# An investigation of energy saving behaviour for residential buildings in Nigeria

By

Aisha Ibrahim Tilde

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## List of Abbreviation

| | |
|---|---|
| $CO_2$ | Carbon Dioxide |
| DISCO | Distribution Company of Nigeria |
| GENCO | Generation Company of Nigeria |
| IEA | International Energy Agency |
| EIA | Energy Information Administration |
| ECOWAS | Economic Community of West African States |
| ECN | Energy Commission of Nigeria |
| ES | Energy Saving |
| KV | Kilo volts |
| Kwh | Kilowatt Hour(s) |
| Mwh | Mega Watts Hour |
| NERC | National Electricity Regulatory Commission |
| SSA | Sub Saharan Africa |
| SP | Service Providers |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UN SDG | United Nations Sustainable Development Goals |
| USAID | United States Agency for International Development |

# Publications

Ibrahim, A.T. and Fernando, N.G. (2021) The obstacles to energy saving in residential buildings in Nigeria: Stakeholders' perspectives. *Proceedings of the 9th World Construction Symposium,* 9-10 July 2021, Sri Lanka. [Online]. pp. 528-539. https://doi.org/10.31705/WCS.2021.46. Available from: https://ciobwcs.com/papers/

Aisha Ibrahim Tilde and Nirodha Fernando. (2021) The Drivers to Energy Saving in Residential Building in Nigeria: Stakeholder Perspective. *IDoBE international Conference November 2021*. London South Bank University. Available from: https://easychair.org/publications/preprint/ngpP

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# Abstract

Threats of climate change, global warming and uncertainty about future energy prices have sparked a global discussion about energy efficiency, particularly energy saving behaviour in residential buildings. Numerous challenges have been faced in achieving energy savings, with specific concern on energy consumption behaviour of building occupants. Accordingly, governments have set targets through policies for the reduction of energy emission, these have been adopted by the building industry through policies on energy efficiency in buildings including public private partnership in energy management and the development of near zero energy buildings.

Previous studies have shown that occupant behaviour can result in a significant amount of variance in building energy use. To address these challenges in line with objectives of sustainable development goal (clean and sustainable energy and climate action), as well as energy efficiency in residential buildings, this research investigated key factors as well as practices that determine and limit energy saving behaviour in residential buildings from a different cultural perspective. Nigeria has been constantly confronted with an electricity demand that exceeded supply capacity. The increased demand for electricity can be attributed to growing populations, increased commercial activity and industrialisation. Households are a significant contributor to the rapidly increasing electricity demand as identified. Energy providers resort to 'load shedding' of electricity supply between communities and industries and even long-term electrical outage due to limited supply. It is also important to understand how the actions of occupants affect energy consumption behaviour in residential buildings. To reduce electricity demand and save energy, this research exploited literature on energy saving behaviour and behaviour change.

The research study was conducted based on a sequential exploratory mixed method and consists of two key phases. Firstly, qualitative data was collected using semi-structure interview with eighteen experts in the energy and construction industry in Nigeria. The purpose of which was to provide an insight into residential energy consumption behaviour and the barriers faced in the adoption of sustainable energy sources. Analysis from the result shows that cost of energy is a major driver to the adoption of energy saving practices as there are no compulsory regulatory agencies to enforce and facilitate the migration to a more sustainable and innovative society. Furthermore, results also show that there is a need for

continuous awareness on energy saving behavioural change, a need for government subsidies on renewable energy, government checks and standardization of energy efficient appliances imported into the country could improve the trust towards sustainable choices and promote efficient energy use.

The second phase involved a household survey with 317 households from the case study area. The survey instrument was developed based on the constructs of energy culture framework, sociodemographic factors and physical environment. The hypothesised relationship from the conceptual model were tested using structural equation modelling (SEM). The results indicated that energy practices, material culture, attitude perception cognitive and social norms with behaviour changes were statistically significant, with attitude perception cognitive and social norms having the least impact on behaviour change. Additionally, the correlations from the constructs shows a direct relationship with behaviour change in achieving energy efficiency and energy saving approach while a deliberate policy to achieve energy efficiency and energy saving practices is vital to achieve sustainable development goals. The outcome from this work provided a better understanding of drivers and barriers to energy use behaviour and will inform future energy policy and interventions related to household energy saving. It also will contribute to the existing body of knowledge as well as give policy direction of governments towards climate action and some specific objectives of sustainable development goals.

# Chapter 1 : Introduction and Background

## 1.1 Background

Energy is essential for sustained human development, social improvement and economic growth. More so, sufficient energy at an affordable price is a necessity for economic stability and regarded as vital for the sustainable development of a nation (Sepúlveda, 2016). The process of energy production and conversion as well as its utilisation in the form of electricity generates harmful emissions. These harmful emissions have direct effects on environment thereby generating concerns globally. Some of these concerns could be attributed to the increase in human activities leading to the current growing global energy demand. The increase in energy demand is influenced by several factors including urbanization, population increases and the over reliance on fossil fuel for energy use (Zaharia et al., 2019). These factors have contributed substantial increases to the emission of carbon dioxide resulting in global warming due to the effects of greenhouse gases (Trenberth, 2018).

As part of the effort to reduce carbon dioxide emissions, the research considers energy efficiency, a reduction in energy usage and conservation as vital to enhance these efforts. This work also considers building as an important component in energy conservation because of its crucial role in energy usage. It was noted that the building industry is viewed as a major contributor to energy consumption and greenhouse gas emissions (Allouhi et al., 2015; European Commission, 2020a). Furthermore, it was observed that the building and construction industry consumes one-third of global energy and contributes up to 40% of total direct and indirect emissions of carbon dioxide to the atmosphere (IEA, 2021) . It is therefore essential to develop a robust framework and effective measures to reduce or mitigate the effects of carbon dioxide emissions, the greenhouse effect, and the negative impact of climate change. One of these critical global efforts is the setting of energy targets to bring about changes to the energy system and the way energy is consumed. For instance, several international agreements have emerged such as the Kyoto Protocol of 1997 which established legally binding limits for industrialized countries on carbon dioxide emissions and other greenhouse gases. Furthermore, the Paris Agreement is another legally binding international treaty on climate change. This treaty was adopted by 196 parties at the COP21 in Paris and came into force in 2016. The goal of this agreement is to limit global warming to 1.5 degrees compared to pre-industrial levels (United Nations Climate Change UNCC, 2015). Furthermore, the recent COP26 in Glasgow saw the development of a climate pact to mobilize countries of their commitment to the Paris agreement (COP26, 2021). These underscore the crucial need to consider energy conservation in buildings as key components part of this research.

As part of the efforts to fulfill their commitment to climate change, several nations have modified the way energy is being used particularly in buildings; thus, energy reduction measures in buildings have been introduced in various forms to achieve the set objectives. For example, the EU have development frameworks to address these issues which include the EU's Energy Performance Directive (EPBD)2010/31EU, the Energy Efficiency Directive (EED) 2012/27/EU, Energy Performance Certificates (EPC), and European Standards EN 15232, 15251 which were established at several levels. Other measures adopted include the National Building Codes as well as initiatives such as EU Building Stock Observatory (European Commission, 2020b). Furthermore, the UK also introduced several implementation frameworks - the Low Carbon Transition Plan and the Smart Meter Implementation Plan - with the latest being the UK International Support for the Clean Energy Transition (Department for Business, 2021). Despite these efforts, energy consumption reached a 2.3 percent rise in 2018. It is pertinent to note that most of these frameworks are easy to implement in industrial buildings, government and private offices and official buildings. However, the implementation of these frameworks to residential buildings are complex due the differences in occupants' behaviours and energy culture in households. Furthermore, assessments reveal that a better understanding of how to reduce residential energy consumption is required to reach carbon emission reduction targets (Csoknyai et al., 2019). With building industry accounting for high energy consumption, the built environment therefore has a vital role to play in delivering a sustainable energy economy as recognised by the UK Government in recent Energy White Papers (Energy White Paper, 2020). It is on this premise that residential buildings were considered as a priority area for this research over other building types.

The research is also mindful of the variation in implementation processes for different countries which are based on the climate change agreements and aim to meet the targets of the UN Sustainable Development Goals (SDGs) on sustainable and clean energy. While most developed countries have established frameworks for implementing sustainable and clean energy in order to achieve the UN Sustainable Development Goals (SDGs), most countries in Sub-Saharan Africa - including Nigeria - are still grappling with the challenges of providing stable energy for their growing population (Adewuyi et al., 2020). This can be attributed to the fact that the energy infrastructure has been in a degenerative state and energy infrastructure are crucial for economic progress. This is a crucial criterial for numerous business development and leading to a potential increase in GDP of a nation. The system faces poor resource and financial management which has affects its generation, transmission and distribution output. It was also noted that the whole of Sub-Saharan Africa contributes a negligible amount of emission to global warming more especially in the energy and industrial sector (Fleurbaey et al., 2014; Steckel et al., 2020). Although three sub-Saharan countries (Angola, Congo and Mozambique) are amongst countries with highest growth rates globally, overall emission increase was 6% annually in SSA (Steckel et al., 2020). For instance, Nigeria heavily relies on the use of fossil fuel to generate energy, which indicates that it could contribute substantially to emission of greenhouse gasses. These amongst other challenges are serious concerns for Nigeria in achieving the Climate Change agreements and the SDGs. Hence, it is crucial to understand the framework and policy direction of the country, amongst other processes, to ensure sustainable energy, energy efficiency, energy conservation and the reduction of energy usage to facilitate the implementation of global climate change agreements. It was also noted that there is limited data on energy efficiency and conservation for residential building in Nigeria. Therefore, the assessment of energy saving behaviour on Nigerian residential building is considered appropriate within this research.

The research also considered two terms in context, which are energy efficiency practices and energy conservation, as they are distinctly different practices that play a vital role in minimising the level of energy use. An energy efficiency approach, on one hand, concerns the reduction of the energy intensity of a process or activity so that less energy is needed to deliver similar goods and services (Li et al., 2021). This approach can be realised through introducing more sustainable technologies, equipment or processes. On the other hand, energy conservation (or energy-saving behaviour) is associated with human behaviours, attitudes, cultures, and organisational procedures. The approach means using less energy through minimal consumption (i.e., turning off equipment when not in use or eliminating unnecessary activities) and not just using less energy to achieve similar outcomes. This can reduce energy costs, help to attain more sustainable energy efficient practices and promote an energy culture or behaviour.

It is also pertinent to note that improving energy efficiency and energy behaviour has been recognised as essential approach for the residential sector and other industrial sectors, which could contribute to sustainability goals through shifts in operations or investments in technologies. Several studies showed that energy efficiency and energy-saving behaviour in the building sectors could enhance productivity, lower operating costs, and minimise environmental impacts (Baatz, Barrett, et al., 2018; International Energy Agency IEA, 2014; Weinsziehr & Skumatz, 2016). These approaches could also extend the life of materials or other natural resources while keeping energy affordable for consumers and lowering investment or saving costs by harnessing new energy resources to meet high demand. Other literature argued that these practices could damage the economic gains of the sector. It is now well established, however, that the influence of energy efficiency and energy conservation approaches on sustainable development goals remains unclear. Studies have called for an in-depth investigation of the residential sector, as it is a major consumer of energy and a key contributor to carbon dioxide emissions (Lamb et al., 2021; Trotta, 2018a). Most importantly, an earlier IEA (2013) report showed that Nigeria's residential sector accounted for over 78% of energy consumption (NESP, 2016). Although this survey was published some years back, this data remains relevant as its skewness affects the drive towards industrialization and more attention to be paid to this. This further underpins the crucial nature of the residential sector and as an essential area of study. Hence, it is necessary to achieve sustainability goals, and focus on energy efficiency and energy conservation in buildings.

The growing demand for energy continues to increase the rate of energy consumption at different levels of public and private organisations as well as residential building. Nigeria's population continues to grow at an alarming rate with an annual population growth rate of 2.4% for urban dwellers (The World Bank, 2021b) . It is expected that by the year 2050, its population is expected to reach about 400 million inhabitants. However, considering energy consumption and human development indices are interconnected, Nigeria needs a massive energy supply to meet the needs for development and transcend the urban poverty (Schneider, 2022). This emphasised the need to ensure a more sustainable approach to energy efficiency and management to meet the relevant UN SDG.

It was noted that an increase in energy consumption has a direct or indirect environmental impact and corresponding carbon dioxide ($CO_2$) emissions are complex concerns for different countries (Khan et al., 2020). Such concerns are amongst the major influences on the policy directions of energy supply, demand and consumption on a global or local level (Osobajo et al., 2020). It was noted that higher energy consumption due to increases in energy generation are likely to contribute substantially to greenhouse gas emissions. For instance, the energy consumption rate from the electricity sector was 37.2% of the total electricity consumption of the USA in 2019 (U.S.E.I.Administration, 2020). The primary source for this energy consumption was estimated to be 81% energy generated from natural gas, coal and nuclear sources. This will generate a significant increase in greenhouse gas emission and carbon dioxide with negative environmental impacts. It is therefore essential to develop the right framework and processes to address the challenges of greenhouse gas emission in line with the global call for climate action.

In order to address the challenges associated with greenhouse gas emission, it is crucial to understand the nexus between population and economic growth with energy consumption. Thus, the increase in population has forced migration from rural to urban areas and accounts for global economic expansion and increases in the standard of living. Consequently, this surge in human activities generates increases in electricity consumption or usage and requires deliberate or concerted efforts to achieve the UN SDG. It was noted that some of the measures to address these inherent challenges are to understand and make relevant changes to the way energy is generated, supplied and consumed (Gupta et al., 2020). Hence, this underscores the importance of a more sustainable approach in the use of energy to achieve energy efficiency.

Energy efficiency and energy-saving behaviour could make major contributions to social wellbeing, environmental protection and energy security while improving the economic growth of the community (sustainable development). As part of the measures that align with UN sustainable development goals, the conventional sources of electricity continue to generate greater concerns. Some of these include the use of fossil fuel to generate electricity where the negative impact could be minimised by employing an energy efficient approach. While the use energy efficiency or conservation could be effectively implemented in structured government organizations or private organisations regulated by the government as matter of policy, the effective implementation of such policy on household could be more complex (Coyne et al., 2018). The challenge of implementing such policies in households could be attributed to different factors such as social divides, cultural and behavioural context, and the government's approach to implementing energy efficiency policies.

Energy efficient, energy saving behaviour or energy conservation could be even more complex where government policies to enforce such measures are either non-existent or difficult to implement because of faulty implementation process. For instance, Nigeria is an oil producing country which relies on oil and gas to generate energy for a growing population. However, a faulty implementation process for energy management across all sectors results in the lack of stable electricity, making it difficult to adequately implement energy efficient approaches (Adewuyi et al., 2020). This has generated concerns amongst stakeholders in Nigeria of the increasing dearth of power infrastructure and the use of oil and gas to generate electricity. Furthermore, even though the government aimed to offer consumers a consistent source of electricity, there are no effective energy efficiency and conservation policies to enable sustainable development. Hence, because of this gap or challenge the potential to conserve energy in order to reduce the negative impact of residential buildings rests with household users. Due to further concerns about the environment, energy use and related emissions have been forecasted to double or even triple in the next 50 years due to several key trends including insufficient housing, poor access to electricity and dependence on solid fuel for cooking and heating (Flores-Larsen et al., 2019). It is on this basis that current research focus on initiatives which promote a more efficient use of energy in buildings in order to the reduce carbon footprint in line with the objectives of UN Sustainable Development Goals (UN SDG).

The UN SDG has several objectives including clean energy for all, climate action and sustainable housing and cities. These objectives are designed to help countries achieve sustainable development, while reducing greenhouse emissions as part of their efforts towards global climate change. To measure progress on the implementation of the UN SDGs, the UN employs various techniques including periodic review performance indices. For example, the United Nations' global index on energy consumption shows that commercial and residential buildings consume about 60% of global energy (United Nations Environment Program, 2016). Additionally, indicators shows that demand for energy in buildings will continue to grow globally in the coming decades (Energy White Paper, 2020; IEA, 2019a), which could further contribute to greenhouse gas emission. To this end increasing the diffusion of best practice, technologies and innovation is regarded as one of the strategies for the reduction of energy consumption and carbon dioxide ($CO_2$) emissions (Hong et al., 2017; Nagy et al., 2015). This could lead to better living conditions, lower energy costs for residents and further minimize the environmental impact of built environmental activities. Therefore, buildings are an important area to achieving a low carbon environment amid the challenge of effectively implementing a sustainable development program.

It was further noted that the Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC) 2007 emphasized behaviour, culture and the use of technology as major determinants of energy use, "*the potential (energy) reduction through non-technological options is rarely assess and the potential leverage of policies over these is poorly understood*" (Intergovernmental Panel on Climate Change, 2007, p. 389). Building energy-related occupant research could be multi-disciplinary in nature with contributions from other disciplines to enable a better understanding of consumption practices. Also, the life cycle of a building - which includes construction, operational and de-commission phases - have substantial impacts on the study. The construction phase involves the design and construction of the building with a greater focus on ensuring that a sustainable approach to building is achieved. De-commissioning involves the end of life of the building, while energy usage in the building life cycle is at its peak within the operational phase. Literature has shown that that energy use at the operational phase is substantial at 80%, while the embodied energy of the building components during the construction phase consume 20% (Azari, 2019; Tuladhar & Yin, 2019). At the operational stage, the building is occupied, and energy management depends largely on the occupants and other factors. Hence, this study focuses on the operational phase, as shown in Figure 1.1.

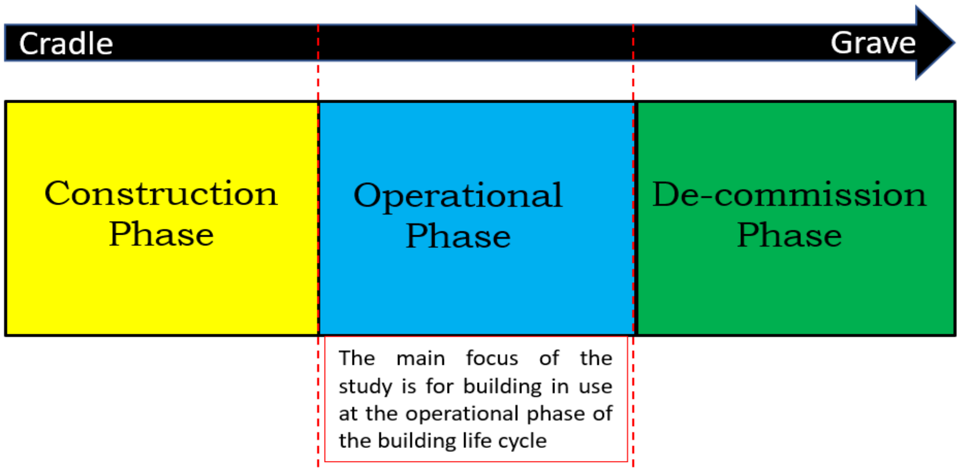



**Figure 1.1**: The life cycle of the building showing the focus of the research (Spisakova et. al, 2022).

The development of technical solutions at the building's design stage facilitates a more robust energy conservation implementation process or a reduction in energy use and can thus ensure a low carbon environment is achieved. Nevertheless, technical solutions are usually insufficient as the literature has shown that there are gaps between the predicted energy consumption at the design stage and the actual energy consumption in buildings (Calì et al., 2016). This difference in energy consumption has been attributed to behavioural and user preferences which are not often considered in the design phase of a building (Paone & Bacher, 2018). Previous research has also revealed that energy consumption can be about 2.5 times more than predicted (De Wilde, 2014) while variations as a result of occupant behaviour can be up to 80% (Kingma & van Marken Lichtenbelt, 2015). It is pertinent to note that the total energy use of occupants is based on both human and physical features and can be characterised as energy consumption behaviour (Ishak et al., 2016). Furthermore, the potential for efficient energy utilization or conservation in the residential sector is substantial as it accounts for approximately one-third of the overall delivered-energy use and carbon-dioxide emissions (Broad et al., 2020). This highlights the need for good knowledge of energy efficient building practices and occupant energy saving behaviour as a first step to close the energy efficiency gap. Despite all the aforementioned research, there is still a huge gap with insufficient research on energy efficiency in buildings from the viewpoint of social science as related to occupant behaviour.

## 1.2 The United Nations Sustainable Development Goals

The Sustainable Development Goals (SDGs), also known as the 2030 Agenda were created to replace the Millennium Development Goals (MDGs), which officially ended in 2015 (Sianes et al., 2022; Smaniotto et al., 2022). The MDGs which are mostly social oriented covered 8 distinct goals with focus on developing and underdeveloped (poorer) nations to meet the expected targets and indicators by 2015. However, unlike the MDGs, the SDGs apply to all nations without distinction between developed and developing nations. These expansive objectives are interdependent but must be achieved independently. As shown in Figure 1, the SDGs encompass a broad array of social and financial advancement issues with focus on economic growth, social inclusion and environment protection including poverty, education, climate change, and the environment amongst others (Hák et al., 2016). The broad nature of the SDG requires more comprehensive and coordinated approaches to achieve the 169 targets across the UN Member States. The 17 UN SDGs which is expected to be accomplished by 2030 are discussed subsequently.


**Figure 1**: The 17 UN Sustainable Development Goals (United Nations, 2015).

a. **Sustainable development goal 1- No Poverty:** Poverty is more than a lack of income or assets and the UN SDG got the commitment of member states to eliminate poverty by 2030. Individuals who live in poverty may require basic services such as healthcare and education. However, with the aftermath of covid-19, rising inflation, and the impact of the Russia-Ukraine conflict more than 4 years of tracked progress against poverty witnessed a huge setback. Before the pandemic, the initial projection was that 581 million people were living in extreme poverty. This is progress was achieved with the after a consistent decline of 740 million in 2015. However, in 2022, this figure of people leaving with extreme poverty has increased by 75 to 95 million people (United Nations, 2023). This underscores the need to redouble current efforts to eliminate poverty in order meet the 2030 target. Furthermore, the attitude and behaviour of people in ensuring energy efficiency may be influence by the level poverty.

b. **Sustainable development goal 2-Zero Hunger Achieve food security and improved nutrition and Promote sustainable Agriculture**: The UN SDG seek to eradicate all forms of hunger and malnutrition by 2030, ensuring that all people especially children have access to sufficient and nutritious food throughout the year. This includes promoting sustainable agricultural practises, assisting small-scale farmers and ensuring equal access to land, technology and markets (United Nations Development Programme UNDP, 2023). It was estimated that about 1 in 3 people lack access to regular food as of 2020 and 1 in 10 people in the world suffer from hunger after the pandemic (United Nations, 2023). The crisis in Ukraine has triggered food shortages for the world's poorest people. Furthermore, food prices have soared and children under the age of 5y ears suffer from stunting. In order to reduce this by at least 50% by the 2030 target, annual decline must double from 2.1% to 3.9% per year (Economic and Social council, 2022) . Hence, more commitment is required by member state to meet the objective as desired.

c. **Sustainable Development goal 3- Ensure Heathy Lives and Promote Well-being for All at All Ages:** The 2030 Agenda acknowledges the complexity and interdependence of both good health and sustainable development. Goal 3 aims to end preventable infant and child deaths under the age of five, with all nations aiming to reduce neonatal mortality to at least 12 per 1,000 live births (United Nations Development Programme UNDP, 2023). It also aims to end the AIDS, tuberculosis, malaria and neglected tropical disease epidemics as well as to fight hepatitis, water-borne illnesses and other communicable diseases. In addition, one of its major targets are to Increase health spending and the recruitment, training and retaining of health professionals in developing nations, particularly in the least developed nations and small island developing States. However, this has all been threatened globally by the covid-19 disrupting essential health services. Furthermore, the pandemic also increased energy usage as most originations resorted to allow their staff work from home to prevent and reduce the spread of the virus. This could have significant impact on energy consumption and efficiency in residential sector.

e. **Sustainable Development goal 4- Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for All**: Although significant progress has been made toward the goal of universal primary education, large disparities still exist. Sub-Saharan Africa has made significant progress in primary school enrolment among all developing regions increasing from 52 percent in 1990 to 78 percent in 2012. Children from the poorest homes are up to four times more likely than those from the rich homes to miss school. There are still significant differences between urban and rural areas. The main goals of this target is to ensure all boys and girls complete free, equitable and quality primary as well as secondary education with effective learning outcomes. This to ensure that all boys and girls have access to quality early childhood development, care and pre-primary education that prepares them for primary education with focus for all women and men to have equal access to affordable and quality technical, vocational and tertiary education amongst others.

f. **Sustainable Development Goal 5- Achieve Gender Equality and empower all women and Girls**: This goal is aimed at achieving gender balance in the in all spheres of life with equity and fairness. Even though there are more women than ever in the workforce, some areas still experience significant injustices, with women routinely denied the same employment rights as men. Women and children continue to be disproportionately affected by migration, conflict and natural disasters. In addition to being a fundamental human right, eliminating all forms of discrimination against women and girls is essential for a sustainable future. It has been demonstrated that empowering women and girls promotes economic growth and social cohesion.

g. **Sustainable Development goal 6 – Ensure Availability and Sustainable Management of Water and Sanitation for all**: According to statistics from 2017, approximately 4.5 billion people worldwide still lack access to safe sanitation systems (Afroz & Ilham, 2020). Water is a problem in more nations, and trends like desertification and rising drought are making it worse. At least one in four people are anticipated to experience ongoing water shortages by 2050. This goal aims to end open defecation, provide everyone with access to adequate and equitable sanitation and hygiene, protect and restore water-related ecosystems, and significantly improve water use efficiency across all sectors.

h. **Sustainable Development Goal 7- Ensure Access to Affordable, Reliable sustainable and Modern Energy for All**: Between 2000 and 2018, the percentage of people with access to electricity rose from 78 to 90 percent. However, as the population rises, so does the demand for affordable energy, and a fossil fuel-based economy is causing significant climatic changes. The goal is to Improve energy productivity, ensure energy for all, and invest in solar, wind, and thermal power, double the global rate of improvement in energy efficiency in order to meet SDG 7 by 2030. However, progress in electrification has slowed due to the challenges of accessibility to remote communities and decline in financial assistance to developing economies (United Nations, 2023). These challenges have been of progress in ensuring the achievement of this goal in most developing and underdeveloped country especially in sub–Saharan Africa including Nigeria. To this end, this research work considers the SDG 7 as a fundamental component to energy efficiency which is the focus of this work.

i. **Sustainable Development Goal 8- Promote Sustained, Inclusive and Sustainable Economic Growth, Full and Productive Employment and Decent Work:** Global economic recovery has been disrupted by the rising inflation, supply chain disruptions, new variants of covid -19 and other related labour market challenges. The SDGs encourage technological innovation, increased productivity and steady economic growth. This requires effective measures to end forced labour, slavery, and human trafficking, as well as encouraging entrepreneurship and job creation.

j. **Sustainable Development Goal 9- Build a Resilient Infrastructure, Promote Inclusive and Sustainable Industrialization and Foster Innovation**: Innovation are fundamental components of growth that could foster economic prosperity and national development. It was reported that well over 4 billion people still do not have access to the Internet and 90 percent are from the developing world (Technological progress is also key to finding lasting solutions to both economic, social and environmental challenges, such as providing new jobs and promoting energy efficiency. For there to be equal access to information and knowledge, as well as to encourage innovation and entrepreneurship, this digital divide must be closed.

k. **Sustainable Development Goal 10- Reduce Inequality Within and Among Countries:** In recent decades, income inequality has increased nearly everywhere, albeit at varying rates. The first increase in country-to-country income inequality in a generation has been brought on by the COVID-19 pandemic (United Nations, 2023). It is least prevalent in Europe and greatest in the Middle East. Inequality in developing nations has increased by 11% when population growth is considered (United Nations Development Programme UNDP, 2023). These widening disparities necessitate policies that empower low-income earners and promote economic inclusion for all, regardless of race, ethnicity, or gender.

l. **Sustainable development goal 11- Make cities and Human Settlements inclusive, safe, Resilient and Sustainable**: This objective aims to make cities and communities inclusive, safe, resilient and a sustainable place. This should also include the reduction of adverse impact on cities while paying attention to air quality and waste management. To reach this objective, the percentage of people living in slums or informal settlements will serve as the metric. Globally, urban population living in slums increased from 23% in 2014 to 24% in 2018, equating to over 1 billion slum dwellers. The regions with the highest concentration of slum dwellers are Eastern and South-Eastern Asia (370 million), sub-Saharan Africa (238 million), and Central and Southern Asia (200 million) (226 million) respectively(United Nations, 2023). This goal could be achieved with more commitments of member states on their targets to uplift the leaving standards with necessary resilience and more sustainable.

m. **Sustainable Development Goal 12- Ensure Sustainable Consumption and Production Patterns**: The objective of the goal is to promote the use of environmentally friendly products while also making sure that waste production is decreased to achieve economic growth and sustainable development (United Nations Development Programme UNDP, 2023). By 2030, the goal seeks to increase waste and material recycling participation while managing our shared natural resources efficiently. Additionally, more support should be given to developing nations to enhance their technological and scientific capabilities in adopting more sustainable production and consumption habits.

n. **Sustainable Development Goal 13- Take Urgent Action to Combat Climate Change And its Impacts**: The goal to combat climate change and its impact is crucial in the current circumstances considering the growing concerns on greenhouse emissions. To achieve this objective, it is important to increase global resilience and adaptive capacities to the effects of global warming as well as education, awareness-raising, and human and institutional capacity for climate change mitigation. Most nations experience the severe effects of climate change with energy related $CO_2$ emission increasing by 6% in 2021 being the highest level ever. It is further forecasted that drought will displace 700 million people by 2030 (United Nations

Development Programme UNDP, 2023). This is a serious concern that could affect the several SDGs including sustainable environment, poverty reduction amongst others. It is pertinent to note that this goal is directly impacted by the amount of usage as well as the type of energy source to reduce the release of $CO_2$ and the impact of the greenhouse gas emission. Accordingly, this goal a valuable and a focus area with direct relationship this research. It is against this background that this research considers this SDG as a key objective to achieve the energy efficiency in residential building with focus on influence of attitude and behaviour.

o. **Sustainable Development Goal 14- Conserve and Sustainably Use the Oceans, Sea and Marine Resources for Sustainable Development:** This SDG seek to manage and protect marine and coastal ecosystems from pollution in a sustainable manner as well as mitigate the effects of ocean acidification(United Nations, 2023). Increase in acidification and plastic pollution continues to threaten marine life and limits the oceans capacity of $CO_2$ absorption. In order to improve ocean health and increase the contribution of marine biodiversity to the development of developing countries, it is important to expand scientific knowledge, build research capacity, and transfer marine technology while keeping in mind the criteria and guidelines of the Intergovernmental Oceanographic Commission(United Nations Development Programme UNDP, 2023). This is vital in executing the set targets towards achieving the objectives of this goal.

p. **Sustainable Development Goal 15- Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification and Halt and Reverse Land Degradation and Halt Biodiversity Loss:** The International Union for conservation of nature(IUCN) red list classifies more than a quarter of species as being at risk of extinction (United Nations, 2023). Although progress have been made towards the achievement of sustainable forest, over 100 million hectares of forest has been lost. Protecting biodiversity, including ecosystems in forests, deserts, and mountains, from further destruction is the main objective of this goal.

q. **Sustainable Development Goal 16-Promote Peaceful and Inclusive Society for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels:** The pandemic has increased children's vulnerability to exploitation, such as child labour and trafficking. Over 160 million cases of child labour were reported in 2020, with 1 in every 3 trafficked victim being a child (United Nations, 2023).

