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A template for promoting energy conservation in Nigeria's residential sector

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ABSTRACT

Energy conservation is an all-encompassing principle that embodies building economics, behaviours, technology and education, and whose cumulative effects can facilitate energy access, availability and sufficiency, quality of life, a positive impact on climate change and a reduction in the carbon footprint of a country. Several studies have revealed factors such as energy literacy, inadequate finances, consumer-electricity utility relationships, and prevalence of energy-inefficient lighting technologies as constraints to energy conservation practices in developing countries. However, in-depth and explicit studies on promoting energy conservation in Nigeria's household is scarce. To fill this research gap, this paper uses a systematic literature review to examine different perspectives on energy conservation and contextualise them under the Nigerian scenario, unearth factors that have constrained energy conservation practices (precursors) and unravel crucial factors (enablers) capable of entrenching the practices in Nigeria's residential sector. The study revealed how the neglect of best practices has complicated energy conservation practices and proffers the way forward for entrenching the culture in the residential sector. Policy prescriptions include the need to reinvigorate the campaign to phase out energy-inefficient lighting technologies, boost a climate of positive consumer-electricity utility relationships that instils mutual confidence that will entrench an energy-saving culture, and accelerate the pace of transition to green lighting through rejigging of government's policies on energy efficiency and renewable energy.

Keywords

Energy conservation;
Household sector;
Energy literacy;
Energy technologies;
Nigeria;

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1. Introduction

The concept of energy conservation has been defined from various perspectives, due to its multidimensional attributes and contexts. In [1], different perspectives on energy conservation were given from behavioural, technological and choice. In general, energy conservation is the effort made to reduce the amount of energy use by using energy more efficiently or by optimising the number of services used simultaneously or concurrently. This implies a reduction in energy consumption by reducing losses and wastage by employing energy-efficient means of generation and utilisation of energy [2].

Like energy efficiency, energy conservation can complement renewable energy in ensuring energy security, access, reduction in consumption of fossil fuels, mitigation of climate change and promoting a green environment [3]. A household by definition consists of one or more individuals who share the same living space with integrated amenities. Household dynamics provide an effective tool for studying and evolving policies for promoting energy conservation, due to the flexibility and adaptability of household energy components concerning consumer behaviour, building and integrated services. Methods of energy conservation in households include

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the use of energy-efficient lights and appliances, optimising the use of technologies like washing machines, refrigerators, electric cookers, computers, television sets, air conditioners and microwave ovens and energy-efficient modelling and design of buildings.

Consumer behaviour has an overarching influence on energy consumption pattern and conservation in households, with consequences for policymakers, estate developers, manufacturers of household technologies and marketers. Accordingly, a great deal of research which have focused on the factors that influence and promote energy conservation in households has appeared in the literature. As factors that are integral to human consumption behaviour and needs, several researchers have contributed immensely to this theme from different perspectives. A common thread in most of these results is the realisation that the quest for energy conservation is universal and shares common characteristics across countries of the developed and developing worlds. Thus, household energy consumption behaviour has been studied in several countries including Kenya [4], South Africa [5], Egypt [6], Ghana [7], Zambia [8], Australia [9], Netherlands [10], UK [11], Germany [12] and Sweden [13] among others. Most of these studies affirmed the impact of consumer behaviour, while a few others are dichotomous in convergence based on their contexts of reasoning [14]. Several studies have examined the influence of energy consumption behaviour using different moderating factors and perspectives including sociological theory [13], political science[15], space heating [16], the role of policies [17], monthly electricity use [18], framing interventions [19] and environmental beliefs [20] Some authors focused on the impact of technology in use on energy conservation behaviour. Technology in use relates to the types of appliances, lighting technologies, renewable energy sources, self-generating technologies and grids. From this perspective, factors that determine the purchase of energy-saving household products [21] and the antecedents of consumers' intentions to purchase some specific energy-saving appliances were also examined [22]. The effects of electrical appliance modelling on energy-saving were investigated in [23]. The usage patterns for electricity end-uses like electric shower, refrigerator, television and lighting in low-income houses in Southern Brazil were investigated in [24]. Under a similar context, barriers to the adoption of photovoltaic systems in urban Nigeria was investigated in [25]. Comparative analysis of smart lighting and conventional lighting technologies to save energy was analysed in [26]. The effects of thermal adaptation of buildings for energy saving in extreme weathers was presented in [27] and the possibility of net-zero energy settlements to cut down energy consumption [28]. Similarly, some studies have focused on energy literacy [29], awareness of energy-saving paradigms [30], public perception [31] and environmental knowledge [32], in the context of consumer behaviour.

