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Electric Energy Impact on the Environment: Factors Influencing the Sustained Energy-Inefficient Lamps Utilisation in Nigeria Residential Sector

Zacchaeus Adesakin Adetona*, Joel Ogunyemi

Department of Electrical Electronic Engineering, The Federal Polytechnic Ilaro, Ilaro, Nigeria

Email address:

zacchaeus.adetona@federalpolyilaro.edu.ng (Z. A. Adetona), joel.ogunyemi@federalpolyilaro.edu.ng (J. Ogunyemi)

*Corresponding author

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Abstract: In this study, the reasons behind sustained utilisation of non-energy saving lamps (ESLs) in Nigeria vis-à-vis global lamps utilisation and environmental impacts of using non-ESLs was examined. The study was conducted via an online questionnaire using a qualitative research approach to survey 62 randomly selected apartments in the six geopolitical zones of Nigeria on policy awareness and motivation for non-ESL utilisation. Data obtained were tested for lamps' utilisation dependency on household income using correlation and regression analysis with 5% significant level. The impact of sustained non-ESL utilisation on CO_2 emission was looked into. Pearson's regression coefficients (R^2) of 0.4646, 0.4772, 0.2716 and 0.4871 were obtained for incandescent, CFL, LED and magnetic ballast fluorescent lamps respectively. The results showed that the utilisation of non-ESL considered is dependent on the household income. On the other hand, LED lamp utilisation shows a moderate dependency; 83% of the respondents were unaware of government policy on non-ESLs and 24% chose market availability of non-ESL as motivation for utilisation; 46% of the respondents chose cheap cost as motivation. Thus, the household economic status, lack of policy implementation, availability and cheap cost of non-ESL in the Nigerian market can be seen to have contributed to the sustained utilisation of incandescent lamps in the country. About 77% of lamps sampled (non-ESLs 13% and CFL 64%) can be replaced with LED. The results showed that Nigeria has great opportunities to contribute to global CO_2 emissions reduction possible form the eradication of non-ESL in the country.

Keywords: CO_2 Emissions, Energy-Saving Lamps, Energy-Saving Policy, Incandescent Lamp, LED Lamp, Nigerian Residential Sector

1. Introduction

Globally, a great proportion of energy use goes to the residential sector as shown in Figure 1 [1] and Nigeria is not an exception. Artificial lighting is used worldwide in varied dimensions among different people of the world. In the past, various methods such as fuel based-lighting were used to produce artificial lighting and these are continuously giving way to electric-based lighting which is on the rise in developing countries. Electric lamps usage is a major consumer of electric energy at about 19% of the world total electric energy use [2] and the residential sector takes 31% of the world's total energy use as shown in Figure 1.

In Nigeria, electric energy remains one of the major sources of lighting. However, the total available electric energy in the country is greatly insufficient and unreliable for a population of over 210 million [3-5]. This inadequacy is responsible for the low level of development as electric energy is the most important form of energy for socio-economic growth. Studies have shown that a larger percentage of the insufficient energy is utilised by domestic consumers (up to 67%) rather than industrial and commercial centres [6-8]. Thus, it is established that the country's residential consumers account for a higher percentage of its electric energy use.

It is evident from Nigeria's large population and the perennial inadequate energy supply with efforts geared towards electrical

energy generation, energy conservation and efficiency, that more energy could be saved by totally embracing ESLs. When such efforts are put in place, a great deal of technological development and socio-economic growth in a developing country as Nigeria can be achieved in the long run. One important component of energy efficiency efforts is energy-efficient lighting.

With advancements in technology, consumers of electricity in the developed world have been mandated to reduce electric energy consumption and this necessitates huge changes in consumer behaviour and lifestyle to save the environment. To replicate these giant strides in the developing world, therefore, requires putting in place efforts at saving energy in lighting. Thus, achieving these goals should be a top priority in Nigeria as a developing country. Nigeria has great opportunities to contribute to global CO_2 emissions reduction possible form the eradication of non-ESL in the country.

Compared to other lamps, incandescent lamps are highly inefficient coupled with the fact that they need constant replacement as they do not last. Thus, a regular budget of an average household comprises 5% cost of electric energy [9]. One of the ways to cut down on this cost is switching to energy-efficient lighting.

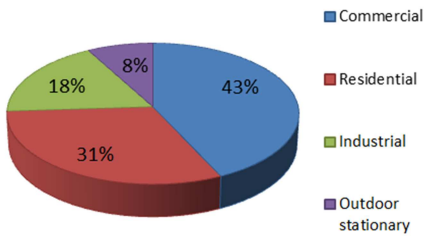

Figure 1. *World energy consumption by sector (IEA, 2006).*

Many studies have been conducted in the past that pointed to factors determining the householder's propensity for energy efficiency investment. Such factors hereunder were also perceived to influence the Nigerian homeowners especially in Lagos State:

i. awareness about energy efficiency [10, 11];
ii. building age [12];
iii. cost of energy [13];
iv. economic status and homeowner's income [14-18];
v. behavioural pattern [19, 20];
vi. inability to measure the saving benefits of CFLs on electricity bills [21], and
vii. factors concerning the environment [22, 23].