Armed conflict and insecurity have a negative effect on a nation's progress, negatively impacting economic growth and frequently giving rise to grievances that last for generations(United Nations Development Programme UNDP, 2023).To achieve this goal, promoting peaceful neighbourhoods, ensuring everyone has access to justice, and creating efficient, accountable, and inclusive institutions at all levels are essential for a sustainable society.

r. **Sustainable Development Goal 17-Strengthen the Means of Implementation and Revitalize the Global Partnership for Sustainable Development:** Due to potential issues that may arise with the execution of the first 16 goals, the final goal (goal 17) was established. Therefore, this goal was added to ensure that countries and organisations work together rather than competing to achieve the goals. Large stakeholder organisations must be established in order to share knowledge, skills, international trade and innovation in order for the SDGs to be successful (United Nations, 2023). Only through effective international collaboration and partnerships can the SDGs be achieved.

### 1.3 Rationale for the Research

The way energy is generated, transmitted and used is important when addressing reductions in the carbon footprint in our society. This process is connected with issues of resource depletion (energy), ecosystem loss and climate change (European Environmental Agency EEA, 2017). This is because an increase in energy usage from fossil fuel and buildings contributes to a rise in carbon dioxide emissions. This trend is worrisome due to its negative effects on the environment, economics and social wellbeing (Davis, 2017). To reduce the critical effect on the environment, policies and legislations were introduced by countries as the result of several international agreements, including the Paris Agreement of which Nigeria is a signatory (Oyewo et al., 2018). Consequently, policymakers now face the task of transitioning to a cleaner energy system, while at the same time supplying and preserving reliable energy supplies at an affordable price with reduced emissions (Oyedepo et al., 2018). Energy efficiency was recognized by researchers and policy makers as one of the strategies to mitigate this problem especially in buildings (D'Agostino et al., 2017). Furthermore, energy use in the residential sector in Nigeria accounts for up to 60% of electricity (International Energy Agency, 2017) making it a sector for energy saving and conservation policy considerations. Consequently, if these concerns are not addressed now, the energy industry will soon be unable to meet the demand for energy and the target for sustainable development. In addition, the target to double the energy efficiency rate by 2030 as part of SDG target may not be achieved unless more technological changes are made, public policies on energy intensities of the residential sector reviewed and standards on enhanced performance and quality of appliances and services, leadership enhanced and behaviour change. Hence, there is a need for an efficient energy agenda to reduce the carbon footprint and achieve the UN SDGs 7 for affordable and clean energy.

Although energy saving initiatives are vital, they are mostly based on technological solutions and innovations that do not consider occupants of the building (Eon, Morrison, & Byrne, 2018), as previous research has emphasized that energy is used by people/occupants and not buildings (Barthelmes et al., 2017). Literature revealed that changes in occupant behaviour can result in significant energy savings (Gynther et al., 2012; Wei et al., 2017). To adopt more sustainable practice to complement innovative solutions for energy efficiency, the behaviour and attitude of occupants are crucial. This is because, after industrial buildings, the residential sector was shown to contribute more carbon dioxide emissions with rural dwellers generating the highest emission rate as result of their reticence to adopt more energy efficient systems (Roberts, 2016). Considering that the building industry alone accounts for up to 40% of the total energy consumption in most developed nations (European Commission EC, 2020),there is an urgent need to address the research gap on occupant behaviours in domestic buildings. It is against this backdrop that this research focuses on reducing energy consumption behaviours by looking at energy cultural practices in residential buildings.

In view of the above issues, the role of users/occupants is significant during the operational stage of a building by complementing the current efforts to achieve the SDG. This considers the way a building is built, commissioned and used, which is vital in reducing energy consumption (Olaniyan et al., 2018). For the users, socio-demographic and social psychological factors may also affect energy management in building. It was also observed that higher income earners may be more likely to consider a more sustainable energy source than medium or low-income earners due to the cost of installation, (Frederiks et al., 2015). Additionally, other studies have identified that high income earners may not consider the importance of energy efficiency because they can afford to pay for energy (Brown et al., 2020). This highlights the importance of income in shaping energy efficiency and energy consumption behaviour in buildings. Unfortunately, the variation in behavioural factors regarding the energy efficiency and management of buildings is not fully exploited. There is the need to assess the energy consumption behaviour pattern by evaluating some indirect aspects of energy efficiency or management as well as energy consumption behaviour. Another limitation is lack of attention to the significant cultural element which is a driver of energy efficiency measures (Ferris et al., 2020; Glass & Westmont, 2014). Hence, this research intends to investigate the impact that energy practices, norms and material culture have in determining energy consumption in residential buildings, and the role played by energy and building stakeholders in efficient energy management including reductions to the negative impact of energy consumption on the environment. It will consider occupants' attitudes and behaviours towards energy consumption and various motives in achieving higher energy saving measures. It also aims to address the challenge of changing attitudes towards energy saving amongst building occupants and identify solutions to barriers to energy efficiency, especially for electricity in Nigerian residential buildings. This research consolidates the direct and indirect aspects of energy consumption which can explain the relevant factors that affect energy consumption.

The research covers the operational phase within the life cycle of existing buildings, because it has been shown that, during the operational phase of a building, more energy is used than in the construction and decommission phases. The main respondents will be drawn from residential buildings of Abuja Metropolitan City of Nigeria. Data from this area will provide an in-depth understanding of energy use with regard to the culture and behaviour of the residents.

### 1.4 Statement of The Problem

Domestic energy demand has risen to the forefront of climate change debates, owing to the fact that residential buildings account for about a quarter of global energy consumption (HM Government, 2021; Staffell, 2017). This has increased tremendously with the spread of the COVID 19 pandemic and subsequent lockdowns increasing domestic energy demand due to higher occupancy at home (Mastropietro et al., 2020), exacerbated energy poverty and worldwide insecurity. It is furthermore noted that the lack of adequate policy direction or efficient energy management in residential or domestic buildings will substantially increase the source of carbon emissions with negative impacts on environment and climate change effects. Furthermore, in developing countries, particularly those in tropical regions such as

Nigeria, the challenge of energy consumption in buildings was attributed to insufficient power from the mains and the use of diesel- and petrol-powered generators to produce electricity amongst most households.

Studies on energy saving in residential buildings have explored the large discrepancies that can occur when occupants with diverse types of behavior patterns reside in identical buildings. Surveys in the literature have revealed that elderly people, single residents and low-income households were less willing to implement energy-saving measures at home and the acceptability of these measures differed by socio-demographic groups (Chen et al., 2017; Poortinga et al., 2004). Furthermore, Vringer et al. (2006) classified households in the Netherlands by income, age, education and household size. Moreover, they discovered no significant differences in energy consumption between groups of households with varying value systems, although families with the least motivation to conserve energy consumed 4% more energy. It is on this premise that the assessment of energy saving behaviour from the perspective of occupants is crucial to energy efficiency, enhancing climate action and achieving the UN SDGs.

In addition, although a substantial amount of research on energy consumption behaviour and energy culture in Europe and Asia exists, little has been explored in sub-Saharan Africa, particularly Nigeria. It was further noted that research efforts in this area are critical for occupants to identify and further acknowledge the significance of their home's energy performance, and how their energy consumption expenses, and environmental impact can be reduced. Understanding energy consumption at home can uncover significant energy savings in all other aspects of the built environment.

### 1.5 Aim and Objectives of the Research

The aim of this research is to develop a model for the reduction of energy consumption within residential buildings in Nigeria from an end user perspective to meet the relevant UN SDG. The research will explore the cultural dimensions to energy use and its key elements. This will be achieved with the following objectives.

a) To critically review literature on energy saving behaviour and energy culture elements that influence occupants' residential energy consumption behaviours.

b) To identify factors that influence the occupant's behaviour and attitude towards energy consumption in residential buildings in Nigeria.

c) To explore the use of drivers to facilitate adoption of energy saving practices against existing barriers for stakeholders.

d) To assess the role of relevant stakeholders in energy saving practices and the future of sustainable energy technology and policies in Nigeria.

e) To develop an energy-saving behavioural model to reduce energy consumption in Nigeria.

**1.6 Research Questions**

The following are key questions to direct this research:

1.) What are the current factors and practices that determine or limit energy saving behaviours in Nigerian residential buildings?

2.) To what extent is behavioural change relevant to reducing energy consumption in Nigerian residential buildings?

3) What are the barriers to the adoption of energy saving practices in Nigerian residential buildings?

4) How can the use of drivers and stakeholder inputs contribute to improving occupants' attitudes and energy consumption behaviours in residential buildings?

5) How can the existing cultural framework be employed to develop a suitable model for energy reduction in Nigerian residential buildings?

Table 1.1: Research objectives with corresponding guiding research question.

| S/NO | RESEARCH QUESTION | RESEARCH OBJECTIVE |
|---|---|---|
| 1 | What are the current factors and practices that determine or limit energy saving behaviours in Nigerian residential buildings? | A B and C |
| 2 | What are the factors responsible for behavioural and attitudinal change relevant to reducing energy consumption in Nigerian residential buildings? | B and D |
| 3 | What are the barriers to the adoption of energy saving practice in Nigerian residential building? | B and C |
| 4 | How can the use of drivers and stakeholders' inputs contribute to improving occupants' attitudes and energy consumption behaviours in residential buildings? | C and D |
| 5 | How can the existing cultural framework be employed to develop a suitable model for energy reduction in Nigerian residential buildings? | E |

### 1.6 Scope and Limitations of the Research

This study developed a model for the reduction of energy consumption for residential buildings in Nigeria with a view to understanding its effects on the end user. It examined the factors and practices that limit as well as the drivers that promote energy saving behaviour. The study also examined how some of the drivers and stakeholder inputs (stakeholders from energy and building industry) can help to improve the attitude and energy consumption behaviour of occupants in the residential sector. At the initial stage of the research, an extensive literature review was undertaken to identify the gap in research. Subsequently, a theoretical framework was developed from an existing energy culture framework to provide a lens through which the research was studied.

The study adopted a sequential exploratory mixed method, starting with semi-structured interviews with stakeholders from the energy and building industry. The scope of this study was restricted to households in Abuja metropolitan city (existing residential buildings only) due to time and resource constraints. The study was limited in regional coverage to just the metropolitan area council involving a few towns within the five phases of the Abuja municipal council. As this research cannot cover all of Nigeria due to time constraints, the selection of Abuja as a case study was deemed appropriate. This is because real estate is a major driver of the Abuja economy, and the city is formed by many ethnic groups of Nigeria. It is worthwhile to note that Abuja, being a cosmopolitan city, allowed the random selection of participants which can provide an overview of the potential energy consumption in most Nigerian residential buildings.

#### 1.7.1 Structure of the Report

This report has been organised into six chapters. The breakdown of the structure of the report is as follows:

**Chapter One** is the introductory chapter to establish the background and rationale of the research, the aims and objectives and the research questions.

**Chapter Two** presents a literature review and contextualises the report with relevant academic literature. This chapter covers sustainable development, energy demand and consumption, the Nigerian energy sector and energy use behaviour. Additionally, it will also discuss the factors affecting energy efficiency and the context of the study on understanding the relevant stakeholders and other areas underpinning the research work.

**Chapter Three** discusses the theoretical framework, the review of theories relevant to the research, cultural approach, conceptual framework and the development of the conceptual framework of the research.

**Chapter Four** details the methodology chosen for the research. The chapter discusses the philosophical considerations underpinning the research and explains the rationale for the chosen strategies and methods including how the objectives of the thesis were achieved. The chapter is concluded by discussing the analysis method for the results from the pilot studies.

**Chapter Five** discusses the empirical data collected from the interview conducted (the first data collection phase) and the analysis of the results from the qualitative component of the research.

**Chapter Six** Presents the findings of the qualitative data and discusses the result in relation to the existing literature.

**Chapter Seven** discusses the empirical data collected from the questionnaire survey of household occupants and other relevant stakeholders. The quantitative data analysed is further discussed in the context of the aim and objectives of the research.

**Chapter Eight** is the conclusion of the report which highlights the essential parts of the research, presented the major findings as its relates to the objectives and research questions. Furthermore, the limitations, recommendations and areas of future research were also discussed.

# Chapter 2: Literature Review

### 2.0 Introduction

This chapter will review literature on the relevance of energy saving behaviour to attaining sustainable development goals. It also provides an insight into energy consumption within the residential buildings, the nature of Nigerian residential buildings and their energy consumption. It reviews literature on attitude, culture and behaviour concerning energy consumption and energy savings. It also highlights current efforts towards sustainable energy efficiency and climate action with emphasis on attitude and the factors affecting energy-saving behaviour. The chapter achieves one of the objectives of the research.

### 2.1 Sustainable Development

The concept of sustainable development has emerged because of the growing concerns about the global humanitarian and environmental crisis. This crisis developed in part due to the impact of the Industrial Revolution, which delineated societies creating imbalance amongst people, societies and countries (Purvis et al., 2019). Thus, there is a need for continuous progress to address some of the emerging social, environmental and economic challenges faced by sustainable development. During the 21st Century, the need to address the growing challenges of extreme poverty and hunger, prevent deadly diseases and expand primary education to all children necessitated global action which emerged in 2000 in the form of Millennium Development Goals (MDG). Although significant steps have been taken to achieve the MDGs which are based on a 15-year timeline, the desire to sustain these achievements require more sustainable development. Consequently, the 2012 UN Sustainable Developments Conference in Rio de Janeiro saw the development of 17 sets of SDGs that became targets for member countries to meet by 2030 (United Nations, 2020). The SDGs are meant to address major global social, environmental and economic challenges including climate action, affordable and clean energy, and sustainable cities and communities. The focus of this research therefore also falls within the realm of the social and environmental impacts of climate change and facilitates the achievement of some key components of SDGs. Hence, it is essential to discuss in detail the concept of sustainable development.

After the Industrial Revolution and Second World War, advanced Western countries saw increased economic growth while environmental disasters across the world also proliferated.

These drastic changes created an awareness of an emerging global social and ecological crisis, resulting in a call for global action to support the development of less advanced countries (Filho et al., 2018). On this premise, the term sustainable development emerged and became the main facet in strategic thinking for countries, international organisations and industries. *The Brundtland Report* first coined the term 'sustainable development' to describe a 'development that meets the needs of the present without compromising the ability of future generations to meet their needs'(Drolet, 2015, p. 481), Hart argued that sustainable development would constitute one of the biggest opportunities in the industrial sector. Indeed, businesses are now required to understand the problems posed by society's current unsustainable pattern of behaviour and develop a strategy to provide solutions (Hart, 1997). Moreover, Elkington (2001) described how, due to public pressure, the business environmental programme grew into sustainable objectives. The researcher argued that often businesses were judged on financial performance, but environmental performance was not taken into account, and in the future social impact would also be considered (J. Elkington, 2001). Businesses should measure performance against what Elkington referred to as 'the triple bottom line' (see Figure 2.1). That is, the ability to deliver profit while preserving the environment and acting in line with the demands of social justice. As Elkington (2001) described, 'business entities - who are alert to some of the key market opportunities that the sustainability change will open up – must recognise that the challenge now is to help to deliver economic prosperity, environmental quality, and social equity simultaneously.'

The influential initiative to emerge from this triple bottom line was that of 'sustainability'. A sustainable business creates profit for its investors but minimises damage to the environment and enhances the existence of the people with whom it has contracts. In other words, it must balance environmental, social and economic interests. The idea underpinning the triple bottom line was that a sustainable business is more likely to remain successful in the long term than one that focuses on economic outcomes alone. An industrial sector that generates a balanced triple bottom line accounts for the total cost of managing its activities to facilitate the attainment of more sustainable development. Additionally, it is important to discuss each component to highlight the importance of energy saving behaviour in achieving sustainable development.

Environmental sustainability addresses the impact of construction activities on the environment and propagates the prevention of harmful and potentially irreversible damage to the environment through the efficient use of natural resources, waste minimization, energy and water efficiency (Tleuken et al., 2021). It considers the extent to which business activity negatively impacts the natural environment. It is the main concern, not because of the impact on the environment of hazardous waste or air pollution, but because of more damaging issues around global warming. It is often industrial sector failure that lies at the root of pollution disasters and poor industry decisions, which impact environmental issues. Environmental sustainability involves other indicators such as reduced energy consumption, material input, waste generation, and other pollution emissions. As one of these components, energy saving behaviour is vital to enhancing environmental sustainability and addressing some of its challenges. The literature has shown that energy saving behavioural change towards sustainable consumption is a critical measure in addressing the environmental challenges of greenhouse gas emissions and climate change (Raihan & Said, 2021; Wentworth, 2021). It was also noted that, due to their behaviour and the way energy is consumed, the activities of energy users could disrupt the climate system and the stabilization of greenhouse levels (IPCC, 2017). The intervening variable between environmental values and behavioural change has a significant impact on climate change, sustainable energy and an enduring energy saving culture (Wan Hussain et al., 2021). Hence, energy saving behaviour in environmental sustainability is crucial to achieving sustainable development.

Social sustainability on the other hand, indicates that businesses should accept responsibility for the impact they have on society and balance the external societal impact of their actions. In the context of individual, social sustainability means creating jobs and work patterns, which allow people to contribute their talents without stress. At the sector level, this means recognising and dealing honestly with the workforce. Besides, it was argued that businesses must realise their responsibility to the community by helping to improve the economic and wellbeing of society. Social sustainability indicators include customer safety, employment impact, staff safety, non-exploitation of providers and employee engagement. These indicators also highlight the impact of energy saving behaviour towards sustainable development. Some scholars have revealed that the quality of energy saving products and social norms have a significant impact on energy saving behaviours in buildings (Nguyen et al., 2021). Furthermore, other factors, such as government policies and other demographic factor such as age and level of education, have direct or indirect influences on the energy saving behaviour of households. However, the impediments to policy implementation and their direct impact on energy saving behavioural change require more in-depth study. Thus, it is also crucial to conduct more research on the impact of demographic factors in energy saving behaviour.

Economic sustainability is measured using profitability, return on assets, customer happiness, operational performance, building capabilities, revenue growth, market share and cost reductions. It means that industry leaders must use resources effectively to protect the interests of shareholders. Some of the key interests are reducing the cost of energy saving appliances and offering incentives to adopt energy saving practices with likely impacts on energy saving behaviours. It was also noted that household income is vital to influencing behavioural change and growing an energy saving culture to attain sustainable development (Wan Hussain et al., 2021). Another important area of focus is understanding the prevalent of SDG in current built environment ecosystem. The work of Wieser and co-workers reviewed the implementation of SGD in building environment using the application of the qualitive system analysis (Wieser et al., 2019). The work demonstrated the interdependence among the various SDGs vis a vis type of structures in built environment. Similar work also considered the post 2015 SDG and its impact on built environment based on qualitative research approach (Chan and Neilson, 2016). The findings from the research indicates the direct impact of SDGs on socioeconomic development through the provision's smart cities and sustainable communities. The integration of renewal energy technology into design and construction of infrastructure in built environment. On the other hand, the critical role of the construction industry was considered vital in achieving the SDGs. This was expatiated by the work (Fei et al., 2021) where the prevalence of over 10 SDGs demonstrated the impact of construction industry (Fei et al., 2021). Another report also looked at sustainable procurement in attaining the SDG 12 of sustainable consumption and production. The work demonstrated the important of sustainable production, its challenges and how to turn the challenges to opportunities to drive the 9 targets of SDG 12 (Opoku et al., 2022). These underscores the import of SDGs into the construction industry or built environment to attain 2030 target.

The most important aspects of sustainability consistent with this research are the environmental and social impacts of residential buildings through the creation of greenhouse gas emissions. Energy use can be linked to all three pillars of sustainability. Furthermore, energy consumption allows for the social stability and economic development of societies

(Oyedepo, 2012). The economic and social development of any country are highly dependent on the energy sector's sufficiency. Therefore, the attainment of Sustainable Development Goals (SDGs) by 2030, as projected by the United Nations, in Nigeria and throughout the Sub-Saharan-Africa (SSA) region is heavily reliant on energy (Adewuyi et al., 2020).

While access to sustainable energy services is a major challenge for the African region, the increase in the demand for energy has been attributed to population growth (Mullan & Haqq-Misra, 2019). Hence, energy savings in residential sectors will lead to the realisation of sustainable development goals, affordable and reliable clean energy and the mitigation of climate change (Di Foggia, 2018). As the International Energy Agency (2017) reported, global energy demand increased by 2.1 % in 2017. This development is an indication that the global fight against climate change may not be enough, due to the over dependence on the use of fossil fuels to meet the demand for energy globally. So, there is the need for countries to improve on energy saving by addressing behavioural practices to enable a more sustainable energy future.

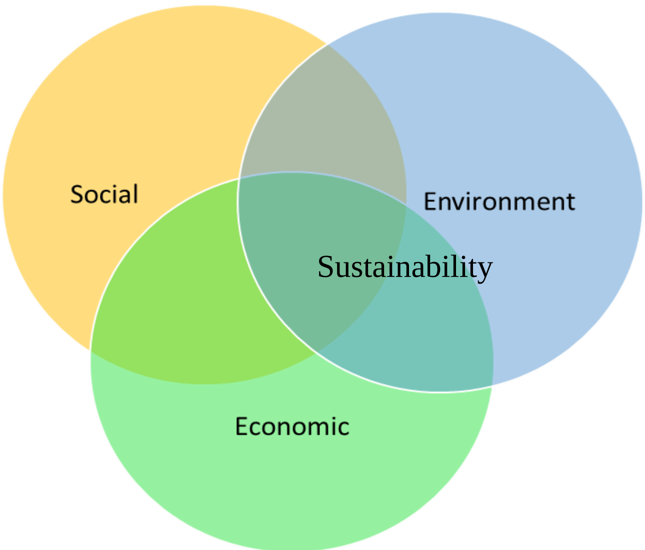



Figure 2.1. The Triple Bottom Line of Sustainable Development (Hooi et al., 2012).

As part of the global efforts towards sustainable energy, most African countries have adopted energy policies to meet the current realities of energy efficiency and the UN SDGs (ECOWAS, 2018). In Nigeria, energy policies were established to address the inherent challenges associated with energy management, in line with Nigeria’s commitment to global efforts on climate change. One area of concern has included inefficiency in the use of energy which contributes to carbon dioxide emissions because of the over-reliance on fossil fuels and biomass. However, the Nigerian government published sustainable energy policies in 2013 which aimed to develop regulation for energy-efficient buildings and saw the launch of the Nigerian Building Energy Efficient Code (BEEC) in 2017 (Federal Republic of Nigeria, 2017). However, the BEEC has not been effectively implemented, as several challenges affect existing households and their ability to meet the minimum required energy savings. Some of these challenges include insufficient and unreliable energy supply, occupant behaviour, poor building design, inconsistent government policy, and the poor implementation of government policies (Ajayi & Ajanaku, 2009). This highlights the need for a holistic approach to the implementation of the BEEC in order to address these challenges. Having discussed sustainable development as it relates to the current research, the next sub-section offers an insight into global energy consumption is necessary.

## 2.2 Energy Demand and Consumption

### 2.2.1 Reports on Global Energy Consumption

An understanding of global energy consumption offers a vital foundation to adequately review current and future efforts on energy efficiency and energy savings. According to the United States Energy Information Administration (Energy Information Administration EIA, 2019), the total primary energy consumption and $CO_2$ emissions globally increased by 85% and 75% respectively between 1980 to 2012. This resulted in an annual average increment of 2% and 1.7% for energy consumption and $CO_2$ emission respectively within the same period (U.S.E.I.Administration, 2013). Consequently, it was projected that between 2012 and 2035, global energy consumption, coal consumption and $CO_2$ emissions would increase by approximately 32%, 19%, and 16%, respectively under these policies. In 2020, global energy demand was projected to have decreased by 4.5% (Statistical Review of World Energy, 2021). This was the steepest decline since the end of World War II, owing to an unprecedented collapse in oil demand caused by the global imposition of lockdowns due to the COVID 19 Pandemic.

Conversely, the assessment of the pandemic's immediate effects on the energy system showed a 5% reduction in global energy demand in 2020 with a related 7% reduction in energy-related $CO_2$ emissions and an 18% reduction in energy investment (IEA, 2021). Furthermore, in 2020, oil consumption declined by 8% and coal consumption by 7% (IEA Report, 2020). For renewable energy, those used in the power sector were less affected by the pandemic and its aftermath than other fuels. Also, in the stated policies scenarios (STEPS) it was projected that global economy would recover to pre-Covid19 levels in 2021 but would remain roughly 7% lower in the long run than that projected in the WEO-2019. By early 2023, it is projected that the total energy demand will also return to its pre-crisis levels, although trends and timing will vary by country. Within the advanced economies, energy consumption has increased slightly following the COVID 19 crisis but has not returned to pre-pandemic levels, whereas it has returned to pre-pandemic levels in parts of Asia that saw early success in containing the pandemic. The pandemic's negative effects on growth and energy consumption are most severe in several low-income countries, where governments are less able to absorb setbacks from the pandemic and where the goals for energy access as well as clean cooking risk being delayed (IEA, 2021). More people now spend 90% of their time indoors and rely on mechanical heating and cooling which has resulted in buildings becoming the world's largest energy consumers (IEA, 2021).

Figure 2.2 shows an increase in energy consumption in buildings which were at the highest compared to other energy sectors during the period of COVID 19 pandemic lockdowns (EIA, 2021). It was noted that due to restrictions on movement, the transport sector recorded very low energy consumption (EIA, 2021). Furthermore, the data also shows a continuous increase in energy consumption amongst residential buildings since 2010 with a climax during the pandemic. It was further noted that the energy consumption from industrial and commercial buildings will increase exponentially between 2023 to 2050, as shown in Figure 2.2. This indicates there will be increase in $CO_2$ emissions from such usage, thus requiring more drastic action on issues of climate change.