Little attention has been focused by researchers in recent years on providing in-depth knowledge of the dynamics that have constrained paradigm shifts from unsustainable energy-wasting behaviours to energy conservation practices in the household sector of Nigeria. Some researchers have generalised, rather than provide specific details of the peculiarities of the Nigerian households that have tended to portray energy conservation as a complex practice. Therefore, in this paper, we discussed the idiosyncrasies of Nigeria's household consumers, the preconditions (precursors) of energy conservation practices in Nigeria's residential sector and also pinpoints the factors which will sustain energy conservation practices, and their consequences on the energy sector of Nigeria.

2. Methodology

The study is a systematic review that literature search, appraise them in the light of the subject matter and synthesise them accordingly [33]. Thus, different literature evidence on energy conservation practices in different countries was aggregated and applied to segregate the factors that have constrained energy conservation practices in Nigeria, under three broad themes, namely energy consumption behaviours (energy literacy, finance, preference, and consumer-electricity utility relationships), building economics (amenities and electrical installations and housing models and designs) and energy technologies (lightings, appliances, renewables, self-generating sets and grids). This evidence is subsequently discussed in the light of past findings in academic publications on energy conservation in Nigeria. In delineating the themes, the paper partly adopted the method applied to critically review literature in [34]. The three broad themes under which the study is reviewed are energy consumption behaviours, building economics and energy technologies. To fully understand

Table 1: Some research studies used for theme analysis.

S/No	Theme	Number of published works on the theme	Percentage contribution to the study (%)
1	Energy consumption behaviour	26	51
2	Building economics	8	16
3	Energy technologies	17	33
	Total	51	100

the perspective of the study, the study posed the following questions:

a) What are the challenges of energy conservation in Nigeria?
b) What are the peculiarities of the Nigerian scenario that tend to complexify a shift of paradigm from energy wastage to energy conservation?
c) Can best practices engender a paradigm shift to an energy conservation culture?

To adequately attend to these questions, studies published in academic journals were reviewed and grouped under the broad themes, by adapting the approach used in [35]. Table 1 gives the number of published works used for the theme analysis.

3. Current energy situation in Nigeria

Perhaps, no sector of Nigeria's economy has been a subject of a prolonged discourse like the energy sector. The energy crisis in Nigeria has been a subject of intense discourse among policymakers, researchers and the global energy community due to the peculiar nature and dynamics which have tended to defy constructive solution models [36]. The burgeoning literature on strategic planning, policies, situational reports, and several other propositions on the way forward for the sector should have been sufficient to engender a holistic change in performance and service delivery of the sector during the last three decades. Unfortunately, this has not been so, as the sector continues in a cycle of endless hydra-headed crises, that has contributed to slow down national growth. Energy is indispensable and pivotal to Nigeria's quest for economic development [37] and the achievement of sustainable development goals (SDGs) [38]. Consequently, during the last decade, Nigeria has sunk humongous funds into the power sector, to generate sufficient electricity to sustain economic and technological growth, and also meet the energy needs of her ever-growing population, which is currently estimated at 200 million and spread across thirty-six federating states and a federal capital territory. However, contrary to expectations and projections, there had not been commensurate dividends by way of sustainability, reliability and service delivery [39]. Electricity access currently remains low, at 56.5% of the population in 2019 [40] and household grid-based electricity connections have been achieved for only an estimated 20 million of the population (10% of national population) [39].

