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Wastage amidst shortage: Strategies for the mitigation of standby electricity in residential sector in Nigeria.

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Abstract-
Due to rising population and the increasing rate of urbanization, residential electricity usage accounts for a large chunk of Nigeria's electricity consumption. However, little attention is paid to electricity conservation in the country. In response to this, several studies are been tailored to ensure a rapid reduction in energy consumption through various alternatives including energy efficient technologies given the current state of inadequate electricity supply in the country. On this note, this article discusses the significance of standby electricity in Nigeria. The electricity generation and consumption patterns were briefly discussed while the current electricity saving behaviour and practices among the urban dwellers were detailed with a case study analysed. Based on the case study, it was discovered that the mean standby load across the 30 households were estimated at 60 W ranging from 34-144 W. Also, standby consumption accounts for 13-44% of the annual electricity consumption across the households. Finally, the strategies for electricity saving and sustainable consumption, most especially the mitigation of standby electricity were highlighted.

Keywords: Policy options; residential buildings; standby electricity; sustainable consumption.

1. Introduction

Globally, the energy (electricity) consumption in residential buildings takes up a significant junk of both the world's energy generated, and energy consumed. The significance of electricity availability to the socio-economic growth of any nation cannot be undermined. Indeed, electricity plays a critical role in the economic growth, progress, and advancement, cum poverty alleviation, and security. As at 2016, 26 % of the total global electricity consumption is from residential sector. This statistic was only outwitted by the industrial sector, which consumed 40 % of the total value [1]. Figure 1 shows the global electricity consumption in 2016 across the economic sector [1].

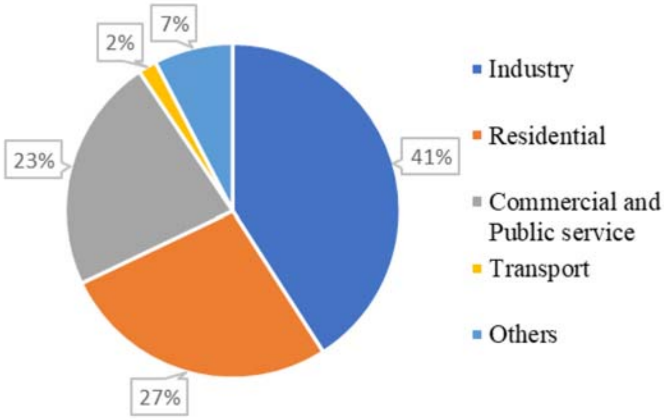

Figure 1: Electricity consumption across the economic sector.

The advancement in science and technology has elevated the standard of living of the people in some across the globe regions. Coupled with this is the increase in market penetration of household appliances, office gadgets, audiovisual product, and automation application. Most of these appliances are internet-enabled [2], thus requiring them being perpetually on; either on standby mode or operational. This consequentially has increased the standby power function across the residential sector. Notwithstanding the convenience which has emanated from the use of these devices, the wasted energy, when these devices are not in operation but in standby mode, has increased and has become a global concern. The issue of standby electricity has been discussed in several fora with a focus on reducing this wasted electricity in residential and non-residential buildings [3-14].

Energy efficiency is one of the fastest and most cost-effective way of addressing the climate change exigencies, high electricity tariff, and the electricity supply issues facing Nigeria. Despite the privatization of power plant in Nigeria, the electricity supply has failed to respond as expected five years after privatization. Energy efficiency is central to the sustainability of renewable and conventional energy consumption. Figure 2 shows the central role of energy efficiency when considering different sources of electricity generation. This reflects a fact that the sustainability of all energy sources will substantially depend on the efficient use of all the sources. It has been globally highlighted that saving one unit is cheaper than producing one unit of energy [43]. The significance of energy efficiency has been highlighted at the global level, by the World Energy Council, and in Nigeria through various policies, particularly National Renewable Energy and Energy Efficiency Policy (NREEEP, 2015) [15, 16]. Given the present state of electricity supply across the nation and our inability to maximize the inherent advantages of renewable energy as it has been emphasised by different authors at various fora [15, 17], the best alternative is to minimize the electricity consumption. In this regard, mitigating standby power consumption is a low hanging fruit to save some amount of electricity.