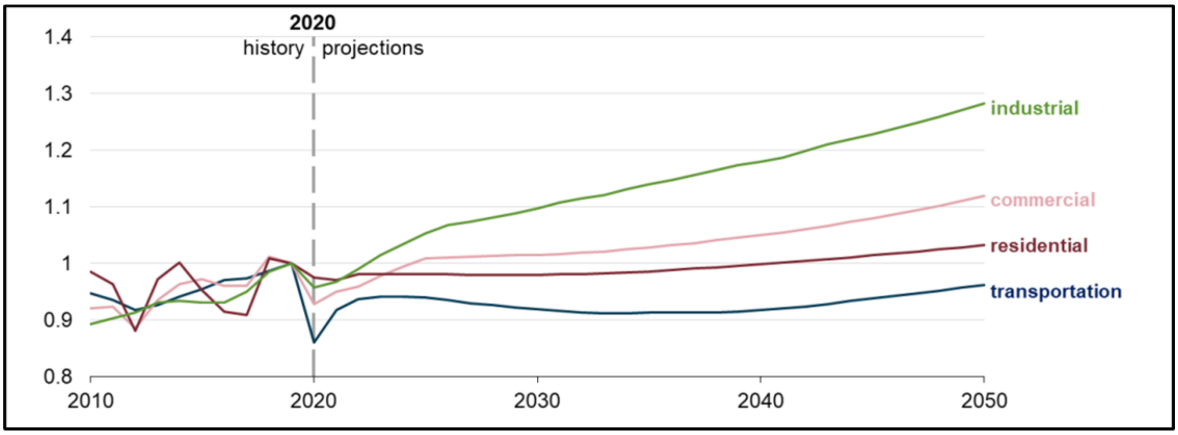



Figure 2.2: Annual Energy Outlook 2021 (US EIA, 2021)

To achieve universal access to electricity by 2030, the annual rate of electrification must increase from 0.82 percentage points in 2019 to 0.87 percentage points in 2030. However, this estimate does not account for the disruption caused by COVID-19 (U. United Nations, 2020). Without preventative measures, progress toward access and energy poverty objectives will be slowed, making universal access - as envisioned in the relevant United Nations Sustainable Development Goal (SDG 7) - increasingly difficult to achieve over the next decade. The data from BP on energy consumption from various energy sources shows a continuous increase in energy consumption from coal, oil and gas with negligible consumption amongst other renewable sources - including, solar, wind and hydropower - in the last decade, as shown in Figure 2.3 (BP Statistical Review of World Energy, 2021). This underscores the impact of over reliance on coal, oil and gas for energy usage with more efforts required towards securing a sustainable alternative energy in the next decade and enhance the implementation of the SDGs.

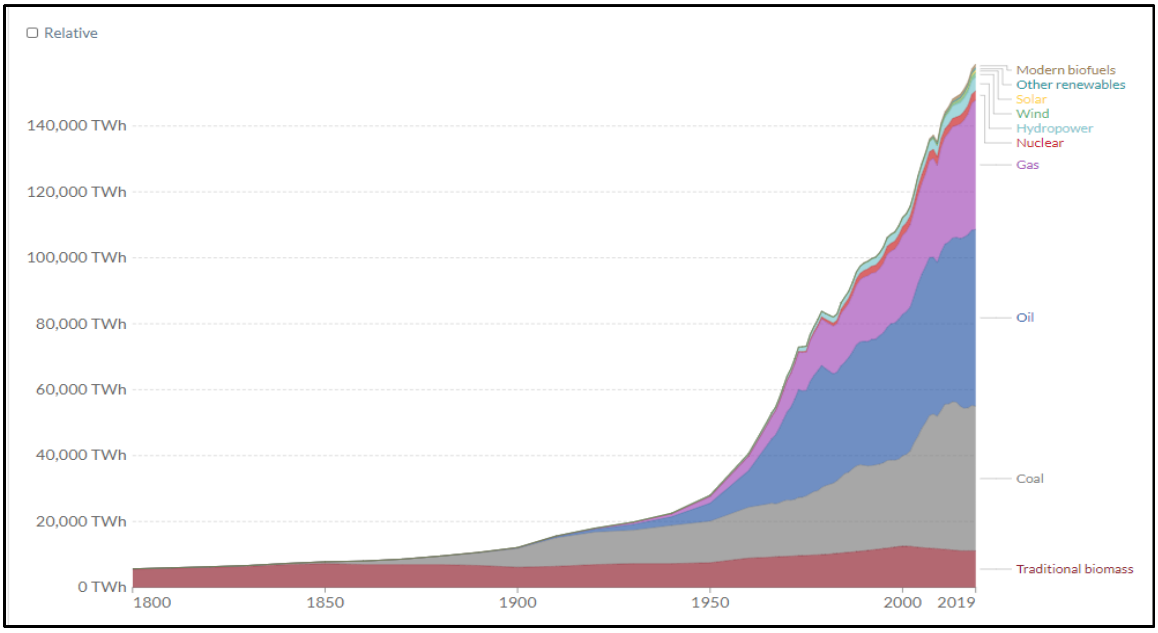



Figure 2.3: Direct primary energy consumption with various sources (BP Statistical Review of World Energy, 2021).

### 2.2.2 Global Energy Production

Global energy production has a direct effect on energy consumption, greenhouse gas emission and the relative impact on the environment. According to current data, the production of fossil fuels declined by 5% in 2020 compared to 2019 (IEA, 2021). As transportation demand declined during the global health crisis, all fossil fuels were affected, particularly oil which recorded a significant loss of -7 % within the same period (IEA, 2021). According to preliminary data, coal production also fell by 4% because of the economic consequences from Covid-19, while natural gas output was less affected, but still reduced by 3%. This reduction in the output of global fossil fuel production and other related sources is likely due to a drastic reduction in the energy consumption by commercial, manufacturing and transport sectors caused by COVID 19 lockdown restrictions. Conversely, in 2019, global energy production increased by 2% to 617 EJ from 616 EJ in 2018. Furthermore, natural gas (+4%) and coal (+2%) were the primary drivers of this increment; however, other renewables grew more significantly in relative terms with solar energy gaining +14% and wind +12% (Friedlingstein et al., 2020). It was further noted that the generation of hydroelectricity remained constant at 15 EJ, while the production of energy from crude oil - estimated at 190 EJ - remained the most abundantly produced energy in 2019, despite its stagnation (IEA, 2021). This data shows the significant reduction in energy production between 2019 and similar periods in 2020, which was influenced by the substantial decrease in energy consumption in commercial and manufacturing buildings. This is likely to decrease $CO_2$ emissions considering the substantial greenhouse gas emissions from the manufacturing sector. However, the reduction in energy production in 2020 does not affect energy consumption in residential buildings, but rather increased energy consumption with a corresponding impact on climate change.

In analysing global energy production prior to 2020, historical data shows that fossil fuel continued to dominate the sources of energy production from 2010 to 2019 with an estimated total output of 81% on average (Jones, 2021). An insight into continuous energy production within the stated period is very revealing. While total energy production amongst the OECD reached 195 EJ in 2019 this was a 3.5% increment from 2018; in comparison, the energy production of Asian countries incrementally increased by 4% within the same period, as shown in Figure 2.4. Similarly, an increase was observed in energy production for non-OECD Europe at 85 EJ which was an increment of 2% in 2019, while the Caucasus and Central Asia surpassed OECD Europe as the third largest energy generating area. Other countries across the globe also showed an increase in energy production in the year before the pandemic. Figure 2.4 illustrates that the Middle East, for example, saw an increase in energy production but was fourth largest compared to other continents, while Africa had a total energy production of 50EJ in 2019 which was a +1.4% increment from the previous year, and the non-OECD Americas had a production of 26 EJ, which represented a decline of -2.5 percent (IEA, 2019b; Jones, 2021). This analysis highlights the contributions of various continents to energy production prior to 2020 when energy production experienced decreases.

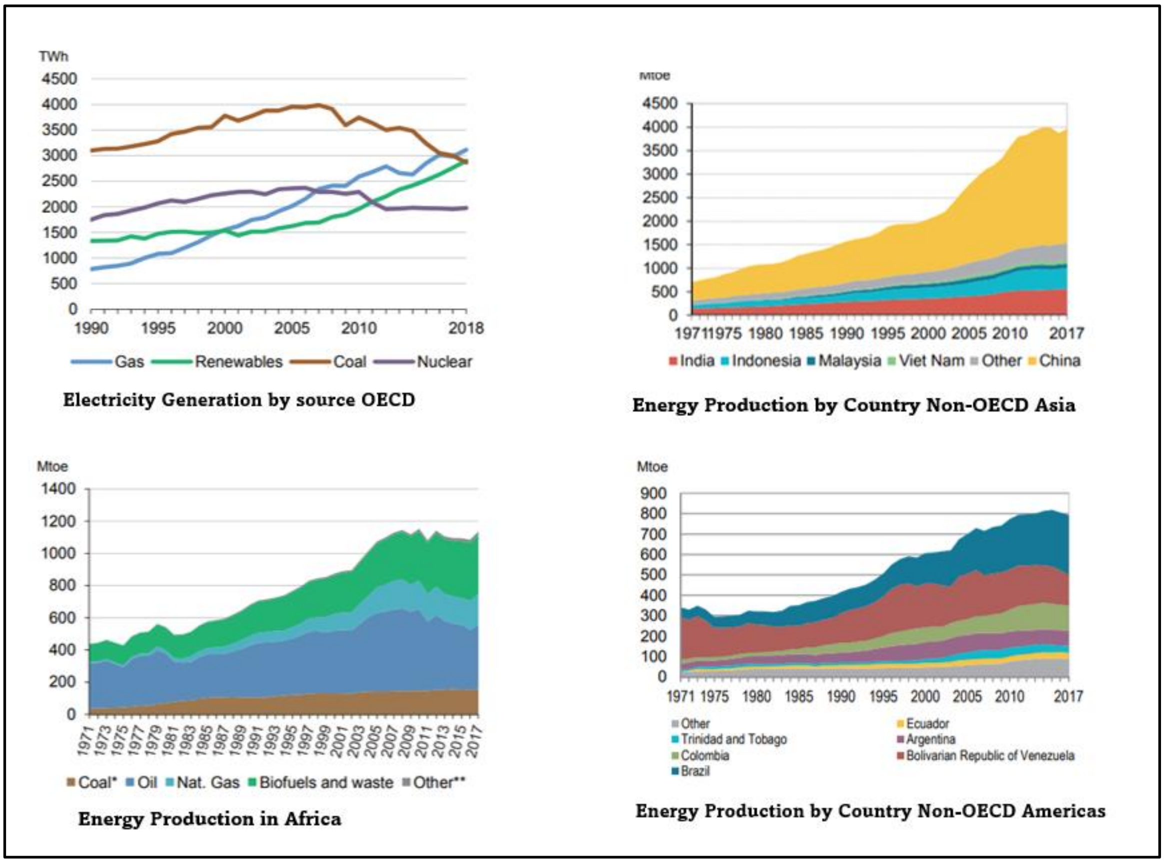



Figure 2.4: Energy Production for Different Continents (IEA, 2019a).

In other global energy statistics, the global Total Energy Supply (TES) rose from 230 EJ to 606 EJ between 1971 and 2019, representing a 260% increment. Additionally, the proportion of oil within the TES declined from 44% to 31% within the same period (IEA, 2019a). It was observed that coal continuously remained stable between 1971 and 2010, with coal providing more than 25% of the energy production in 2019, followed by natural gas which increased from 16% in 1971 to 23% in 2019. Moreover in 2019, coal remained the most common fuel for power generation in 2019, accounting for 37% of the worldwide energy output, and meaning it was 10% ahead of renewables (UK National Statistics Publication, 2019). Since the mid-2000s, coal's share of electricity production has fluctuated around 40%, until starting to decline in 2015 as renewables grew rapidly. In 2013, renewables overtook natural gas as the leading source of electricity, and the gap has continued to widen. Renewables provided about 27% of global electricity in 2019, which was three percent more than natural gas. Furthermore, nuclear power has remained stable at roughly 10% for the previous eight years, whereas crude oil and other associated components for generating electricity globally reduced by 3% in 2019 (EIA, 2021). In view of the aforementioned, it is pertinent to state that global energy production before 2020 continued to grow despite global efforts on greenhouse gas emission and climate action. Additionally, this increase in production could have direct consequences on increases to energy consumption amongst all sectors including residential buildings.

### 2.2.3 Global Electricity Demand and Supply

A review of electricity market is essential to identify or assess the impact of electricity supply and demand by energy production and consumption, as discussed earlier. This section will consider the review of demand and supply prior, during and following the Covid 19 pandemic. Energy is vital for social development, economic growth, and to meet the world's increasing demand, which is a critical concern (Abdelaziz et al., 2011; Jakob et al., 2020). Furthermore, global energy production has a direct impact on electricity demand and supply. The demand and supply of global energy has shown a significant increase over the last 50 years with the energy sources containing fossil fuel dominating the market (IRENA, 2018). Similarly, global electricity production has also shown a remarkable consistent increase over the last few decades (Jones, 2021). For instance, the global energy consumption of fuel from 1989 to 2014 indicates that the combustion of fossil fuels produces at least 84% of today's global electrical energy (Kataria & Khan, 2021), while alternative renewable energy sources account for barely 2% of total energy production. Furthermore, Figure 2.5 also shows a continuous increase in electricity production with coal dominating consistently for over the past four decades. The data shows there has been a tremendous increase in electricity production from 9,825.23 TWh in 1995 to 25,865.75 TWh in 2020 representing an approximate 160% increment within this period (Jones, 2021). Similarly, coal contributed to 30% of the electricity production in 1985 and 2020 at 3,747.63TWh and 8,735.8 respectively. In addition, even though the contribution of solar and wind energy to the production of electricity significantly increased between 1985 and 2020, on the total global scale this is negligible compared with other energy sources.

While electricity production has shown consistent growth, electricity consumption has shown a similar trend over the past 50 years. Between 1980 and 2018, net global electricity consumption increased by 229% with a net global electricity consumption rate of 7,323 billion

KWh in 1980 and 23,398 billion KWh in 2018 (Alves, 2022). Furthermore, Figure 2.6 also shows an increase in net electricity consumption from 2.8% from 2016 to 2017 to 4% between 2017 to 2018. This shows a steady increase in consumption with a corresponding increase in electricity production, as observed in Figure 2.5. It also reflects the global outlook of electricity demand and supply over the last four decades, suggesting there could be increase in population or human activities demanding more electricity across all sectors including residential buildings. This calls for more a robust approach to energy efficient or electricity consumption or management to minimise or mitigate any social or environmental concerns.

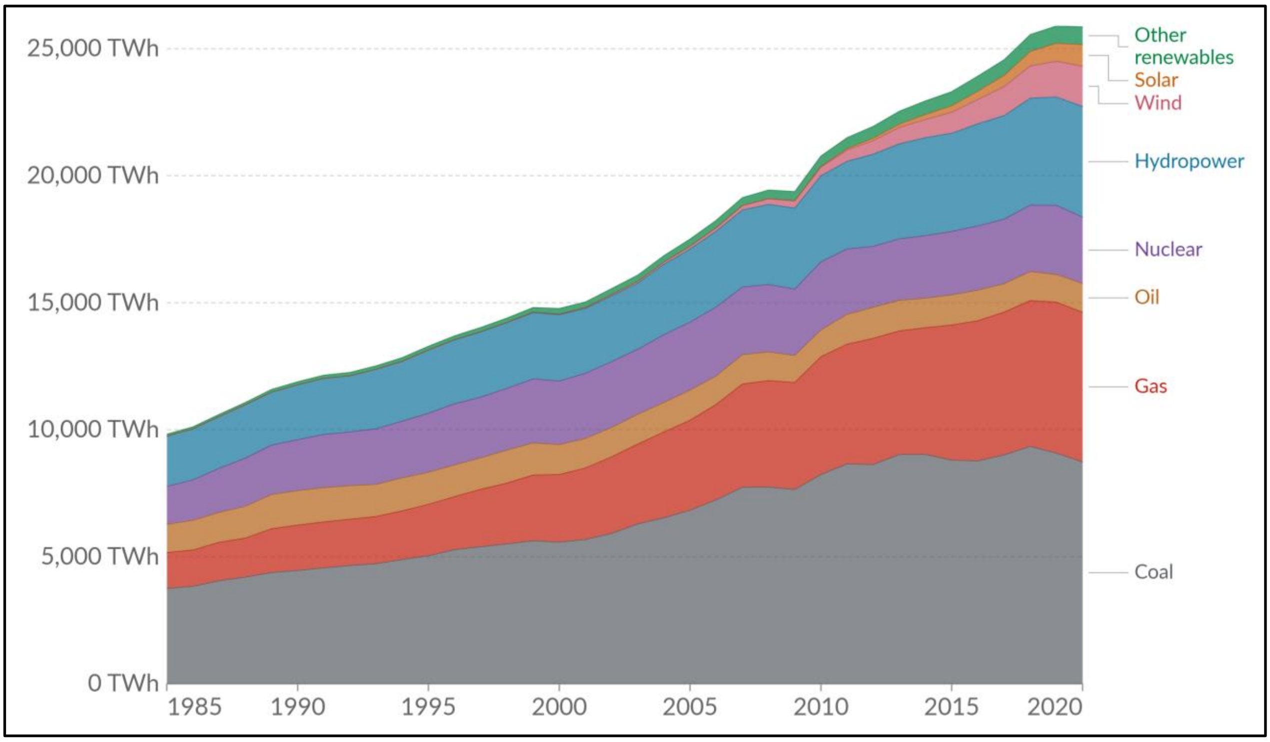



Figure 2.5: Global Electricity production by Source (Jones, 2021)

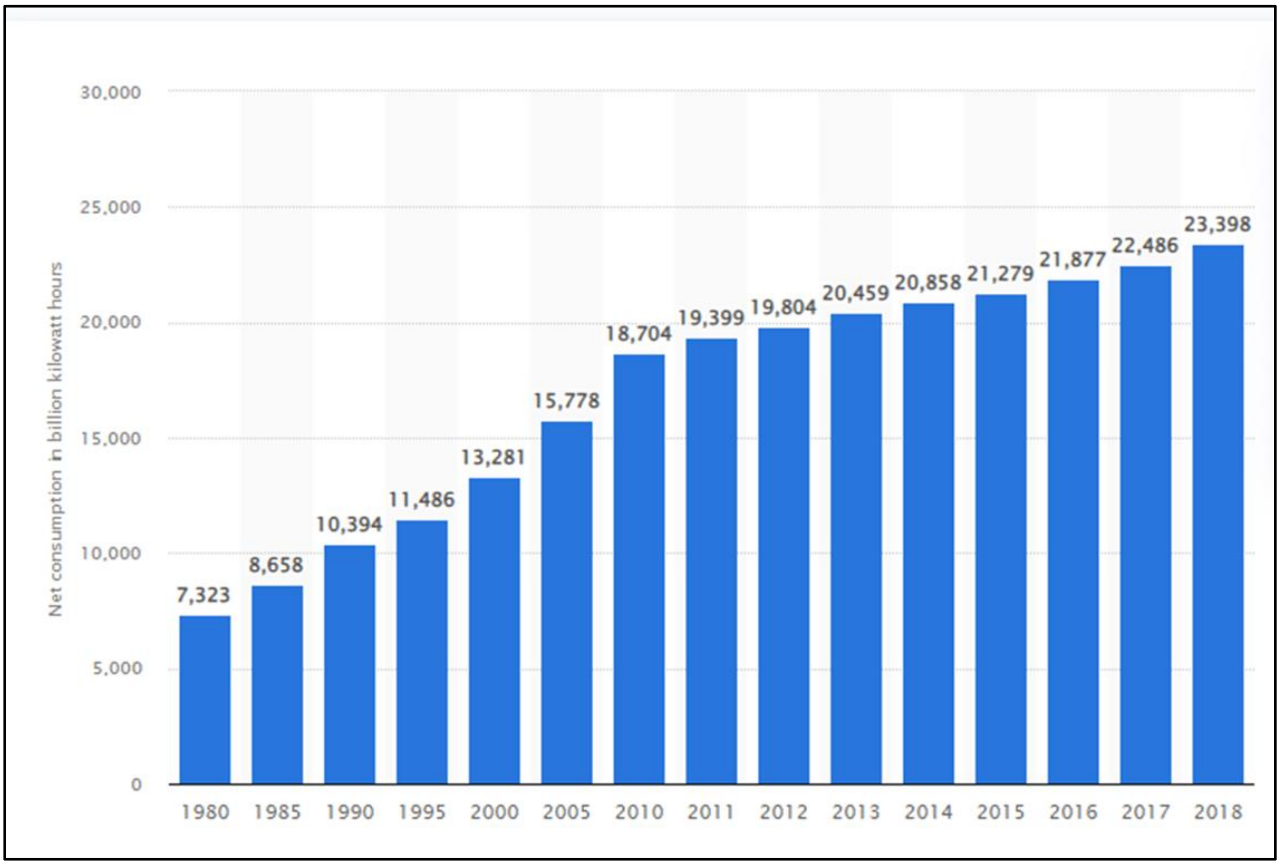



Figure 2.6: Net Global Electricity Consumption between 1980 and 2018 (Alves, 2022).

Global electricity demand and supply were also observed during the period of the Covid pandemic. A significant decline in global demand for electricity of approximately 2% was noted, which is the biggest in decades (IEA, 2021). This decline resulted from the disruption of activities across several sectors globally which affected normal activities. It was further noted that while electricity generation from fossil fuel was hugely affected due to the disruption in energy demand, the electricity generation from renewable energy, like hydropower, wind and solar remained consistent with a slight increase of 7% during the pandemic (IEA, 2021). This could be a result of the lockdown restrictions which affected most of the manufacturing, transport and commercial sectors that consume substantial amounts of electricity from fossil fuel. It was observed that the fall in demand for electricity reduced wholesale electricity prices due to the reduced availability of fuel and the increased demand for renewable energy powered the demand for electricity. Furthermore, Figure 2.5 shows a 4.3% decline in energy production from fossil fuel, while between January and December 2020 the contribution of renewable energy sources to electricity production increased by 6.3% during the pandemic (Jones, 2021). This underscores the impact of the restriction of activities during the year and could reduce the impact of greenhouse gas emissions although the impact on emission of $CO_2$ and greenhouse gas effects is not known. Nevertheless, it could have a pivotal role in enhancing current efforts to achieve the sustainable development goals of clean energy, climate action and sustainable environment.

On the other hand, the consumption of electricity globally in 2020 during the pandemic also declined across most sectors. The literature showed that strict government restrictions to reduce the spread of COVID 19 impacted travel, and saw the shutdown of commercial and retail businesses including the hospitality sector. These measures were responsible for the decrease in global electricity consumption (Buechler et al., 2022).The statistics also revealed that electricity consumption differed depending on the country with the biggest decline exceeding -25%, with an average global decline of -7% across all countries at the early stage of the pandemic, as shown in Figure 2.7. While studies demonstrated a decline in electricity consumption in commercial and industrial buildings, residential buildings demonstrated a sudden increase in consumption within the earlier stage of the pandemic (Halbrügge et al., 2021; Santiago et al., 2021). This increase in electricity consumption in households was likely due to the confinement of people within their households to comply with COVID 19 protocols, when many people were working from home. However, there are still gaps to determine the degree of increase in electricity consumption. Also, energy efficiency, conservation and management from residential budlings within this period have yet to be determined.

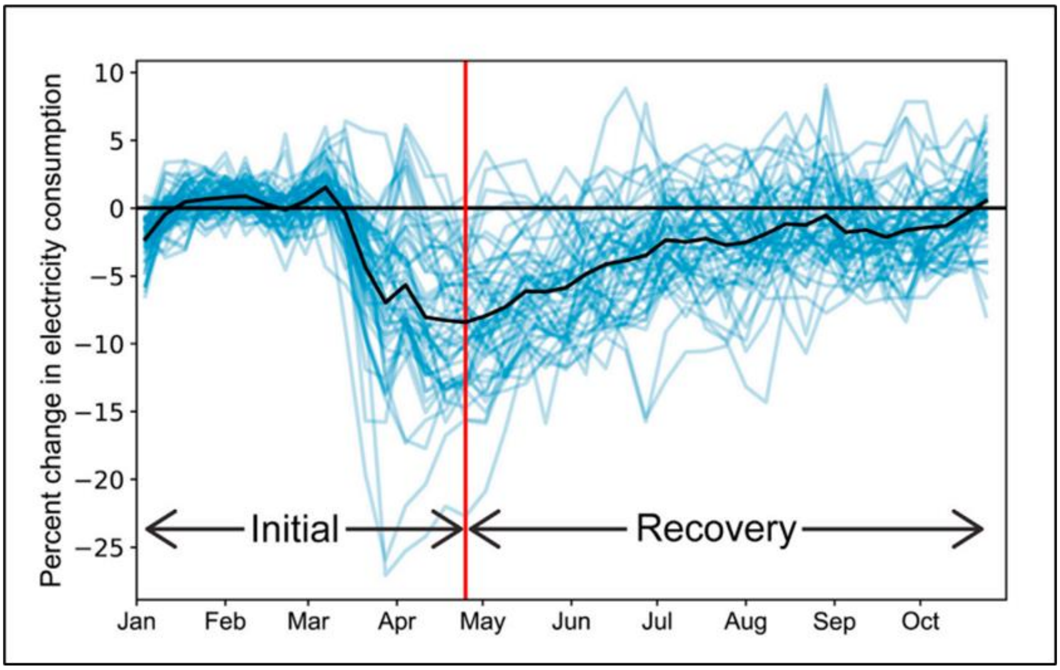



Figure 2.7: Electricity consumption for all countries between January and October 2020 (Buechler et al., 2022).

The assessment of the recovery period in Figure 2.7 revealed a rebound in global electricity demand and supply. After fall in 2020, the demand for electricity globally increased by 5% in 2021 with a subsequent rise in the coming years (International Energy Agency IEA, 2021a). It was also projected that the global demand for electricity would increase by 4% or more in 2022, while demand for electricity from renewable sources would increase by 6% in 2022 compared with the 8% increment in 2021. Statistics also revealed that the demand for fossil-based electricity would increase by 40% in 2022 while a 45% increase was recorded in 2021 (International Energy Agency IEA, 2021a). This is an indication of a continuous rise in demand for electricity which would be likely to influence a similar increase in consumption for various sectors including residential buildings. While it is encouraging to see a steady increase in electricity demand and consumption before, during and after the pandemic, there are also concerns about the exponential recovery rate of fossil fuel generated electricity due to its associated environmental effects. This requires the efficient management of consumption in households to address some of the inherent challenges and enhance current efforts on climate action.

### 2.2.4 Electricity Demand in Africa

Africa is positioned to become a major driver of the growth in demand for energy globally, owing to its rich deposits of fossil fuels, solar energy, and minerals, all of which are critical for a global transition to clean energy. Access to electricity has repeatedly been considered a necessary condition for socioeconomic development (Blimpo & Cosgrove-Davies, 2019). This assertion is applicable to Africa with its abundance of natural resources, which are yet untapped; however, there is insufficient and inconsistent electricity supply. Furthermore, the continent has continued to witness continuous population growth at an average rate of 2.5 per cent annually while 2020 recorded a growth rate of 2.5% in 2020 from the previous year (Saleh, 2021). This also suggests a growth in energy demand, which also means an increase in the generation and consumption of electricity across the continent. This rapid growth in population will contribute to an increase in $CO_2$ emissions from the current 4.6% average growth (Ayompe et al., 2021). Additionally, population growth in Africa has also directly influenced economic growth which contributes to $CO_2$. The literature has shown that $CO_2$ emissions have increased alongside economic growth in over 79% of countries in Africa (Olubusoye & Musa, 2020). This indicates that more conscious efforts are required to address the issue of climate change in Africa and to achieve the current global objectives for sustainable development. It also stresses the need for more proactive action by members to meet their commitments on climate action amid the increase in energy demand and electricity consumption.

The growth in energy demand as well as electricity generation and consumption have positive effects on national, social and economic prosperity. However, as the electricity consumption in Africa continued to increase, 2018 statistics show that over 600 million people, approximately half of the African population, lack access to an electricity supply (IEA, 2019b). This challenge could negatively impact economic growth and development as well as the SDG to achieve clean energy for all by 2030. Furthermore, the insufficient supply of power in Sub-Saharan Africa (SSA) has gained considerable attention over the years due to its intractable nature and importance for development. It was observed that over 80% of companies in SSA suffered electricity disruption leading to huge economic losses (IEA, 2019b). It was further revealed that only 15% of rural and 35% of urban populations in SSA have access to electricity (Tiwari et al., 2015; Trotter & McManus, 2017) while over 30 countries experience systematic power shortages and/or rationing. This underscores the need to close the gap or address this challenge in order to attain universal access to electricity. The region's electrification rate and average annual per capita energy consumption are the lowest in the world. Furthermore, it was noted that over 8% of businesses in the region face regular power outages (World Bank, 2017). Additionally, electricity access rates are declining as electrification efforts keep pace with population growth. This disparity is exacerbated by the fact that only 55% of Sub-Saharan Africans have access to electricity, while the second lowest access region, South and Southwest Asia, provide electricity to 82% of the population, as shown in Figure 2.8.

