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Strategic Assessment of the Utilization of Energy-Efficient Lighting Devices in Municipal Residential Complexes in Selected States in Southwestern Nigeria

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ABSTRACT

This study characterized electric lighting devices utilized in municipal residential complexes in Southwestern Nigeria, assessed the utilization of energy-saving lighting devices, and investigated the factors influencing this utilization to assess the effectiveness of energy savings policy implementation in the region. The study entailed a survey analysis of 300 housing units across three government-approved housing estates in Oyo and Lagos States located in Southwest Nigeria. The study determined that energy-saving lighting devices constituted 97% of lighting bulbs in municipal residential complexes in the region, with the 15W-light emitting diode (LED) bulbs being the dominant bulb type. The study provided evidence of a significant shift in lighting bulb usage from the dominant incandescent bulb (especially the 60W type) in the early 2000s to the LED bulb (especially 15W type) in 2023. Furthermore the study revealed that the most important factors influencing the utilization of energy-saving bulbs in the study area (on a 10-point Likert scale) were the energy-saving lighting devices' (ESLD) performance trustworthiness (8.71), energy-saving capabilities (8.63), bulb luminance (8.36), bulb durability (8.14), product availability (7.77), and price-to-performance perception (7.45). Government policy awareness and implementation was revealed to be a moderately important factor (5.88). The study concluded that the Nigerian government's strategic energy policy measures to promote the usage of energy-saving lighting devices in municipal housing could be considered as effective, albeit a secondary rather than a primary consequence of the policy in selected States in the Country's Southwestern Geopolitical Zone.

Keywords:
Energy saving; Lighting devices; Energy policy; Municipal electricity demand; Energy policy analysis; Nigeria

INTRODUCTION

Energy is critical to the sustenance of life, socio-economic growth and development of any nation. Electricity is a versatile form of energy which can be transmitted almost spontaneously and can travel great distances with ease (Ogundari *et al.*, 2020). In Nigeria, the residential sector accounts for about 60% of electricity consumption, and its use is predominantly for the provision of comfort, ambience and illumination – cooking, heating, air-conditioning and operation of electrical appliances among others (Momodu *et al.*, 2011; Ogundari and Otuyemi, 2020; Salu *et al.*, 2022). Lighting is identified as a significant electricity consumer accounting for 25-55% of household electricity consumption, while residential lighting accounts for an estimated 15-33% of total electricity consumption in Nigeria (Momodu *et al.*, 2011; Ogundari and Otuyemi, 2020; Salu *et al.*, 2022).

Nigeria's ever increasing population and urban sprawl have triggered residential building expansions, led to increased residential electricity consumption, and stimulated public awareness on the need to curtail electricity consumption (Salu *et al.*, 2022; Jesuleye *et al.*, 2023). The Federal and State Governments in Nigeria, taking cognizance of these developments and their implications on national electricity consumption, intensified efforts towards promoting public policies such as the National Energy Policy (NEP) (2003) and the National Renewable Energy and Energy Efficiency Policy (NREEEP) (2015) to enhance the adoption of appropriate energy efficient technologies such as energy-saving lighting devices (ESLDs) in the national residential sector (Olaniyan *et al.*, 2018; Adepoju *et al.*, 2020; Salu *et al.*, 2022)

Studies on residential electricity consumption in Nigeria from the early 2000s to the mid-2010s had reported an estimated 250 – 300 million incandescent bulb-based lighting points in almost 20 million households with access to electricity in the country, and noted that the 60W incandescent bulb was the prevalent type in use (Momodu *et al.*, 2011; Ahemen *et al.*, 2016; Ogundari *et al.*, 2017; Ajayi *et al.*, 2018). The incandescent light bulb requires its constituent wire filament to be heated until it glows, and with only about 5% of its total energy use being converted to light energy, and the remaining 95% being converted to heat. This implies that the bulb is basically an inefficient energy device (Ndinechi *et al.*, 2012). In spite of having a low service-life of 1,000 – 2,000 hours, the incandescent bulb has high electricity consumption; and its use in Nigeria in mid-2010s was determined to have led to huge energy losses at an estimated cost of ₦ 8.7 billion annually (Bloomberg, 2021; CWAT.com, 2023). The transition to energy-efficient lighting was considered one of the most cost-effective measures to reduce grid electricity consumption in Nigeria's residential sector; with the compact flourescent lamps (CFL) (with life expectancy of 10,000 – 20,000 hours) and light emmiting diodes (LED) (with life expectancy of 20,000 – 50,000 hours (Viribright, 2023)) types found prevalent in the Nigerian market (Momodu *et al.*, 2011; Ogundari *et al.*, 2017; Ajayi *et al.*, 2018; Salu *et al.*, 2022). Although the rate of utilization of these energy-saving lighting devices (ESLDs) in Nigeria is growing, their exact numbers and share of total lighting points in the country are not readily available. Studies indicate that ESLDs still constitute less than 50% of the lighting market as at 2020, while the incandescent bulbs and compact flourescent lamps (CFL) still significantly dominate the market (Otobo *et al.*, 2020; Dioha, 2022; Babatunde *et al.*, 2023).

