 1.34. This factor is 'very insignificant', suggesting that respondents do not find it as a deterring variable influencing their usage of CFLs. Kendall's Coefficient of Concordance of the sample data was computed for measuring the agreement of the respondents on their rankings of the factors influencing the low usage of CFLs. The Kendall's Coefficient of Concordance for ranking the 7 factors is 0.218, which is statistically significant at 1 percent level, implying that the respondents in the study areas survey shared similar opinions about the relative importance of the 7 factors influencing their low usage of CFLs.

Table 3. Factors Responsible for Household' Low Usage of CFLs

Factor	Mean	SD	Rank
High Initial cost/Expensive	4.51	0.89	3
Inability to measure benefits of CFLs	4.76	1.18	1
Health hazard of CFLs because of its mercury content	1.34	0.04	7
Proliferation of inferior CFLs in the market	4.21	0.69	4
Awareness of CFLs	3.59	0.44	5
Lack of affordability	4.69	0.91	2
No guarantee upon mal-functioning of CFLs	1.67	0.07	6

4. Conclusion

This study has presented the findings from a questionnaire survey conducted in Lagos, Nigeria investigating the factors influencing the low usage of CFLs in existing residential buildings. Ranking analysis was used to identify the relative importance of the 7 factors gleaned from literature. The findings show that "inability to measure the saving benefits of CFLs on electricity bills as the most important factor influencing the low usage CFLs. This is followed by affordability, high initial cost of acquisition and installation of CFLs, proliferation of inferior CFLs in the market, awareness of CFLs, no guarantee of the performance from CFLs retailers and health hazard associated with CFLs due to presence of mercury content. The results revealed in this study are of great benefit to the three tiers of government in Nigeria. Nigeria governments could use the outcome of the study as a sound platform towards promoting the usage of CFLs in the study areas and in Nigeria as whole. The results also help deepen electric power authorities' understandings about the major barriers they would encounter in promoting the usage of CFLs, so that attention and efforts can be devoted to solving them.

Based on the findings, the following recommendations might help promote the use of CFLs in the study areas and in Nigeria as a whole:

1. Consumer awareness should be increased in the study areas and in Nigeria as a whole through more advertising efforts, seminars, conferences and trade shows both by the government and NGOs.

2. There is need for accurate and credible metering system so that household can easily measure economic benefits associated with use of CFLs.

3. Groups such as landlord associations, community development associations (CDAs), residents association and professionals in the built environment in the different states of the federation should be furnished with results from the demonstration projects so that they can be used effectively.

4. There should be incentives from the government of Nigeria towards manufacturers of energy efficient bulbs to site their plants in Nigeria. Most of the manufacturers are presently located in China and they export these bulbs to many countries around the globe. Nigeria has a viable market for lighting with an estimated population of 154 million and a strong workforce that can support the industry. When these companies are sited in Nigeria, the cost of the light bulbs will go down considerably to the extent that many poor households can afford to pay the initial cost which in most cases deters them.

5. The Standard Organization of Nigeria (SON) should ensure that the energy efficient bulbs in the Nigerian market are of good quality in terms of the number of hours they take to burn out.

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