Giving the fact that incandescent lamp usage has been terminated in many parts of the developed countries [24-29] and subsequently replaced with ESLs, there is the need to investigate why it is still in use in Nigeria and possible remedies.

The 'revolution in energy efficiency' has a long history dating back to the 1970s when the fear of fuel shortages in the wake of the first oil crisis resulted in public concerns. In the early years of energy use, energy efficiency was of very little public concern but this has changed suddenly with the oil crisis [30], resulting in an unprecedented conservationist approach to energy use [31]. In the energy efficiency literature, there has been a long history of research on the cost-effectiveness of energy efficiency tools [32] leading to various policies formulated in various countries over the years. However, in Nigeria, there has not been such widely established research leading to energy efficiency policy formulation.

In this study, six geo-political zones of Nigeria were focused for investigation on the adoption (and lack of it) of ESL. There are varying levels of energy consumption across the country. For instance, Lagos State has been identified as the largest electric energy consumer state in Nigeria [33] but much energy is seen to be wasted in the state. In terms of population, the Lagos energy scenario is worrisome because the State is home to upwards of 60 per cent of the country's industries while consuming 50% of the total electric power generated [34]. Despite this fact, the state still has low per capita consumption in comparison to other similar cities around the world. Though Nigeria as a whole suffers inadequate electricity proportionately, it is obvious that the situation can be improved if energy efficiency measures are adopted.

Further, on the international scene, there has been a heightened public interest in the ban of incandescent lamps as reported in the literature (Figure 2) [26]. Electric lamps such as incandescent, compact fluorescent (CFL), magnetic ballast fluorescent, and light-emitting diode (LED) lamps are widely used in Nigeria and the usage of the incandescent lamp is still very high [35]. Thus, this study was set out to identify the factors responsible for the low acceptance of ESLs in the country.

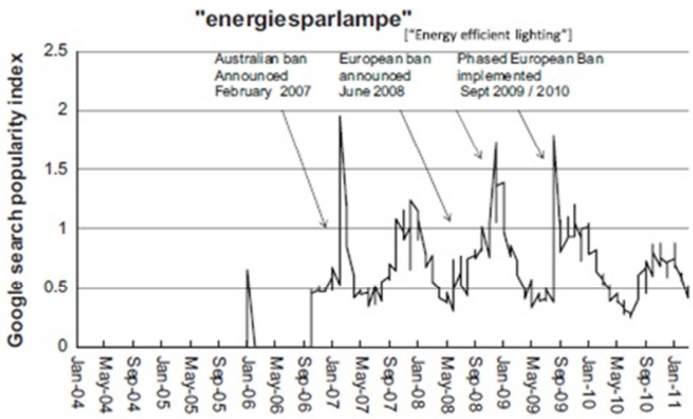

Figure 2. *Public interest in energy-efficient lighting [26].*

2. Evolution of Electric Lamps and Energy Efficiency Considerations

Thomas Alva Edison developed and tested the first practical commercial electric lamp in 1879. That lamp, constructed shown in Figure 3, used a voltage of about 110 V, lasted for 13.5 hours and it was the first appearance of the incandescent lamp. The design made it work in a similar way to an electric heater. In this way, over 90% of its energy production is heat and not illumination [33, 34] and as such this type of lamp converts only 5% of the energy they use into illumination with standard light bulbs giving 2.2% on the average.

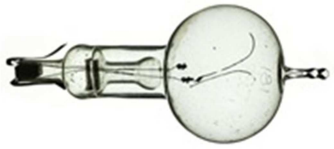

Figure 3. *First incandescent Lamp [42].*

Several efforts had been made to replace the incandescent lamp over the years. One of such efforts was the construction of the tube fluorescent. Peter Cooper Hewitt in the late 1890s invented the first type of this lamp [36] followed by a screw-in lamp that used a folded tube, stable tri-colour phosphors, and a mercury amalgam, an integral magnetic ballast fluorescent type introduced by Philips in 1980. The Philips make was the first effective replacement for the incandescent lamp and in 1985 the electronic ballast CFL was introduced [37].

The introduction of CFL resulted in great energy savings in lighting devices. However, in spite of all benefits of saving energy [38], CFL has accompanying environmental harmful effects namely toxic elements, toxic fumes, fire hazards, and hazards to health [39]. To ensure an energy-efficient lighting safe for the environment, and far higher energy savings, the LED lamp was introduced.

Technological innovation has made LED to become the global leading lighting technology [40]. Oleg Vladimirovich Losev created the first LED in the mid-1920s. This was followed by the development of the first constructive LED giving light of the visible-spectrum in 1962 by Nick Holonyak Jr. [41].

The years 1990, 1993, 1996 and 2005 saw the introduction of LEDs of one-lumen output, the first high-brightness blue LED created by Shuji Nakamura, the white light LED and LEDs with 100 lumens output respectively. Thus, LED could compete with conventional light sources and fixtures. Some of the advantages of LED illumination are [43]:

1) no production of harmful radiations (mercury-free);
2) ability to work in cold environments;
3) ability to withstand impact and vibrations.