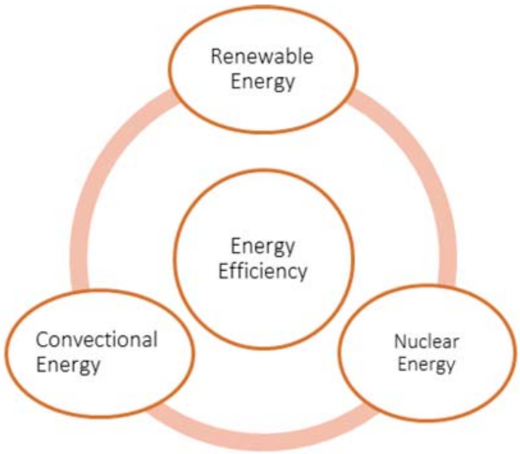

Figure 2: Central role of energy efficiency

The multiple benefits of electricity efficiency are so enormous and can be quantified in term of financial savings, economic progress, job creation, reduced energy demand, reduced carbon footprint, emission saving, health and wellbeing, energy security, improved productivity, and asset value among other advantages. Notwithstanding these numerous benefits, energy efficiency strategies have not been appreciably explored in Nigeria. This is partly due to the start-up cost of the energy-efficient equipment and wrong notion as per the probability of reducing income accrue to the energy distribution companies. In 2014, International Energy Agency (IEA) reported that in developed countries, wasted standby power accounts for around 2 % of global electricity use and 10 % of the total electricity consumption in the residential sector [18-20]. This was found to result from failure to remove plugs from wall sockets.
According to International Energy Agency, between 1984 and 2004, primary energy and CO_2 emission has grown by 49 % and 43 % respectively [21]. The standby power for every family was nearly 30 kWh in a month and this resulted in the emission of 16kg carbon dioxide (CO_2) to the environment [21]. Standby power accounts for almost 1 % of world CO_2 emissions [3]. In 1998 Alan Meier and co-workers discovered that standby power added up to more than $3 billion in the annual energy cost of America. According to America's Department of Energy, national residential electricity consumption in 2004 which was wasted due to standby power is equivalent to the output of 18 typical power stations [14]. This among other things poses a significant danger to our environment as it serves as a notable threat to energy sustainability, facilitates greenhouse effect, and derail national economic well-being. If the standby power is not curtailed, it will eventually exceed the energy use for the major appliances in the house. In view of the above, this article discusses the standby electricity in Nigeria and highlight the strategies to mitigate it.

1.1. Electricity generation and efficient consumption in Nigeria.

So much has been said about electricity in Nigeria [15, 17, 22]. While several authors decried the situation, other has reposed hope in the possible exploration of renewable through microgrid to alleviate the present poor supply of electricity. At 149kWh per capital, Nigeria's electricity consumption stands among the lowest in the world at around 7 % of Brazil's and 3 % of South Africa's consumption [23]. Even at that, the supply remains epileptic. Again in 2018, a case of zero generation was reported for some states in Nigeria [24]. The electricity generated in the first quarter of the year 2018 is a painful reminder of the persistently low electricity supply in Nigeria [25]. The overall power supply reduced to approximately 114GW as against 144GW recorded for the last quarter of the year 2017 [25]. In the last 17years, several billions of dollars have been splashed on electric power sector, yet the sector is in doldrums [26]. The reported peak electricity generation capacity of Nigeria as of April 2018 is 5,080 MW [24] compared to an estimated peak demand of 12,800 MW representing a power deficit of 74% [27]. Despite the recent privatization of electric power generation and distribution companies, there are no commensurate improvements in supply. According to a survey by world bank [28], Nigeria is the next country to India in terms of her inability to provide electricity to 80 million of her population and the largest access deficit in sub-Saharan Africa [28]. Given the abysmal low energy supply, there is a serious need to mitigate any form of losses which could emanate in the course of electricity consumption. Adoption of efficient energy consumption can somewhat lessen the challenges associated with inadequate supply. Moving in this direction, the Federal Government of Nigeria established the National Centre for Energy Efficiency and Conservation [15, 29] with a focus on organizing and conducting research relevant to the energy efficiency code, standards, and specifications for residential and commercial facilities. This lead to the formulation of National Renewable Energy and Energy Efficiency Policy (NREEEP 2015) [15, 29], which among other things were to guarantee efficient, and cost-effective consumption pattern of renewable energy resources and improved energy efficiency [15, 17, 29, 30]. Amidst this lean electricity supply, the country cannot avoid any further waste that may emanate from consumption. There are ample evidences to show that there is a relationship between electricity consumption, economic growth and CO_2 emission, which consequentially affects our environment and the quality of life. In 2019, Gorus and Aydin [31] investigated the causal relationship between energy consumption, economic growth, and CO_2 emission within the context of MENA countries namely; Algeria, Egypt, Iran, Iraq, Oman, Saudi Arabi, Tunisia, and the United Arab Emirates for a period between 1975-2014. Also, Mardani et al. [32] established a long time relationship between the energy consumption, economic growth, and CO_2 emission in G20 nations to which Nigeria belong. Ahmed et al. [33] probed into and find a unidirectional relationship between the energy consumption and economic growth in Pakistan. The evidence obtained from the Economic Community of West African States (ECOWAS) based on 15 countries from the region confirmed a long run co-integration nexus between the GDP and electricity consumption [34]. Therefore, countries which can cultivate an energy-efficiency and electricity-saving culture stand to benefit economically in term of environmental health and GDP growth [35-37].