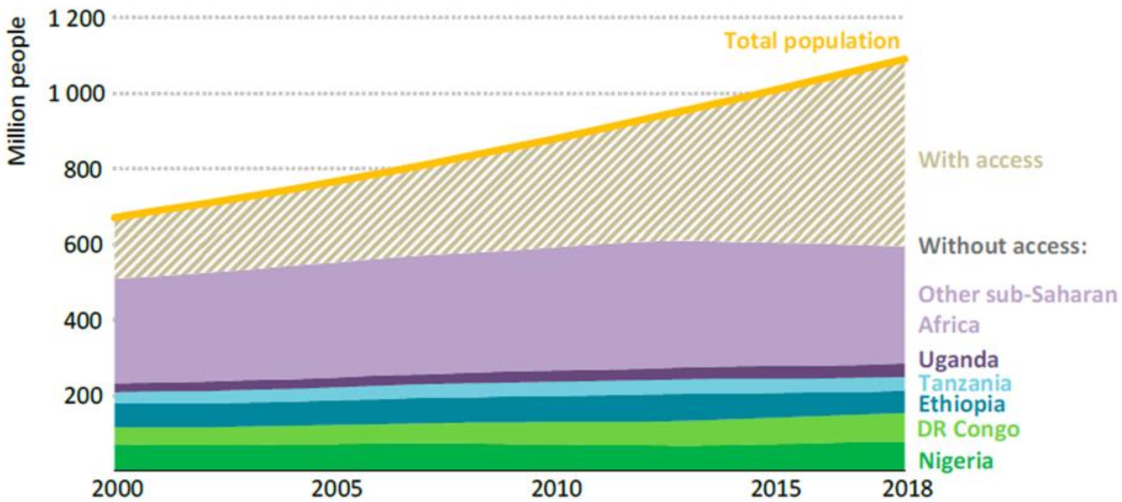



Figure 2.8: Electricity Access by Countries in Sub-Saharan Africa 2000 – 2018 (IEA, 2019a)

Figure 2.8: Electricity Access by Countries in Sub-Saharan Africa 2000 – 2018 (IEA, 2019a)

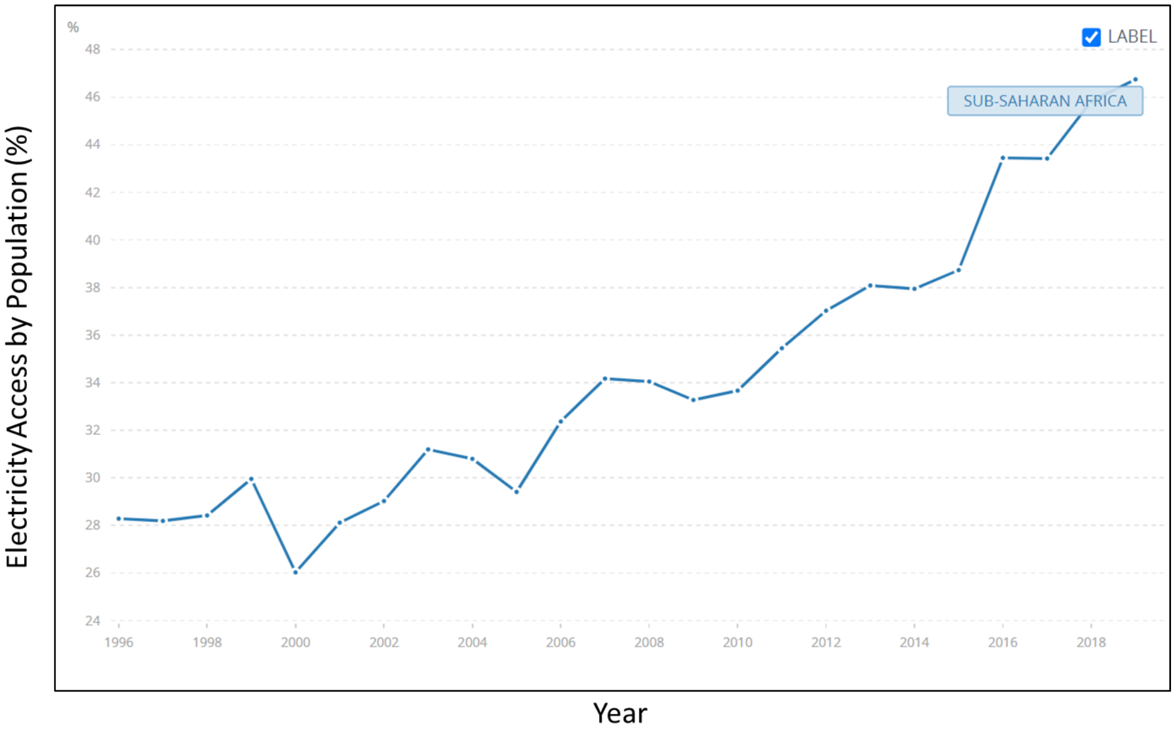



Figure 2.9: Access to electricity by per centage population in SSA (The World Bank, 2021a)

Despite the challenges associated with poor access to electricity in Africa, positive changes have also occurred over the last decade. To begin, populous low-access countries such as Kenya, Malawi, Sudan, Uganda, and Zambia have demonstrated that rapid progress is possible with political will and adequate financing. Secondly, there is a growing awareness among the international development community of the critical role of energy in human development and the imperative to adopt 'green' energy.  This is reflected in the definition of Sustainable Development Goal 7, which states that by 2030, it is important to "ensure universal access to affordable, reliable, sustainable, and modern energy."  Figure 2.9 also shows growing access to electricity over the past two decades alongside fast growth. This requires the efficient management of electricity consumption to enable increased access and greater consumption. The objective is to ensure that as energy is consumed, there is lower $CO_2$ emissions, fewer greenhouse gas effects, less climate change and greater achievement of the SDGs.  However, based on the usage and purpose of such buildings, there is insufficient data to demonstrate the energy consumption level for various sectors including buildings and their electricity consumption.

## 2.3 Nigerian Energy Sector

### 2.3.1 Energy Consumption

Energy is the major fuel for economic and social development, and a fundamental element of any sustainability objective (Kaygusuz, 2012; Ouedraogo, 2017). The need for household energy is not a direct demand for energy but rather derived from the generation of energy services such as lighting, water heating, cooking, space heating, air cooling, amongst others (Fell, 2017; González-Torres et al., 2022; Stankuniene, 2021). Over the years, many studies have been undertaken to identify factors that dampen household energy use and improve energy-saving behaviour (Kang et al., 2013; Steg et al., 2018; Trotta, 2018a). Furthermore, Trotta (2018b) looked at factors affecting energy-saving behaviours and energy efficiency investment in British households. The researcher found that different household profiles with specific features drive energy-saving behaviours and energy efficiency investments. Several factors also affect energy parameters including environmental factors, which are good predictors of energy-saving behaviours, the investment in energy efficiency appliances, and the avoidance of energy efficiency retrofit measures. There have been few to no studies in this area in the African context, particularly in Nigeria.

In Africa, it was observed that energy consumption is about 45% of the total energy used (AIE, 2014), and this figure has been increasing over recent years. This makes household energy use a vital contributor to the region's greenhouse gas emissions. Despite the increasing demand for energy consumption, energy sectors are mostly underdeveloped and unable to meet the need and expectations of consumers. Even though available natural resources are sufficient to meet domestic energy consumption, access to energy resources are still limited (Ouedraogo, 2017). According to the current trends, over one billion people are without electricity, while others are suffering from low-quality service, most of whom live in the suburban or rural areas of Sub-Saharan Africa and South Asia.

Also, about 3 billion people lack access to clean energy for cooking and have to rely heavily on biomass fuels (Mulugetta et al., 2019). This could be a concern in achieving the sustainable development goal. In 2014, Africa's primary energy demand accounted for 752 million tonnes of oil equivalent (Mtoe), 20% of which was from North Africa. Also, since 2000, energy demand has risen by 50 percent in Sub-Saharan Africa (SSA), reaching 590 Mtoe in 2014 (AIE, 2014). However, Sub-Saharan Africa still accounts for 4 percent of the world demand. With just a quarter of the population, South Africa (141 Mtoe) and Nigeria (133 Mtoe) are the region's largest energy users, accounting for more than 40% of the total production (AIE, 2014). Furthermore, its energy consumption is around one-third of the total energy use in SSA compared with 18 percent of the global average (AIE, 2014). This underscores the increasing need for energy and for a holistic approach to meet the growing demand.

Nigeria, on the other hand, has an uneven gap between demand and supply with about 90 million people in urban and rural areas not connected to the grids due to the lack of transmission infrastructure (SE4LL-AA, 2016). According to IEA, the Nigerian total primary energy supply is over 118,325 ktoe. Biomass is the dominant energy source, because of the huge reliance on energy sources for cooking and heating. While little progress has been made regarding access to non-solid cooking fuel since 1980, only one-third of the pollution have access to non-solid cooking fuels, and a marked difference is found between urban and rural areas (Sustainable Energy for All, 2013). In terms of the distribution of demand, total consumption was 116,457 ktoe (International Energy Outlook, 2013) within which the residential sector accounted for most of the energy consumed (see Figure 2.2 below). The use of electricity for cooking is insignificant, most people are dependent on biomass (International Energy Outlook, 2013). Space cooling is by far the greatest energy use, accounting for two-thirds of the domestic energy consumption. Space and water heating account for half of the balance, while lighting and appliances share the remaining (International Energy Outlook, 2013). The trend in energy use may reflect the increases in household per capita income and the falling prices of appliances. Moreover, measures to enhance the energy efficiency of residential buildings’ insulation and boilers would help to achieve the objectives for sustainable energy reduction.

Over the years, Nigeria’s grid supplies have underperformed in comparison to other developing countries. This is because more than half of the electrical energy generated was estimated to be off grid, and mostly produced by diesel and gasoline generators. Besides, the most pressing issue is the undersupply of electricity among people who do not have access to the grid and cannot afford off-grid energy. The recent privatisation by the Government was not only aimed at raising energy access, but also at promoting the capacity for productive uses. The country has set a target for 2030 to increase electricity from the current low level of 90% in urban and 60% in rural areas and to provide energy from renewable sources to augment the current deficit in supply (SEforALL in Africa, 2019). As discussed, the significant gap between the supply and demand of electricity has led to recurrent energy scarcity.

However, there is a high dependence on biomass, coal, a lack of technology, a lack of energy management practises and poor infrastructure maintenance, insufficient regulations and threats to energy infrastructure which add to the challenges facing the sector. These challenges are areas of interest for research while the scarcity of data to address these challenges is crucial.

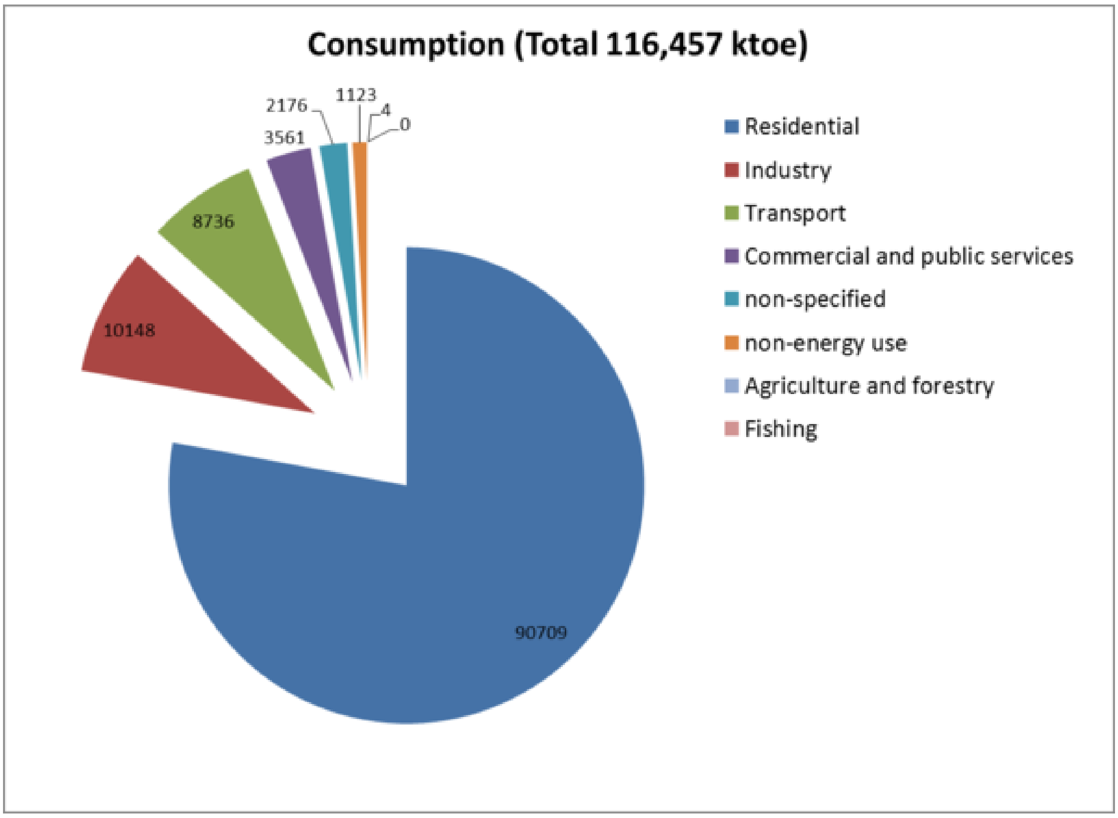



Figure 2.10: Energy consumption by economic sector in Ktoe (International Energy Outlook, 2013) .

### 2.3.2 Energy Efficiency Practices

Energy efficiency refers to the ratio of energy consumed to the output of production or services performed (International Energy Agency IEA, 2014). It means using less energy to provide products or services. Reducing energy demand, or conserving energy, has been the key driver for energy efficiency policies in some countries. This is aimed at enhancing the efficiency of energy use in products and processes on the demand and supply side. Economidou et al. (2020) indicated that energy efficiency requires the adoption of particular technologies that minimise total energy consumption without changing behaviours and optimising services. In comparison, energy saving means a change in consumer behaviour resulting in savings without investments in new technologies. Energy efficiency programmes remain the most effective tools for attaining sustainable energy goals.

A set of measures could increase the efficiency of energy use throughout the household and industrial sectors. These include setting standards to improve vehicle fuel efficiency; establishing building energy regulations; setting minimum energy performance needs for energy-using equipment; developing efficient transport systems and promoting energy management systems. Other measures include reducing the technical losses in generation, transmission and distribution. Besides, insulating a home enables a building to use less heating and cooling energy to maintain a comfortable temperature. Unlike traditional methods, the installation of LED lighting, fluorescent lighting, and natural skylight windows can also help to reduce the amount of energy use. The DTI (2004) survey indicated that the rates at which energy-intensity reductions have been changing in the residential and other sectors. Modern appliances use less energy than old ones. According to the McKinsey (2016) report, the replacement of old appliances is the most efficient global measure to reduce the emission of greenhouse gases. Action such as switching off the light, fridge, or water heater will help to reduce energy use. Often little adjustments are the simplest methods to reduce energy consumption.

As previously mentioned, the effect of energy efficiency approaches was measured in terms of units of reduced energy demand, namely, the level of improvement in the ratio of energy to output as measured against energy consumption. This appears immaterial and has led to several researchers referring to energy efficiency as the hidden fuel. There is also considerable uncertainty regarding the role of consumer behaviour in improving (or not) the economic and social factors that influence how efficiency improvements are adopted. Improvements in energy efficiency are achieved using ‘efficiency technology’ or processes (Diesendorf & Diesendorf, 2007; Iris & Lam, 2019; Tanaka, 2011) alongside recognised methods to lessen energy losses. Indeed, literature, such as (Gram-Hanssen, 2011; Morley & Hazas, 2011; Santin et al., 2009) emphasised that occupant behaviour is as important as building physical objects when considering energy use. Other researchers propose that reductions in household energy consumption are unlikely to be reached from interventions designed to finance building retrofitting alone. A report was published suggesting the potential energy savings of concurrently adopted technological, appliances and behavioural intervention shifts (Trotta, 2018b). This highlights the influence of energy savings as an essential component to facilitate energy management and energy efficiency.

The benefits of energy efficiency have been acknowledged in the literature (Baatz, Relf, et al., 2018; International Energy Agency IEA, 2014; Weinsziehr & Skumatz, 2016). Some studies have identified energy efficiency as an essential measure to reduce greenhouse gas emissions which can help in climate change mitigation strategies. Besides, another important motivation behind energy efficiency investment is its capacity to lower demand and deliver cost savings (International Energy Agency IEA, 2014). The implementation of sustainable energy efficiency investment (International Energy Agency IEA, 2014) would result in more the efficient use resources across the sectors, with the potential to boost economic outcomes (Weinsziehr & Skumatz, 2016). It was also noted that improved energy efficiency in buildings and other industrial sectors could reduce the global energy demand and can help to manage global carbon emissions (International Energy Agency IEA, 2014). Scholars have argued that the most obvious measure to combat greenhouse gas emissions is to remove government-led energy subsidies, which promote higher energy consumption and inefficient energy use in many countries (Sovacool, 2017). This indicates that several factors affect the efficient management of energy consumption or energy saving behaviour including an appropriate policy direction from government. While some of these factors have been identified as major drivers or barriers to an energy saving culture and its management, there is limited data to determine the influence of these factors in Sub-Saharan Africa. Hence, there is need for more in-depth research to close the research gap in Sub-Saharan Africa, especially Nigeria.

An increasing range of evidence shows that energy efficiency can deliver significant value across a wide range of economic and social impacts beyond the conventional emphasis on reducing energy demand (International Energy Agency IEA, 2014). Energy efficiency retrofits in a building can create conditions that support improved occupant health and wellbeing, most essentially among vulnerable groups such as children, the elderly and those with pre-existing illnesses. Other potential benefits include reduced symptoms in respiratory and cardiovascular conditions, rheumatism, arthritis and allergies, as well as fewer diseases (International Energy Agency IEA, 2014). However, the effect of energy efficiency policies on the sustainable development objectives of social, environmental and economic performances still needs to be better understood. In particular, it is essential to understand how energy efficiency measures influence these objectives – whether positively or negatively – which depends on the scale of the underlying energy strategies.

**2.3.3 Energy Efficiency Policies in the Nigerian Household Sector**

Although a number of policies have been formulated in the energy sector in Nigeria, only a few have been approved and enforced. These policies include the National Electricity power policy 2002, National Energy Policy 2003 and the Rural Electrification policy paper 2009. Others are creation of electricity distribution companies (DISCO) and the Nigerian Electricity Regulatory commission (NERC). Furthermore, to assist these, the federal government introduced the National Renewable Energy and Energy Efficiency policy in 2015 to further emphasize Nigeria's commitment to the reduction of greenhouse gases. The National Electricity Regulation Commission also approved a renewable energy feed-in tariff regulation and a procurement programme where investors can select from a range of options to achieve a set goal towards greenhouse gas mitigation. While these regulations are welcome developments to facilitate the major objectives of the government including access to electricity and attainment of some objectives of the SDG, the smooth implementation of most of these policies still remain a huge challenge.

With regards to building, a great number of frameworks used in the promotion of energy consumption reduction are voluntary. For instance, the United States Energy Star programme is one of the ground-breaking initiatives to identify energy conservation opportunities. Another example is the Leadership in Energy and Environmental Design (LEED), a sustainability rating program for buildings operating in the United States. While it remains a voluntary initiative, its rapid development and extensive use appear to have been embraced as a national framework for evaluating building sustainability. In 2002, the Buildings Energy Performance Directive, an EU legislation, took effect and was designed to support energy and carbon reduction policies. Its goal was to increase awareness about energy usage and encourage investments in building energy efficiency initiatives. EU Member States were instructed to implement the Directive while member states will establish their own initiatives and the structure for energy reduction, depending on their specific interests. This suggests a change from the voluntary mechanism to enforceable regulations/policies. Other policies, like the United Kingdom's "Zero carbon homes" introduced in 2008, has focused more on the reduction of carbon dioxide emissions in buildings. Thus, there is the need for the stronger enforcement of policies and regulations in order to address energy consumption reduction as well as environmental problems in developing nations.

### 2.3.4 Energy Legislation

As part of the efforts towards the efficient management of power or electricity in Nigeria, the country has metamorphosed different legislation over time. The Electric Power Sector Reform Act (EPSRA, 2005) was the main regulation that enabled ongoing energy sector reforms in Nigeria. The act makes provision for the creation of entities in the liberalised energy sector such as the Nigeria Electricity Commission (NERC). It gives guidance concerning the issuance of licenses, calculation of tariffs, land access rights, and so on. It also facilitates the unbundling of the sector with the creation of Transmission Company of Nigeria (TCN) and the Nigerian Bulk Electricity Trader (NBET) and makes provision for the creation of the Rural Electrification Agency (REA), and the Rural Electrification Fund (REF). The legislation aims to facilitate energy efficiency and a sustainable approach to energy usage.

### 2.3.5 Nigeria's Building Sector

Nigerian's architecture is described as a mix of post-modern buildings of the 1990s and a new architectural practice, which is being shaped by the introduction of new building materials that are mainly imported from abroad (Rikko & Gwatau, 2011). The designs used do not often consider the local climatic conditions and building materials but international standards which demand more energy to operate (Todd & Geissler, 1999). These are challenges that will affect energy efficiency and the sustainable efficient practice of energy consumption.

Another key challenge according to reports on the building sector in Nigeria is the current deficit of about 17 million homes in Nigeria (Geissler et al., 2018). However, the provision of housing for this group will place additional pressure on a low energy system (NESP, 2016), although Nigerians mostly lease or build houses, and purchasing is uncommon (Geissler et al., 2018). Public sector intervention in the provision of residential buildings is low and inaccessible for low income households (Morakinyo et al., 2015). Studies have shown the government's failure to support private developers by encouraging them to participate in the provision of more residential buildings; this is attributed to poor planning and the lack of implemented housing policies (Ayedun et al., 2018). Hence, a robust arrangement to bridge the housing deficit with an efficient energy management plan would facilitate the attainment of a sustainable energy consumption system.

### 2.3.6 Residential Energy Consumption

To achieve the 2030sustainable development goals, countries must have a coordinated plan on energy use for all sectors, with the residential sector crucial considering its volume of energy use. In Nigeria for instance, residential occupants tend to be in energy poverty due to the rising energy price and the erratic supply of electricity; they, thereby revert to traditional biomass fuels (Ogwumike et al., 2014). Household energy consumption is mainly used to operate electrical appliances which require about 3%, lighting requires 6%, while the largest consumption is from cooking at 91% (ECN, 2012). Researchers have identified that the most well-known occupant attributes to the affect energy consumption of households include income, family size, age and the desire to make a house more efficient (Guerin et al., 2000; Mayer, 2018; O'neill & Chen, 2002). However, inefficient energy use and management practices have been the main setbacks of this sector in Nigeria (Oyedepo, 2012). Apart from the initial building design and building construction challenges which have a direct effect on the energy efficiency of residential buildings, poor occupant attitude, inefficient electrical appliance and changes in living standards also contribute to energy inefficiency in this sector (Hussaini & Abdul Majid, 2015).

Abrahamse et al. (2005) examined 38 studies on residential energy consumption in the field of social and environmental psychology. The researchers acknowledged three distinct patterns: (1) household information on energy efficiency and conservation led to more enlightenment about the topic but no behavioural changes; (2) monetary rewards in the form of rebates succeeded in enhancing household energy savings, but had temporary effects; and (3) recurrent energy consumption household feedback reduced energy consumption for high-energy consumption households, but not necessarily among low-energy consumption families (Abrahamse et al., 2005). Also, it is generally assumed that the technology-based up-grade of energy efficiency is strongly influenced by human behaviour (Ubale & Abdul Majid, 2014). Hence, there is a need for more efficient energy management practice in Nigerian residential sector, bearing in mind that Nigeria has been rated low in energy efficiency amongst other west African countries, irrespective of the low energy supply of the increasing population.

### 2.3.7 Current Status of Energy sector in Nigerian

Nigeria is one of the largest oil producing nations in the world with a population of over a 190 million people (Olaniyan et al., 2018). It is a lower-medium income economy with a per capita income of about $2790 (World Bank, 2017). An undeveloped electricity production system also exists making generation and distribution unreliable (Emodi & Yusuf, 2015; Urban et al., 2007). It has an old generation of power plants with an installed capacity of 84% thermal (mainly gas for generation) to 16% hydro power (ECN, 2012), which were mostly built before the 1990s, and produced about 6840MW in 2015 (Geissler et al., 2018). This situation has an impact on the electricity generation and consumption as well as efficient usage especially, with the growing demand of energy in the country. It is important to note that Nigeria is also richly endowed with both natural energy and renewable resources but some of these resources are yet to be explored, making energy an important concern and priority for the country (Oseni, 2012). The Nigerian government estimates that Nigeria needs to install at least 40 GW by 2020 in order to meet the projected goals to become one of the 20 largest global economies by 2020 (Ikpe & Torriti, 2018). Unfortunately, the aim to achieve the target failed as a result of numerous challenges associated with the power sector. This underscores the need to critically analyse the challenges facing the Nigerian power sector with a view to suggesting a workable solution.

In addition, some of challenges continue to degenerate leading to the current energy crisis which has been attributed largely to the inefficiency of the energy industry to meet the needs of its customers and the low generation of local power plants (Hussaini, 2018). Consequently, the 2005 Electricity Power Sector Reform Act brought about a discussion on independent energy projects (Dada, 2014). However, the results were generally considered mixed or discouraging. As a result of the above, Nigeria is faced with a supply and demand gap with an erratic and insufficient electricity supply (Hussaini & Abdul Majid, 2015). This has resulted in 74% of households depending on fuel wood as a source of cooking and heating, which means the deforestation of about 350,000ha/year and the emission of a high proportion of greenhouse gases into the atmosphere (Hussaini & Abdul Majid, 2015).

This situation is capable of frustrating current global efforts towards climate change and the attainment of the 2030 SDG target. This situation is also likely to influence the pattern of energy usage and behaviour of households towards energy management. It was further observed that only one percent of energy consumption is generated from hydropower plants compared to oil and natural gas at 13 and 12 percent respectively (U.S.Energy Information Administration, 2016). This shows the distribution of energy consumption in Nigeria for 2013. Consequently, efforts have been made to transform the electricity sector through privatization with the use of renewable sources as a basis for generating electricity, with particular interest in hydropower, solar energy, biofuels and wind. Furthermore, Nigeria endorsed the Paris Climate Change agreement in October 2016, while concrete efforts were made in November 2016 to enhance the compliance of the COP22 in Marrakech, Morocco by primarily adopting clean energy solutions and prioritizing the widespread use of low-carbon technologies (FGN, 2016). Based on the above, the need for a strategy in Nigeria to reduce energy challenges and promote sustainable clean energy solutions has become necessary.

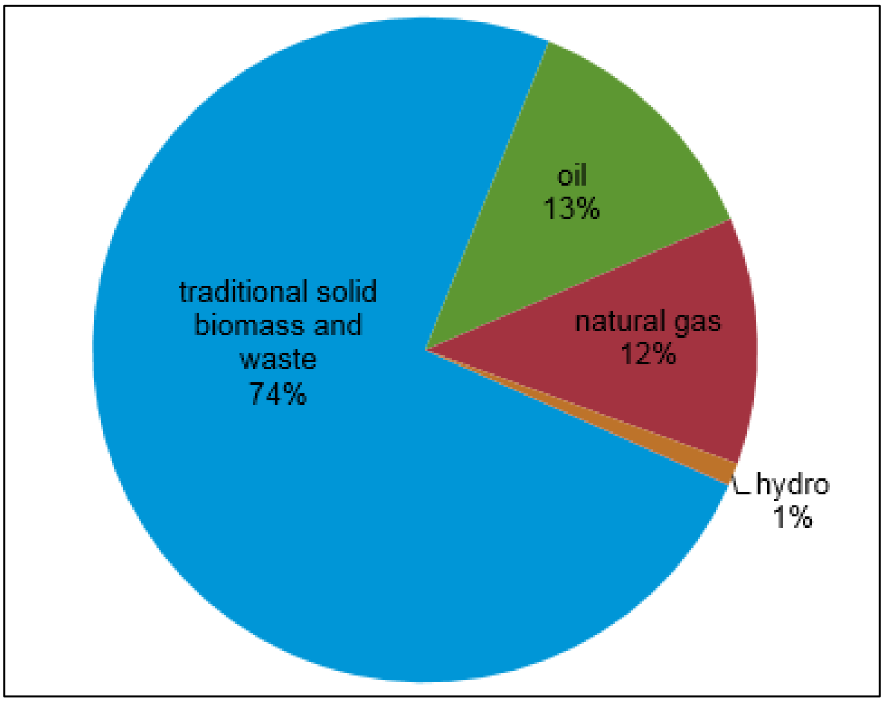



Figure 2.11. Nigeria's primary energy consumption (U.S.Energy Information Administration, 2016).

**2.4 Why Residential Buildings?**

Energy is an essential resource for life to thrive and households are significant electricity consumers. Households depend on energy for functions such as cooking, water heating, space heating in colder climates and in warmer climates for cooling, lighting amongst other end-uses. The household demand for energy in urban areas is growing because of increasing incomes and improved living standards. In the Organization for Economic Cooperation and Development (OECD), the size of the dwelling in developed countries has risen while the size of the household (persons per household) has fallen (De Rosa et al., 2014; Eurostat, 2012). Such trends are also observed in developing economies like Nigeria mainly due to economic development. This leads to the construction of houses and the consumption of more finite resources like energy. Earlier discussions have emphasized the importance of the energy use at the occupancy phase which accounts for up to 39% of the final energy consumption (Azari, 2019). Furthermore, the fact that a typical residential building lasts between 30-50 years its role in energy savings cannot be overemphasized (Huang et al., 2015). In terms of policy initiatives and practise, residential energy usage is experiencing major changes in the context of climate change, energy efficiency, technological developments, social and institutional dynamics (Foulds & Robison, 2018). Furthermore, it is also a major contributor to the overall consumption of electricity and contributes significantly to peak demand, particularly in Europe during winter months (Ramírez-Mendiola et al., 2017). Hence, residential buildings are a critical sector for the energy savings culture, which could help to facilitate energy policies and regulations.