The typical lifespan, cost and luminous efficacy of the various lamps are summarized in Table 1 [44]. As seen on the table, the incandescent lamp is the least efficient, LED the most efficient and CFL has efficiency close to that of the LED. In terms of lifespan, the incandescent lamp is short-lived compared to the CFL as it has a lifespan of only one tenth of the CFL. In addition to the CFL energy savings, it also reduces lighting costs. Also, the lifespan of the LED lamp is 30 times better than the incandescent lamp.

Table 1. *Electrical power equivalents for different lamps [44].*

Output (lumens)	Power Rating (W)		
	Incandescent Lamp	CFL	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

3. Methodology

3.1. Research Design

The study was set out by carrying out a Google Form online survey of randomly selected apartments in the six geo-political zones (South-East, South-West, South-South, North-East, North-West and North Central) in Nigeria. The stratified random sampling as arbitrary and only depended on the residence of the respondent to the online survey. This made it possible to have several locations in rural and urban areas included in the study with all the geopolitical zones covered. Figure 4 shows the distribution of respondents across the six geopolitical zones. In the study, socioeconomic status (SES) of each household is taken into considerations. Income was used as a basis for classification into different SES categories. For the sake of analysis, the SES classifications adopted for the study are presented in Table 2.

Table 2. *Respondents' income as socioeconomic classifications.*

Annual Income	Economic status classification
N 0-100,000 ($ 0-200)	Lower
N100,001-500,000 ($201-1,000)	Lower
N500,001-1,000,000 ($ 1,001-2,000)	Middle
N1,000,001-5,000,000 ($ 2,001-10,000)	Middle
N5,000,000-10,000,00 ($ 10,001-20,000)	High
>N10,000,000 ($ 20,000	High

3.2. Sample and Selection Characteristic

Lighting units such as incandescent lamps, magnetic ballast fluorescent lamps, CFL and LED lamps were considered in the study. For easier analysis, the CFLs and LEDs were considered together as energy-saving lamps. The incandescent lamp and magnetic ballast fluorescent lamp (referred to simply as fluorescent) were regarded as energy-inefficient lamps. All apartments considered were randomly selected based on the respondent's location in the country. Only lamps were considered in the study and other loads in the buildings and their likely effects on the lamps ignored. The apartments considered in the survey included one bedroom self-contained, one room and parlour self-contained, two bedroom flat, three

or more bedroom flat, multiple-room apartment (in local parlance, *face-me-I-face-you*), and duplex apartment.

3.3. Survey Questions

A well-structured questionnaire was developed to be completed by an adult in each residence in an informal survey. The questionnaire was developed to interact with the adult respondent in each of the 62 sampled households from the six-geopolitical zones providing empirical primary data on each residence. The KPI (key performance index) for the study is summarized in Table 2. The study focuses were:

1) bedrooms number in an apartment (type of dwelling);
2) household annual income;
3) number of lamps of interest (ESL [LED and CFL], incandescent and magnetic fluorescent) available in the apartment;
4) market availability of lamps as determinant for ease of purchase;
5) cost of lamps as a determinant for ease of purchase;
6) lifespan of lamps;
7) presence and awareness of government policy on the ban of non-ESL.

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the reference list. Use letters for table footnotes.

3.4. Data and Analysis

The study was conducted via an online questionnaire using a qualitative research approach to survey 62 randomly selected apartments in the six geopolitical zones in Nigeria. To determine the dependency of lamp utilisation on the household income, the data obtained were tested using correlation and regression analysis with 5% significant level. Each lamp utilisation in the 62 sampled houses was considered with household income groups as indicated in Table 1. The Pearson's regression and the correlation coefficients were obtained. In running the test, other factors that may influence the lamps utilisation dependency on household income such as market availability of lamps, cost and lifespan of lamps, dwelling type and number of bedrooms in the dwellings were not considered.

Table 3. *Research KPI.*

Performance Index	Expected Response
Household income	N 0-100,000 ($0-200) N100,001-500,000 ($201-1,000) N500,001-1,000,000 ($1,001-2,000) N1,000,001-5,000,000 ($2,001-10,000) N5,000,000-10,000,00 ($10,001-20,000) >N10,000,000 (>$20,000)
Number of incandescent lamps	≥ 0
Number of ballast fluorescent lamps	≥ 0
Number of ESL	≥ 0
Product Cost	≥ 0 ₦ 0
Market Availability	Easily obtainable Not easily obtainable
Awareness of government announcement.	Yes No Not sure
Awareness of government policy/law on.	Yes No Not sure

4. Results and Discussion

4.1. Lamp Utilisation and Household Economic Status

Table 4 shows the results for the correlation and regression analysis of the lamps' utilisation. The proportions of utilisation distribution for the various lamps in the survey are given in Figure 4. A total of 13% of non-ESL is observed as can be seen in the figure. The results show that non-ESLs were very much in use in the entire country as respondents from the six geopolitical zones had the lamp in use. The correlation and regression analysis with 5% significant level yielded the Pearson's regression coefficient (R^2) indicated in Table 4 for the four lamps considered. The R^2 coefficients obtained (0.4646, 0.4772, 0.2716, 0.4871 for incandescent, CFL, LED and magnetic ballast fluorescent lamps respectively) show that there was a strong indication to conclude that the utilisation of incandescent, CFL and magnetic ballast fluorescent is highly dependent on the household income and a moderate dependency of the utilisation of LED lamps on the income. This is consistent with the previous results in literature. References [45, 46] noted that, there was a positive link between income and choice of energy consumption by households that showed the low-income earners consumed more energy than the high-income earners due to their cooking frequency and unit energy purchase index and ref. [6] showed that household decision to invest in energy-efficient CFLs is determined by factors such as household income, education level of the household head, presence of a technically skilled person in the household, use of prepaid meter, formally employed household head and male household head.