The major effort of the government concerning energy conservation was the enactment of the National Renewable Energy and Energy Efficiency Policy (NREEEP) [41], which spelt out the ambitious projection of Nigeria's energy efficiency outlook for the next two decades since its formulation. Key action plans enunciated to drive energy efficiency particularly in the lighting sector are recapped as follows:

i. The nation shall promote the adoption of energy-saving appliances and devices through a nationwide energy campaign and training sessions.
ii. The nation shall provide incentives for retailers and importers of energy-efficient products and promote local manufacturing of such products.
iii. The Federal government shall take the lead in implementing the replacement of inefficient devices with energy-efficient ones and promote the same at the state and local levels.
iv. The nation shall monitor progress being made in the adoption of energy efficiency.

Unfortunately, efforts made to materialise this policy has been constrained by the lack of political will by the government and regulatory bodies established to enforce it. One of the critical factors that the government rested her confidence in was the improvement in electricity generation and distribution during the intervening period. Unfortunately, this projection has become a mirage due to the slow pace of progress on the concurrent maintenance of old generating stations and construction of new ones, caused by pervading corruption

and insecurity [42], retrogressive politics [43], and uncontrolled anthropogenic activities [44] that exacerbates disaster risks to critical national infrastructure [45]. In addition, there is lack of real-time synergy between policy implementation and time-tested strategies for measuring energy sustainability as enunciated in the templates of sustainable development goals [46].

Nigeria's electricity generating capacity has continued to fluctuate between 3,000 MW and a little above 5,000 MW during the past years. The reported generating capacity in 2012 fluctuated between 4,000 MW and 5,000 MW, for an estimated population of 150 million. Several years later in 2020, the capacity has not peaked significantly, as it continues to swing between 3000 MW and 5,000 MW. This implies that the power sector reform roadmap that set up the ambitious goals of revolutionising generating capacities of the energy mix to 5,690 MW (hydro), 20,000 MW (thermal) and 1,000 MW (renewable) has remained a mirage [47]. A recent International Energy Agency (IEA) energy situation reports on Nigeria shows a total energy consumption which stood at 1354.40 TWh and a residential sector which consumed 77.89 % of it [40].

Nigeria's power sector has been cyclically marked by peaks and troughs in electricity generation over the years. A recent compilation captures the instability of the sector with figures of power generated with corresponding dates, as tabulated in Table 2.

Before the Covid-19 pandemic, Nigeria's households were known to endure epileptic power supply caused by the unreliability of the national electricity supply, resulting in poor rationing and load shedding [25]. Compounding the situation was energy wastage among household consumers due to the unaccountability of energy use, the prevalence of energy-inefficient technologies and energy-irresponsible behaviours. With the emergence of the Covid-19 pandemic, energy insecurity has pervaded many households as people moved their personal, professional and business activities to their homes as part of the strategies to slow down the spread of the pandemic. Expectedly, energy demand and consumption rise with straining effects on grid-based infrastructures and distribution systems. Of course, this scenario is common to all nations [50]. The scenario provides enough motivation to examine factors that influences energy conservation in Nigeria's households. Moreover, if proactive steps are initiated by the government and consumers towards energy conservation, it can be safely projected that in the next 10 to 20 years, Nigeria's energy demand may not differ from the current figures despite the expected explosion in the number of technologies, households, population and building services. [51].

Table 2: Sample power generation data in Nigeria.

Date	Power generated and transmitted on the national grid (MW)	
February 7, 2019	5,375	Source: [48],[49]
June 2, 2020	Zero (System collapse)	
August 1, 2020	5,377.80	
August 18th, 2020	5,420.30	
August 20, 2020	3,356	

4. Energy conservation practices in Nigeria

A whole gamut of variegated factors militates against the entrenchment of energy conservation as a national ethos in Nigeria. These factors encapsulate behavioural, building economics and technologies in use. A spectrum of these factors is depicted in Figure 1. These factors are contextualised to elucidate the peculiar challenges confronting Nigeria's residential sector. Although some of these factors have been discussed in relation to other countries that grapples with the challenges of energy conservation, they equally affect Nigeria's consumers in a peculiar way that requires principles and home-grown approaches to circumvent. In this section, we will briefly review these factors.