Preliminary policy measures in restructuring the national electric power sector in the early 2000s, such as the National Energy Policy (2003), have included the utilization of energy-efficient lighting technologies in Nigeria's residential sector to primarily reduce the sector's total electric power load demand (PwC, 2016; ECN, 2020 CF; Otobo *et al.*, 2020; Babatunde *et al.*, 2023). Further restructuring over the last 25 years – which included new laws, policy measures and programmes such as the National Renewable Energy and Energy Efficiency Policy (2015), the Nigeria Sustainable Energy for All Action Agenda (NigeriaSE4ALL) (with a target of 100% efficient lighting by 2030), as well as the recent Electricity for All Act (2023) (which amended Nigeria's constitution moving electricity generation, transmission and distribution from the exclusive list to the concurrent list) – have intensified measures for the reduction of residential electric power consumption and improvement in national electricity access (Aliyu *et al.*, 2018; Arowolo *et al.*, 2019; Otobo *et al.*, 2020; Dioha, 2022; Babatunde *et al.*, 2023). These studies however

critically note that under the extant national energy-efficiency policy direction, there are no specific national targets for the replacement of incandescent bulbs and CFLs with ESLDs in the economy in general and in residential housing in particular. Rather, the policy measures on the adoption of energy-efficient lighting were still only constituents of the broader national energy efficiency goals.

In Nigeria's South-West Geopolitical Zone, the States and the regional Development Agenda for Western Nigeria (DAWN) Commission, by explicit and implicit means, incorporated the Federal Government's strategic electricity sector policies into regional infrastructure planning; promoting the usage of energy-efficient lighting devices in the regional residential housing sector to reduce its observed high electric power consumption pattern and increase the percentage of energy-saving lighting devices in the regional residential housing sector (ECN, 2020; FMP, 2020; OGSG, 2022; LASG, 2022; Ogundari *et al.*, 2021).

Policy evaluation is a critical component of policy development. Consequently, it is imperative to determine the extent of policy adherence and success of the utilization of energy-saving lighting in the regional residential housing sector as an input to strategic power infrastructure planning. Disconcertingly, this strategic policy analysis for regional infrastructure development has been ineffectual due to inadequate intelligence on the characteristics and utilization of energy-saving lighting devices in the region's suburban housing developments, thus, necessitating this study.

METHODOLOGY

Nigeria's South-West Geopolitical Zone is one of the six geopolitical zones of the Country and it comprises six states – Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti, with an estimated population of 47 million people (about 21.8% of Nigeria's population). The Zone, culturally within Yorubaland, stretches along the Atlantic seabed from Benin Republic in the West to the South-South geopolitical zone in the east and the North-Central geopolitical zone to the North. Lagos (population: 21 million) and Ibadan (population: 6 million) are the major urban areas of South-West Nigeria. The rapid economic and population growth of Lagos and Ibadan has spurred the advancement of built-up areas and newly-developed residential complexes.

The study was carried out in two of the six States of the South-West Geopolitical Zone, namely, Lagos and Oyo for critical reasons – the two States combined have about 57.5% of the total population and more than 75% of the total number of grid-electricity consumers in the Zone. Furthermore, three out of the four electricity distribution companies (DISCOs) operating in the Zone have their headquarters in the two States – the Ibadan Electricity Distribution Company (IBEDC) in Ibadan, Oyo State, while the Eko Electricity Distribution Company (EKEDC) and Ikeja Electricity Distribution Company (IKEDC) are in Lagos and Ikeja, Lagos State respectively. Ibadan, Oyo State and Ikeja, Lagos State were purposively sampled for having large populations and availability of residential estates. Three government-approved private residential estates were sampled in each location, making a total of 6 residential estates. Each estate has 150 housing apartments, making a total of 900 housing apartments. In each estate, 50 housing apartments were randomly sampled, making a total of 300 housing apartments (NPC, 2023; Propsult.com, 2023).

In each of the 300 apartments, the head of the household was administered a survey form with three different sets of questions to answer. One set elicited information on the socio-demographic characteristics of the household head, namely, gender, age, marital status, educational qualification and household income level. Another set of questions elicited information on the characteristics of the electric lighting devices used in the apartments entailing their type (whether incandescent bulbs, CLFs or LED bulbs), number, wattage, average service life, and average initial unit costs. Personal observation was also used where necessary to supplement the data given. From these data, total number of bulbs, percentage wattage and average initial total costs were determined. The third set of questions elicited information on the factors influencing the utilization of energy-saving lighting bulbs. These factors were identified from literature and included price, quality, energy saving, durability, trustworthiness of LED performance, compatibility of LED lamps with the lighting fixtures amongst

others. The respondents rated these factors on a 10-point Likert scale, where 1 was lowest and 10 was highest influencing factor. The analysis of the evolution of the utilization of lighting bulbs in residential housing in Southwestern Nigeria entailed comparing data on the types of electric lighting devices utilized over a specific period of time, which, in this study were ten-year intervals from 2003 to 2023. Consequently, secondary data on types of electric lighting devices used in 2003 and 2013 in Lagos were obtained from energy planning journal articles as well as energy intelligence reports of the Federal Ministry of Power, and compared with the data obtained from this study. The analytical techniques used in this study were descriptive statistics and strategic assessment (trend analysis/analytical reasoning).

RESULTS AND DISCUSSIONS

In this section, the results of the study were presented and strategic assessments of the results provided.