Table 4. *Results for Correlation and Regression.*

Performance Index	Lamp Type			
Income	**Incandescent**	**CFL**	**LED**	**Magnetic Fluorescent**
50,000	19	60	15	7
250,000	36	152	58	7
500,000	10	77	21	1
2,500,000	4	93	61	3
5,000,000	1	82	16	2
10,000,000	0	11	2	0
R Square (R2)	0.4646	0.4772	0.2716	0.4871
Correlation (R)	0.6816	0.6908	0.5212	0.6979

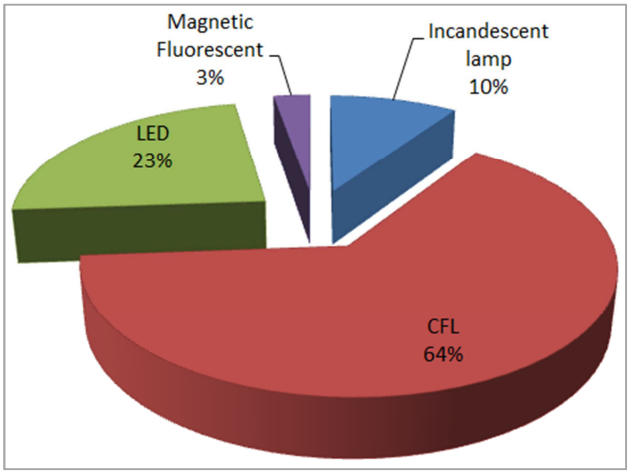

Figure 4. *Proportions of lamp utilization.*

It has been established [35] that low-income earners are predominantly the inhabitants of certain areas where the incandescent lamps are still much in use in Nigeria. With the poor economy and many living on less than $1 per day, the probability of many being able to afford the ESLs is low. Even with the knowledge of the long-time benefits of ESLs, the incandescent lamps and the fluorescent lamps are still in use partly because of the prevailing low economic status.

It is interesting that many households now utilize the ESLs in the country with ESL accounting for 87% of all lamps utilisation (Figure 4). However, incandescent lamps utilisation stood at 10% and fluorescent 3%. The high utilisation of ESL can be attributed to the economic status of the house owners. About 75% of the respondents are more than middle income earners. Thus, they are capable of purchasing ESLs even though the lamps are much more expensive than non-ESLs. However, 13% of all lamps utilisation is non-ESL (incandescent and magnetic fluorescent lamp) and the utilisation is widespread among the middle to lower economic group of the respondents as seen in Figure 5.

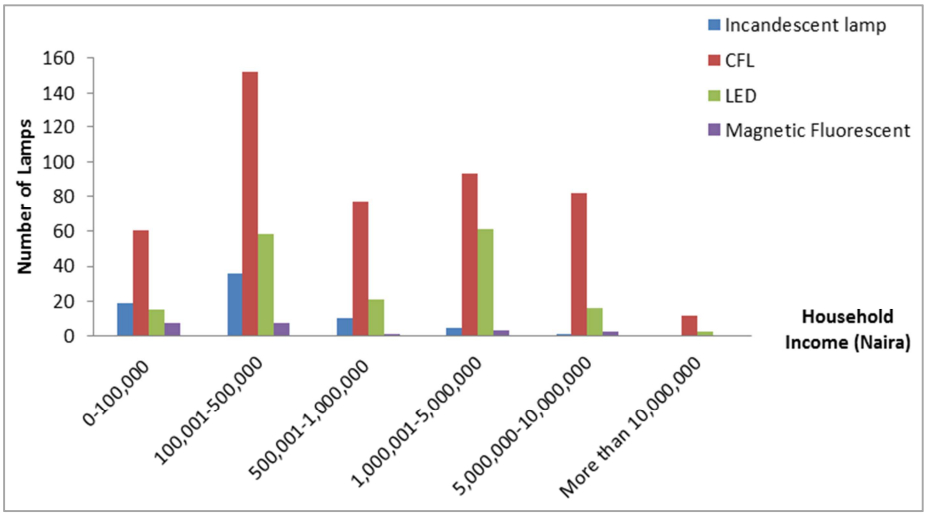

Figure 5. *Variability of lamp utilisation with income.*

4.2. Market Availability, Cost Versus Poor Quality Lamps and Power Supply

A high number of respondents chose 24% lamps (all non-ESLs) based on market availability and 46% lamps, all non-ESLs, based on cheap cost as motivations for utilisation (Figure 6). This indicated that if the lamp is phased out, the consumers would readily adopt the utilisation of ESLs.