It was noted that urban households benefit from a wide range of primary fuels to generate electricity and a reduction in the use of oil, while coal can be substituted by a wider range of renewable sources, gas and nuclear energy have also been recorded (Garg et al., 2017). Therefore, such energy needs are higher than those of rural residents. With growing urbanisation and population, in a developing country like Nigeria, urban household energy demand becomes a significant problem. Changing the habits of building occupants also has a significant impact on the quantity and pattern of energy use of households in these areas. Studies on energy-efficient steps in households usually focus on economics (including behavioural economics), psychology, technology and sociology. Furthermore, psychology and sociology literature analyse the impact of psychological variables such as values, beliefs or attitudes towards energy conservation, as well as the impact of social norms shared by relevant groups on energy efficiency activities (Bergquist, 2020; Gardener & Stern, 2002). Accordingly, this research highlights the interactions between norms, energy practices and material culture, as well as the external influences that shape energy consumption behaviour.

The research considers the operational phase within the life cycle of existing buildings, because it has been shown that more energy is used at this stage compared with the construction and decommission phases. The main respondents will be drawn from the residential buildings of Abuja Metropolitan City of Nigeria. Data from this area will provide an in-depth understanding of energy use with regard to the culture and behaviour of the residents.

### 2.4.1 The Setting of the Study

Nigeria is situated within the tropical zone of Africa occupying an area of about 923,773km between N4.00-14.00° and E3.00-E14.00° (Ifegbesan et al., 2017). The country shares its northern border with the Republic of Niger, the North East with Chad, the South Eastern with Cameroun and the South with the Gulf of Guinea. Nigeria is divided by ethnic, regional and cultural lines to represent six geopolitical zones and the Federal Capital Territory location of the case study area. Below is a map of the world showing the location of Nigeria (National council on power, 2016).

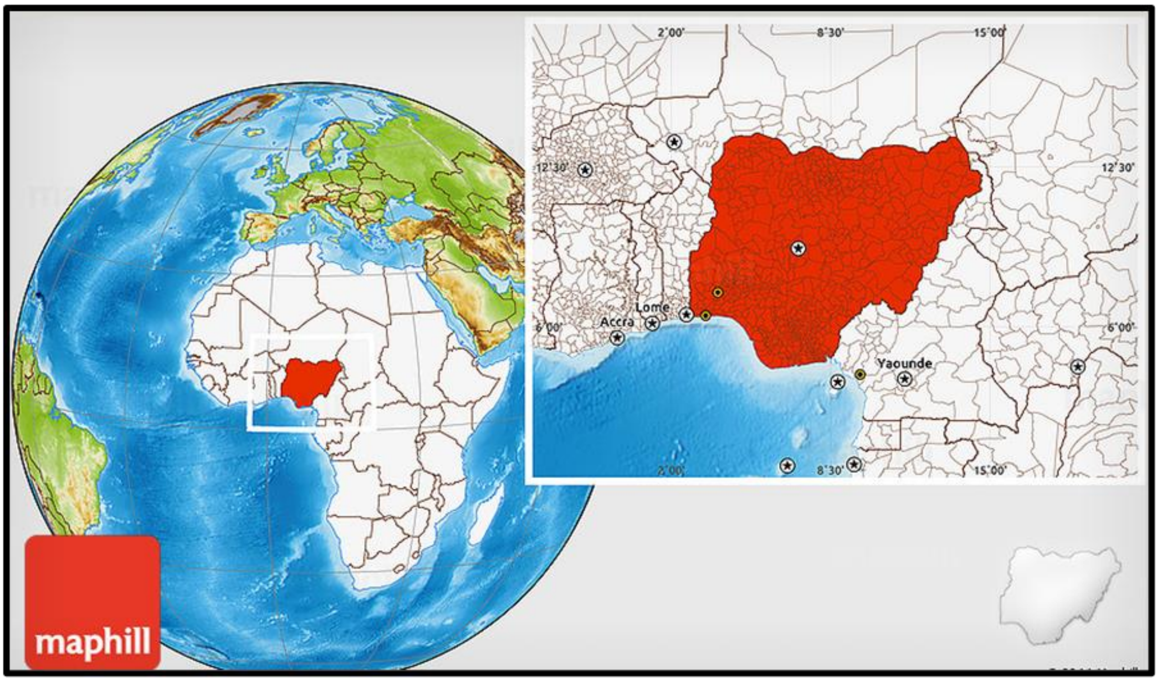



Figure 2.12: Map of the world showing Nigeria (Maphill, 2011)

Nigeria's population is the seventh largest in the world with more than 190 million inhabitan ts (Olowe, 2021) and it continues to grow by at least 2% per year. Currently the largest nation in Africa, it accounts for almost half of West Africa's total population and more than 15 percent of the entire African continent's total population. Nigeria represents more than 65% of the productive West African economy and is perceived as the most attractive destination for the establishment of medium and large scale manufacturing (National council on power, 2016). However, despite having the second largest proven oil reserve in Africa and being a major exporter of oil, most Nigerians have limited access to electricity in their communities (Gift et al., 2020). Additionally, Nigeria has an abundance of other resource reserves besides crude oil, such as natural gas, which includes both associated and nonassociated reserves; as a result Nigeria ranks among the top ten countries in the world in terms of gas reserves (IEA, 2019a). Nigeria's other resources include 4.1 billion tonnes of tar sands and 1.52 billion tonnes of coal and lignite. Renewable energy sources such as wind, solar, biomass, and hydropower also have potential in Nigeria (Adewuyi et al., 2020).

**2.4.2 Electricity in Nigeria**

The electricity sector in Nigeria has experienced a significant change in recent years. This is due to the National Parliament's enactment of the Electric Power System Reform (EPSR) Act 2005 in the power sector (Dada, 2014). The initial power industry, Nigerian Electric Power Authority (NEPA) was dissolved, and legislation also saw the creation of 18 separate successor companies composed of six generation firms, one transmission company and 11 distribution companies (Ikpe & Torriti, 2018). The Nigerian electricity company subsequently changed ownership in 2013 from a publicly owned government agency to private sector ownership. It was further divided into Generation Companies (GENCOs), which oversee the generation of power and Distribution Companies (DISCOs) which handled the marketing and billing. These included Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port Harcourt and Yola. The electricity generated in the country consists of a combination of three hydro and nine thermal powers, with thermal generation based on gas (Aliyu et al., 2015; ECN, 2012). The generation plants have a total installed capacity of 6910MW which is generated mainly from hydro and fossil fuel sources (oil and natural gas) at a ratio of 27.9% and 67.2% respectively (Centre for Democracy and Development CDD, 2020). The electricity generated from transmission stations is distributed to the district business unit where the final delivery is made to end users. Billing/metering, collection and other customer services are the responsibility of each business unit. This has led to the emergence of Independent Power Producers (IPP), the involvement of international and national governments in electricity generation and the establishment of Nigerian Electricity Regulation Commission (NERC) as a regulating agency for the sector which coordinates efforts and monitors the quality of services.

Despite these energy challenges, Nigeria still consented to the Paris Climate Change agreement which came into force in October 2016. Additionally, it made a commitment in subsequent discussions regarding compliance to the decisions of the 22nd Conference of the Parties (COP22) in Marrakech in November 2016. The COP22 included the prioritisation of sustainable energy solutions, particularly renewables such as solar, biofuels, wind and hydropower, and the optimisation of low-carbon technologies on a large scale (Federal Republic of Nigeria, 2017). Hence, the implementation of the Paris agreement may be unrealistic if the current energy challenges persist. This elicited further discussion during the COP 26 meeting in Glasgow, UK on facilitation of existing agreements amongst others. The key objectives of the Glasgow meeting aimed to secure global net-zero carbon emissions by the mid-21$^{st}$ Century and keep 1.5C degrees within reach. It also included the adaption of a framework to protect communities and natural habitats, mobilisation of finance and work as well as the delivery of climate change and climate action (COP26, 2021).

### 2.4.3. Challenges of Residential Properties in Nigeria

Housing is required to provide comfort, safety, and convenience for its occupants as essential social condition for living standards. If housing is of adequate quality and readily available, households will spend less on health care, crime prevention, and other bills, resulting in increased productivity and prosperity (Gan et al., 2019). Nigeria, which is already densely populated, has been confronted with numerous challenges that have adversely impacted the residential property sector and its inhabitants. Among the specific issues confronting Nigerian residential properties and people are inadequate housing, exorbitant cost of housing, poor infrastructure, and security concerns. Undoubtedly, one of the most significant issues affecting Nigerian residential properties and people is the inadequate supply of housing (Ihua-Maduenyi, 2019; Makinde, 2014). According to an earlier report, Nigeria has a housing deficit of about 17 million units, and the country needs to build at least 700,000 units annually to meet the increasing demand for housing (Ekpo, 2019). The lack of adequate housing has led to overcrowding, informal settlements, and slums, which are prone to health hazards and social problems (Jiboye et al., 2020).

The work of Ezeanah (2021) explored the various challenges affecting housing in Nigeria with focus on solutions to assist in the achievement of the SDGs. It was noted that poor quality of housing material, poor policy implementation and the surge in the rural-urban migration are key issues frustrating the progress in the Nigerian residential sector. Similar research considered the issue of housing deficit in Nigeria and associated challenges with proposed solutions for the way forward in this regard. The work highlighted some key areas of concerns including rural-urban migration, high interest rates and inflation, currency devaluation, high costs of property development and the land tenure system as key factors affecting Nigerian residential Sector (Akpan, 2019). Consequently, a robust deliberate government policy taking into consideration of these concerns with effective implementation will assist to address most of these challenges. On the other hand, some of the issues associated Nigerian residential building also have direct influence on the behaviour of peoples. For instance, the currency devaluation as one of the key challenges associated with residential sector also has direct influence on the ability of people rent, purchase or maintain residential properties. This assertion is supported by the work of Gardner and Co-workers (Gardner et al., 2019) where the work analysed the Nigeria's housing construction and housing rental activities with focus on the cost benchmark and impact on the economy. The work analysed amongst other issues how housing users are affected by government monitory policies vis a vis the sector and the results show that there is direct relationship between people, monetary policy and their influence on the housing sector.

In addition, another critical issue is the high cost of housing. The cost of housing in Nigeria is prohibitively expensive, making it unaffordable for many low and middle-income earners (Moore, 2019). The high cost of housing is driven by several factors, including land tenure, high construction costs, and the lack of access to affordable financing options (Moore, 2019). Furthermore, poor infrastructure is also a significant challenge facing Nigerian residential properties. Many residential areas lack basic amenities such as potable water, electricity, and good roads, making it difficult for people to live comfortably. The lack of infrastructure also affects the value of properties in these areas, as the poor state of infrastructure discourages investors and potential buyers. Security concerns also pose a significant threat to Nigerian residential properties and people. The country has been plagued by insecurity for many years, with incidents of kidnapping, armed robbery, and other forms of violent crime occurring frequently in residential areas. The high level of insecurity has led to many people living in fear and has also discouraged investment in the residential property sector.

In conclusion, the Nigerian residential property sector is facing several challenges that affect the quality of housing and the well-being of its residents. Urgent action is required to address the above-mentioned critical issues that need intervention from the government and other stakeholders. Addressing these issues will not only improve the quality of life of Nigerians but also create opportunities for investment and economic growth in the country. This underscores the need to consider the energy behaviours in Nigerian residential building.

### 2.5 Energy Use Behaviour

#### 2.5.1 Energy Use Behaviour in Buildings

Research into energy consumption behaviour is a new area as indicated by the recent emergence of the *Journal of Energy and Social Science* (Sovacool, 2014b). Some of these studies observed that the use of energy in residential buildings depends on the number of people per household, the household type, appliance ownership, lifestyles physical characteristics of the home, climate and human behaviour (Barthelmes et al., 2017; Brandon & Lewis, 1999; Yohanis, 2012). Earlier research has also shown that 40% of the variability in energy consumption can be explained by building factors while others depend largely on behavioural effects (Huebner et al., 2015). In the recent years, important theoretical and empirical work has been undertaken on energy considerations in design, building materials and installation. However, the study of energy consumption and energy saving behaviour is relatively new (Słupik et al., 2021). Recent trends have shown that technological improvements alone will not achieve low energy and improved comfort in buildings, but rather the inclusion of human factors; however, these considerations are often neglected in the design and use of buildings (D'Oca et al., 2018). Hence, there is a need for researchers to consider energy use behaviour more closely and the consumption of energy in buildings.

Researchers have shown that energy consumption in complimentary buildings can differ remarkably due to occupant behaviour (Gill et al., 2010; Gram-Hanssen, 2014) . The majority of building occupant behaviour studies have focused on office buildings due to the fact that residential buildings are characterized by varying occupancy hours and activities, which complicates the observation and modelling of residents' behaviours (Balvedi et al., 2018). Similar contributions have been made to understand the factors that determine the use of household energy and the results show that household energy consumption depends not only on the location and design of the building, but also on the behaviour of the homeowner (Yang, 2013; Yohanis et al., 2008). Furthermore, some researchers in Lithuania focused on how behavioural changes can reduce energy use and found that a potential energy saving of up to 16.6% was possible through changes in consumer behaviour (Štreimikienė et al., 2016). This underpins the need to consider behavioural changes as crucial to energy consumption in households.

A recent study was conducted online with Chinese households and focused on the energy consumption and behaviour of occupants and buildings, occupant comfort within indoor conditions, and their attitude to energy saving policies (Hu et al., 2017). It was found that behaviour of Chinese urban households is decentralized and varies with low energy use. In another study to determine the influence of occupant behaviour on building energy use, two types of action were identified - Adaptive action and non-adaptive energy related actions - which differ based on occupant needs, available alternatives and the operation of appliances (Hong et al., 2016). Another study based on computer simulation showed certain occupants engaged in wasteful behaviour and used twice as much as non-wasteful workers (Tianzhen et al., 2013). Other empirical studies demonstrated the importance of physiological, socio-demographic, cultural, climatic and psychological factors. Also, field studies were conducted during the summer and monsoon seasons in India and it was discovered that age, gender and tenure had a weak correlation with thermal comfort, while women house owners and older residents have a higher thermal acceptance (Indraganti & Rao, 2010). In contrast, the relationship between yearly energy consumption was tested against building factors, attitude and self-reported behaviour. It was found that the physical characteristics of buildings explained an approximate 39% inconsistency in energy use, socio-demographic 24%, heating behaviour 14% while attitude and other behavioural determinants about 5% (Brandon & Lewis, 1999; Gatersleben et al., 2002; Huebner et al., 2015). Other studies tested socio-demographic and psychological factors with residential energy use and found that psychological variables like attitudes and behavioural control were not associated with energy consumption, but only with energy saving intervention programmes (Abrahamse & Steg, 2009). However, contrary views indicate the need for further research into energy consumption and human behaviour. An earlier study collected data from spouses in the same residence and show a relatively high correlation in attitudinal variables (Becker et al., 1981). Because of the differences noted, results cannot be generalized when considering the social psychological factors of residential energy consumption. Hence, the low level of research and lack of sufficient data on human behaviour related to energy consumption necessitates further research.

### 2.5.2 Energy Saving Behaviour in Buildings

As previously mentioned, energy use behaviour in buildings is still not adequately understood. Another area requiring attention is energy-saving behaviours, which involves the daily and habitual practices of households that focus on specific reductions in energy use (Trotta, 2018a). It was observed that a household decides how to warm their home in the winter or how to stay cool in the summer. It was further noted the practice depends largely on the users and the way they manage their electricity or energy. They alone decide whether to leave lights and appliances on or turn them off, select the temperature of the water to wash their clothes, and decide which dishwasher cycle to use. Furthermore, individual households also decide how to use their energy system. Literature has highlighted the importance of occupant behaviour as a measure to reduce energy consumption in buildings (Lucon et al., 2014). Furthermore, (Barr et al., 2005) studied the categories of energy behaviour in the household sector. They identified two main groups of energy behaviour - habitual and daily actions or curtailment behaviours - which focused on reductions in energy use. Energy-saving behaviour such as, switching off the lights in unoccupied rooms, turning off the heating when leaving the house for a few hours, and filling the kettle full before boiling relate to the habitual characteristics of individual lifestyles as residents undertake daily activities. These habitual actions vary in frequency and in the impact on energy consumption. Besides, in a single household, different members can behave differently and such behaviours can influence energy consumption (Palmer & Cooper, 2014). This buttresses the impact of occupants' behaviours when reducing energy consumption in buildings.

Another form of energy behaviour is purchasing activities or energy efficiency choices (Barr et al., 2005; Trotta, 2018a). This relies on the financial capacity of the occupant and can vary from installing wall insulation to buying energy efficiency appliances. Numerous scholars have differentiated between daily energy-saving behaviour, which includes repetitive efforts to reduce energy use and energy efficiency as one-shot/one-off behaviour that requires a financial investment. Another energy-saving behaviour can be view as:

- **Single non-recurrent changes**- energy efficient or renewable energy technologies which are relevant to residential owners (Bruce, 2008), organisations, and the technical and administrative managers of organisations (Banks et al., 2012). This can include double and triple glazing, the replacement of boilers, loft and wall insulation.
- **Daily repeated activities**- mostly employed by low energy households (Lopes et al., 2012).

Achieving energy savings in buildings will not only decarbonise the energy system, but also ensure that the energy supply is safe and affordable (World Energy Council, 2016). This study will focus on the second category and involve energy saving measures that are not financially related. This is because building occupant behaviour has an important role in energy consumption and positive changes in such present the potential for energy savings.

## 2.6 Factors Affecting Energy Efficiency

### 2.6.1 Taxonomy of Barriers to Energy Efficiency

Numerous lenses can be used to examine the potential barriers to energy efficiency. While the majority of studies employ economic concepts (such as orthodox, transaction cost, and behavioural economics), the concept of barriers can also be viewed through the lens of social psychology (Lacroix & Gifford, 2018) and in relation to organisational theory (Montalvo, 2008; Sorrell et al., 2000). Certain authors  Foxon (2005)advocate for a systems-level approach, in which barriers and strategies to overcome them are addressed at the macro-level. Theoretically,  there are additional barriers to implementing EE technology that are technical, financial, policy, and regulatory in nature and can be resolved if governments take appropriate action (UNIDO, 2017a). While energy-efficient technologies hold considerable promise for reducing the financial costs and environmental impacts of energy use, it has long been observed that these technologies may not be adopted to the extent that is justified, even on a purely financial basis. Nonetheless, there is a common belief that various barriers to the adoption of energy-efficient technologies have prevented many of these benefits from being achieved (Gerarden et al., 2017); this often referred to by authors as the “energy efficiency gap” (De Groot et al., 2001; Sorrell et al., 2000; Thollander et al., 2010). One strategy to address the energy efficiency gap is to focus on the barriers to implementing energy efficiency technologies and behaviours. Below are some of the sub-categories of barriers identified from existing literature.

**Armel's behaviour and energy barriers**: Armel (2014) research on behaviour and energy identifies the main categories of barrier, as depicted in Table 2.0.

Table 2.1 Extract of Research Barriers (Armel, 2014).

| Main Category of Barriers | | | | | |
|---|---|---|---|---|---|
| | **Policies** | **Physical Environment** | **Sociology** | **Interpersonal** | **Individual** |
| **Sub-Category Barrier** | | | | | |
| **Intervention from government** | Built environment | Communication Habits and Norms | Face to Face | Goals | |
| **Intervention from organizations** | | | Lack of interpersonal approach | Addressing barriers | |
| | Technology | Implicit marketing | | Feedback | |
| | | Entertainment Education | | Skills | |

However, Kadam's research on energy efficiency in the automobile industry identified the main barriers as economic, organisational and behavioural, as shown in Table 2.1.

Table 2.2: Extract of Research Barriers (Kadam, 2014).

| Main Category Barriers | | |
|---|---|---|
| Economical | Organizational | Behavioural |
| **Sub-Category Barrier** | | |
| Management concern Investment cost of EE | Business given more importance than EE | Lack of awareness amongst employees |
| Unavailability/difficulty obtaining financing for EE. | Lack of certified experts on energy management | Insufficient trainings on EE |
| Limited Financial incentive through the government | Lack of policies on energy management | |
| | Lack of frequent energy audit | |

Another classification of the barriers to energy efficiency can be found in the Third Assessment Report (IPCC, 2001) of the Intergovernmental Panel on Climate Change (IPCC). This panel conducted a thorough review of the existing literature on barriers to the mitigation of greenhouse gas (GHG) emissions. The IPCC has documented sector- and technology-specific barriers in eight areas, namely: technical innovation, cost, funding, trade and environment, market structure and functioning, institutional frameworks, information provision. Others are social, cultural, behavioural norms and aspirations. Moreover,(Weber, 1997) also proposed a classification of barriers into the following categories: (a) institutional, (b) market (barriers and failures), (c) organisational, and (d) behavioural. With an economic focus, Sorrell et al. (2011) identified the following barriers: (a) risk, (b) imperfect information, (c) hidden costs, (d) capital access, (e) split incentives, and (f) bounded rationality. Cagno and

Trianni (2014) recently regrouped the barriers into internal and external alongside the actors affected by the barriers. This included (a) market, (b) government/politics, (c) technology/service suppliers, (d) designers and manufacturers, (e) energy suppliers, (f) capital suppliers, (g) organisational, (h) economic, (i) behavioural, and (j) awareness. Almost every classification scheme identifies end-user behaviour as a significant barrier, both on an individual and organisational level.

**2.5.2 Barriers for the Energy Efficiency Residential Sector**

Several factors contribute to the limited uptake of energy efficiency opportunities (Guo et al., 2018; Trotta, 2018a). These include information failure; the invisibility of energy efficiency; a lack leadership commitment to energy efficiency and conversation practices; insufficient incentive systems; unclear priorities; poor cross-functional teams; the subsidised pricing of energy; the inadequate pricing of externalities, and a shortage of financing (International Energy Agency IEA, 2014; Trotta, 2018a). Another obstacle is the lack of attention paid to energy efficiency investment opportunities by stakeholders in both the industrial and government sectors relative to the supply-side opportunities (International Energy Agency IEA, 2014). An in-depth understanding of these factors is essential for investment in energy efficiency practices, which is likely to improve knowledge about the benefits that energy-saving behaviour can deliver.

Experts acknowledge that existing energy-saving behaviours play an important role in generating a broad range of outcomes, but the degree to which energy efficiency could enhance economic and social development is not well understood. Harnessing viable energy efficiency investments would facilitate a more efficient and effective performance across the industrial sectors. Studies have showed that households' energy saving behaviours positively correlate to electricity consumption. Furthermore, a study of single- and double-person electricity consumption was carried out in Ireland and it was found out that a single apartment uses about 19% less electricity per week than a double (Leahy & Lyons, 2010). This has shown that the size/number of people in an apartment affects the energy consumption. Other researchers studied the composition of family to energy consumption, and it was found out that families with children consume more electrical energy (McLoughlin et al., 2012). However, a more comprehensive explanation was provided, that the electrical energy consumption of a family with one child consumes more than one-fifth of that of a family without children and as a child's age increases, the household energy consumption similarly increases (Brounen et al., 2012). Conversely, another study showed that mothers taking part in enlightenment programs have more knowledge and information about energy saving (Nakamura, 2013). Hence, energy consumption in households could be influenced by the number of people, their age, behaviour and size of the building.

The level of education within a household was also considered in another study and divergent views were noted on influence of educational level on energy consumption. It was observed that families with a higher education level consumed less electricity compared with families with a low education level (McLoughlin et al., 2012). However, an earlier study in the Netherlands and the United States shows that the level of education has no significant influence on electricity consumption (Cramer et al., 1985). Consequently, the level of education, amongst other factors as shown in Figure 2.3, may influence occupants' energy saving behaviours in buildings. All factors listed in the diagram were identified in the literature and the study of their influence on occupants' energy saving behaviours is still ongoing. Hence, to achieve the objectives, this study will adopt some existing factors, alongside other factors identified throughout the research.

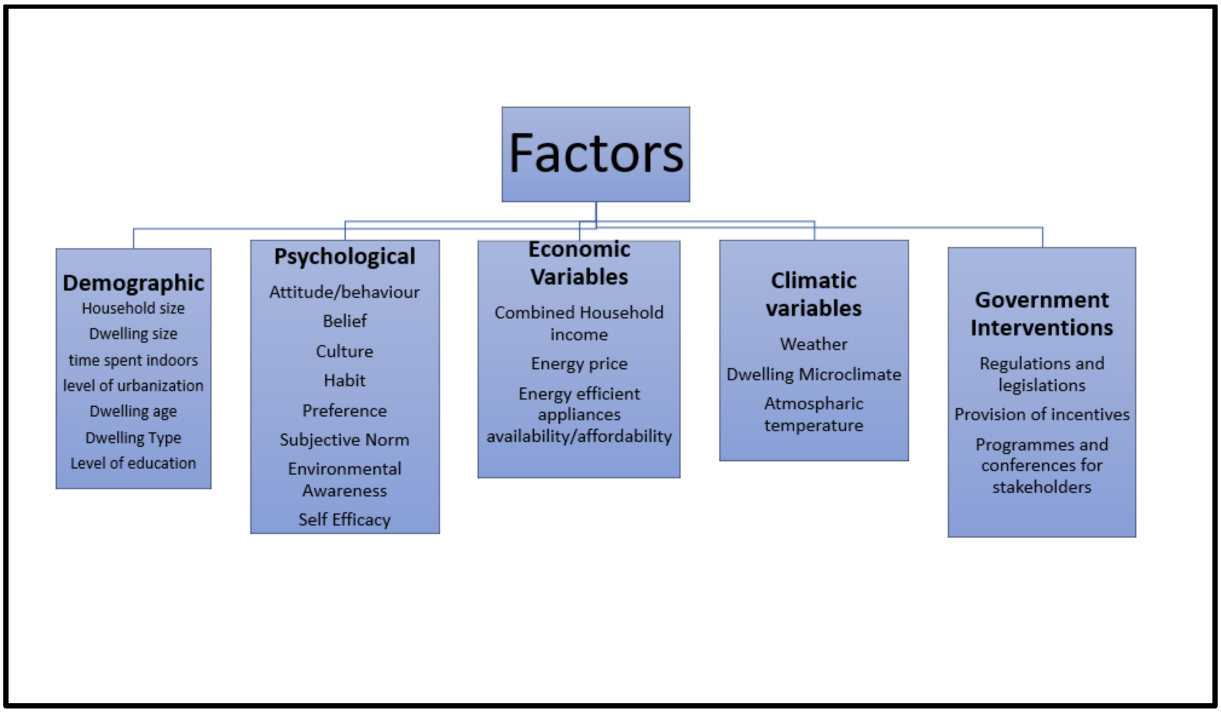



**Figure 2.13**: Factors affecting energy efficiency approaches (Abrahamse & Steg, 2009; Bhattacharjee & Reichard, 2011; Zhihua Ding et al., 2018; Guo et al., 2018).

### 2.5.3 Drivers to Saving Behaviour

In discussing energy conservation and energy saving behaviours, it is important to consider some of the fundamental factors like the influence of energy stakeholders, barriers and drivers and possible changes to energy consumption habits. The literature has also shown that the drivers of energy behaviour are crucial to understanding energy efficient behaviour and pave the way to achieving the SDGs. One of such study explores the perception of the drivers of energy behaviour amongst young adults, who had recently become energy independent consumers but were not yet paying for energy bills. The research demonstrated that participants did not believe that energy savings could lead to the conservation of the environment, indicating a lack of motivation to save energy and low awareness of energy savings. The intervention proposed in this research would guide government policies for this category of person. Conversely, the focus on teenage youths would not offer a realistic view of the drivers to energy behaviour. It would also limit the type of drivers required to accommodate the relevant demographic in energy saving behaviours.

In another study, the influence of occupants' behaviours on building energy consumption was analysed using a basic data mining technique to develop a methodology to improve the behaviour of building occupants, help reduce energy consumption and enhance the modelling of energy consumption in a building (Yu et al., 2011). In a similar study, the impact of household energy consumption choices amongst fuel poor residents in New Zealand (McKague et al., 2016) was explored. The impact of fuel poverty on households was significant to influencing their way of life and their choices in terms of energy consumption. While the focus of the study is vital, because of limited literature on fuel poor households, a more viable option that considers various groups - from the fuel poor to the fuel rich - could adequately accommodate the demography in order to identify the drivers influencing behavioural change.

It was observed that most literature demonstrated the need to holistically explore energy saving behaviour with various stakeholders in order to determine the impact of occupants' behaviours in residential buildings. It was also noted that it is important to address the challenges associated with efficient energy savings in residential building in order to sustain energy saving cultures. However, there is a need to consider more closely the drivers associated with energy savings in residential buildings as this is critical to achieving behavioural change. Hence, due to limited data, there is a need to generate data on energy saving behaviour with a focus on the drivers that influence behavioural change or energy saving practices.