Socio-demographic Characteristics of the Respondents

Precisely 250 out the 300 respondents returned completed questionnaire sets, making a 83.3% return rate. Table 1 presents the socio-demographic characteristics of the respondents, revealing that most of the respondents were male (62.8%), predominantly in the 41–60-year-old age bracket (52%), married (76.0%), well-educated (91.2% held tertiary degrees) and earned between ₦100,000 to 500,000 per month (47%). Thus, if one randomly picked a respondent in the residential complex, they would most likely be a middle-aged, well-educated, married man in the middle-class economic bracket. This class of people in Africa tend to seek comfort, convenience, self-improvement, safety and security in their lifestyle (Adeyeye and Makinde, 2020; Kariuki and Kamau, 2020; Opoku *et al.*, 2020). They also tend to demonstrate significant environmental consciousness (Eze and Ndubisi, 2019; Okumah *et al.*, 2019; Oludayo and Oke, 2019). It is not out of place to infer that this class of people are more likely to accept novel technologies like energy-efficient lighting which have energy cost implications and environmental consequences (Gillingham and Palmer, 2019; Kristrom and Lundgren; 2019; Okunlola and Ismail, 2019; Ramos *et al*., 2019).

Table 1: Socio-demographic Characteristics of Respondents

Variables	Levels	Frequency	Percentage (%)
Gender	Male	157	62.8
	Female	83	37.2
	Total	**250**	**100.0**
Age	20-30 years	28	11.2
	31-40 years	46	18.4
	41-50 years	87	34.8
	51-60 years	68	27.2
	61- above	21	8.4
	Total	**250**	**100.0**
Marital Status	Single	47	18.8
	Married	190	76.0
	Divorced	13	5.2
	Total	**250**	**100.0**
Educational Qualification	Primary School Certificate	12	4.8
	Secondary School Certificate	10	4.0
	HND/Bachelor's Degree	165	66.0
	Post Graduate degree (Masters/PhD)	63	25.2
	Total	**250**	**100.0**
Household Income Level	Below ₦50,000	25	10.0
	₦50,000 – 100,000	38	15.2
	₦100,000 – 200,000	81	32.4
	₦200,000 – 500,000	59	23.6
	₦500,000 – 1,000,000	25	10.0
	₦1,000,000 and above	22	8.8
	Total	**250**	**100.0**

Characteristics of Lighting Devices Utilized in the Residential Complexes

There were approximately 3,600 bulbs utilized in the residential complexes in the study area. These bulbs were made up of 94 (2.62%), incandescent Bulbs 21 (0.59%) Fluorescent Bulbs, 741 (20.63%) Compound Fluorescent Lamp (CFL) Bulbs and 2,736 (76.17%) Light Emitting Diode (LED) Bulbs (see Figure 1 and Table 2). Thus, this section shows that almost all (96.8%) the bulbs used in the study area were energy-saving bulbs, 81.42% of total bulb wattage, and 99.15% of total costs of bulbs purchased, with LED bulbs dominating, and 15W LED bulbs being the primary bulb utilised (being about a quarter of all utilization in each section assessed).

Of the top 10 energy-saving bulb specifications in utilization (as identified in Table 2), the LED bulbs were more in use relative to the CFL bulbs at a ratio of 7:3, with the 15W LED bulb being the most utilized (23.5%), with the next two in use being the 10 W LED (13.67%) and the 8 W LED (11.69%). Together, the 15W and 10W LED bulbs constituted 37.17% (almost 40%) total lighting bulbs' in utilization in the study area (see Figure 2).