Reference [47] observed that quality and cost-saving benefit, energy saving benefit and durability of bulb influenced the choice of fluorescent tubes, compact fluorescent bulbs and light emitting diodes. In this study, as

shown in the results presented in Figure 7, the majority of respondents (79.36%) did replace their electric lamps within one year and 95.23% in 3 years. This is far less than the rated lifespan presented in the literature of the common lamps as indicated in Table 5. Thus, the poor quality of lamps and power supply in Nigeria were other reasons why non-ESLs are still popular in the country. Most of the ESLs in circulation are easily affected by power fluctuation problems, a phenomenon very common in Nigerian electrical power distribution system. The very short replacement period for lamps as presented in the survey is an indication of this. The ESLs tend to burn out easily during power fluctuation especially during restoration after an outage. This can serve as a demotivation for those willing to lower their energy consumption by purchasing ESLs as they would not want to waste their hard-earned resources on anything that lacks durability.

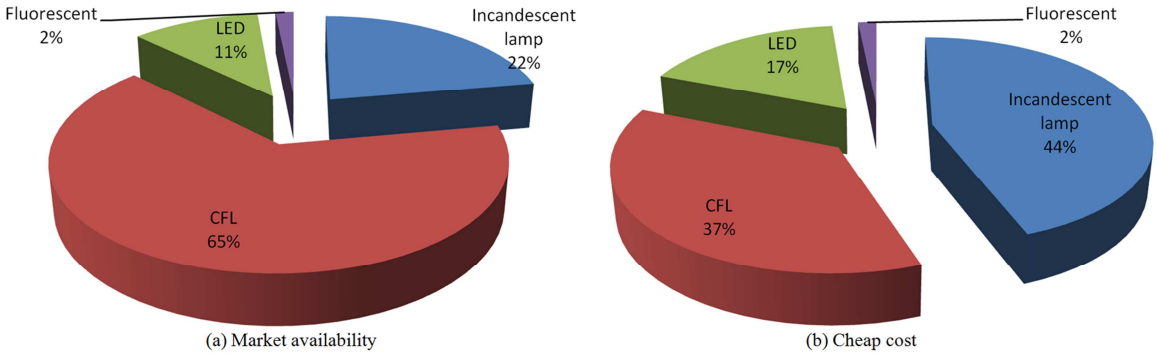

Figure 6. *Motivation for lamps utilization.*

Table 5. *Cost and lifespan of various lamps Source: (Authors based on [35]).*

Lamp Type	Cost (₦)	Lifespan (hr)	No. of Years Using 8 hr/day and 365-day year
Incandescent	100	1,000	0.34
Fluorescent	1,200	15,000	5.14
CFL	1,000	10,000	3.42
LED	1,200	30,000	10.27

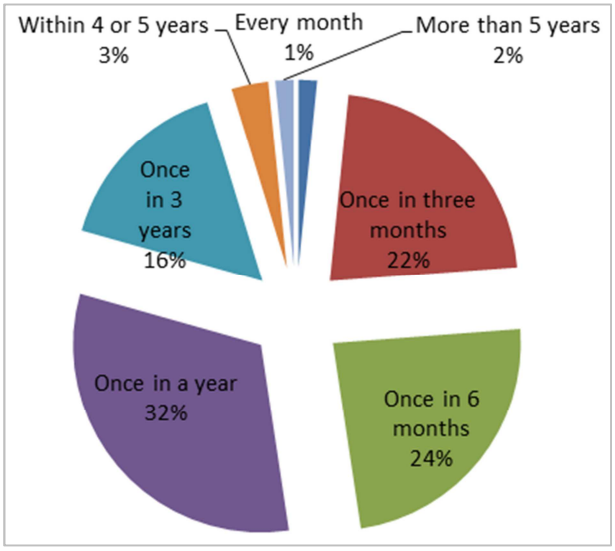

Figure 7. *Lamps replacement duration.*

Further, the high cost of purchase of ESLs as compared to incandescent lamps will discourage a willing buyer if such lamps will be replaced so often due to the foregoing reasons. The prevalence of adulterated lamps in the Nigerian market aggravates the situation. Both incandescent lamps and ESLs are branded about with many fake products. The low cost of incandescent lamps appeals to a low-risk investment rather than high-cost ESLs that cannot be guaranteed to last.

4.3. Lack of Prohibitive Policy Enforcement on Non-ESL Utilisation

The results suggest that there was a lack of policy prohibiting the manufacture and importation of the non-ESLs in the country. Only about 8% respondents claimed to have heard any government announcements on stoppage of the use of incandescent lamps (Figure 8). Responses to the query on the awareness of a governmental policy banning the use of incandescent lamps (as seen in Figure 9) show that 83% of the respondents were ignorant of such. These results indicated that there was no strong policy in place with lack of adequate awareness. Further, the non-ESLs are very much available in the Nigerian market (Figure 4) indicating that there was no ban on the manufacture and importation to the country.