Residential electricity consumption

The Nigerian power market can be categorised into four which are; residential, commercial, industrial and public [28]. The residential usage of electricity accounts for the bulk of consumption in Nigeria due to her rising population, and fast rate of urbanization. As at 2018, Nigeria population is estimated at 203 billion and approximately 50 % are residence in urban locations with a potential increase in the rate of urbanization estimated at 4.23 % per annum [38, 39]. Electricity consumption in the residential sector is very significant. As at 2012, 57.8 % of total electricity consumption in Nigeria were from residential sector [40]. Of the total final energy consumption by sector in Nigeria as at 2016, 81 % was from the other sectors among which is residential sector [41]. It is forecast that the residential electricity consumption in

Nigeria will increase to 45 TWh/year by 2030 [42]. Against this background, there is an urgent need for an efficient energy consumption with focus on electricity saving.

Now-a-days several methods are used for saving of electricity in residential buildings such as high-efficiency lighting systems, which save as much as 30 to 50 % of lighting costs but its main demerit is a short life cycle [43]. Apart from population, several other factors affect the energy saving in various residences. These include lifestyle change and living behaviour and so on. There has been a significant increase in the number of appliances use in the residential buildings. The substantial portion of residential electricity consumption is used for lighting, television, radio, refrigeration, ironing and so on. The technology advancement means that almost all the households, especially in urban areas, will require electricity in one form or the other. Most often the consumption increases with improved lifestyle without any recourse to electricity saving. Most household do not even have a detailed understanding of the contribution of standby power to their electricity consumption.
Otegbulu [44] carried out a field survey to assess the level of energy efficient practice and awareness among some households in Lagos, Nigeria, being the most urbanized state in the country. The study cuts across the high, low, and middle-income residents. The responses obtained from this survey proved that standby power may be very high in the sampled areas since most of the residents often give negligence to putting off their electrical appliance while some often leave their TV and computer in sleeping mode. Figure 3 shows the energy-saving behaviour among the residence [44]. Of all the residence sampled, 22% acknowledged that they do not switch-off their television set very often while 20% leave their microwaves without switching off.