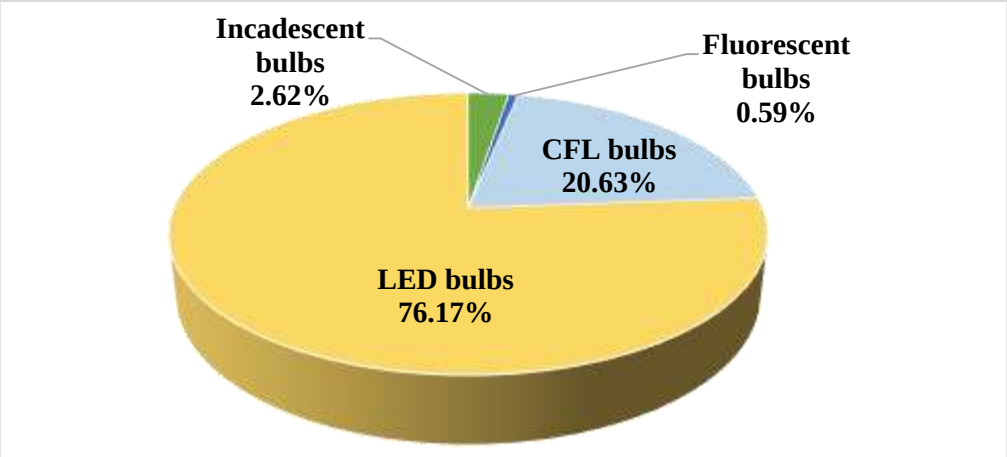

Figure 1: Utilization of Bulbs in the Residential Complexes

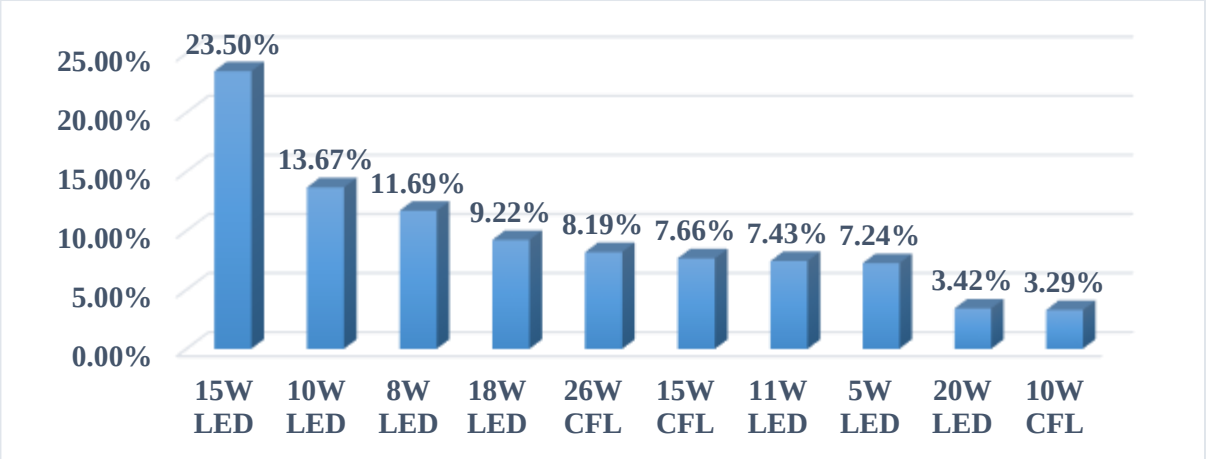

Figure 2: Top 10-Lighting Bulbs in the Residential Complexes

Table 2: Characterization of the Lighting Technologies by Number, Total Wattage and Initial Costs

Lighting Technology	Wattage (W)	Number	Percentage of Sum Total (%)	Total Wattage (W)	Percentage of Total Wattage (W) (%)	Average Service Life (Hours)	Average Initial Unit Cost (₦)	Average Initial Total Cost (₦)
Incandescent Bulb	200	25	0.70	5,000	8.51	1,000	200	5,000
	100	34	0.95	3,400	5.79	1,000	150	5,100
	60	35	0.97	2,100	3.57	1,000	150	5,250
Sum		**94**	**2.62**	**10,500**	**17.87**			**15,350**
Fluorescent Tube	24	7	0.20	168	0.29	7,000	800	5,600
	18	14	0.39	252	0.43	7,000	800	11,200
Sum		**21**	**0.59**	**420**	**0.72**			**16,800**
CFL	40	17	0.47	680	1.16	8,000	1,800	30,600
	32	16	0.45	512	0.87	8,000	1,500	24,000
	26	294	8.19	7,644	13.01	8,000	1,200	352,800
	15	275	7.66	4,125	7.02	8,000	1,100	302,500
	10	118	3.29	1,180	2.01	8,000	900	106,200
	5	21	0.59	105	0.18	8,000	750	15,750
Sum		**741**	**20.63**	**14,246**	**24.25**			**831,850**
LED	20	123	3.42	2,460	4.19	30,000	1,800	221,400
	18	331	9.22	5,958	10.14	30,000	1,500	496,500
	15	844	23.50	12,660	21.55	30,000	1,200	1,012,800
	11	267	7.43	2,937	5.00	30,000	1,000	267,000
	10	491	13.67	4,910	8.36	30,000	1,000	491,000
	8	420	11.69	3,360	5.72	30,000	800	336,000
	5	260	7.24	1,300	2.21	30,000	500	130,000
Sum		**2736**	**76.17**	**33,585**	**57.17**			**2,954,700**
Sum Total		**3592**	**100**	**58,751**	**100**			**3,818,700**

The analysis of lighting bulbs' utilization by total bulb wattage (TBW) revealed that while TBW was 58,751W (58.75 KW), energy-saving bulbs (CFLs at 24.25% and LEDs at 57.17%) dominated with a combined 81.42% of the TBW (Figure 3). The three top bulbs by wattage usage, with a combined 44.7% of TBW, were the 15W LED, 26W CFL, and 18W LED at 21.55, 13.01 and 10.14% of TBW respectively (see Figure 4). The analysis of the lighting bulbs' utilization by total initial costs (TIC) showed TIC at an estimated ₦ 3.8 million, with the energy-saving bulbs (CFLs at 21.78% and LEDs at 77.37%) dominating with a combined 99.15% of the TIC (see Figure 5). The top bulbs, with a combined 52.38% of TIC, were the 15W LED, 18W LED, and 10W LED at 26.52, 13.00 and 12.86% of TIC respectively (see Figure 6).

Evolution of the Utilization of Lighting Bulbs in Residential Complexes in Southwestern Nigeria

The incandescent and fluorescent bulbs were the dominant lighting bulb types used in residential complexes in Southwestern Nigeria in the early 2000s, constituting an estimated 96.7% of total bulb usage during that period; while the CFL and LED bulb types were almost unknown in the market, and together constituted only about 3.3% of total bulb usage (Momodu *et al.*, 2011; Ogundari *et al.*, 2017) (Table 3). The prevalent bulb type used in households was specifically the 60W incandescent bulb (Momodu *et al.*, 2011; Ogundari *et al.*, 2017).