High energy-consuming lamps are no longer allowed in the developed countries as a result of the energy crisis and environmental concerns surrounding the production of electricity in those countries. ESLs as a solution to the energy crisis have been popularized and accepted as the de-facto source of illumination in the developed world but not so in Nigeria. The Nigerian government has an energy efficiency policy to phase out energy inefficient devices in place and the policy has a provision to "attain 60% consumption of energy-efficient lighting, refrigerators, freezers and air conditioners by 2016 and 100% by 2020". This policy however, "is only on paper and only weakly implemented so as to promote practice of energy efficiency and energy

conservation principle in the country" [48, 49]. It was observed in ref. [50] that the lack of policy and legislation to address the inefficient use of energy is a very key barrier to the development of energy efficiency. Policy and legislation will help to change behaviour towards an energy-efficient economy. With a lack of policy implementation to outlaw the importation and manufacturing of the non-ESLs, and an abundant market availability of these devices, consumers continue to be at liberty to choose the energy-wasting devices. Such policy pathway toward increasing the energy efficiency of the Nigerian building sector was described by ref. [51] and can be formulated by government and other stakeholders [46].

Further, as suggested by ref. [47], efforts must be made by government to increase consumers awareness and enlightenment on the types of lighting bulbs to procure and there is also need to strengthen mechanisms through the importation and sales of energy efficient bulbs only so as to enhance its cost-saving and environment–related benefits amongst others.

Of the 40% populace connected to the national grid, about 77% lamps utilisation can be replaced by LED. This will reduce the total energy need by up to 80% for CFL and magnetic fluorescent; and 90% for incandescent lamps. Thus, there can be an equivalent percentage of CO_2 emission reduction in lighting of the residential sector alone. This undoubtedly results in huge gains in energy efficiency in the country. In addition, because of unavailability of grid energy, a large percentage of the populace has resorted to the use of stand-alone generators with associated health risks. These also contribute in no small measures to the pollution of the environment by their greenhouse gases emission.

5. Conclusion

Non-energy-saving lamps are cheaper to acquire thus there is continued utilisation in Nigeria. The middle to the lower economic level of the populace finds it easy to purchase and replace incandescent lamps. ESLs are more capital intensive to use and the adulterated ESLs flood the Nigerian market thus making it difficult for those that invest in them to see expected value for their investment thereby discouraging their continued use.

There is no clear-cut policy outrightly prohibiting the utilisation, manufacturing and importation of incandescent and other energy-wasting lamps and devices. When put in place, such policy will ensure that the utilisation of non-ESLs is drastically reduced thereby making consumers choose available ESLs. There should also be put in place incentives such as subsidies to consumers investing in ESLs and manufacturers of the devices. When these steps are taken, both the consumers and the entire populace will benefit from the possible savings in electric energy.

Thus, there should be a massive campaign to create a nationwide awareness on the ineffectiveness of non-ESL lamps and the need for the populace to switch to the use of ESLs (CFL and LED lamps).

There should be regulation on the influx of substandard electrical devices through monitoring and stiff penalties should be meted out on violators**.**

If the emissions from the stand-alone generators are also put into considerations in the country, the greenhouse gases reduction becomes higher and the attendant health risks associated with the utilisation of the generators is greatly reduced. If all non-ESL are replaced, the energy savings from the lighting sector throughout the country can be redistributed to the populace and bring about a good reduction in the utilisation of stand-alone generators.

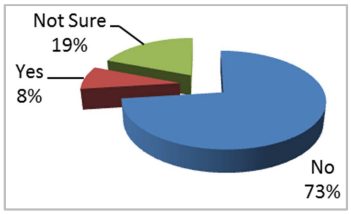

Figure 1. *Awareness of government announcement on the stoppage of utilisation of incandescent lamps.*

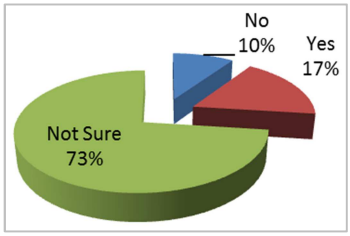

Figure 2. *Awareness of government policy on banning of manufacture and importation of incandescent lamps.*

Conflict of Interest

The authors declare no conflict of interest.

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References

[1] IEA. Light's labour's lost policies for energy-efficient lighting; 2006.

[2] B. Stoffel, 'The Role of Pumps for Energy Consumption and Energy Saving'. In: Assessing the Energy Efficiency of Pumps and Pump Units', B. Stoffel, ed., 2015. pp. 1-25. https://doi.org/10.1016/B978-0-08-100597-2.00001-X.

[3] United Nations Population Fund. World Population Dashboard, Nigeria. https://www.unfpa.org/data/world-population/NG, 2021.

[4] Central Bank of Nigeria, 'Central Bank of Nigeria Statistical Bulletin', Abuja, 2009.

[5] Country Meters: Nigeria Population. https://countrymeters.info/en/Nigeria, 2021.

[6] C. Ezema, A. O. Olotuah, and O. I. Fagbenle, 'Evaluation of Energy Use in Public Housing in Lagos, Nigeria: Prospects for Evaluation of Energy', Int. Journal of Renewable Energy Development, 5 (1), 15-24, 2016. http://dx.doi.org/10.14710/ijred.5.1.15-24.

[7] M. U. Nwachukwu, N. F. Ezedinma, and U. Jiburum, 'Comparative Analysis of Electricity Consumption among Residential, Commercial and Industrial Sectors of the Nigeria' s Economy', J. Energy Technol. Policy, 4 (3), pp. 7–13, 2014.