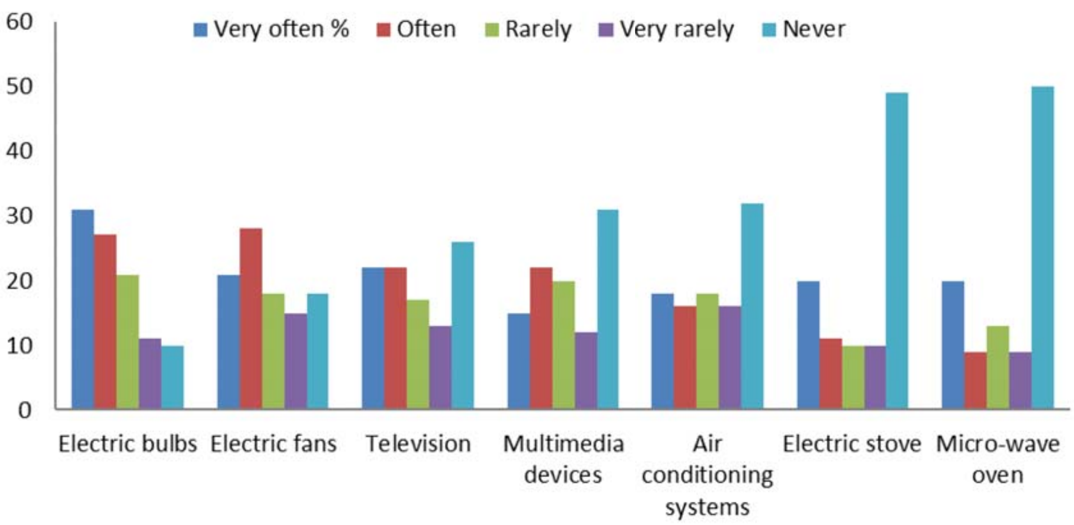

Figure 3: Energy saving behaviour among users [44]

2. Understanding standby electricity

In 1990 the phenomenon of standby electricity was first noticed by Alan Meier, a scientist at Lawrence Berkeley National Laboratory in California. He noticed the multiplication of appliances which are often not fully switched-off. Adding up the nationwide energy cost due to this behaviour, he concluded that the amount of energy wasted must be very staggering. “We're

moving from an electromechanical world that's on and off to an electronic world that's never off," he concluded. Standby power is electricity used by appliances and equipment while they are switched off or not performing their primary functions. It has also been defined as the power consumed by the electrical appliances when they are in the lowest power mode [12]. The standby power can be consumed in off mode, passive mode, active mode, or delay start mode. Electrical product is said to be in off mode if the product is connected to the power source, but it is not performing any function and the remote control cannot activate the appliance in that mode, in case it is an appliance which can be remotely controlled. For passive mode, the device is not performing the primary function, but the standby mode which can be activated by remote control is active or the equipment is performing other secondary functions such as timer display. For active standby mode, the device is enabled but not performing the primary function. In delay start mode, the user programs an electric device to perform a specific primary function at a certain future time which may be up to 24 hours [2, 45].
So many appliances remain in standby mode for long period, thereby accumulating a significant energy cost. For instance, in developed country, 3-11 % of the total electricity consumption per annum is lost on home appliances in the standby mode [3]. Apart from electrical appliances, there is a class of "phantom" consumption which is very common in almost all consumer devices, which are built with digital display, remote controls, and network connection. Even though the standby consumption varies and can be as low as 1W for some devices, the cumulative amount consumed by billions of devices and electrical appliances is very significant. There is rarely no equipment without standby power in this century. Most of small devices, consume the major power in standby mode.
The word "electricity saving" goes beyond only saving money; it includes saving of resources from the electricity generation end, preventing fire accident, mitigating the climate change and protecting the environment and lives. In 2018, there were several fire incidences which were reported across the residential sector in Nigeria and were attributed to inefficient electricity consumption behaviour. According to a survey which access the US carbon emission, it was reported that electricity consumption in households accounted for 15 % of the total carbon emission [46], though similar information is not available in Nigeria. Also, most household in Nigeria do not have a detailed understanding of the contribution of standby power to their electricity consumption. In New Zealand, microwave oven consumes 40 % of electricity as standby power just to run the digital clock, while a survey in Thailand showed that standby losses were accumulated to 53 % attributed to personal computers, 90 % to copiers, printers and fax machines. Idle power consumption is even more than 7.4 % of total residential consumption in Taiwan [3, 47]. A study conducted in 2001 showed that 9.4 % of household energy use in Japan is consumed in standby mode while the figure stand at 11.6 % in Australia [7]. While 14 TWh of standby power was reported for Germany in the year 2000 [5]. In South Africa, the standby power wastage due to household appliances at national level lies between 0.05 % and 0.36 % of national electricity consumption, these values translate to a range from 0.9 % to 6.5 % of the total domestic electricity consumption [13]. As at 2001, a typical household in USA consumed 440 kWh/ annum which translate to 5 % of the total electricity used in that household [7]. Even though the manufacturers of the equipment have made significant progress in reducing the standby power in nearly all the products, there is still a big concern around the possibility of the eradication of standby power due to its evolution in some spaces which were previously not acknowledged. Hence, Meier [8, 11] proposed that it is possible to design an electrical equipment with zero standby power [8, 11]. Also, the appliance which are often exported or

manufactured in the developing countries are not yet at the same level in term of efficient power consumption in the developed countries.