**2.6 Stakeholders Participation in Energy Efficiency**

Stakeholders are individuals or groups of individuals who have the potential to influence or are affected by the accomplishment of a project and organisational goals (Freeman et al., 2010). Depending on whether they take part in a project and intervene at various stages or are affected by the outcome of a project, they have been categorised as internal or external stakeholders (Freeman et al., 2010). There is no disputing the significance of stakeholders in the successful implementation of energy management projects. And the most common way in identifying stakeholders in energy research field is through the study of similar projects. As an alternative to focusing on the specific stakeholders, roles are outlined to identify a comprehensive list of stakeholders (Riahi, 2017). As a result, each role is related to relevant stakeholders, who are divided into internal and external stakeholders. Furthermore, as acknowledged by the work of Macaulay (1994), this research identified that potential stakeholders involved in energy management are also engaged at various stages of the project's life cycle.

To gain an insight into the specific roles played by stakeholders (general contractors, construction firms, architects, households and governments) in building and energy saving, a case study methodology was used. In this research, stakeholders were selected based on their influence, interest and power within the building and energy sector (Li et al., 2017) . Although in this case, there exist different stakeholders with competing interest to meet their independent goals. The service provider is all about the profit they make, the construction experts/developer often has low interest in investing in energy-saving technology (Albino & Berardi, 2012) due to cost on the developer and the benefit to the end user. Contrasting cases have raised concerns about the potential influence of stakeholders on the adoption of energy-saving and behaviour change. In this research, only stakeholders who have interest and power in the different organizations were contacted during the data collection process though more attention is placed on internal stakeholders due to their critical roles in energy savings, energy management and influence in behavioural change of energy users.

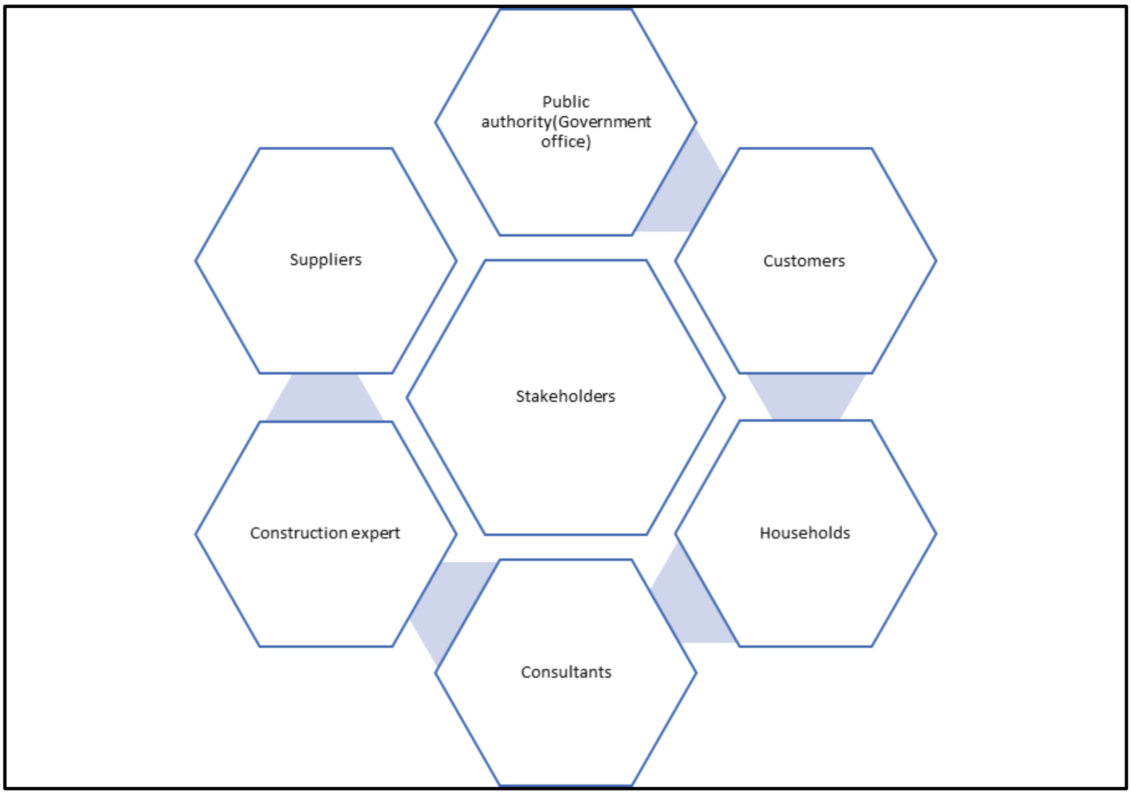



**Figure 2.14:** Stakeholders Involved in Energy Efficiency (Adopted from **(Li et al., 2017; Tcvetkov, 2022; Virkki-Hatakka et al., 2013).**

**2.6.1 Key Stakeholders Involved in Energy Saving**

There are several stakeholders involved in the design, management and utilization of energy management in residential buildings. Building owners and managers are responsible for the overall energy performance of a building, including implementing energy-efficient technologies and practices, and tracking energy usage and savings. These are critical areas that is considered from the design concept to achieve maximum efficiency (Carlander & Thollander, 2023) . Another critical stakeholder is Energy Service Companies (ESCOs). The ESCOs provide energy efficiency services to building owners, including conducting energy audits, recommending energy-saving measures, and implementing energy-efficient technologies. As part of key stakeholders, architects and engineers play a crucial role in designing and constructing energy-efficient buildings, including incorporating energy-efficient materials, designing for natural ventilation and daylighting, and specifying energy-efficient HVAC systems (Ganiyu and Olatunji, 2017). This underscores the vital importance of architects' foundational stage of building constructions to attain energy savings. Some other key stakeholders are energy regulators who develop and enforce energy codes and standards for buildings, incentivize energy efficiency and provide technical assistance to building owners and managers (Adeniji, Fajemirokun and Mustapha, 2022). As part of this responsibilities, energy utilities, energy-saving programs and incentives to building owners and managers, including rebates for energy-efficient upgrades and demand response programs are vital components for efficient implementation of the roles of energy regulators. Tenants and occupants/Customers can play the role in energy savings by adopting energy-efficient behaviours, such as turning off lights and electronics when not in use, and using natural lighting and ventilation whenever possible, and changing their behaviour. In some rural and semi-urban areas especially in developing countries, community organizations can promote energy efficiency and provide education as well as outreach to building owners, tenants, and occupants on the benefits of energy efficiency and how to achieve it. This is often done through town hall meetings. It is critical to note that governments at the local, state, and federal levels often establish energy codes and regulations that require buildings to meet certain energy efficiency standards.

### 2.6.2 Government as a Key Stakeholder

These stakeholders have been shown to play an important role in improving the energy efficiency of buildings and reducing energy consumption and greenhouse gas emissions. Overall, effective energy-saving measures require collaboration and coordination among all the governments which plays a critical role as key stakeholders in building and energy saving (UN Environment, 2019). It was further noted that government as key stakeholder has the powers to create, enforce policies and regulations that can drive sustainability and energy efficiency improvements in the built environment. Some of its major responsibilities are the establishment of building codes and standards that require new buildings to meet energy efficiency and sustainability criteria such as minimum insulation levels, efficient lighting and HVAC systems and use of renewable energy (Geissler et al., 2018). Governments can also establish energy efficiency standards for existing buildings to promote energy-saving retrofits. In addition, governments can provide incentives and subsidies to encourage building owners and developers to invest in energy-saving measures. This can include grants for energy audits, rebates for installing efficient lighting and HVAC systems, and tax incentives for renewable energy installations. The development and implementation of energy efficiency programs, such as home energy audits and retrofit programs, to promote the adoption of energy-saving measures and support building owners and residents in making energy-efficient choices are also viable options available to governments.

As part of its critical roles to ensure energy efficiency, governments can invest in renewable energy infrastructure, such as solar and wind power, to support the transition to a low-carbon energy system. This can include funding for research and development, as well as support for the deployment of renewable energy technologies. More so, governments can regulate energy providers to promote energy efficiency and sustainability (Ogbumgbada et al., 2023). This can include setting targets for energy efficiency and renewable energy as well as regulating energy prices to encourage the adoption of energy-saving measures. Education of the public is another essential responsibility of government, targeted on the importance of energy efficiency and sustainable building practices. This can include public awareness campaigns, educational programs in schools and universities, and providing information to the public on energy-saving measures and incentives. Overall, governments have a key role to play in promoting sustainability and energy efficiency in the built environment, through establishing energy codes and standards, providing incentives and subsidies, developing and implementing energy efficiency programs, investing in renewable energy infrastructure, regulating energy providers, and educating the public and other stakeholders to achieve energy saving.

### 2.6.2 The Regulator

The Nigerian Regulatory Commission (NERC) was established in 2005 by the Electricity Power Sector Reform (EPSR) Act as an independent regulator, which proceeded with the responsibility of issuing licences to businesses for electricity generation (excluding captive generation), electricity transmission, electricity system operations, electricity distribution or trading in electricity (Nigerian Electricity Regulatory Commission NERC, 2021). This commission is also in charge of monitoring and regulating activities in the Nigerian electricity industry, with it additionally regulating the process of licensing in relation to generation capacity procurement (2014). The various types of licencing provided by the regulator include generation, transmission, distribution and trading, with NERC establishing the regulations to reform the electricity sector in order to attract private sector investors.

Another important function that NERC has is shown in Section 32(d) of the ESPR Act (2005), which focuses on guaranteeing fixed prices for licences which do not take advantage of clients, whilst simultaneously enabling funding for activities and making profit to allow efficient operations. This is achieved through the Multi-year Tariff Order (MYTO), which provides the electricity industry with a 15-year tariff plan, with minor reviews annually based on specified indicators (inflation, exchange rates, operating cost and gas prices) and significant revisions every five years. In general, NERC has been an active component in the present reform process, as it has been entrusted with providing regulatory clarity, as it is designed to serve as a 'one-stop shop' for all regulatory functions in the power industry (Aladejare, 2014).

Furthermore, the EPSR Act (2005) provides regulators with the authority to establish a licence framework and set structure, as well as to provide the administration to the Power Consumer Assistance Fund (PCAF) (Ole, 2020). Specifically, the PCAF focuses on financial sustainability that should be present in the electricity sector through the provision of subsidies that help to reduce or stop any differences that are present between the underprivileged consumers' paid tariffs and the standard tariff (Ezenekwe et al., 2014). The regulator has the authority to grant, alter, and revoke any licence for the different forms of electricity operations; whilst making sure that the electricity generation and supply remains safety and secure, together with maintaining high service quality (Nigerian Electricity Regulatory Commission NERC, 2021).

The regulator has established a licencing regime and a certification framework for the quality of electricity technology and services, including those connected to off-grid renewable electricity (OGRE). Additionally, a one particular challenge in the energy sector relates to electricity consumers in Nigeria, who often struggle with cost-reflective tariffs. Correspondingly, the ESPR Act (2005) states that NERC has the authority and obligation to implement prices for licences' that are fair to all consumers, whilst also enabling sufficient revenue to proceed with effective operations. The EPSR Act provides the authority to deal with the issue of financial sustainability, due to its stated mandate. The regulator; however, recently made a retrospective tariff adjustment to account for changes in macroeconomic indices from 2016 to 2018. Moreover, the regulator has also stated that it will continue to review electricity tariffs on a regular basis in accordance with the current tariff methodology (Gershon & Ezurum, 2017).

### 2.6.3 Energy Service Provider

The Nigerian Distribution Company (Discos) was formed as a result of the 2005 reform of the Nigerian power sector (Aigbovo & Ogboka, 2016). Subsequently, after privatisation in 2013, the Power Holding Company of Nigeria (PHCN) was grouped into 11 distribution companies, which comprised the energy service providers included in this research. From 2013, these distribution companies were privatised and directed to new investors. As a result, private sector investors hold 60% of the equity in the company while the Federal Government of Nigeria holds 40%. Private investors are selected based on a proposal that is aimed at limiting aggregate technical, commercial and collection losses over a five-year period (Odje et al., 2021). The energy service providers franchise area encompasses the Federal Capital Territory (Abuja), Niger, Kogi, and Nasarawa States, covering a total area of 133,000 $km^2$ and 162,342/350,000 customers (Okorie and Ezekiel, 2014). Across the four states, the company is divided into nine regions and 39 area offices but has maintained customer service performance standards that are in line with international standards (IEC 60050: Generation, Transmission and Distribution of Electricity).

The 330kV/132kV Katampe bulk transmission substation supplies power to the Abuja Territorial Area Network, which is reduced to 33kV/11kV for primary and secondary feeders in order to function with Abuja territory's (approximately 100sq kilometres in the North Central geopolitical zone of Nigeria) electricity requirements. Distribution and marketing begin on the secondary side of the 132/33/11kV transmission substation. The energy service providers thus manage and control the 33kV, 11kV, and 0.415kV network infrastructures. Residential and commercial/industrial customers are able to receive power from the 33kV line by using an appropriate 33/0.415kV distribution transformer. The electricity distribution is characterised by long radial distribution lines that have various injection substations at load centres. Further for large customers, substantial amounts of feeding distribution transformers are placed at point loads, which is also true for small isolated rural communities. There is diversity to this energy service provider's distribution network that consists of overhead and underground network outlay; overhead accounts for more than 75% of the total kilometre length.

The distribution companies (Discos) have the responsibility for making electrical power available to end-users. Each of the 11 Discos is allocated a certain amount of grid energy, despite the variation in grid size according to the demographic population's demands (Ahmed, 2020). Aside from Eko Distribution Company Plc and Ikeja Distribution Plc, nearly every Disco operates in three to four states. Overall, the Discos are strategically important, as they act as a link between the generators (who expect payment from the Discos) and final consumers (who are expected to pay the generators' payment to the Discos) (Bloomfield Law, 2019). According to a document from the Eko Electricity Distribution Company dated 25$^{th}$ August 2021 and bearing the reference number 023/EKEDP/GMCLR/0025/2021, the Nigerian tariff increased from N42.44 to 58.94, depending on the customer's class. The tariff was scheduled to remain in effect until December 2021 before increasing again in January 2022, which could affect low-income electricity users and potentially influence electricity users' behaviours in meeting energy demands.

**Table 2.3**: Distribution companies in Nigeria with corresponding coverage states and daily power demand. ((Onyishi & Ofualagba, 2021)

| No | Distribution Company | States Covered | Allocation (% of Grid Energy) [5] | Daily Power Demand (MWh) |
|---|---|---|---|---|
| 1 | Abuja Distribution Company | FCT, Kogi, Nassarawa, Niger | 11.5 | 5562 |
| 2 | Benin Distribution Company | Delta, Edo, Ekiti, Ondo | 9 | 6157 |
| 3 | Eko Distribution Company | Lagos | 11 | 7660 |
| 4 | Enugu Distribution Company | Abia, Anambra, Ebonyi, Enugu, Imo | 9 | 7577 |
| 5 | Ibadan Distribution Company | Kwara, Ogun, Osun, Oyo | 13 | 7233 |
| 6 | Ikeja Distribution Company | Lagos | 15 | 7660 |
| 7 | Jos Distribution Company | Bauchi, Benue, Gombe, Plateau | 5.5 | 6811 |
| 8 | Kaduna Distribution Company | Kaduna, Kebbi, Sokoto, Zamfara | 8 | 7664 |
| 9 | Kano Distribution Company | Jigawa, Kano, Katsina | 8 | 9227 |
| 10 | Port Harcourt Distribution Company | Akwa Ibom, Bayelsa, Cross River, Rivers | 6.5 | 6533 |
| 11 | Yola Distribution Company | Adamawa, Borno, Taraba, Yobe | 11.5 | 5684 |

The Discos face numerous challenges, including distribution losses, technical difficulties, inadequate tariffs, and commercial and billing system incompatibilities. Technical barriers resulted in a 12% revenue loss, commercial 6% and revenue collection 28% (Edomah et al., 2016). A recurring issue has been the grid's insufficient capacity to wield power in adequate quantities with the electricity distribution companies. Hence, this underscores the numerous associated electricity distributions, which directly affect energy consumption and management, and require viable solutions.

### 2.6.4 Consultants

The Consultant Commission was founded in 1988 with the aim of implementing strategic plans to coordinate national policies and guidelines in the energy sector. The Commission began its operations in 1989 following a decision by the ECOWAS Heads of State and Government, which functioned on the premise that member states would establish different government bodies that were responsible for the coordination and supervision of various energy functions and activities. The commission is further charged with the diversification of energy resources by developing and maximising the use of all available sources, including innovative and alternative forms of energy: solar, wind, biomass, and nuclear energy (Usman & Abbasoglu, 2014). The Energy Commission prepares plans on an annual basis that balances and coordinates Nigerian energy, which occurs following consultations with separate government agencies that focus on the development and/or supply of energy. Furthermore, it serves as a centre for resolving technical issues that may develop throughout the implementation of policies that relate to the field of energy. The energy commission of Nigeria further established six research centres around the country, which include the Usman Danfodiyo University Sokoto Energy Research Centre, amongst others (Usman & Abbasoglu, 2014).

### 2.6.5 Construction Experts

a. **<u>Construction Firm</u>**. Founded in 1984, this construction industry undertakes all aspects of building works from conceptual design through to the administration of construction contracts, including: planning and interior design, bidding for lands, processing plans (designs) for approval from the local authority, and newly built buildings as well as the renovation of existing buildings. The company boasts over a hundred projects annually with a workforce of over 400 technical and non-technical workers. Furthermore, the company has a very experienced team, some of whom are multi-tradespersons, and deliver to a very high standard. Throughout its history and the completion of many milestones, the firm has developed its status as a modern reputable business, and has developed many outstanding projects in the case study area and outside Nigeria. The company provides management for both hard and soft facilities to over 20 government departments and public buildings and provides apprentice positions as well as industrial attachments for undergraduate students from various universities across Nigeria.

b. **Research and Practice.** The school is also situated within the case study area, which was established with three colleges in 1988. Since then, it has witnessed notable and rapid growth in its academic programmes, infrastructural development, staff strength, student population, together with increasing research and innovation. This demonstrates its dedication to improving the level of teaching, learning, and research, whilst offering staff and students environments that improve living, working, teaching, learning, and research standards. In addition, the department was separated into five individual sections to more effectively manage its teaching, consultancy and research; this included architecture, building and quantity survey departments. The programmes in the department aim to develop a broader level of education in architectural design, which includes the provision of environmental control courses, building materials, concepts, historical influences, art and sustainability. What is more, lecturers have noted that, through the incorporation of research and design modules architecture has a significant cultural relevance that is helped by the multi-cultural heritage of the region. In total, there are 55 senior staff and nine junior staff in the school as well as other technical and non-technical staff. The majority of the senior staff members are involved in research and private practice both within and outside the country, which enables them to gain greater knowledge of the research involved.

### 2.6.6 The social Responsibility of Energy Providers and Residential Developers

Energy providers and residential developers play a critical role in promoting sustainable practices and energy conservation. These stakeholders have the responsibility to ensure that their practices and products are environmentally responsible and promote energy efficiency (Fobbe and Hilletofth, 2021). In this essay, we will explore the social responsibility of energy providers and residential developers in promoting energy saving.

Energy providers are responsible for supplying energy to residential and commercial customers. The energy sector is one of the biggest contributors to greenhouse gas emissions, which is a significant cause of global warming. Therefore, energy providers have the obligation to promote energy conservation and reduce their carbon footprint (Yserte and Gallo-Rivere, 2020). One way in which energy providers can fulfil their social responsibility is by investing in renewable energy sources such as wind, solar, and hydro power. Renewable energy sources are sustainable and have minimal impact on the environment (UNEPA, 2022). Energy providers can also promote energy conservation by encouraging customers to use energy-efficient appliances, offering energy-saving tips, and providing incentives for customers who adopt energy-saving practices.

Residential developers, on the other hand, are responsible for designing and building homes and other residential buildings. Residential buildings are one of the biggest consumers of energy, and their design and construction have a significant impact on the environment (Umbark, Alghoul and Dekam, 2020). Therefore, residential developers have a social responsibility to ensure that their buildings are designed and built in an environmentally responsible way. One way in which residential developers can fulfil their social responsibility is by designing buildings that are energy efficient (UNEPA, 2023). This includes using materials that have a minimal impact on the environment, installing energy-efficient appliances, and incorporating sustainable practices such as rainwater harvesting and recycling.

Residential developers can also promote energy conservation by educating residents on the benefits of energy conservation and providing them with tools to reduce their energy consumption (Kuenzli and Gardner, 2020). This can include providing residents with energy-efficient light bulbs, offering energy-saving tips, and providing incentives for residents who adopt energy-saving practices. Additionally, residential developers can design buildings that are powered by renewable energy sources such as solar power.

In conclusion, energy providers and residential developers have a social responsibility to promote energy saving and reduce their carbon footprint. This can be achieved by investing in renewable energy sources, encouraging customers to adopt energy-saving practices, designing buildings that are energy efficient, and educating residents on the benefits of energy conservation. By fulfilling their social responsibility, energy providers and residential developers can play a significant role in promoting sustainability and protecting the environment.

**Summary**

The major focus of this chapter was to give theoretical context of literature review with a view to conducting a holistic literature search to identify necessary gaps and thereby enhancing the research. Furthermore, the chapter discussed sustainable development and how energy saving behaviour facilitates the attainment of its objectives. This was followed by the global demand for energy as well as the energy challenges in sub-Saharan Africa including Nigeria. It also highlighted the characteristics including the barriers and drivers of energy savings behaviours, as well as the context of the study. The next chapter will look at the development of conceptual framework and the review of relevant literature as it relates to the model development.

# Chapter 3: Theoretical Framework

### 3.1 Introduction

This chapter discusses the theoretical framework of the research by looking at the underlying theories and establishing the relationships between the economic value of rational choice and human behaviour in energy efficiency. Apart from the physical and environmental effects, the chapter also discusses social, psychological and multidisciplinary approaches to behavioural change in energy efficiency. It establishes the factors that influence energy-saving behaviour from a theoretical perspective.

This chapter further discusses Rational choice theory from the economic perspective, the Sterns ABC Model, Triandis Theory of Interpersonal behaviour, Saturation Theory from the social psychology perspective to understand behavioural change in detail. Additionally, Bagozzi's model of consumer action are all reviewed in this theoretical element of the literature review.

The last section of this chapter considers the concept of energy cultural behaviour, highlighting lifestyle as it affects behavioural change while expatiating on the energy culture framework to acknowledge the influence of culture in behavioural change as it relates to energy-saving behaviour and energy efficiency. Lastly, a conceptual framework is developed based on the reviewed theories, which stresses the major constructs of physical components, material culture, attitude, perception, and cognitive and social norms as potential major determinants of behavioural change towards energy saving and energy efficiency.

### 3.2 Theoretical Approach to Energy Research

When energy efficiency is discussed, there are two broad frameworks within which improvements can be considered. The first is an engineering-centric perspective known as the Physical-Technical-Economic Model (PTEM), which approaches energy efficiency from the premise that new technologies are the only driver of increased efficiencies when they are economically viable (i.e., subsidized) (Foulds et al., 2021). The PTEM places a premium on the availability of information, technology and the prevailing economic incentive structure as critical determinants for improvements to energy efficiency, emulating the dominant paradigm of rational choice theory (Robinson, 2020). This presumes that people make economically rational choices regarding the physical and technological environment and will automatically invest in more efficient technology when it is cost-effective to do so.

The second aspect of the framework is human behaviour approach. Individuals do not always act rational in their economic or technological actions. Thus, human behaviour can be irrational and unpredictable which includes energy consumption behaviour (Cattaneo, 2019). According to some studies, over half of all actual energy use is a result of operating behaviour, not installed technologies (Robinson, 2020). Changing behaviour has been recognised as a challenging subject even when incentives are involved. From the above discussion, it can be deduced that the main difference between PTEM and human behaviour is quantifiability. Therefore, in increasing energy efficiency, a mixture of qualitative and quantitative approach will ensure maximum success and realistic results.

**3.2.1 Rational Choice Theory (Economic)**

According to economists, individuals are rational actors who weigh their options and make decisions based on the best possible outcome and money saving. Economic theories have influenced the development behaviour change models which are widely used. The central concept underlying these models is the economic theory of rational choice, which states that "individuals make choices based on a cost/benefit analysis of the perceived benefit from engaging in a particular behaviour"(Darnton, 2008; Jackson, 2005). While evidence exists to support short-term responses to increased energy prices, they are frequently overridden by external factors such as weather conditions and physical environments. However, it is essential to consider factors as an important driver in behavioural change (Chatterton, 2011). Thus, even though people's energy consumption cannot be solely driven by economic signals in the long run, economic signals frequently drive decision-making.

However, studies have produced mixed results. Although rising energy prices may cause households to change their behaviour (Exadaktylos & van den Bergh, 2021; Van den Bergh, 2008), studies have found that households with higher incomes are less sensitive to rising energy prices, implying that the energy consumption of high-income households will remain high regardless of rising energy prices (Alberini et al., 2011). This has shown compelling evidence of behavioural inconsistencies caused by the cognitive constraints and psychological biases that people face when making decisions, which behavioural economists and psychologists explore (Mundaca et al., 2020). This underscores the importance of further studies in behavioural change to enable a balanced conclusion. The next section will discuss social-psychological theories which also hinge on behaviour.

### 3.3 Social-Psychological Theories

Research into human behaviour and the pathways by which it can be changed are undertaken across a variety of disciplines and applied to various fields. Psychological research can shed light on the factors that contribute to energy conservation behaviour as well as help to improve the success of behaviour change interventions. Furthermore, this can help to better understand public approval on issues related to technology, strategic guidelines, regulation and changes to infrastructure which are enablers to 'energy transition' (Abrahamse & Schuitema, 2020). Similarly, personal determinants like intention, attitude, norms and contextual influences that shape energy behaviour and predict people's willingness to adopt energy-efficient behaviour could be understood (Abrahamse & Schuitema, 2020). Additionally, an understanding of how and why people respond to change and ways to encourage behavioural change can be achieved. It was noted that researching residential buildings could significantly help to address the $CO_2$ emissions associated with residential energy consumption by altering their own behaviours and adopting energy saving behaviours. In general, psychological theories maintain that "energy use can be influenced by stimulus-response mechanisms and by engaging attention"(Chatterton, 2011, p. 7). This perspective relies on visual cues and environmental manipulation to promote energy conservation. Finally, according to sociology theories, "energy use is essentially invisible, as energy systems are complex, and daily practises are significant" (Bjornfors, 2009). This is because energy consumption is indirect and the result of a range of daily activities or practices. This emphasises the diversity of these activities and that each requires a unique level of attention and focus to affect behavioural change.

Consequently, the process of identifying the drivers and barriers to energy-saving behaviour is more effective when guided by behaviour theories and models. Theory here refers to "a collection of concepts and ideas and their proposed relationships, a structure designed to capture or model some aspect of the world" (Maxwell, 2012, p. 43). Furthermore, as stated by Lewin (1951), "there is nothing as practical as a good theory" making theories the foundation of behaviour research (Delouvée et al., 2011, p. 8). Social-psychological theoretical approaches seek to 'change behaviour,' attempting to engage the individual in more environmentally sustainable behaviours within the context of the environment. This approach has dominated research and policy with a focus on measuring the social behaviours and cognitions of people. Accordingly, this research has some elements of social psychological research as it will be asking 'what are the barriers to adopting energy-saving practices in Nigerian residential buildings?' It will also consider how the use of drivers and stakeholders can help to improve occupant attitude and energy consumption behaviour in residential buildings. These are unclear because they have not been adequately addressed from a theoretical viewpoint. Hence, there is a need for greater insight into the approaches to behavioural change in order to satisfactorily answer the aforementioned questions.

### 3.4 Integrative/Multi-disciplinary Approaches to Behaviour Change

As stakeholders form an important piece of behaviour change research, multidisciplinary research should include not only other disciplines within academia, but also stakeholders within public and private sector organisations including politics and businesses. This area of research helps to understand the factors that shape energy consumption, and those that facilitate or hinder the adoption of energy efficient technology and behavioural change. Numerous disciplines have developed theories and interventions to alter the behaviour of residential electricity customers. Behaviour change in residential electricity use represents a technical, economic, and social challenge (Sorrell, 2015). Each technical, economic, and behavioural discipline has made significant contributions to the promotion of behaviour change. However, given the difficulties of changing the behaviour of a large population, some scholars (Keirstead, 2006; Wilson & Dowlatabadi, 2007b) have advocated a multidisciplinary approach. An integrated approach to the multifaceted problem of behaviour change can leverage the expertise of multiple disciplines while also acknowledging the issue in a broader context (Keirstead, 2006). A broader context involving multiple disciplines within behavior change is still not clearly understood.

This section further discusses a review of the integrative/multidisciplinary theories of consumer behaviour, namely Sterns' ABC model (2000), Triandis' theory of interpersonal behaviour (1980), Bagozzi's model of consumer action (1990) and Structuration (1979) theory. The theories have been reviewed to assist in the exploration of energy consumption in residential buildings. These models tend to define behaviour from different theoretical positions. The theories have been specifically used to understand pro-environmental consumer behaviour (Jackson, 2005:23). Although they are more complex than other behavioural change theories, they tend to offer a practical approach to behaviour change. In addition, it was observed that attempts were made to apply the aforementioned models using empirical data to collect the objective evidence of real attitudes and behaviours (Jackson 2005). Hence, the successful application of this model could highlight the impact of attitudinal and behavioural change in energy consumption.