a) Energy consumption behaviour

Nigeria's consumers exhibit peculiar consumption patterns due to their levels of energy literacy, financial capabilities and customer experiences with the electricity utility. Energy literacy relates to the understanding of individual energy consumption and how final energy prices are arrived at, which could result in the willingness or otherwise, to adopt energy-saving behaviours [52]. Energy literacy sensitises a consumer, and the lack of it can lead to poor interest in energy conservation practices [46] and energy-irresponsible behaviours [53]. In Nigeria, consumer-electricity utility relationship is uninspiring and unable to improve consumer's energy literacy due to supply-demand imbalance and accountability problems. Generally, consumers are unfairly charged for unreliable and under-supply of electricity, which results to demotivation towards leveraging their energy

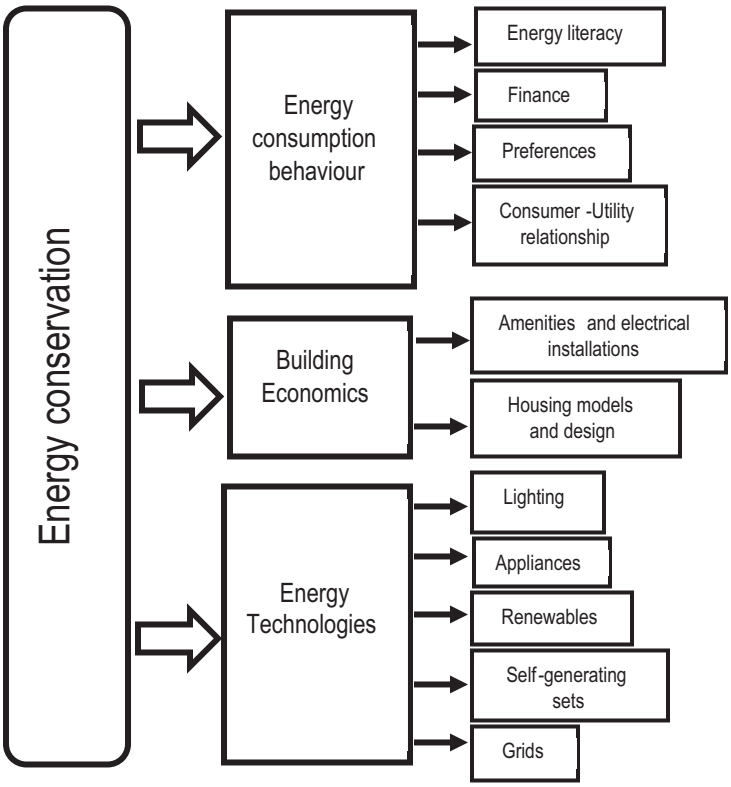

Figure 1: Spectrum of factors constraining energy conservation in Nigeria.

literacy in decision-making, since doing so may have little or no positive impact on their energy bills and supply reliability. Financial capability as used in this paper, may be viewed from the perspective of the consumer's ability to pay for utility-modelled charges for energy consumed or their ability to self-generate. The former perspective does not encourage literacy as it is conceived as the mere ability to pay for electricity cost, whether value-added or otherwise. The latter perspective relates to the purchasing power of acquiring self-generating sets to ameliorate the effects of the lack of electricity and the bashed psychology of poor customer-electricity utility relationships.