2.1. Measuring technique for standby electricity

Several methods have evolved for the measuring of standby electricity [2, 4, 8], the three commonly employed for measuring residential standby electricity are briefly discussed;
Whole household measurement- As defined by Meier [9, 11] this involves visiting residences and measuring the standby energy consumed by all the appliances, this gives a perspective regarding the variation in standby power consumption in various homes. Although there are some uncertainties such as number of hours of standby power consumption and appliances sampling in homes related to this measuring method, an important perspective which could affect the policy direction could be obtained [8, 9]. Also, not including the electrical products in the measurement can lead to an underestimation of the standby power.
Bottom-up estimation technique- This is based on the measured standby power in specific appliances multiplied by the average market saturation of those appliances, standby duration, and the number of households [2]. While the bottom-up technique can be accurate in estimating standby power depending on if enough sample size is collected, the electricity consumption attitude of the users may weigh heavily on the accuracy.

Product-based measurement- In this approach, the researcher would have to visit the factories or retail stores to collate the standby measurement of the new products. This method ensures a rapid measurement of standby power for various devices, but the measured power may differ from the actual measurement of the end user [2], since the devices in stock may not reflect the number of appliances in various residences.

3. Research method

This study is majorly based on a desktop review of the state-of-the-art in standby energy management, as such several literatures were reviewed as the primary data source. The current technique which have been adopted in standby electricity measurement were outlined and the possible barriers to the energy saving through the elimination of standby power were highlighted. The measurement approach used in this study is whole house measurement [2, 4, 8, 11]. Out of 50 households which were approached, 30 homes in Ifako-Ijaiye local government, Lagos state which volunteered were recruited in this study. The homes consist of multi-family units and stand-alone units with occupancy varying from 2 to 7 people, the group consist of great diversity of residential household which can be obtained in a typical middle-income urban location. The appliance in each resident were surveyed and the standby electricity for each appliance were noted. Except for some few appliances, the minimum power for an equipment was measured while plugged into the power mains but not performing the primary functions. A fluke wattmeter was used to measure the standby power while the TV, DVD, DStv paying station, home theatre and others were plugged into the wattmeter when the power is switched off. This was to ensure that the standby power was measured at the lowest point. The standby power measurement mode for the computer were based on the most frequently used setting specified by the owner, in this case, sleeping mode was specified. Where applicable, the telephone was measure with the handset removed from the charger. A summation of the standby power for each residence was estimated based on the individual appliance's measurements. For verification purpose, the measured standby power was compared with the electricity consumption which is displayed by the utility meter. The permanent load such as security systems were removed from the total estimate while all the equipment with automatic cycle (air-conditioning system, refrigerator, water pump) were unplugged. The lower limit of standby consumption was based on the calculated household appliances load while the upper limit is based on the measurement from the utility meter. The total annual electricity consumption by each residence was also calculated based on individual monthly utility bills obtained from the residence. We further interrogated the occupant about the likely future choice of electrical appliances. Finally, a policy direction based on the best practices in other countries were discussed. The average load was calculated by summing up all the standby power for each appliance and divided by the number of each type of the appliances measured.

Table 1: The standby electricity consumption by appliances

Appliances	Average Power rating (W)	Average load (W)	Min (W)	Max (W)	No of units
Water heater (Geyser)	3250	7.8	4.0	12.0	15
Washing machine	330	5.8	3.0	8.0	20
Electric kettle	1900	4.0	2.2	4.0	30
Electric cooker	1250	4.2	2.0	6.0	30
Air-conditioning system	6700	4.3	3.0	10.0	30
Laptop computers	160	5.0	2.5	18.0	30
Desktop computers	100	4.6	1.5	8.0	20
DVD Player	17	4.5	3.0	8.0	26
DSTv pay station	10	3.2	2.0	4.0	35
Television	200	6.8	3.0	10.0	40
Phone charger	3	1.6	0.8	1.9.0	85
Microwave	1075	3.6	1.5	7.0	30
Rice cooker	975	4.0	2.0	8.0	20
Toaster	100	5.8	2.0	8.0	20
Internet router	6	3.4	2.1	4.0	10
Total number of appliances measured					**441**