Previous research has analysed domestic households to ascertain their behaviour in terms of energy usage (Van Raaij & Verhallen, 1983). The research aimed to assess the ability of a residential household to conserve energy by modelling their energy usage. As part of this research, the behavioural pattern of energy use, supplied energy prices, the impact of family and other factors (including socio-demographics) and individual lifestyle choices were examined. Other factors included the cost/benefits trade-off and information about the buildings including views on temperature and ventilation (Ishak, 2017). Their work focused on energy use patterns as it affects behaviours including the effects on purchases, usage and maintenance and their interrelationships.

An earlier theoretical framework was developed for a macro-micro energy consumption behaviour model (Dholakia et al., 1983). This framework was developed in response to individual behavioural insensitivities to price signals and conservation campaigns. The framework emphasised that choice was critical to influencing energy consumption behaviour and explained the influence of macro-level factors like socialisation and psycho economic. Additionally, it demonstrated the interaction between the policy and behaviours of people as well as the alternatives. This resulted in the classification of the pattern of household energy consumption into the social relations of consumption, the domain of availability and human involvement (Ishak, 2017). The actor-network theory was also used as a foundation to develop an integrated framework to examine residential energy consumption. The interaction between agents, which includes standards, government policy, stock market structure and housing was modelled. Further models were developed to discuss consumption behaviour in detail. An example is the use of the Multigenic model to measure consumption where the product of factors that drive or restrict consumption are examined (Wilk, 2002). The model is a combination of three theories: individual choice theory, social, and cultural theories. In addition, Wilk (2002) considered three major approaches to consumption, which are cultivation, habit and naturalisation. This combination enabled the development of effective policies and offer an insight into the causes and changes to energy consumption. The model also establishes a link between energy consumption and gender relations within the family, public governance organisations, real estate regulations and health.

Similarly, Keirstead (2006) reviewed five models of energy consumption behaviour in relation to residential use, which were: the behavioural model (Van Raaij & Verhallen, 1983); the systems approach (Hitchcock, 1993); the cultural model;-(Lutzenhiser, 1992), the political-economic model (Dholakia et al., 1983), and the global consumption model (Wilk, 2002). Keirstead (2006), argued that other examples have been unsuccessful in showing the way that such integrated models can be designed and implemented. He presented an integrated framework of residential energy consumption that recognised other approaches. Wilson and Dowlatabadi (2007) considered a model for analysing the drivers for behavioural change towards energy consumption in residential buildings with a focus on the impact of technological and social elements on decision making. The work also identified the research gap in order to resolve the differences between theoretical and traditional research approaches and considered combining economic and sociological grounds for behaviour (Wilson & Dowlatabadi, 2007a). The researchers argued that an integral model would be successful giving the properties applicable to research on behaviour and decision making, and identifying an intervention. Also, their work suggested that an integral model is appropriate for contexts that involve heterogeneity, scale and energy.

Barr and Gilg (2007) proposed the Multi-factorial model based on the relations between ideals or values, and situational and psychological variables. The model aimed to bridge the divide between behaviour and behavioural intention. It was further noted that the Multi-factorial model demonstrated a relationship between the behaviour and behavioural intention variables (Barr et al., 2002). Furthermore, Lutzenhiser's cultural model of energy consumption integrated different multi-disciplinary studies of energy consumption, including anthropology, psychology, economics and engineering. Hitchcock (1993) recommended an integrated descriptive framework on system theory related to behaviour and energy use. It was further noted that the framework illustrates the human and physical subsystems of a house through an engineering and social science perspective. He explained that energy is driven by both behaviours and the physical attributes of a house, and therefore requires an integrated approach (Hitchcock, 1993). According to Darnton ( 2008), there are over 60 models of pro-environmental behaviour; Table 3.1 summarises a few of the popular models relevant to the issues of pro-environmental consumer behaviour discussed by Jackson (2005).

Further to the above, there is a need for an insight into the other integrative models used in energy related studies. These models have been reviewed based on their potential to support an investigation into energy use. Lastly, an overview of energy culture frameworks is provided to demonstrate the need for a new framework to address behaviour change

**Table 3.1**: Explanation of pro-environmental behaviour using the social-psychological theories of behaviour ((Jackson, 2005).

| **Social Psychology Theory** | **Author/Reference from Jackson(2005)** | **Description** |
|---|---|---|
| Attitude-Behaviour-Context (ABC) Theory | Stern and Oskamp, 1987; Stern, 2000 | A field theory for environmentally significant behaviour. Behaviour (B) is an interactive product of 'internal' attitudinal variables (A) and 'external' contextual factors (C) |
| Cognitive Dissonance Theory | Festinger 1957 | Argues that people are motivated to avoid internally inconsistent (dissonant) beliefs, attitudes and values. |
| Cultural theory | Thompson et al., 1990 | Hypothesises a four-fold typology of cultural 'types' with different conceptions of governance and the good life: hierarchists, egalitarians, individualists, and fatalists. |
| Norm Activation Theory | Schwartz, 1977; 1992 | One of the better-known attempts to model pro-social or altruistic behaviours: a personal norm (PN) to behaviour in a prosocial the way is activated by awareness of the consequences (AC) of one's actions and the ascription of personal responsibility (AR) for them. |
| Motivation-Opportunity-Abilities model | Ölander and Thøgersen, 1995 | An integrated behavioural model that combines both internal motivational variables – usually based on the Theory of Reasoned Action – with the external contextual variables of ability (including habit and task knowledge) |
| Rational Choice Theory | Elster, 1986; Homans, 1961 | The underlying basis of most economic theories of consumer preference and several other social-psychological theories of behaviour. Suggests that behaviour is the outcome of rational deliberations in which individuals seek to maximise their own expected 'utility'. |
| Structuration Theory | Giddens, 1984 | Attempts to provide a model of the relationship between agency (how people act) and structure (the social and institutional context). Giddens structuration theory relies on a distinction between 'practical' and 'discursive' consciousness. |
| Theory of Interpersonal Behaviour (TIB) | Triandis, 1977 | Similar to the Theory of Reasoned Action, the Theory of Interpersonal Behaviour (TIB) it includes both expectancy-value and normative belief constructs. However, TIB also includes the influence of habitual, social and affective factors on behaviour. |
| Theory of Planned Behaviour (TPA) | Ajzen, 1991 | Adjusts the Theory of Reasoned Action to incorporate the actor's perceived control over the outcomes of his or her behaviour. |
| Theory of Reasoned Action (TRA) | Ajzen and Fishbein, 1980 | Perhaps the best-known social psychological attitude behaviour model, the Theory of Reasoned Action adjusts expectancy value theory to incorporate normative social influences on behavioural intention. |
| Value-Belief-Norm Theory | Stern et al., 1999; Stern, 2000 | An attempt to adjust Schwartz's Norm Activation theory to incorporate a more sophisticated relationship between values, beliefs, attitudes and norms. |

### 3.4.1 Stern's ABC Model

Stern's (2000) ABC theory incorporates one of the best-known psychological approaches used to explain human behaviour, the Theory of Planned behaviour (TPB) by Ajzen (1991). Sterns' proposed integrated model combines both individual variables (including attitude, habit, and routine) and contextual variables (external conditions and capabilities) which influence environmental behaviour (Stern, 2000; Wilson & Dowlatabadi, 2007a). Research previously developed models on environmental behaviour which emphasized either the external or internal elements that influence behavior (Jackson, 2005; Steg & Vlek, 2009). It was observed that the central concern of the ABC model is the relationship between the influence of attitude (the internal factor) and context (the external factors). Behaviour (B) in this case is 'an interactive product of personal sphere attitudinal variables (A) and contextual factors (C)' (Stern, 2000). Beliefs, norms, values, and a propensity to behave in certain ways are all examples of personal attitudinal variables. The contextual factors are mostly external and include monetary incentives and costs, institutional influences, physical capabilities and constraints, social norms and legal factors (Martiskainen, 2007). Specifically, its proponents have argued that the correlation between attitude and behaviour is strongest when the contextual link is weak. It further stated that conversely, when the contextual link is strongly negative or positive, then there is virtually no connection between the attitude and behaviour variables. Nevertheless, there has been slow progress in developing such models (Wilson & Dowlatabadi, 2007b) due to a number of underlying factors. Figure 3.1 shows the empirical findings according to Jackson's (2005) study, namely that positivity toward recycling is less relevant when access to facilities is either extremely difficult or extremely simple. If recycling is extremely difficult, people are not encouraged to recycle; and if simple, most people recycle. When recycling is possible but not easy, then there exists a strong correlation between recycling behaviour and attitude. Guagnano et al. (1995) empirically supported the argument to the hypothesis.

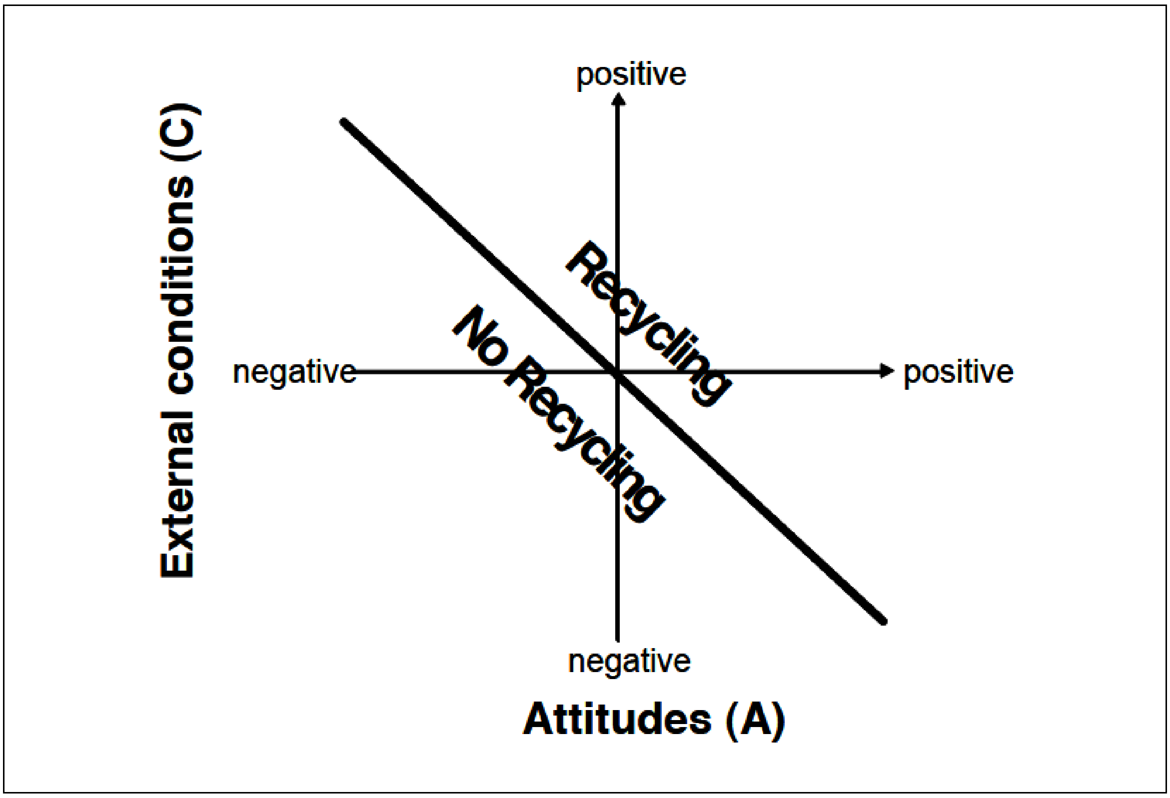



**Figure 3.1**: Stern's ABC Theory (Jackson, 2005).

ABC theory has been found to be actor-centred and, as Shove (2010) mentioned, too linear and simplistic to address and capture the complexity of social change. Furthermore, the Attitude-Behavior-Model gives a clear view of the internal factors responsible for certain behaviour. It was observed that context theory does not recognise habit, as it is crucial to eliminate old habits before people can form new ones. However, this has been proven otherwise, as a recent study indicates that a traditional habit has an effect on an existing attitude (Ajit Prabhu et al., 2013). Hence, it is necessary to understand the application of ABC theory and its associated factors to further analyse the influence on human behaviour.

#### 3.4.1.1 Application of ABC Theory to Explain Pro-Environmental Behaviour

According to applied behaviour analysis, in order to alter behaviour, one must first analyse and modify its consequences (Bolderdijk et al., 2018). Almost all behaviours are motivated by consequences and the promises of results (Skinner, 1974). That is, we act to obtain the positive consequences of carrying out an activity and to evade negative outcomes. This simple concept provides the theoretical foundation for interventions aimed at improving environmental behaviour through the use of rewards and penalties. This demonstrates the critical role of environmental stimuli (antecedents) which signal the presence of consequences and thereby direct behaviour toward a desired outcome. Pro-environmental behaviour can thus be promoted by enhancing the antecedents that communicate pleasant consequences for environmentally friendly behaviours and consequences for otherwise through interventions which provide rewards and penalties (Bolderdijk et al., 2018). This has been applied by Hines et al. (1987) and assumed that behaviours influenced by environment are dependent on certain factors such as economic cost of doing the activity. Furthermore, drivers received a price reduction on their insurance premium if they drove safely and were conscious of environmental impacts, most notably by adhering to the posted speed limit (Bolderdijk et al., 2011). In this case, adhering to the speed limit was promoted not by emphasising its appropriateness, but by ensuring it was rewarded. When the scheme was implemented, participants committed fewer speeding violations than the control group. However, once the financial incentive was removed, the experimental group's speeding violations increased and the differences between the experimental and control groups vanished. Thus, participants committed fewer speeding violations when such behaviour was profitable, but returned to unfavourable behaviour when the reward was removed, thus implying a lack of consistency in behavioural change.

### 3.4.2 Triandis' Theory of Interpersonal Behaviour

As a component of his theory, Stern proposed that a key element to be added to an integrated model should include contextual factors, attitude, personal capabilities and habits. With this suggestion, Trandis' Theory of Interpersonal Behaviour (TIB) includes several behavioural determinants (internal and external elements that determine behaviour) which are found in other models, such as TPB and Technology Adoption Model (TAM) (Trandis, 1980). In this model, behaviour is driven by three aspects important to residential energy consumption, namely: intention, habit and facilitating conditions (Jackson, 2005). The Theory of Interpersonal Behaviour aims to understand how patterns of behaviour develop from an aggregate of what is intended, habitual responses, and situational conditions under which an individual operates (i.e. facilitating conditions or external elements). While intentions are an immediate antecedent of behaviour, they are also affected by the influence of social, normative and affective factors and by rational judgments. (Jackson 2005).

Triandis theory accommodates some of the criticisms directed at rational choice theory in ways that are not explained by other models. It provides a clear heuristic value as a model. Ironically, the model has been less used than Ajzen-Fishbeins' model, which can be attributed to its complexity. However, the models have been used due to their greater explanatory value, as seen in the works of Bamberg and Schmidt (2003) where the predictive powers of TIP are favoured over TPB and Schwartz's Norm-activation model. It was discovered that Triandis' variable habit, substantially amplified the explanatory control when predicting self-reported car use (Koustova, 2017). The common determinant in this case was both household and car consumed energy. The Theory of Interpersonal Behaviour can be adopted as a framework for the empirical analysis of the component factors' strengths and weaknesses in a variety of situations and would be appropriate for pro-environmental behaviour. However, this approach is centered on the agency of the individual, with occasional references to external influences.

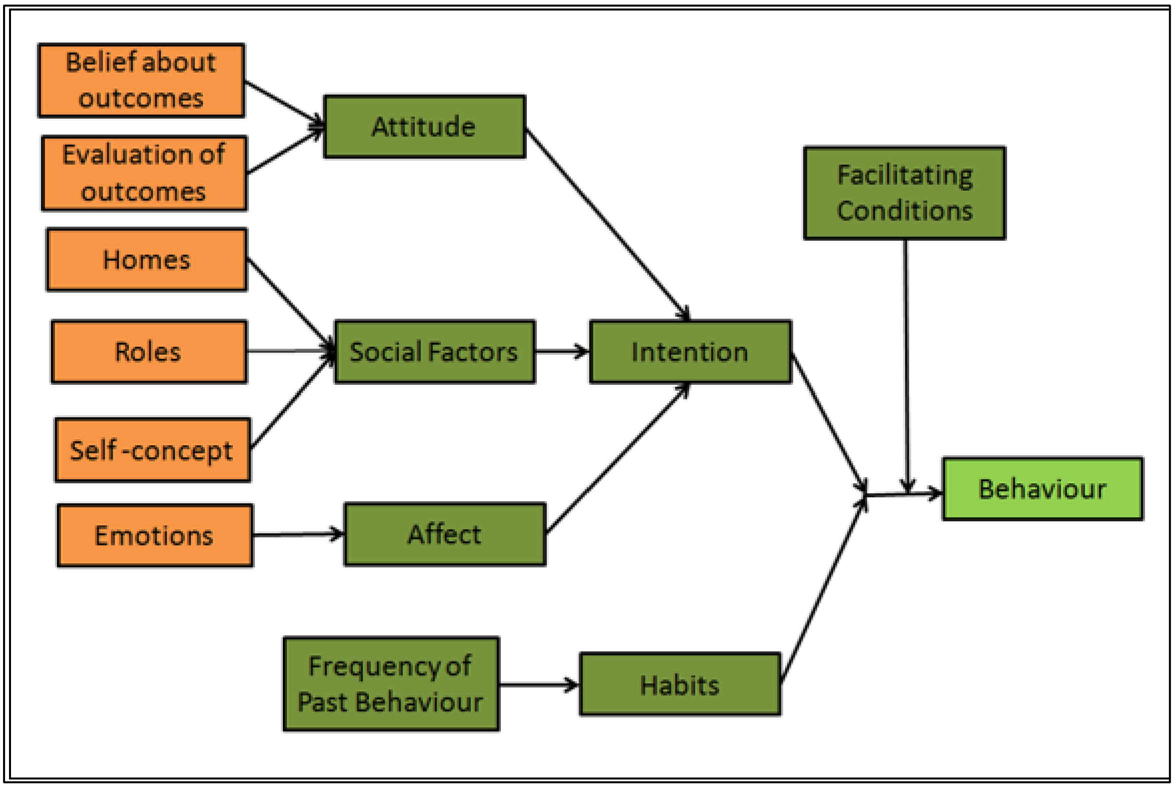



Figure 3.2. Trandis' Theory of Interpersonal Behaviour (Jackson, 2005).

#### 3.4.2.1 Application of the Theory of Interpersonal Behaviour (TIB) to Explain Pro-Environmental Behaviour

The Theory of Interpersonal Behaviour identifies the popular theories of social behaviour and explains the difference between the intention to perform a specific behaviour and the actual performance of that behaviour. TIB incorporates the theory of interpersonal behavior and advocates a close proportional relationship between consciousness and habit, as consciousness increases, the influence of habit behaviour decreases (Bamberg & Schmidt, 2003).

TIB was used to investigate conscious concern  related to factors of hand hygiene behaviour (Kupfer et al., 2019). The study identified some important areas related to TIB in its projection, as highlighted in a self-report for hand hygiene frequency. Results from self-reports showed that, the protection of the patient was a priority in performing hand hygiene. An overview of the result showed that the influence of access to equipment and time constraints were insignificant. However, there are also two TIB related determinants that gave a contrary output - the availability of time and access to equipment - when compared with the self-reporting determinant (Kupfer et al., 2019).

### 3.4.3 Structuration Theory

The concept of structure duality is central to structuration theory. This means that structural properties are both the result and the medium of recursive practises (Kort & Gharbi, 2013). The most popular example of structuration theory is the study of Giddens (1976, 1984), who first adopted the name 'structuration'. His work created an integrated model of human activity and social organisation that was taken from Mead and other interactionism (namely Draw Saturation theory). Social interaction is influenced by individual subjectivity and exposes individuals to knowledge, language and other elements that influence judgement. Additionally, through consistent involvement in social activities, individuals can achieve 'ontological stability' (Giddens, 1984).

Giddens' Structuration Theory relies on three basic considerations which are identified within social interaction: relexification, reclusiveness and regionalisation. Based on these influences on social life, Giddens built a model of the relationship between normal ordinary routine activity and the long-term, large-scale advancement of social organisations. In this model, individual and agencies accommodate the creation, regularisation, augmentation and generation of complex examples of social interaction (Jackson, 2005). Thus, this concept of agency is based on the grounds that actors have access to transformative potential like power, language, rules, standards and meaning.

However, other researchers criticise the conflation of structure and agency citing that structure is not external to individuals and exists within the minds of the agent (Rose, 1998); moreover, the convergence decreases the analysis leading to a lack of unity between interaction and the social system (Archer, 1990). Gregson (1989) asserts that Structuration

Theory's abstract nature precludes it from providing empirical utility, as it provides neither the methodological guidelines for conducting research nor concrete examples on the application of the theory to social science, with the exception of Willis' study (Haralambos et al., 1996). Further discussions on other models, including the model of consumer action, will offer an additional perspective for better application in the research.

### 3.4.4 Bagozzi's Model of Consumer Action

Early attempts by Bagozzi to understand the actions of consumers centred on the "act of trying". Bagozzi and Warshaw (1990) suggested that customer behaviour could be studied from the standpoint of consumer action; 'To satisfy one's consumption goal, a consumer needs to see their own action as a purposive effort where both foresight as well as initiative are required' (Bagozzi et al 2002). In their review, they considered an attempt by an individual to buy a present for a friend. To be successful, the consumer was required to perceive that the attempt comprised of a selection of different activities. This collection of tasks made up the activities required to fulfil the initial intentio=n. Significantly, the theory relates to the attempt to moderate events through regulation based on consistency and past behaviour. It was noted that the incorporation of elements of past behaviour was similar attempted by Triandis in the integration of habit. Another work by Wood (1998) analysed over 64 different studies and identified the influence of previous regularity on future behaviour. In Bagozzi's and Warsaw's model, the immediate antecedents of intent was comparable to the work of Ajzen-Fishbein. However, Bagozzi made clear demarcations between the attitude of success from failure and the attitude towards the process of self-trying. This indicates the influence of habits and other factors on behavioural change from the perspective of customer action. The next section will discuss the concept of energy cultural behaviour.

## 3.5 The Concept of Energy Cultural Behaviour

The use of the term "culture" in energy research emerged from Lutzenhiser's Cultural Model of Household Energy Consumption (Lutzenhiser, 1992), in which it was suggested that energy consumption is an integral part of cultural processes. It was also noted that material culture is intertwined with "traditional roles, relationships, understandings, rules, beliefs in the cultural practices of groups"(Lutzenhiser, 1992, p. 54). The model developed in this study drew from the fields of anthropology and sociology to address consumption. The concept of the energy cultural framework was further developed in detail in the works of Stephenson et al. (2010) which was guided by other social theories, such as social practice theory.

Furthermore, the term energy consumption behaviour has been defined as the total energy use of an occupant from their human and physical characteristics. This definition amplifies Hitchcock's (1993) explanations from Stafford (1985) and (Cramer et al., 1985) that: "Buildings per se do not consume energy; rather people living and working in buildings use energy" (Stafford, 1985).

And are closely linked to the explanation by (Janda, 2011, p. 17) who also mentioned that:

*"*Building do not consume energy, people do*"*.

The above definitions show that a good understanding of user behaviour is essential to the understanding of energy use. This must include human variables, like belief, lifestyle, demography, and physical elements, such as building characteristics and appliances. Fowler et al. (2017) argued that energy research should broaden its scope to include the relationship between culture and energy, rather than remain within the technical domain. Other researchers also understand energy consumption behaviour as demand, which is used to explain people's needs and preferences concerning their energy consumption (Hargreaves et al., 2010; Palensky & Dietrich, 2011; Wilk, 2002). There are two approaches to understanding consumption behaviour. The internal studies and models behaviour as a function of processes conceived as internal to an individual: attitude, habit, belief, value and personal norms. In contrast, external factors include norms and institutional constraints.

Lutzenhiser (1992) discussed various theoretical approaches to energy research, including physical-technical-economic (PTEM), economic, psychological, and sociological/anthropological models. The work developed a cultural model to explain household energy consumption. This model was a pioneer in the development of energy culture research and represented an attempt to integrate different disciplinary approaches to energy behaviour research. He noted that energy consumption is inextricably linked to cultural processes, while material culture (which may include furnishings, technologies and buildings) is also linked to "roles, relationships, conventional understandings, rules, and beliefs into the cultural practices of groups" (Lutzenhiser, 1992). Lutzenhiser (1992) further explained that an individual's behaviour is influenced by their culture group "as the entity primarily responsible for deploying technologies, practices and meanings in what can be called 'styles' of life". Stephenson et al. (2010) and Stephenson (2018) noted a significant limitation of Lutzenhiser's culture model namely the inability to describe the concept of energy culture outside of a theoretical model. Stephenson et al. (2010) overcame the limitation of Lutzenhiser's (1992) energy culture model by developing an empirical energy culture framework. Hence, when considering this in the context of current energy efficiency programmes, there are a plethora of rebate programmes and tax credits designed to incentivise residential and commercial energy efficiency improvements. However, people do not always behave rationally when dealing with economics or technology. People are human, and our behaviours are frequently irrational and unpredictable, and this includes our energy consumption behaviour. This assertion is supported by the views of some experts that nearly half of all actual energy consumption is the result of an operating behaviour, not installed technologies (Xu et al., 2021). Although it is difficult to change behaviours, it is critical to understand the factors that influence behavioural change to enable a better energy-saving culture.

### 3.5.1 Lifestyle in Energy Research

Lifestyle, as a component of energy research, is an important factor in behavioural change and is defined as “distinctive modes of existence that are accomplished by persons and groups through socially sanctioned and culturally comprehensible patterns of action” (Eyre et al., 2011). Lifestyle is common within the field of marketing as a system of concept (Lazer, 1963), and has been used in consumer research and marketing. The concept of lifestyle and culture have been employed in energy research to build a better understanding and explain the variations to energy use (Burger et al., 2015; Ingle & Wilhite, 2018). Cultural anthropologists have studied the meanings and choices made by members of different groups regarding energy and goods, energy conservation, energy and meanings, power, and conflicts between groups (Strauss et al., 2013; Wilhite, 2013; Wilk & Wilhite, 1985). Research has made it clear that, due to social and cultural variables, lifestyles significantly affect energy consumption (Eyre et al., 2011). Within the field of sociology, lifestyle differences between social groups and classes were examined through the concept of “habitus” in the works of Bourdieu (1984). The study made another important contribution to understanding human action by conceptualizing the impact of lived experience and future human practices.

In energy research, lifestyle is viewed as a mixture of some factors which include behaviour, consumer choices, culture, social class, past trends and marketing, which determine energy end-use (Kempton, 1993). It has been applied to explore the variation between lifestyle groups in energy use, the adoption of energy-efficient appliances and conservation behaviour (Lutzenhiser & Lutzenhiser, 2006). The work of Sankost et al. (2012) also highlighted that the importance of lifestyle to energy consumption is shown by the finding that similar households with identical physical shells are associated with completely different energy consumption behaviours (Sanquist et al., 2012). This indicates that the study of lifestyle in relation to energy consumption could comprise the demographic elements and categories of appliance the end-user owns including how appliances are utilised (Sanquist et al., 2012). The energy culture framework developed by Stephenson et al. also contains some interesting similarities to all of these approaches and suggests that different patterns of behaviour and similar lifestyles should be defined on differences in cognitive norms, material culture and daily practices (Lawson & Williams, 2012). Hence, gaining an understanding of lifestyles could facilitate the design of better public policy concerning energy. The next section will highlight the physical environment as a key construct to facilitate an understanding of the theoretical framework.

### 3.5.2 Physical Environment

In this research, the physical environment concerning energy is viewed in terms of the building type, building design and aesthetics, and the climatic conditions. It has been shown that wall insulation, roof and windows, building shape, and household characteristics (such as the number of family members and income) were associated with attitude and energy consumption (Kavousian et al., 2013; Pachauri, 2004; Seryak & Kissock, 2003). Previous research findings from Bell et al. (2014); Stephenson, Barton, et al. (2015); Stephenson et al. (2010) argued that there are two major aspects of energy use that influence decision making: material and physical environment.

## 3.6 Cultural Approach

Culture can be defined as the lifestyle of a certain category of people at a given time, based on their customs and beliefs. According to Hofstede (1999), culture is a form of mental programming where each person develops their own models of thought, feelings, and possible behaviours throughout their lives. Hofstede (2001) developed the cultural dimensions model and established that there are cultural conglomerates at the regional and national levels that exert a long-lasting influence on the behaviour of societies and organisations. However, in terms of ways to explore energy, Savocool (2016) posits four distinct perspectives: 'economic', 'political', 'professional', and 'epistemic' cultures (Sovacool, 2016). The researcher acknowledges these disparities in cultural perspectives and the research explores the Savocool perspectives.

### 3.6.1 The Energy Cultures Framework

The foundation of energy cultures is based on consumer energy behaviour and concepts borrowed from the theory of structuration, and the practice and socio-technical systems theories. Energy cultures as a framework "offers a relational and context-specific perspective on energy behaviour" (Stephenson, Barton, et al., 2015, p. 119). It is a multidisciplinary behavioural model that seeks to understand the factors that affect energy consumption. This describes energy consumption through a culture-based model, which is defined by three core components:

i. cognitive norms–the understanding and belief of a person about energy;
ii. material culture–behaviour-technologies and infrastructure that determine behaviour;
iii. energy practices–actions and behavioural patterns (i.e., routines or habits).