Consumer preferences are inhibited by lack of sustainable alternatives to grid-based electricity. The bulk of Nigeria's residential consumers have no financial muscles to procure and install solar home systems. Consequently, they are constrained to passively accept and endure erratic and insufficient electricity supply or self-generate for complementation using electrical generators, both of which do not promote energy literacy, at least with the typical mindsets that is skewed through exploitation by the electricity utility.

b) Building economics

According to [54], building economics is concerned with identifying the optimal allocation of resources for building owners and developers. It is also about economising the use of scarce resources throughout the life-cycle of a building. An energy-efficient building, modelled to conserve energy depends on factors such as quality of the building materials, technical installations such as electrical (electrical wiring, lighting and power installation and fittings) and mechanical (air-conditioning, cooling and heating system control and automation) and the ways building services are subsequently maximised by owners and other end-users [55]. In this connection, building forms [56] and the effects of compartmentalisation of living spaces [57] affects energy use and preferences [58]. Energy can also be conserved through load

management and communication and information systems, ultimately resulting in optimised energy costs, reduced consumption and improved reliability and availability[59]. Since building owners and developers are usually not generally equipped with basic knowledge on how to integrate energy-efficient electrical installations into building projects, it is common to see buildings with superfluous installations in the residential sector of Nigeria. Superfluous lighting and power installation layouts admittedly taps extra energy in these buildings. In the same vein, when enforcement of building standards and codes are not strengthened, developers and owners tend to build to waste scarce energy resources as is obtainable in the Nigeria's residential sector.

c) Energy technologies

The types of energy technologies in use contributes significantly to the characterisation of buildings as energy-efficient or otherwise. Energy conservation can be affected when energy-inefficient lighting technologies and appliances are in dominant use in a building. This is common among households with poor finances or low energy literacy. As posited earlier, the use of energy-inefficient lighting technologies like incandescent light bulbs and appliances is still popular among the low-income population who cannot afford energy-efficient counterparts such as light-emitting diode (LED) lamps and compact fluorescent lamps (CFL), and are therefore constrained to patronise cheap, energy-guzzling and unreliable technologies.

Renewable energy technologies have not significantly penetrated the Nigeria's built environment, partly due to consumers' perception of solar home systems as "elitist" and unaffordable by the poor and middle bracket population, and also due to low energy literacy and apathy. Admittedly, solar home systems are not affordable by the majority poor population who constitutes the bulk of consumers in the rural and urban areas. Self-generation of electricity through small, medium and large-scale diesel and gasoline generators has been normal in Nigeria, as a way of mitigating unreliable and undersupply electricity from the electricity utility [60]. It has been projected to account for 50% of electricity, with over 14 GW capacity in existence [61]. The peculiar challenges confronting Nigeria's residential consumers concerning energy conservation requires genuine commitments from the government and stakeholders to unearth the interrelated factors militating against the normalisation of energy conservation as a national ethos and behaviour to be internalised by consumers. In the following sections, we unearth some activities and programmes that are precursors of energy conservation culture, enablers of energy conservation and the benefits and sequels to the entrenchment of an energy conservation culture in Nigeria.

5. Precursors of energy conservation in Nigeria's residential sector

Precursors of energy conservation are sets of actions, policies, interventions and technologies that are expected to be in existence or in place to pave the way for sustainable use of energy and imbuement of energy conservation behaviours. In Nigeria, certain basic norms that are taking for granted in other climes are made difficult to entrenched in the society. From the available literature, some of these precursors are:

a) Phasing out energy-inefficient technologies from the market

Promoting energy conservation requires the collaboration of stakeholders to scale up actions to phase out energy-inefficient technologies, especially lighting technologies (incandescent light bulbs) and address the ingrained obsession with technologies that are inimical to energy conservation. Incandescent light bulbs guzzled much energy to produce about 10% of luminance, while 90% of the energy is dissipated as heat to the environment to contribute to climate change. The phase-out inefficient lighting technologies campaigns, initiated during the dying years of the last century by global stakeholders including the United Nations Organization (UNO) and the World Bank, has helped several countries to attain energy efficiency (or currently in the process of attainment) in their jurisdictions, and conserve energy and mitigate climate change. However, Nigeria is yet to join the comity of nations who have successfully phased out, or are in the process of phasing out energy-inefficient lighting technologies from their jurisdictions [62]. While several residential homes have informally adopted energy-efficient lighting technologies, factors like unit cost, the proliferation of substandard quality lighting technologies and

high tariffs have continued to militate against complete phase-out. It is presently difficult to know the percentage of households that have fully transited to energy-efficient lighting in Nigeria.