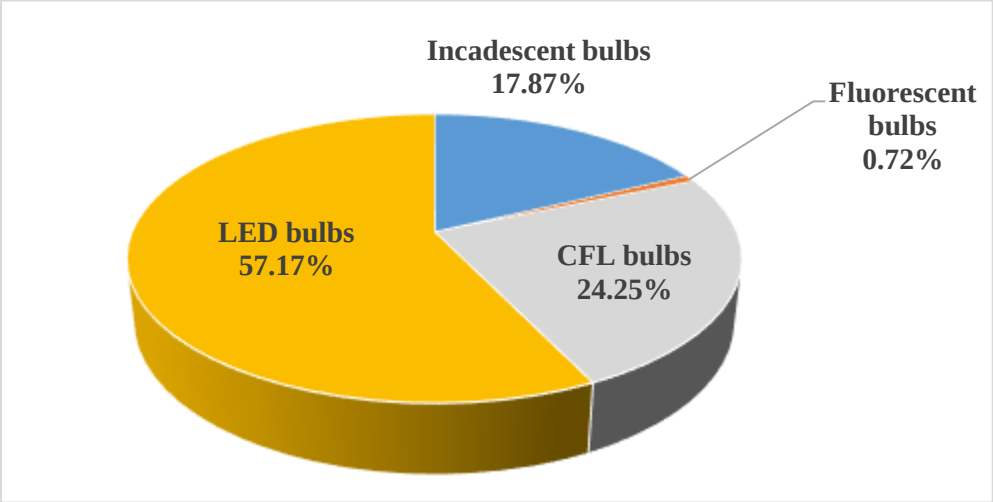

Figure 3: Utilization of Bulbs by Total Bulb Wattage in the Residential Complexes

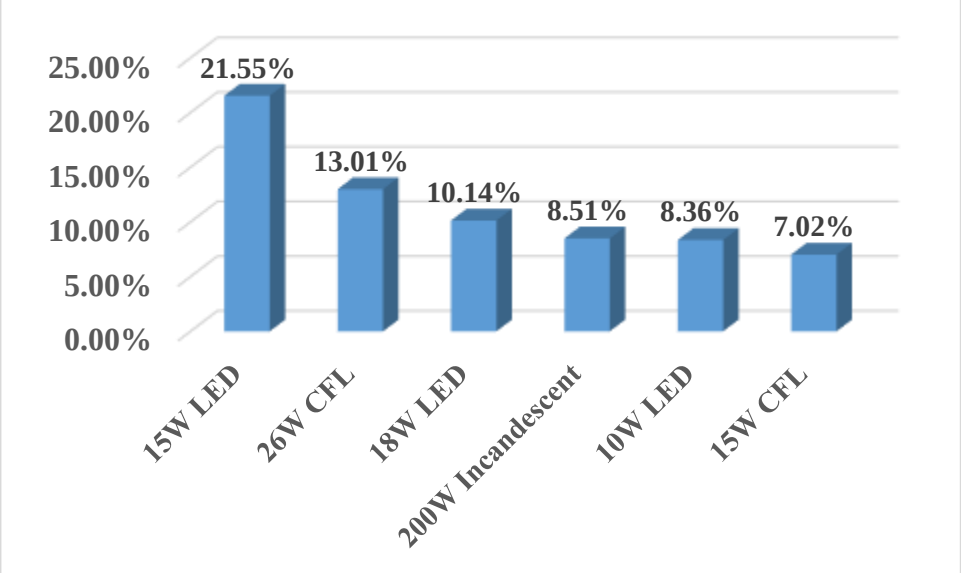

Figure 4: Top Lighting Bulbs by Wattage Usage in the Residential Complexes

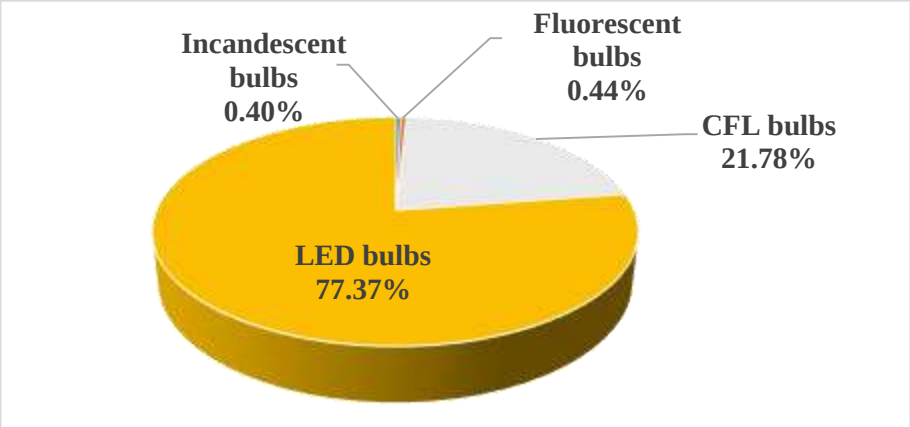

Figure 5: Utilization of Bulbs by Total Initial Costs in the Residential Complexes