4. Results and discussion

A total of 441 domestic appliances sourced from 30 homes were investigated. The number of appliances across these recruited household are of great diversity; hence they give a good representation of domestic devices which could consume standby power. The standby cost for each household was calculated by multiplying the total household standby consumption with the prevailing electricity tariff (₦20.59) for Ikeja distribution company for the class of residential building in this study. As shown in Table 1, water geyser, washing machine, toaster and television have the greatest standby consumption. The mean standby load across the 30 household were estimated at 60 W ranging from 34-144 W. The households had an average of 15 appliances. Standby consumption account for 13-44% of the annual electricity consumption, that translate to almost half of the total annual consumption in some household with the cost ranging from ₦6000-₦26000. The annual consumption for ease residence is also displayed with the average consumption across all the surveyed home standing at 2043 kWh/yr. A comparison of standby electricity consumption in the surveyed location and the literature [4, 9] showed that developing countries may be more vulnerable to electricity wastage despite the poor state of energy supply in the most part of the continent. As shown in Table 2, there are variation in standby consumption based on different location and the number of appliances considered, for instance, while the mean percentage standby electricity consumption in California, in the United States (10 homes) stand at 9% as at 2000 [4], and Korca city, Albania (5 homes) stand at 8% in 2017 [6], the standby consumption at a location in Ifako-Ijaiye, Lagos, Nigeria was estimated at 26% as at 2017 in this report.

Table 2: Comparision of standby electricity consumption.

Location	Number of households	Number of units	Standby consumption	Standby consumption/ annum (%)	Year	Reference
California	10	190	67	9	2000	[4]
Albania	5	75	37	8	2017	[6]
Nigeria	20	441	60	26	2017	This study

Table 3: Standby electricity consumption in households.

Residence	Electricity consumption/ annum(kWh-yr)	Standby consumption (W)	%Standby consumption / annum	Number of devices	Standby Cost/annum (kWh-yr)-residence
1	2470	85.9	30.5	19	15493.65
2	2920	73.8	22.1	17	13311.19
3	2240	70	27.4	17	12625.79
4	2011	62.2	27.1	14	11218.91
5	1432	67.4	41.2	16	12156.83
6	2675	88.7	29.0	20	15998.68
7	1203	59.3	43.2	14	10695.85
8	1898	95.3	44.0	20	17189.11
9	2878	144.2	43.9	32	26009.12
10	1813	73	35.3	19	13166.89
11	1614	35.4	19.2	10	6385.04
12	1618	41.2	22.3	11	7431.18
13	1621	44.6	24.1	12	8044.43
14	2419	63.2	22.9	15	11399.28
15	2397	52	19.0	14	9379.16
16	1803	44	21.4	11	7936.21
17	2500	40.4	14.2	10	7286.88
18	1617	51.2	27.7	13	9234.86
19	2693	53.1	17.3	13	9577.56
20	1995	49.9	21.9	12	9000.38

21	2310	34.3	13.0	9	6186.64
22	2421	45	16.3	12	8116.58
23	1560	54.2	30.4	14	9775.97
24	2013	54.2	23.6	14	9775.97
25	1600	45	24.6	12	8116.58
26	2381	61.6	22.7	16	11110.69
27	1998	71.6	31.4	18	12914.38
28	1199	35.4	25.9	10	6385.04
29	2397	62.4	22.8	16	11254.99
30	1594	42.5	23.4	11	7665.66

Figure 4 shows the standby consumption for each of the 30 households which were surveyed. The standby consumption for the house 8 and 9 is approximately the same. However, further investigation from Table 3 shows that these homes (8 and 9) have different standby power and total electricity consumption. House 6 with 20 appliance has a lower standby consumption compared to house 8 which has the same number of appliances. More power is lost in standby consumption by house 8 despite the lower electricity consumption per annum compared to house 6. These bring to fore the impact of human behaviour on the standby electricity consumption and these also support the report by Otegbulu [44] on the electricity saving practices among the Lagos residence.