b) The proliferation of energy-efficient technologies in the market

Availability of energy-efficient lighting technologies and appliances can have a dramatic impact on the de-proliferation of their energy-inefficient counterparts. During the halcyon days of the global phase-out incandescent bulbs campaign, compact fluorescent lamps (CFLs) dominated the energy-efficient lighting technologies markets. However, with the development of light-emitting diode (LED) lamps, comes better luminous efficacy and longevity improvement over CFLs and a consequent shift of patronage to LEDs lamps. The high luminous efficacy of LED lamps is a justification for replacing or retrofitting existing technologies with LEDs. In Nigeria's lighting markets, there is a preponderance of incandescent bulbs despite the big share of CFLs and LED lights on market shelves. The comparatively low cost of incandescent bulbs has continued to attract patronage than CFLs and LEDs on account of their cheap high unit costs.

c) Increase access to grid-based electricity and renewables

Electricity access via grid or renewables is a requisite for entrenching energy conservation culture in Nigerian consumers. As expressed in the previous section, energy conservation practices have not taken root as a culture in the residential sector of Nigeria due to the deplorable condition of electricity supply and the inaccessibility of grid-based and off-grid electricity by the majority of the population. Persistent unscheduled blackouts have proved beyond doubt the importance of the self-generation of electricity in Nigeria. As a result, most consumers have lost interest in tracking their energy consumption for the sake of benefit comparisons, thus defeating the prospects of energy conservation. It has been estimated that approximately 50% of electricity generated in Nigeria comes from the grid, while the rest are from individual self-generating sources [47].

d) Availability of smart energy metering devices

For the majority of household consumers who can access electricity, transparency and equitable energy pricing remains a challenge in Nigeria. According to the Nigerian Electricity Regulatory Commission (NERC), only 50% of electricity consumers have meters [63]. And among these consumers, less than 10% may have smart (prepaid) meters. Consumers are disgruntled by the prospect of acquiring prepaid meters due to previous experiences with the electricity utility. A burgeoning number of consumers who have installed "digital" electricity meters have not benefitted from their investments because the electricity utility habitually bypasses the computation of monthly consumption by opting to estimate bills, resulting in large-scale electricity pricing fraud. In the light of this, making smart meters readily available for consumers at a subsidized cost will contribute to energy literacy and assist consumers in making decisions that emphasise energy conservation.

Energy theft is a universal phenomenon that is endemic in Nigeria, due to the lack of smart metering systems [64] and exploitative billing systems [65]. Energy theft can deprive consumers of the avenues to understand energy conservation. Real-time monitoring of energy consumption and tamper-proof installations of electricity meters can discourage energy theft, leaving consumers with no alternative than to imbibe energy-responsible behaviours.

e) Transparent and equitable energy pricing

The Achilles heel in the relationship between consumers and the electricity utility in Nigeria is electricity billing systems. Transparent billing systems generally contributes to enlighten consumers on the actual cost of consumption, indicating the positive and negative impacts of excessive use of loads on their finances, environments and quality of life. Inappropriate electricity billing, on the other hand, dips motivation and slows down behavioural adjustments to energy conservation. The estimated billing model used by the electricity utility in Nigeria foreshadows the imperative of transition to energy conservation practices among ill-treated consumers. Thus, transparent and equitable energy pricing is a precursor of

trust between the electricity utility and consumers and can serve as a strategy to change consumers' mindsets towards energy conservation [65].