[8] Otegbulu, A. J. Odekoya, and O. Johnson, 'Determinants of investment in energy efficient light bulbs in Lagos residential buildings', Elixir Proj. Manag., 51, 11159–11163, 2012.

[9] US Department of Energy, 'Energy Saver', 2014. https://www.energy.gov/energysaver/energy-saver.

[10] G. Nair, L. Gustavsson and K. Mahapatra. 'Factors influencing energy efficiency investments in existing Swedish residential buildings', Energ. Policy, 38 (6), 2956–2963, 2010.

[11] K. P. Tsagarakis, F. Bounialetou, K. Gillas, M. Profylienou, A. Pollaki and N. Zografakis, 'Tourists' attitudes for selecting accommodation with investments in renewable energy and energy saving systems', Renewable Sustainable Energy Rev., 15 (2), 1335–1342, 2011.

[12] L. Gustavsson and A. Joelsson, 'Energy Conservation and Conversion of Electrical Heating Systems in Detached houses', Energ. Build., 39, 717–726, 2007.

[13] J. S. Black, P. C. Stern, and J. Elworth, 'Personal and Contextual Influences on Household Energy Adaptations', J. Appl. Psychol., 70, 1985, 1985.

[14] S. Barr, A. W. Gilg, and N. Ford, 'The household energy gap : examining the divide between habitual-and purchase- related conservation behaviour', Energ. Policy, 33, 1425–1444, 2005.

[15] D. Urge-Vorsatz and J. Hauff, 'Drivers of market transformation: Analysis of the Hungarian lighting success story', Energ. Policy, 29, 801–810, 2001.

[16] Z. Gou, S. S. Lau and D. Prasad, 'Market Readiness and Policy Implications for Green Buildings: Case Study From Hong Kong' J. Green Build, 8 (2): 162–173, 2013. https://doi.org/10.3992/jgb.8.2.162

[17] M. Suzuki, 'Identifying roles of international institutions in clean energy technology innovation and diffusion in the developing countries: matching barriers with roles of the institutions', J. Clean. Prod.(2014), http://dx.doi.org/10.1016/j.jclepro.2014.08.070

[18] C. Aravena, A. Riquelme, and E. Denny, 'Money, Comfort or Environment? Priorities and Determinants of Energy Efficiency Investments in Irish Households', J. Consum. Policy, 39 (2), 159–186, 2016.

[19] Masini, and E. Menichetti, 'The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings', Energ. Policy, 40, 28–38, 2012. doi: 10.1016/j.enpol.2010.06.062.

[20] S. Ebrahimigharehbaghi, Q. K. Qian, F. M. Meijer, H. J. Visscher. 'Unraveling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making?', Energ. Policy, 12 pp. 546–561, 2019.

[21] Johnson, A. J. Odekoya & O. L. Umeh, Factors Influencing the Usage of Compact Fluorescent Lamps in Existing Residential Buildings in Lagos, Nigeria', International Journal of Energy Economics and Policy, 2 (2), 2012, 63-70.

[22] S. C. Lillemo, 'Measuring the effect of procrastination and environmental awareness on households' energy-saving behaviours: An empirical approach', Energ. Policy, 66, 249–256, 2014. doi: 10.1016/j.enpol.2013.10.077.

[23] G. Trotta. 'Factors affecting energy-saving behaviours and energy efficiency investments in British households', Energ. Policy, 114. 529-539, 2018.

[24] Brazil, 2010. Interministerial Ordinance no 1.007 of December 31, 2010. Brazil. Available at: http://www.mme.gov.br/documents/10584/904396/Portaria_interministral+1007+de+31-12-2010+Publicado+no+DOU+de+06-01-2011/d94edaad-5e85-45de-b002-f3ebe91d51d1?version=1.1.

[25] E360 DIGEST, 'EU Ban on Incandescent Bulbs Goes into Effect on September 1', Yale Environment 360, Yale School of the Environment https:// e360.yale.edu/digest/european_union_ban_on_incandescent_light_bulbs_begins_september_1, 2012.

[26] N. A. A., Howarth, and J. Rosenow, 'Banning the bulb: Institutional evolution and the phased ban of incandescent lighting in Germany', Energy Policy, 67, 737–746. 2014. doi: 10.1016/j.enpol.2013.11.060.

[27] M. Bross, A Pirgov, 'Do new types of energy-saving lamps change the markets? In: Energy Efficiency in Domestic Appliances and Lighting' (Eds.) Bertoldi P, Werle R. Proceedings of the Fifth International Conference vol. 2 (EEDAL'09 16- 18 June, Berlin, Germany).

[28] J. Edge and H. McKeen-Edwards, 'Solid state lighting review – Potential and challenges in Europe Light Bulbs and Bright Ideas?: The Global Diffusion of a Ban on Incandescent Light', 80th Annual Conference of the Canadian Political Science Association University of British Colombia 5 June 2008, 2008.

[29] L. J. Sandah, T. L. Gilbride, M.R. Ledbetter, H. E. Steward and C. Calwell, 'Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market', The U.S. Department of Energy, 2006. https://www.energy.gov/sites/prod/files/2014/04/f14/cfl_lessons_learned_web.pdf

[30] N. Eyre. 'Barrierstoenergy efficiency more than just market failure'. Energy Environ. 8, 25–43, 1997.