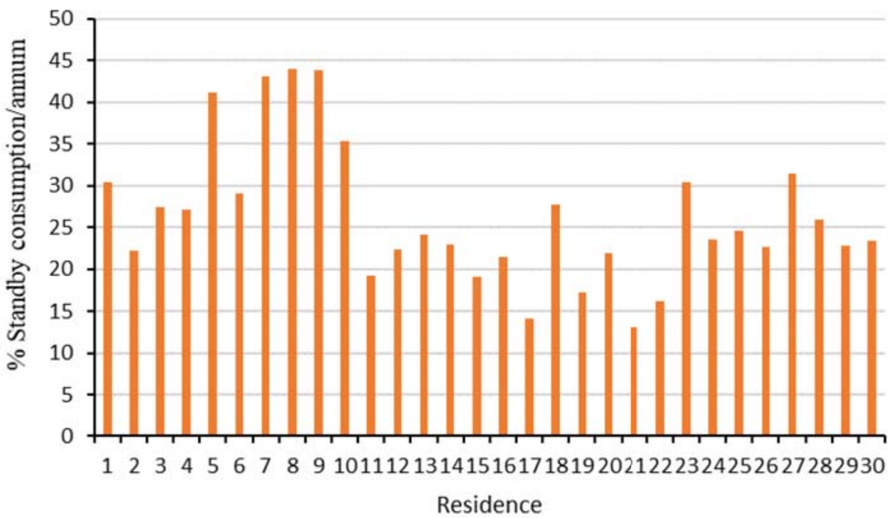

Figure 4: Percentage standby consumption

5. Strategies to reducing standby power in Nigeria

Following the survey above and considering the best practices in the developed nations, the strategies which could engender the reduction of standby electricity is proposed and broadly divided into behavioural, policy and technical approach. Each of the approach is briefly discussed below;

5.1. Technical approach

For technical approach, the following are discussed;

Intelligent standby consumption monitoring- Artificial intelligence (AI) is gaining momentum across the globe including in renewable energy space [48] and electricity consumption management [49]. It has also provided a viable platform through which the standby electricity in the household can be drastically reduced. A recent study by Roland Berger [21] predicted that AI can improve the efficiency in utility companies by five-time within five years [21]. The same trend is achievable in residential sector if the intelligent energy management is adopted. This method will include the real-time monitoring of standby consumption which may include an alarm system such that an alarm is triggered once the standby consumption has reached a threshold. The smart home can be achieved via the application of computer vision [50-53].

*Radiofrequency Identification (RFID) control-*Radio Frequency Identification (RFID) system is an efficient electricity saving approach which reduce man dependent factors in the mitigation of standby electricity [54]. In some cases, this technology adopts the use of pre-programmed tags, alongside its reader to control the switching on and off of the electrical appliances in home. There are many wireless non-contact systems, but Frequency Identification (RFID) stands tall with a lot of promises [55]. This technology interchanges information by the means of electromagnetic signals. Because of its ability to identify and track objects, RFID is being used in diverse applications such as; aviation, construction and facility management, health, retailing, logistics or security, Library system, Access control, Race timing, among others. Tag detection which does not require human intervention help to lower the deployment costs and eliminate human errors in data gathering. The merits of the RFID include the following: Tag is not fixed to a location since there is no need for a line-of-sight; RFID cards can read data within a long range, unlike bar code. Tags can also have read or write memory capabilities; A RFID tag can store large amounts of data in addition to its function as a customized identifier. RFID has been employed in other forms in smart homes as a smart plug system and a smart wave system based on RFID technology. In the smart plug system, every power outlet in the house was equipped with a RFID reader and the plugs of electrical devices like lamps or radios were attached with a RFID tag. Whenever a device was plugged into an outlet, the RFID reader in the outlet read the tag and sent data to the main computer. The computer could directly identify each device and its location, as well as control the device [12, 47, 50]. Radio frequency identification technology demonstrates a great potential in electricity saving and the monitoring of consumption. Therefore, deployment of this technology can provide a convenient approach to the reduction of standby electricity consumption while conserving electricity.

5.2. Policy support

Policy support is the rallying point for the eventual achievement of the minimum standby consumption threshold.
The policy focus which can engender energy saving are hereby discussed;

Energy efficiency standard and codes
Currently, there are no mandatory energy efficiency standards and codes for building, either residential, commercial or industrial [56]. Efficiency standard has been successfully applied in some developed countries [57-59] and as well as some developing countries [60-62]. For

instance, South Africa has a well-developed standard and codes which include energy efficiency. Taking a cue from these countries, our present energy standards and codes should be amended to include energy saving and standby power reduction. A compulsory standby electricity reduction benchmark should be made an integral part of energy efficiency strategies. In setting up the standards and codes, a strategic instrument which makes provision for the training and retraining of electricity auditors should be included. A continuous accreditation of energy inspection should be included.