6. Enablers of energy conservation in Nigeria's residential sector

Enablers of energy conservation are sets of actions, policies, interventions and technologies that sustain behaviours, beliefs, awareness and adoption of building codes and technologies to facilitate the entrenchment of energy conservation culture. The absence of precursors implies the lack of enablers to sustain a conservation culture, and therefore the need to adopt and adapt the following enablers to the peculiarities of Nigeria's household sector.

a) Energy policies and incentives
Campaigns for energy conservation among consumers can serve to motivate them to key into the paradigm. Initiatives aimed at energy conservation have been reported in some counties and countries. For example, the "Big Switch Campaign" in Durham County reportedly saved 5-10% energy through simple acts of switching off unused lights, computers and reduction in gas consumption for an hour per day, resulting in a 17% decrease in energy use in a year [66]. Innovative programmes by the government, state and local government councils, targeted at residential consumers with the sole aim of orienting them toward energy conservation can be a big boost to the energy economy. Adopting a similar strategy will save a quantum of energy in the residential sector of Nigeria.

b) Stable grid-based electricity supply
A stable electricity supply is an intrinsic enabler of energy conservation. Measuring the benefits of energy conservation and providing feedback is inherently data-driven, and this is made possible by the availability of electricity, time and resources for measurement and analysis. Without a stable electricity supply, the concept of energy conservation exists in a vacuum. And where electricity supply is epileptic or non-existent, reliable data will not be available for strategic planning and benefit comparisons.

c) Availability of energy options for consumer preferences
Availability of energy options (grid-based or renewables) can serve as an enabler of energy conservation, as consumers are thus empowered to take responsibility and make informed choices on their energy preferences. Thus, with the exercise of consumers' prerogatives come the tendency to conserve purchased energy.

d) Availability of energy-efficient technologies
Availability of energy-efficient technologies can act as a precursor and an enabler of energy conservation as they can effectively demonstrate the benefits of efficiency and conservation through their efficacies and product lifespans.

e) Availability of smart energy metering devices
The availability of smart metering devices is both a precursor and an enabler of energy conservation. As an enabler, the impact of appropriate energy pricing can fast-track behavioural change in energy-literate consumers, leading to prudence in energy use.

f) Energy-efficient housing
Before the recent emphasis on energy efficiency, many residential and public houses in Nigeria were not built with energy conservation and sustainability in mind. Property owners were motivated primarily by taste and financial capabilities, rather than the desire to build sustainable houses. Consequently, some models used for electrical services (lighting installation, power installation and environmental security lighting) resulted in redundant and wasteful installations. To curb energy wastage and promote conservation therefore, an integrated design approach must be adopted by architects and other experts in the building sector, to promote buildings that integrates efficiency and conservation principles [57].

7. Subsequences of energy conservation practice in Nigeria's residential sector

Resultant benefits of entrenching an energy conservation culture in Nigeria's residential sector include the following:

- Delays in the facilitation of the construction of new power generation plants.
- The greater motivation of consumers to adopt energy-saving technologies and integration of renewable energies into their preferences.
- Enhancement of qualities of life of consumers.

- Mitigation of climate change via the low carbon footprints of the country, as inefficient lighting technologies are effectively phased out of use among consumers.
- Amelioration of the impacts of electricity pricing, as conserved energy adds to the energy reserve, resulting in uninterrupted electricity supply. Consumers are thus willing to pay due to the assurance of constant supply.
- Government is motivated to implement distributed energy systems to increase preferences among consumers, a strategic plan that is long overdue in Nigeria.
- Facilitation of smart grid infrastructures in Nigeria.

8. Strategies for promoting energy conservation in Nigeria's residential sector

a) Establishment of an energy information administration

Information is critical to meaningful engagement in energy efficiency and conservation. The establishment of an energy information administration (similar to the US Department of Energy (DOE) counterpart) will serve the purpose of aggregating data on energy consumption in households and other sectors for strategic planning and development of the energy sector. Energy information can be collected and uses to forecast future energy demand in different sectors [67].

b) Re-invigorating the campaign to phase out energy-inefficient lighting technologies in Nigeria

Nigeria may not attain energy efficiency and a sustainable energy future without phasing out energy-inefficient lighting technologies (incandescent lamps) from her jurisdictions. Energy efficiency practices will tendentiously result in energy conservation. Re-invigorating the campaign to phase out energy-inefficient lighting technologies will fast-track the internalisation and a holistic adoption of energy conservation principles among residential consumers [62].