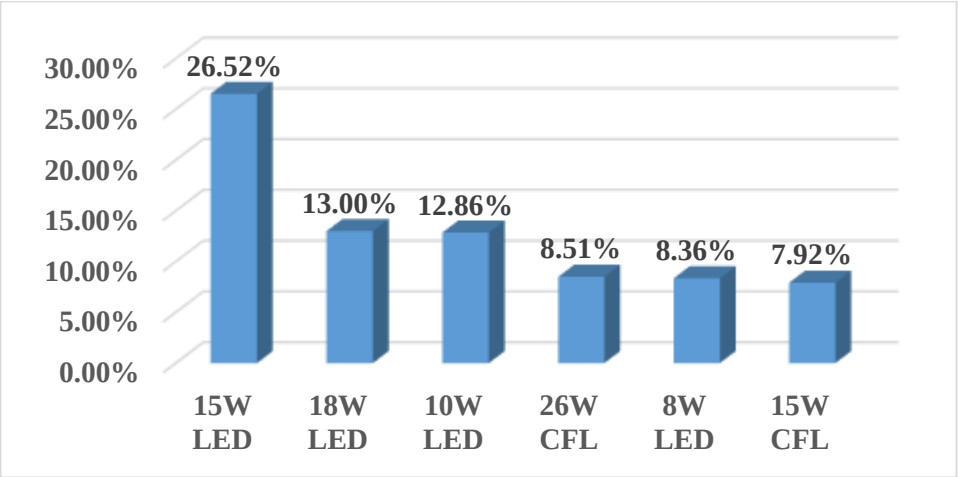

Figure 6: Top Lighting Bulbs by Initial Costs in the Residential Complexes

Within a decade, as indicated in Table 3, the residential usage of incandescent and fluorescent bulbs had declined significantly from almost 97% of total bulb usage in 2003 to only 25% in 2013, while the energy-saving bulbs had gained prominence from 3% of total bulb usage to 75%. The residential usage of incandescent and fluorescent bulbs has been shown to have declined further to a low of only 3% of total bulb usage by 2023, while the usage of energy-saving bulbs has increased to 96% of total bulb usage (see Table 3). The evidence from this study is indicative of a critical shift in light bulb type and wattage demand over the last 20 years – specifically, from the dominance of the Incandescent bulbs (especially the 60W type) to the current dominance of the LED energy-saving bulb (especially the 15W type). The significant shift in light-bulb utilization in Southwestern Nigeria has as one of its attributions, the government policy focus on the adoption of energy-saving lighting devices in Nigeria (Ogundari, 2009).

Table 3: Evolution of the Utilization of Lighting Bulbs in Residential Complexes in Southwestern Nigeria

	Type of Bulb	2003 (%)	2013 (%)	2023 (%)
Energy-Saving Bulbs	Incandescent Bulb	61.30	19.60	2.62
	Fluorescent Bulb	35.40	5.50	0.59
	CFL Bulb	3.10	66.20	20.63
	LED Bulb	0.20	8.70	76.17

Source: Momodu *et al.* (2011); Ogundari *et al.* (2017)

Factors Influencing the Utilization of Energy-Saving Lighting Bulbs in Residential Complexes in Southwestern Nigeria

Concerns over limited efficiency of incandescent light bulbs and high costs of household lighting may have influenced public policy on lighting bulb technology and utilization in Nigeria since the mid-2000s (Momodu *et al.*, 2011; Ogundari *et al.*, 2017). With this increase in public awareness and perceived increase in government pronouncements on the subject matter, it was not illogical to assume that the shift in light-bulb acquisition in Southwest Nigeria may be attributable to policy focus on the adoption of energy-saving bulbs in the study area. This assumption has led to the examination of the factors behind the high utilization of these energy-saving lighting bulbs in the study area.

From literature, factors identified as influencing the utilization of energy-saving lighting bulbs included price, quality, energy saving, durability, trustworthiness of LED performance, compatibility of LED lamps with the lighting fixtures amongst others. The 6 dominant factors identified in this study as influencing the high utilization of energy-saving lighting devices in residential complexes in Southwestern Nigeria were: the trustworthiness of the ESLD performance (mean rating = 8.71), energy saving capabilities (8.63), luminance of the bulbs (8.36), durability of the bulbs (8.14), the availability of the product in the market (7.77), and price-to-performance perception (7.45) (see Table 4). Government policy awareness or implementation (mean rating = 5.88) was deemed a medium factor influencing the utilization of energy-saving lighting devices in the study area.

Table 4: Factors Influencing Utilization of Energy-Saving Lighting Devices (ESLD) in Residential Estates in Southwestern Nigeria

S/N	Factors	Mean Rating	Modal Rating
1	Trustworthiness of ESLD performance	8.71	10
2	Energy Saving capabilities	8.63	7
3	Luminance of bulbs	8.36	10
4	Durability	8.14	9
5	Product Availability	7.77	8
6	Price-to-performance	7.45	7, 9
7	No Heat Generation	7.26	10
8	Environmental Consciousness/No carbon emission	6.39	9
9	Compatibility of ESLD with the lighting fixtures	6.07	
10	Advertisement	5.88	5
11	Government Policy Awareness or Implementation	5.88	5
12	Promotion & Corporate Social Responsibility	1.34	1
13	Social Wellbeing	1.21	1
14	Brand Awareness	1.20	1

On a scale of 1 – 10 where 1 is lowest Rate and 10 is highest Rate) (1 – 3 (Low); 4 – 6 (Medium); 7 – 10 (High)

These findings indicate that, at least from the perspectives of the homeowners, trustworthiness in the physical performance of the ESLD to provide desired illumination and save energy, as well their availability in the open market were a more compelling reason to opt for the use of energy-saving lighting devices rather than simply following government policies and directives. This may provide evidence that government policy is not directly involved in ESLD utilization at the household level; rather, it is indirectly involved. It could be speculated that the availability of the products was consequent to the product vendors themselves being directly influenced by the government policy on greater ESLD utilization in the polity, while the household end-users were indirectly influenced. Thus, indicatively, the utilization of ESLD in residential complexes in Southwestern Nigeria was a secondary consequence of the government policy on ESLD deployment rather than a primary consequence to it.