Electricity saving audit
Electricity audits have been applied across the globe to determine electricity-saving measures which can be adopted. As a part of energy efficiency policy, electricity saving audit can be implemented in Nigeria, provided that a holistic audit procedure is produced. The authors are aware that there will be a need for accurate identification of residential building for this auditing method to be effective. The audit should be made compulsory for all the residence starting with urban household. This process is recommended to commence from the urban residence since it may be easier to get information in those places than in the rural areas. A study which could assist in determining the most impactful audit model and address the uniqueness of Nigeria residential sector should be carried out. If strategically implemented, electricity-saving will improve.

Mandatory standby requirement
In most of the researches on electricity saving, the emphasis has been on the behavioural change of the user and the equipment redesign, however, the acceptance of this approach is subjected to the will power of the user. Therefore, there is a need for a policy approach, which mandate the residential building to include the RFID in their design right from the scratch. This approach should be a part of the checklist before electrical power approval is given for a residential building construction by all the building agencies. California energy commission has introduced mandatory standby requirement since 1990 [4, 8] and that is the first across the globe. The world is already driving towards zero standby consumption [8], therefore Nigeria need to up her game in order to meet up with the global standard.

5.3. Behavioural approach
Sensitization and awareness
There is clear variation in the behavioural approach to electricity-saving in different homes. While some see it as a luxury to leave the appliances on or in standby mode, some make little effort to avoid this due to their level of understanding or financial status.
In some cases, the lack of technology may not be the reason towards electricity efficiency, but lack of motivation and information. In Nigeria, lack of motivation is a consequence of a corruption-ridden and rent-taking process, which is largely associated with estimated billing system. It is obvious that most home do not consider electricity saving in the choice of their electrical equipment as the level of sensitization and awareness is far between. It is not enough to establish standards and codes; people need to be informed about the workings of the new regulations and procedures. Awareness raising should start from elementary school and should be deliberately made a part of academic curriculum across all levels of learning. Electricity-saving should be taught and examined while it should be made a part of competency requirement. Much need to be done to sensitize the people about the overall benefits of

electricity saving. The country can take advantage of the internet of things (IoTs) to circulate the information across to her citizens.

5.4. Further Research and Innovation

Research and innovation provide the avenue for electricity saving across all the sectors. Most of the electrical appliances which are presently used in Nigeria are imported. This may pose a serious threat to economy. Reverse engineering and the adaptation of energy-saving technologies may be an appropriate strategy in internalizing energy saving since government have more control over locally produced goods. A dedicated research and development program, which is centred around standby electricity reduction should be supported by private and public institutions.

6. Further recommendations

This study has considered a microcosm of the whole picture, further research with wider household coverage should be conducted to reflect the state of standby consumption in Nigeria, or at least across the major urban location in the country.
Different standby electricity measuring approaches should be considered.
Relevance agencies should collaborate with government to consider the standard practices which involves the examination of household appliances in the country with focus on standby power consumption.
Relevant agencies should work with government to gather the data on standby electricity consumption and subsequently set up the minimum benchmark for the country.
For product manufactured in the country, standard organization and the relevant agencies should ensure a thorough, unbiased supervision and regulation of the appliances produced while also encouraging innovation in electrical appliances manufacturing.

7. Conclusion

The natural increase in population growth and urbanization rate is consequentially causing an increase in electricity demand in Nigeria. It was observed that the electrical appliances have varying standby consumption, which is also depend on the electricity consumption behaviour of the residence. Some equipment has inherently high standby consumption. The total standby power for each household were estimated. The result of the measurement was done over 30 recruited households. The estimation was done based on whole house measurement technique. The result of this study reinforces the significance of standby electricity consumption accumulated over a long period of time which could be avoided by simple tactile motion of the hand. The strategies for the reduction of standby electricity consumption were discussed and further recommendations were made. Proactive steps which can engender a reduction in standby losses is highly encouraged.

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