[31] M. Perez-Guerrero. 'Energy, styles of life, and distributive justice', J. Energy Dev., 38–44. 1975.

[32] K. Gillingham., R. G. Newell and K. Palmer. 'Retrospective Examination of Demand-side Energy Efficiency Policies Discussion Paper 04–19, June, rev. Sept. (Resources for the Future, Washington D.C.), 2004.

[33] M. Tribedi, 'Essay on Compact Fluorescent Lamp (CFL): Top 6 Essays Energy Management', [Online]. Available: https://www.engineeringenotes.com/essay/energy-management/essay-on-compact-fluorescent-lamp-cfl-top-6-essays-energy-management/18639, 2017.

[34] D. F. de Souza, P. P. F. da Silva, L. F. A. Fontenele, G. D. Barbosa, M. de Oliveira Jesus, 'Efficiency, quality, and environmental impacts: A comparative study of residential artificial lighting', Energy Rep. 5, 409-424, 2019.

[35] Z. A. Adetona and J. Ogunyemi, 'An Investigation into the Utilisation of Energy Saving Lamps in Residential Buildings−A Case Study of Lagos Nigeria', 2020 IEEE PES/IAS PowerAfrica, Nairobi, Kenya, August 25-28, 2020, 1-5, doi: 10.1109/PowerAfrica49420.2020.9219873, 2020.

[36] Becir, D., 'Longetivity of Light bulbs and how to make them last longer'. http://www.robaid.com/gadgets/longevity-of-light-bulbs-and-how-to-make-them-last-longer.htm, 2012. Retrieved June 16, 2020.

[37] R. Kane and H. Sell, 'Revolution in Lamps: A Chronicle of 50 Years of Progress'. 2nd ed. Fairmont Press, Fairmont, 2001, pp. 189-190.

[38] De Almeida a, B. Santos, B. Paolo and M. Quicheron, 'Solid state lighting review - Potential and challenges in Europe', Renew. Sustain. Energy Rev. 34, 30–48. 2014. http://dx.doi.org/10.1016/j.rser.2014.02.029, Elsevier.

[39] P. K. Maity, 'Energy savings by excessive use of CFLS ensuing disastrous ecosystem', Int. J. Dev. Res. 6 (8), 8884-8889, 2016.

[40] M. A. Novikov, "Oleg Vladimirovich Losev: Pioneer of Semiconductor Electronics (Celebrating One Hundred Years since His Birth)" Phys. Solid State, 46 (1), 1–4. 2004. Translated from Fizika Tverdogo Tela, 46, No. 1, 2004, pp. 5–9.

[41] L. DiLaura, K. Houser, R. Mistrick, and G. R. Steffy, The lighting handbook, 10th ed. Society of North America, New York, 2011.

[42] T. A. Edison, Electric-Lamp. US Pat. 223.898, 1880. https://patents.google.com/patent/US223898A/en

[43] R. K. Chaudhary, M. Kumar 'Comparison of Different Light Sources', International Advanced Research Journal in Science, Eng. Technol., 4 (4), 2017. DOI10.17148/IARJSET.2017.440736.

[44] E. Martinot and N. Borg, 'Energy-efficient lighting programs Experience and lessons from eight countries', Energy Policy. 26 (14), 1071-1081, 1998.

[45] A.A.O. Akinola, O. T. Oginni, O. L. Rominiyi, and J. F. Eiche, 'Comparative study of residential household energy consumption in Ekiti State, Nigeria'. British J. Appl. Sci & Technol. 21 (2): 1- 10, 2017.

[46] M. B. Adamu, H. Adamu, S. M. Ade, and G. I. Akeh, 'Household Energy Consumption in Nigeria: A Review on the Applicability of the Energy Ladder Model', J. Appl. Sci. Environ. Manage. Vol. 24 (2) 237-244 February 2020.

[47] W.A. Bolaji, 'Investigation of the Use of Energy Efficient Bulbs in Residential Buildings in Ile-Ife, Osun State, Nigeria', International Journal of Built Environment and Sustainability 5 (2)/2018, 155-162.

[48] K. Ley, J. Gaines, A. Ghatikar, 'The Nigerian Energy Sector: An Overview with a Special Emphasis on Renewable Energy, Energy Efficiency and Rural Electrification', Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Nigerian Energy Support Programme (NESP). (2015).

[49] S. O. Oyedepo, Energy efficiency and conservation Measures: tools for sustainable energy development in Nigeria. Int. J. Energy Eng., 2 (2012), pp. 86-98.

[50] E. Uyigue, M. Agho, A. Edevbaro, O. O. Godfrey, O. P. Uyigue and O. G. Okungbowa. Energy Efficiency Survey in Nigeria A Guide for Developing Policy and Legislation. Community Research and Development Centre', 2009. https://www.osti.gov/etdeweb/servlets/purl/21328691.

[51] S. Geissler, D. Österreicher, and E. Macharm. Transition towards Energy Efficiency: Developing the Nigerian Building Energy Efficiency Code', Sustainability 2018, 10, 2620; doi: 10.3390/su10082620.