SUMMARY AND CONCLUSION

The States and regional development agency in Nigeria's South-West Geopolitical Zone developed and deployed strategic policy measures to promote the usage of energy-efficient lighting devices in the region's residential housing sector to reduce high electricity consumption and actualize a predetermined energy-savings threshold. An effectual strategic analysis of this policy required determining the characteristics and utilization of

energy-saving lighting devices in the region's suburban housing developments. This study investigated 250 housing units across three government approved housing estates in each of two States in Southwestern Nigeria, namely, Lagos and Oyo States in order to provide the critical policy intelligence. The study determined that energy-saving lighting devices constituted 97% of lighting bulbs in residential complexes in Southwestern Nigeria, with the 15W LED bulbs being the dominant bulb type. The study provided evidence of a significant shift in lighting bulb usage from the dominant Incandescent bulb usage (especially of the 60W type) in the early 2000s to the LED bulb (especially 15W type) in 2023. Furthermore the study revealed the 6-dominant factors influencing the utilization of energy-saving bulbs in the study area were the trustworthiness of the ESLD performance (mean rating = 8.71), energy saving capabilities (8.63), luminance of the bulbs (8.36), durability of the bulbs (8.14), the availability of the product in the market (7.77), and price-to-performance perception (7.45). Government policy awareness and implementation was revealed to be only a medium factor (mean rating = 5.88). The study concluded that the policies of the State governments and development agency in the Southwestern Geopolitical Zone of Nigeria to promote the usage of energy-efficient lighting devices in the residential housing sector could be considered as adequate, appropriate and effective, albeit they were not explicit to the household utilization of these energy saving devices but rather implicit to their utilization,

Reference

Adepoju, A. Jesuleye, O., and Arigbede, O. (2020). Solar photovoltaics contribution to energy mix in selected Nigerian estates, *Archives of Business Research*, 8(3), 131-164

Adeyeye, A. D. and Makinde, O. O. (2020): Consumer behaviour in the African middle class: The roles of safety and security in product choice, *African Journal of Business Management*, 14 (3), 75-83.

Ahemen, I., Amah, A. N., and Agada, P. O. (2016). A survey of power supply and lighting patterns in North Central Nigeria – The energy saving potentials through efficient lighting systems, *Energy and Buildings*, 133, 770-776.

Ajayi, P. I. (2018). Urban household energy demand in Southwest Nigeria, *African Development Review*, 30 (4), 410 – 422

Aliyu, A. K., Modu, B., & Tan, C. W. (2018). A review of renewable energy development in Africa: A focus in South Africa, Egypt and Nigeria. *Renewable and Sustainable Energy Reviews*. 81, 2502– 2518

Arowolo, W., Blechinger, P., Cader, C. and Perez, Y. (2019): Seeking workable solutions to the electrification challenge in Nigeria: Minigrid, reverse auctions and institutional adaptation, *Energy Strategy Reviews*, 23, 114-141.

Babatunde, O., Buraimoh, E., Tinuoye, O., Ayegbusi, C., Davidson, I. and Ighravwe, D. E. (2023). Electricity sector assessment in Nigeria: the post-liberation era, *Cogent Engineering*, 10:1, 1-24.

Bloomberg (2021): Nigeria's Power Sector Gets $500 Million Boost From World Bank, https://www.bloomberg.com/news/articles/2021-02-05/nigeria-s-power-sector-gets-500-million-boost-from-world-bank?leadSource=uverify%20wall Accessed on May 13, 2023

CWAT.com (2023). The future of LED market in Nigeria is brighter, 1-5, https://www.cwat.com.ng/the-future-of-led-market-in-nigeria-is-brighter/ Accessed on September 13, 2023

Dioha, M. O. (2022): Making Nigeria's energy transition plan a reality, https://energyforgrowth.org/wp-content/uploads/2022/11/Making-Nigerias-energy-transition-plan-a-reality-3.pdf Accessed on February 13, 2023

Energy Commission of Nigeria (ECN) (2020). "National Energy Policy" released by the Presidency, Federal Republic of Nigeria, 1-89. Accessed: April 15, 2023

Eze, U. O. and Ndubisi, N. O. (2019): Green consumer behaviour and environmental sustainability in South Africa: A study of consumers' attitudes towards environmental responsibility, *African Journal of Business Management*, 13(15), 516-528.

Federal Ministry of Power (FMP) (2020). "Power Situation in Nigeria". Federal Republic of Nigeria's National Energy Policy, 1-89. Accessed: March 26, 2023

Gillingham, K. and Palmer, K. (2019): Bridging the energy efficiency gap: Policy insights from economic theory and empirical evidence, *Review of Environmental Economics and Policy*, 13(1), 136-155.

Jesuleye, A., Oriola, O., and Adepoju, A. (2023). Evaluating Prospective Energy Services Demand for Residential Solar Photovoltaic (RSPV) Generated Electricity in Lagos State, Nigeria, *Journal of Digital Foods, Energy and Water Systems*, 4(2), 159-177

Kariuki, J. G. and Kamau, J. W. (2020): Perceptiion and adoption of smart home technologies among middle-class households in Nairobi, Kenya, *Journal of Sustainable Development in Africa*, 22(3), 42-56.

KPMG (2023). Commentaries on the Electricity Act, 2023, https://assets.kpmg.com/content/dam/kpmg/ng/pdf/commentaries-on-the-electricity-act--2023.pdf

Kristrom, B. and Lundgren, T. (2019): Energy efficiency and household behaviour: The rebound effect in Swedish households, *Energy Policy*, 129, 685-695.