c) Mapping existing technologies in residential buildings

Modern developments in the housing and energy sectors are data-driven. The knowledge of how many households exists in a setting and taxonomy of technologies in use will aid appropriate authorities in policy decision-making to conserve energy in Nigeria.

d) Positive image laundering of Nigeria's electricity utility

The peculiar situation which relates to the sour electricity utility-consumer relationship in Nigeria requires an improved image laundering by the electricity utility to regain the confidence of the population. The image of utility companies has been bashed by self-destructive policies and actions over the years. Prominent among these actions is the forceful extortion of consumers through inequitable and exploitative electricity billing systems, coupled with perennially unreliable electricity supply and unscheduled outages. Evolving new templates to resuscitating mutual trust and confidence is critical to a meaningful working relationship between the electricity utility and consumers in Nigeria.

e) Installation of smart metering systems

Beyond politics and propaganda, the electricity utility must expedite actions to procure, distribute (or sell) and install smart meters in households, to push for accountability and reduction of incidents of energy thefts.

f) Initiating energy literacy programme for consumers

Raising awareness on energy conservation through energy literacy programmes using the print and electronic media is important. As a sequel to phasing out energy-inefficient lighting technologies and appliances, energy literacy programmes can provide the platform to inculcate energy-responsible behaviours in consumers.

g) Enforcement of compliance with energy-efficient lighting standards and building codes

Regulatory bodies must enforce compliance with energy-efficient lighting standards and formulate appropriate policies to stop the importation of energy-inefficient lighting technologies and appliances into Nigeria. The process of steering the housing sector towards a new wave of research and development of energy-efficient houses for the future will also

lead to the evolution of sustainable housing and cities where energy conservation is embedded as a structural characteristic and as an ethos in consumers, developers and owners.

h) Prioritisation of renewable energy for energy sustainability

Renewable energy holds the key to energy sustainability and security of the future. Renewable energy, due to its inherent characteristics enforces accountability and prudence among users. This has encouraged several countries to invest in the large-scale development and utilisation of hybrid power systems (a mix of grid-based and renewable energy) in their energy mix [68]. Hybrid power systems are especially recommendable for households in situations where grid-based electricity is intermittent and unreliable [69]. In addition, renewable energy is affordable for households in remote areas of the Sahelian zone of Nigeria that are unserved by grid-based electricity, but are endowed with intense insolation [70].

9. Conclusion and policy implications

Like other countries of the world, Nigeria is passing through an unprecedented energy crisis that can be partly tackled through the behavioural characteristics of household energy consumers. With a generating capacity averaging 4,000 MW, which is grossly inadequate to meet the needs of a population of 200 million people, coupled with a household sector that consumes over 77.89% of her generated electricity, energy conservation practices can mop up a quantum of energy that can be used to improve electricity access to the unserved population. This paper systematically reviewed critical factors that have constrained the entrenchment of energy conservation culture in Nigeria's residential sector. Reviewed literatures on the challenges of entrenching energy conservation culture in several countries shared similar threads like that of Nigeria. However, certain factors that are related to electricity utility-consumer relationships, billing systems and value systems are found to be peculiar to the Nigeria's residential sector. The paper unearthed precursors to energy conservation such as the campaign to phase out energy-inefficient technologies, re-orientation of the electricity utility towards the use of equitable billing systems and stocking of the lighting markets with affordable energy-efficient technologies to incentivise household consumers who are willing to adopt energy conservation practices. The paper also unravelled the enablers that can sustain the culture such as stable electricity supply, construction of energy-efficient houses and a preponderance of smart metering devices for installations. The paper emphasised the need for the government to formulate sustainable policies to enforce energy-saving practices in the residential sector by streamlining the NREEP to specifically target measurable goals. The need for new strategies to re-invigorate the moribund campaign to phase out incandescent bulbs in the Nigerian market, and promulgate new laws to reform her electricity billing system for equity and transparency was discussed. Future studies on energy conservation challenges in Nigeria should focus on the possibility of net-zero energy housing design to usher in sustainable housing schemes.

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