Lagos State Government (2022), Lagos State Development Plan 2052, https://api.lagosmepb.org/lsdp-resources/LSDP_2052_Full_Report.pdf

Momodu, A. S., Abraham, O. E., Ogundari, I. O., Jesuleye, O.A., Sanni, M., Ibuoye, T. F., and Siyanbola, W. O. (2011). Cost-benefit analysis of promoting energy efficiency diffusion in Nigeria's Residential and Commercial Buildings". *Nigeria Journal of Solar Energy*, 22, 105-119.

Ndinechi, M. C., Oluwaseyi, O. A., Nwadiuko, O. C. and Ikechukwu, I. (2012). Reliability assessment of incandescent light bulbs in Nigeria market and case for energy saving alternatives, *Academic Research International*, 2(3), 259-264

Nigeria Property Centre, Land for sale in Ibadan and Lagos (2023) http://nigeriapropertycentre.com Accessed June 30, 2023

Ogun State Government (2022), Ogun State Development Plan: Mission to Rebuild 2018 – 2030, 1-110, https://budgetpedia.ng/wpfd_file/ogun-state-development-plan-2018-2030/

Ogundari, I. O. (2023). Techno-Economic Analysis of Waste-to-Suburban Cooking Energy Critical Infrastructure Development in Southwestern Nigeria. *Journal of Energy and Power Technology*, 5(2), 1-20

Ogundari, I. O., Akinwale, Y. O., Adepoju, A. O., Atoyebi, M. K., and Akarakiri, J. B. (2017). Suburban housing development and off-grid electric power supply assessment for North-Central Nigeria, *International Journal of Sustainable Energy Planning and Management*, 12, 47–64.

Ogundari, I. O., Ayoola, P. O., and Bakare, H. O. (2021). Techno-economic assessment of municipal natural gas-powered (off-grid) alternative electric power supply in Lagos State, Nigeria, *Ife Journal of Technology*, 28 (1), 28 - 36

Ogundari, I. O. and Otuyemi, F. A. (2019): Project planning and monitoring analysis for sustainable environment and power infrastructure project development in Lagos State, Nigeria, *Int. J. Critical Infrastructures*, 15 (1), 24 – 45.

Ogundari, I. O. and Otuyemi, F. A. (2020): Project Planning and Control Analysis for Suburban Photovoltaic Alternative Electric Power Supply in Southwestern Nigeria, *African Journal for Science, Technology, Innovation and Development*, 13 (7), 1-19

Okumah, M., Ankomah-Kachman, P. and Yeboah, A. S. (2019): What shapes attitudes towards solid waste disposal? Insights from a Ghanaian urban community, *Resources, Conservation and Recycling*, 150, 104444

Okunlola, A. and Ismail, K. (2019): Energy Efficiency awareness and adoption of sustainable lighting systems in Nigeria, *International Journal of Energy Economics and Policy*, 9(5), 423-429.

Olaniyan, K. McLellan, B. C., Ogata, S., and Tezuka, T. (2018). Estimating residential electricity consumption in Nigeria to support energy transitions, *Sustainability*, 10, 1440, 1-22

Oludayo, O. T. and Oke, A. O. (2019): The influence of pro-environmental beliefs on green purchase intentions in Lagos Nigeria, Journal of Business and Retail Management, 13(4), 133-143

Opoku, R., Abratt, R., and Pitt, L. (2020): Branding in emerging markets: The importance of self-improvement and lifestyle enhancement for Africa's middle class, *Journal of Brand Management*, 27(1), 5-16

Otobo, J., Estebsar, A., Hartungi, R. and Ibraheem , Y. (2020). A Critical Review of Nigerian Electricity Policies between 2001 and 2020, https://openresearch.lsbu.ac.uk/download/fcb7e27bdc3f3d9ba957f859816619677ee75ef3bb2b33dec670a8d24410be7a/930934/A%20Critical%20Review%20of%20Nigerian%20Electricity%20Policies%20between%202001%20and%202020%281%29.pdf Accessed on September 13, 2023

Propsult.com (2023): Government owned housing estates in Lagos, https://propsult.com/government-owned-housing-estates-in-lagos/ Accessed on October 10, 2023

PwC (2016). PwC's Annual Power and Utilities Roundtable: The challenges with transforming the Nigerian power landscape, https://www.pwc.com/ng/en/assets/pdf/power-roundtable-2016.pdf Accessed on October 10, 2023

Ramos, A., Labandeira, X. and Loschel, A. (2019): Pro-environmental households and energy efficiency in Europe: Insights from the European energy survey, *Energy Economics*, 79, 110-124.

Salu, B. O., Ogundari, I. O**.,** Akinbami, J-F. K., and Akarakiri, J. B. (2022): Determination of solar irradiance benchmarks for municipal off-grid photovoltaic power system development in Lagos State, Nigeria, In O. O. Adejuwon and A. A. Egbetokun (Eds.) *Technology Management and the*

Challenges of Sustainable Development: A Festschrift for Matthew Ilori, Obafemi Awolowo University Press, 64-75.

Viribright (2023): Comparing LED vs CFL vs incandescent light bulbs, https://viribright.com/blogs/insights/comparing-led-vs-cfl-vs-incandescent-light-bulbs?srsltid=AfmBOor6dPsqDj42n3mBnmixmcrpLe_tFTc2p2RQuobjfobI9JfOkrt1 Accessed on October 10, 2023