These are also defined as highly interactive, and each feature has a direct effect on behaviour. External influences are external factors that can significantly influence the energy culture of an entity. The overall model can be viewed as an integrated macro system and every core idea can be interpreted as a micro-system within the framework.

The framework incorporates the egoistic variables which are based on the individual, and the more widely dispersed social and technological constructs. This gives it an advantage in terms of validity over most other models discussed in this study. It also provides a versatile structure that describes the variables that may affect behaviour but does not recommend how it is characterised or quantified. The energy behaviour of occupants in buildings is a complex combination of these three primary components which work together to create a self-reinforcing system (Ishak, 2017). (Ambrosio-Albalá et al., 2019; Ford et al., 2017; Mirosa et al., 2013; Stephenson et al., 2010) present research on energy culture in residential buildings, while Dew et al. (2019) and (Bell et al., 2014) present research on energy culture in non-residential settings. It was noted that the interpretations in both results are not contradictory because they share a common concept. The only difference lies in the fact that the norms, material culture, and practices are shaped by the context of the research (domestic or non-domestic buildings). Furthermore, several researchers have explored the framework (Scott et al., 2016) in relation to the impact of different home energy advice approaches (Hopkins & Stephenson, 2014; Stephenson, Hopkins, et al., 2015); concerning mobility and the future of transport (Young & Middlemiss, 2012); in connection with individuals' actions on greenhouse gas emissions and regarding energy behaviour in higher education in Malaysia (Ishak, 2017).

The fundamental basis for energy behaviour is norms, and in behavioural models, norms are often presented as perception and motivation (Aune, 2007; Hasanbeigi et al., 2010). Furthermore, they are identified as "the values and aspirations of people for their activities and material culture" (Stephenson, Barton, et al., 2015), and include shared beliefs for certain situations (Rotzek et al., 2018). Norms impact technological preference (material culture) and energy-related activities (practices) and subsequent behaviours (Stephenson et al., 2010). Also, norms mirror different features across sectors. An example is the application of the model in the Waitati Energy Project (WEP) which aims to better understand and foster behavioural shifts in a New Zealand transition town. It helps to develop 'energy literacy' by shifting the community's implicit and explicit norms toward more sustainable energy consumption patterns (Stephenson et al., 2010). Hence, these reflect various components and theoretical stands that form the energy cultural framework that is fundamental to this research. It is also important to define material culture and practices to better understand the energy culture framework.

**Material culture** is "the technologies, structures, and other assets that play a role in how energy is used(practices)" as well as the norms relating to technology (electricity) use (Stephenson, Barton, et al., 2015, p. 119). The material culture depicts both "physical evidence" and functionality, including infrastructure, buildings and machines, which influence people's standards and likely practices (Stephenson et al., 2010). This has a significant role in the people’s practice or the behaviours of energy users, which depend on its use and purpose.

**Practices** explain routine and irregular behaviours and actions that occur over a subject's lifetime (Stephenson, Barton, et al., 2015). These also depict changing values and beliefs that become integrated norms. Therefore, practice is the product of interaction between norms and material culture. Some of these also describe the "belief and understandings of the people" (Stephenson et al., 2010). Practises include both everyday actions and the acquisition of material objects that enable individuals to enact and replicate social practices. (Ford et al., 2017). The framework for energy cultures can describe the internal and external influences on energy behaviour which were originally illustrated under the broad term culture (Bell et al., 2014). Consequently, both material culture and practices are vital components of the cultural framework shown in Figure 3.3 with their ability to influence the behaviour of energy users. This, amongst others, is vital to the development of the conceptual framework for this study.

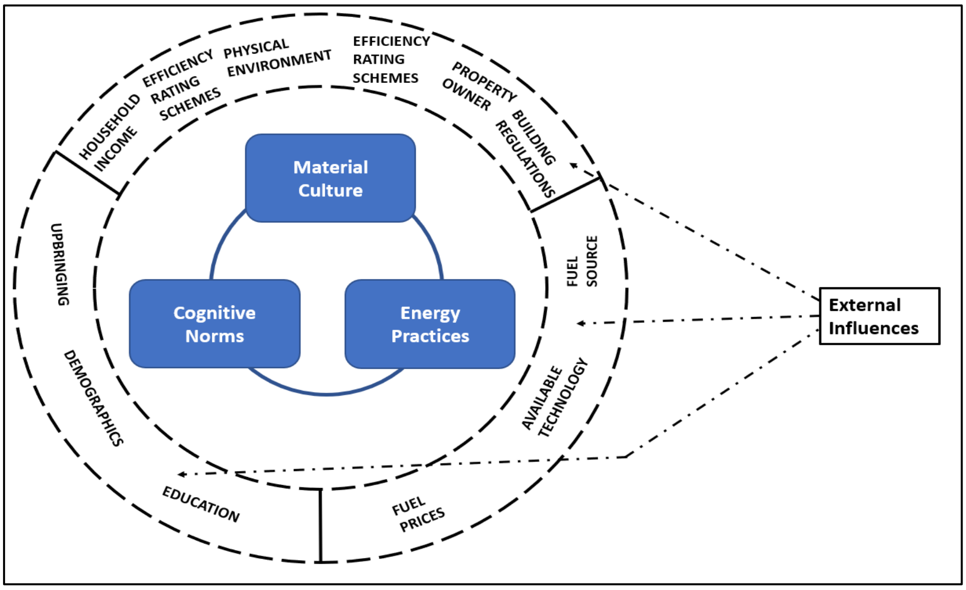



Figure 3.3: Energy Culture Framework (Stephenson et al., 2010).

### 3.7 Conceptual Framework

The literature reviewed has demonstrated a lot of determinants to energy-saving and behavioural change. This section develops a conceptual framework, which could be employed to guide future empirical studies (see Figure 3.4). The theory was developed from the person-specific factors (including socio-demographic and psychological factors) of household energy consumption. These factors have been suggested to explain the difference amongst households energy consumption and conservation (Frederiks et al., 2015). This will help the researcher to identify the potential causal as well as an explanatory variable that will encourage a shift in behaviour. This is significant as inadequate attention has been paid to the issue of contextual variables (Abrahamse & Steg, 2011; Jackson, 2005; Sonnenberg & Erasmus, 2013). For electricity-saving, contextual variables like socio-demographic factors (household size, household income) and the contextual variables suggested by Stern (2000) (social norms, cost and benefits, available technology, policies and regulations) may affect energy-saving behaviour in residential buildings. These factors were examined alongside constructs from the energy culture framework from Stephenson et al. (2010) while the physical environment was adopted from Aune (2012) and Brown (2017). Brown (2017, p. 62) applied the physical environment to organisations noting that, "it is the physical environment where energy behaviours occur and may include infrastructure and technology". This led to the development of the workplace energy culture framework in association with other variables. The understanding of the above factors would ensure better comprehension of the type of intervention required, which may include technological solutions, human-focused action or policy strategies. Thus, Table 3.2 also lists significant literature on which the conceptual framework was developed.

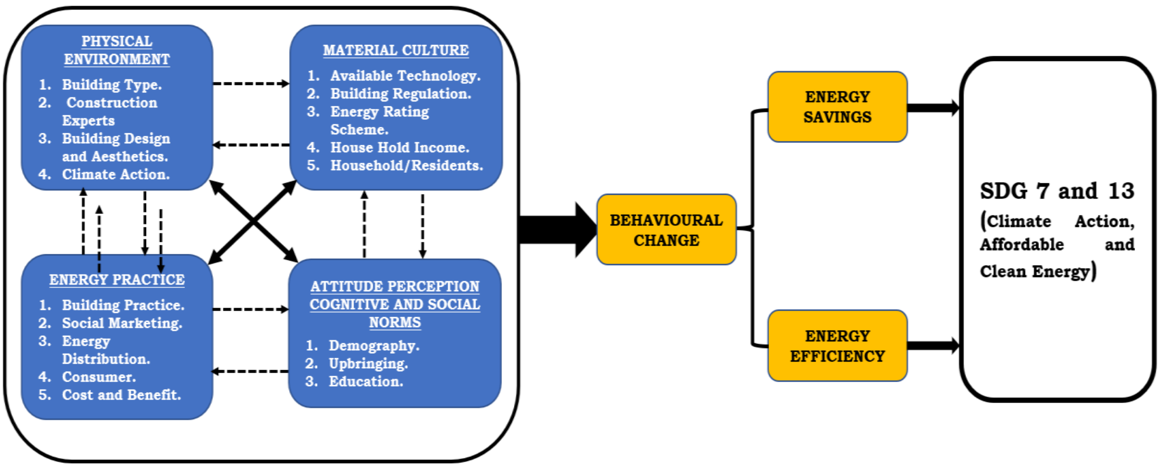



Figure 3.4: Proposed conceptual framework.

Table 3.2: Literature that informed the development of the conceptual framework.

| Variable | Predictor | Source of relationship |
|---|---|---|
| Phycological variable | Attitude, perception, cognitive and social norms | Greaves et al. (2013); Abrahamse & Steg (2009); Stephenson et al., (2010, 2015) |
| Socio-demographic characteristics | Age<br>Level of education<br>Household size<br>Household income | Sardianou (2007); Brohmann et al. (2009); Brohmann et al. (2009) ; Botetzagias et al. (2014); Stern (2000). |
| Physical environment | Building type<br>Building design and aesthetics, climatic conditions<br>Construction Experts | Lutzenhiser (1992); Aune (2011); Brown (2017) |
| Energy Practices | Maintenance of technology, Energy distribution, cost and benefit | Stephenson et al., (2010, 2015) |
| Material culture | Available technology, household characteristics, Building regulations<br>Households income, Households, | Stephenson et al., (2010, 2015) |

### 3.8 Theory Development

The development of the proposed conceptual framework in Figure 3.4 was designed based on the established relationship between identified constructs as it relates to behavioural change to achieve energy efficiency and energy savings approach in Nigerian residential building. Furthermore, theorical tools from existing studies as discussed previously also highlights that physical environment, energy practice and material culture a play vital role in this regard. These amongst other constructs were key components required for the development of the proposed framework as a vital theoretical tool required for testing with the generated data for implementation. However, beyond its application as a theoretical tool, the framework must have predictive outcomes. Accordingly, the theory was developed based on two areas of focus which includes the relationship between the constructs and behavioural as well as the impact of energy saving behaviour and energy efficiency approach on some sustainable development goals. These two component areas will be discussed subsequently to justify their selection in the design of the proposed model.

### 3.8.1 Influence of Constructs on Behavioural Change

The constructs that were considered in the proposed conceptual model likely to influence behavioural change in residential buildings include physical environment, material culture, energy practice as well as attitude, perception, cognitive and social norms. In the Work of Stephenson and others the issue of energy culture framework was discussed in the context of understanding energy behaviour (Stephenson et al, 2010). The study developed the energy culture framework and showed that consumer energy behaviour has direct relationship through interaction between energy practice, material culture and cognitive norms. It was further noted that the interaction of some key constructs is fundamental in shaping energy behaviour as reflected in the modified energy culture framework (Stephenson et al 2015). This work shares similar views with Williams (Williams, 2012) on material culture and another work on energy efficiency (Ford, Doering and Stephenson, 2015). This underscores the importance of material culture, norms and practices. Furthermore, the relationship between attitude and behaviour was earlier observed in the Triandis' Theory of Interpersonal Behaviour (Jackson, 2005). Additionally, Sterns proposed integrated model combines both individual variables (including attitude, habit, and routine) and contextual variables (external conditions and capabilities) which influence environmental behaviour (Stern, 2000; Wilson & Dowlatabadi, 2007b). This is to highlight the vital nature of the identified constructs as it relates to energy behavioural change. Furthermore, Table 3.2 also gives breakdown of the constructs and the relevant sources showing their relationship with behavioural change in energy consumption and savings.

Material culture (available technology, income, regulations) are increasingly effect reducing resource consumption, but also occupant routines, habits, and choices can have a significant impact on the overall performance of the building. These play a role in how energy is being used and also the role played by material culture in behaviour (Stephenson,2015). These behaviours include curtailment actions (e.g., turning off equipment when not in use, performing routine building system operation and maintenance procedures) as well as more complex behaviours, such as procurement or contracting procedures, that are required to implement policies that have a high impact on outcomes (emission and energy use).

In order to reduce household electricity consumption, one cannot depend exclusively on material culture (electrical appliance and buildings), but must also consider household attitudes, norms and perception. While positive attitudes toward the environment may not predict whether an individual will engage in specific environmental behaviours, specific attitudes toward specific problems do (Bell et al. 1996). Despite ongoing debates about the precise relationship between attitude and environmental behaviour, the majority of studies indicate that attitudes do have an effect. Accordingly, it is critical to investigate and understand the mechanisms of attitude, particularly when pursuing behaviour change. Cognitive norms have a significant influence on how people choose technologies and practises they engage in (Stephenson, 2010). It is affected by education, upbringing as well as demographics.

### 3.8.2 Energy behaviour practices and energy efficiency approach on sustainable development goals

Energy-saving behaviour here refers to conserving energy, which involves practices aimed at using less energy by shifting in the mindset of consumers. This approach seeks to minimise emissions using behavioural methods which focus on well-defined sustainable goals rather than solely investment into technologies (Oikonomou et al. 2009; Trotta, 2018). Such practice is people-intensive and relies on consumer awareness and leadership commitment. Even though it could be argued that energy-saving behaviour does nothing more than focus on activities such as switching off the light, fridge, or water heater, when living the house, it can help to reduce energy use. In practice, it is difficult to distinguish energy-saving behaviour and efficiency when reaching sustainability outcomes. It is the little adjustments in behaviours that are often the simplest methods of reducing energy consumption and improve sustainable change.

Given the conceptual linkages between energy-saving behaviour and energy efficiency, it could be possible to increase the sustainability objectives through a change in consumer attitudes. In the industrial sector that does not have well-developed cultural behaviours, there might be barriers to implementing energy efficiency practices because it requires the involvement of people or all stakeholders, and a shift in occupant attributes, employees, and leaders (Ajayi & Ajanaku, 2009; Morley and Hazas, 2010; Santin et al., 2007; Gram-Hanssen, 2011). An energy-saving culture should, therefore, afford a window of opportunity for sustainable competitive advantage through awareness, information sharing, motivation, and leadership commitment. More so, as energy-saving behaviour is people-oriented, not technology-oriented, individuals or organisations should realise the concurrent reductions in carbon emissions, costs, and improvements to the health and wellbeing of residential occupancy.

However, there seems to be a limit to energy-saving behaviour which does not account for energy efficiency practice. Efficient energy consumption means using less energy to offer at similar levels of power. Oikonomou et al. (2009) suggested that energy efficiency involves the reduction of overall energy consumption as a result of deploying certain technologies without any change in behaviour and attaining maximum services. Indeed, several studies have recognised the values of energy efficiency practices (Baatz, Barrett, et al., 2018; International Energy Agency IEA, 2014; Weinsziehr & Skumatz, 2016), while some linked energy efficiency as an essential measure to reduce the greenhouse gas emissions that can help to mitigate climate change. Besides, another important motivation behind the investment in energy efficiency is its ability to reduce energy demand and improve energy cost savings (Baatz, Barrett, et al., 2018; International Energy Agency IEA, 2014; Weinsziehr & Skumatz, 2016). The execution of sustainable energy efficiency investment is likely to produce a more efficient use of natural resources across the sectors and could facilitate economic growth (Weinsziehr et al., 2016). According to IEA (2013), if houses are insulated, less energy is used in heating and cooling to achieve a satisfactory temperature, which could reduce the global demand for energy and help to manage global carbon emissions (IEA, 2014). Moreover, in many countries, government-led subsidies have been found to encourage higher energy consumption and inefficient energy use (Overland, 2010; Ürge-Vorsatz & Metz, 2009.). Hence, the removal of such subsides could better address the challenge of greenhouse gas emissions.

This could facilitate the employment of energy-efficient practices prompted by the huge cost of poor energy management.

Increasingly, research studies have found that employing energy-efficient practices have significant social and economic benefits and reduce energy demand (IEA, 2014). Additionally, energy efficiency retrofits in buildings can help to improve the health and wellbeing of occupants, particularly those with underlying ailments, with the most vulnerable being households with young children and elderly. Other possible benefits include the reduction of some respiratory, cardiovascular, allergies and other related diseases (Payne et al. 2015; IEA, 2014). However, the effect of energy efficiency policies on the sustainable development objectives concerning social, environmental and economic performances still need to be better understood. In particular, the influence (positive or negative) of energy efficiency on the objectives depends on the scale of the underlying energy strategies.

**Summary**

The development of a theoretical framework for energy research is a vital tool in understanding the factors that directly affect behavioural change in energy savings and efficiencies. In this chapter, most theories relate to technology, the environment, cultural influence, attitude, habits, and norms (amongst other factors) which influence energy usage and behavioural change. This section was able to develop a conceptual framework based on the existing literature on theories and models relating to behavioural change in the context of energy efficiency and energy savings.

The next chapter will discuss the methodology employed for this research. The chapter will also highlight research tools used to generate data, outline the scope of the work, and describe the sample of respondents involved in generating data for the research. Also, all tools for data analysis will be described in Chapter 4.

# Chapter 4: Methodology

## 4.1 Introduction

This chapter identifies the main research decisions taken for this inquiry, including the philosophical underpinnings, ontology, epistemology, axiological considerations, and methods undertaken that arise from the nature of the research. The chapter identifies the four main stages of the research. The first stage involved a review of relevant literature on energy saving and energy culture elements and offers an insight into the study area. The second stage involved the collection and analysis of qualitative data to explore the phenomena. The third stage is a point of integration and involves the development of a suitable quantitative instruments using the identified variables from the second stage and literature. The last stage involved the quantitative data collection and analysis which enabled the development of the proposed model. This chapter provides a rationale for the selection of the data collection method and analysis which were determined as the most appropriate to answer the research questions outlined in chapter one. It provides an understanding of how the energy culture framework can be adopted to provide a better understanding of residential energy consumption behaviour.

Table 4.1: outlines the research process alongside the methods used at each stage.

| CHAPTERS | CONTENT | METHOD USED | Research Objectives |
|---|---|---|---|
| 2 | Sustainable Development, Status of electrical energy, Residential buildings, Nigeria | Literature Review | Objectives 1 and 2 |
| 3 | Theoretical framework and the development of conceptual framework | Literature Review | Objectives 1 and 2 |
| 4 | Philosophy, Methodology, Pilot quantitative, data collection of quantitative and qualitative data | Literature Review, semi-structured interview and questionnaire survey | Objectives 2, 3 and 4 |
| 5 | Analysis of qualitative data from the research | Thematic analysis using NVIVO | Objectives 2,3 and 4 |
| 6 | Analysis of quantitative data from the research | Descriptive (Using SPSS) and Structural Equation Modelling (Using SPSS Amos). | Objectives 2,3, 4 and 5 |

### 4.2 Concept of the Research

Research is defined as the process of generating new knowledge and/or making new and innovative use of existing knowledge to generate new ideas, methodologies and understandings. It may involve the interpretation and examination of previous work to the degree that it results in new and innovative results. Research is also a discovery process that includes three central research questions: 'what', 'why' and 'how' (Fellows & Liu, 2012). What questions define the characteristics of an approach, why questions the relationships between processes or events, and how questions contribute concrete results and interventions (Blaike & Priest, 2019). However, some researchers have proposed other types of research question, such as who, when, how much, how many and when (Blaxter, 2010; Yin, 2018), although they agree that these are different forms of what questions. This research answered what and how through the following questions: "what are the current factors that determine energy saving behaviours in Nigerian residential buildings?", and "how can the existing energy cultural framework be employed to develop a suitable model for energy reduction in Nigerian residential buildings?".

### 4.3 Research Design Framework

A research design can be achieved in different ways to address the study's objectives and answer the research question. However, there are two ways to solve the research design problem, according to Blaikie (2007), namely to follow one approach or explore a combination of suitable approaches. However it is essential for researchers to focus on the problems in order to employ the most suitable approach to solve the research question (Patton, 2002; Rossman & Rallis, 2003). To identify the most suitable design for this research, a comparison of the two most prominent models is provided below.

Firstly, (Kagioglou, 1998) introduced the "Nested Research Methodology" (see Figure 4.1) which consists of philosophy, approach and techniques. This guides the selection of a suitable, comprehensive methodology, and helps to link the research theory, strategy and technique. Research philosophy is the basis for knowledge creation while research approach is the method used to produce and test a hypothesis and can take the form of a case study, survey, action analysis or evaluation. Research techniques refer to the means of data collection which include interview, questionnaire, observation or focus group. Many scholars have used the nested approach for their research (Dangana, 2015; Kasim, 2008; Ling, 2003).

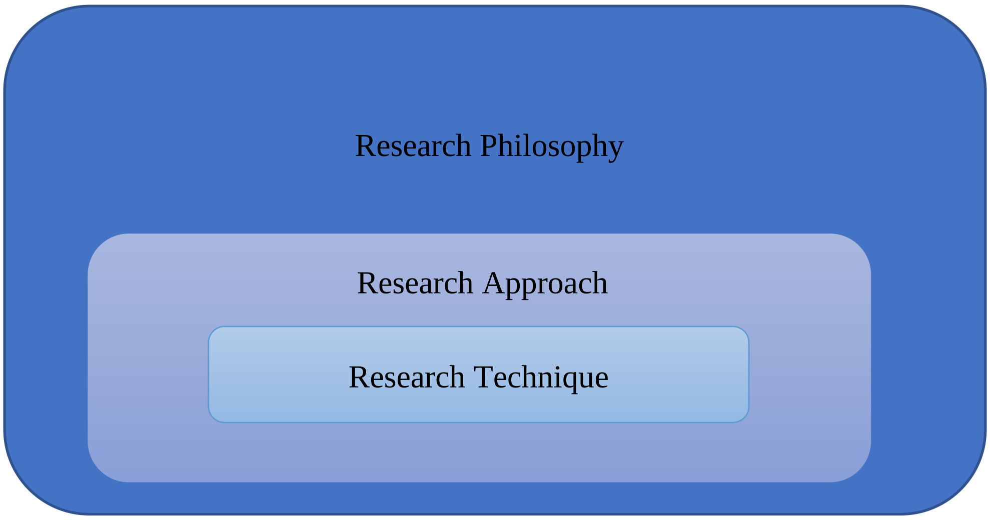



**Figure 4.1**: Nested Research Model (Kagioglou, 1998).

The second model was developed by (Saunders et al., 2003) and called the Research Onion" which is shown in Figure 4.2. It comprises of the six layers which include research philosophy, research approach, research strategy, time horizon, methodological choice, and data collection and analysis. When developing a research design, the Research Onion offers a wider overview and clearer guidance compared to the Nested Research Model. Its methodological structure and completeness provide a useful guide to demonstrate the unique nature of this study. Furthermore, the inclusion of the time horizon layer offers an added advantage and more detail than the Nested Design. Therefore, the Research Onion (Saunders et al., 2009) was applied to explain the research design for this work. Its different layers will be discussed in the sections that follow to show how the researchers' beliefs and assumptions impacted the choices made.

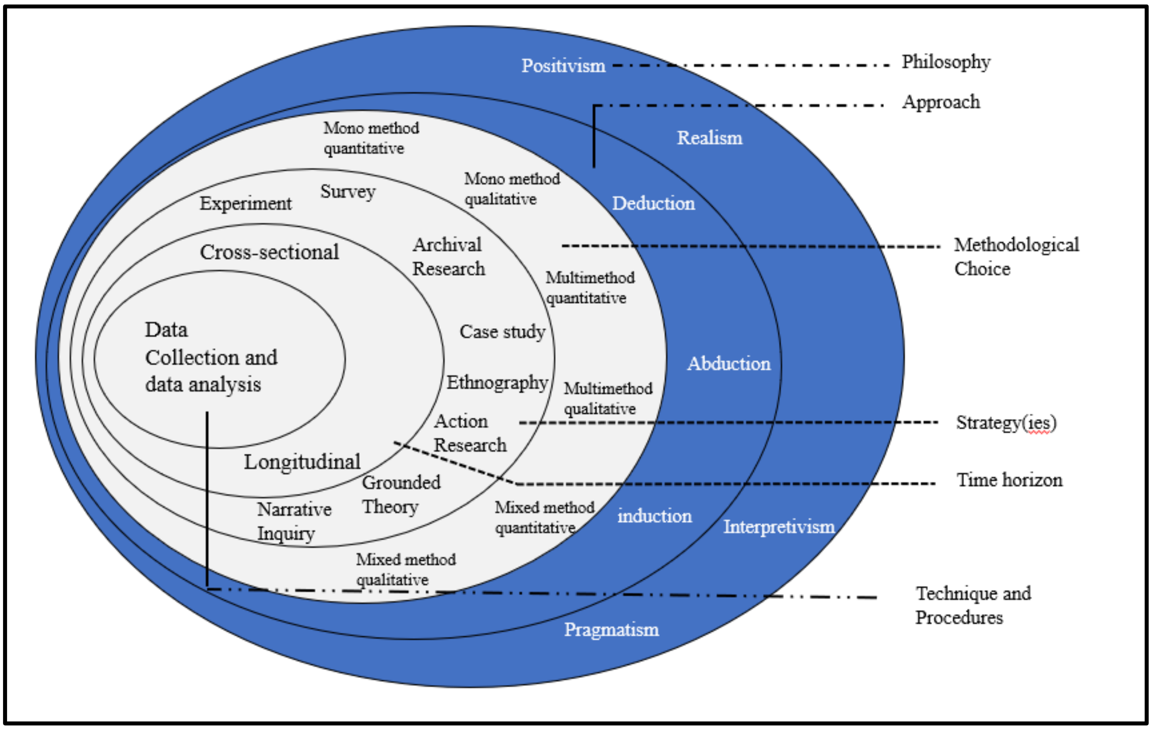



**Figure 4.2**: Research Onion Model (Saunders et al., 2019)

### 4.4 Research Philosophy

Philosophy can be the study of knowledge including the nature of reality and existence (Manicas, 1991), or a way to identify and evaluate the lens through which experience is constructed (Stubley, 2021). However, research philosophy is defined as the general beliefs and world view that inform the study undertaken. Saunders et al. (2019) viewed research philosophy as important beliefs and assumptions which researchers have about the world. Thus, these assumptions reinforce the choice of research approach and methods undertaken to achieve the objectives. Within the mixed methods research, it is seen as a set of belief or assumptions that guide inquiries (Guba & Lincoln, 2005). The term "paradigm" refers to the philosophical principles or basic set of beliefs that directs action and defines the researcher's worldview (Lincoln et al., 2011). The term was proposed by Thomas Kuhn (1970), and used to describe shared generalisations, world views, and beliefs about the nature of reality and knowledge (Kuhn, 1970). Moreover, the term “world view," is often used synonymously with paradigm (Creswell et al., 2011; Lincoln, 1990; Patton, 2002; Rossman & Rallis, 2003), and is defined as "a way of thinking about the dynamics of the real world and making sense of it" (Patton, 2002, p. 69). These assumptions can be based on the reality encountered in the course of the research (ontological assumptions), what constitutes knowledge (epistemological assumptions) and the way the values of the researcher influence the research (axiological assumptions) (Saunders et al., 2018). These philosophical assumptions are based on the discipline of the researcher, the background and field of the supervisors, previous research experience, and the time and finance available (Saunders et al., 2018). Philosophical assumptions influence the researchers' understanding of the research question, chosen methods and interpretations of the findings (Crotty, 1998). Therefore, it is important to ensure that the assumptions made appropriately inform the choice of methodology, research strategy, collection of data and analysis method.

Creswell (2014) identified four assumptions that resonate with mixed methods research: Post positivism, Constructivism, Pragmatism and Transformativism. The chosen world view for this study, pragmatism, focuses on the importance of answering research questions, thus multiple data collection methods were selected to enable problem solving (Creswell & Clark, 2017). Residential energy consumption behaviour is a real-world problem, and a pragmatic world view is oriented towards real life problems and "what works". It is also concerned with practical and relevant issues in social life. Hence, it views current truth as tentative and changing all the time. In addition, three further philosophical considerations inform this study - ontology and epistemology and axiology - as these vary in their ontological and epistemological positions.

### 4.4.1 Ontology

Ontology is the branch of philosophy that is concerned with the nature of reality, types and their connections (Saunders et al., 2016). The earlier section established the ontological considerations of the research. Ontological considerations shape the way the world is viewed, what to research and the research objectives. It is a belief system that reveals the researchers' point of view of what can be considered true. Ontology identifies the existence of reality - objective reality which holds the world and objects to exist independent of external factors, experience and the subjective reality based on the researchers' experience and perception. These are described as polar opposite on the continuum aligning variations of philosophical positions (Holden & Lynch, 2004). Figure 4.4 describes the three research philosophies that are frequently discussed in academic research: positivism, interpretivism, and pragmatism (described below). These philosophies generally differ by the ontological view of subjective and objective perspectives. The ontology, perception of the truth/ reality, in this research leans more towards the centre of the continuum as shown in Figure 4.4. Ontologically, mixed method research acknowledges that reality is complex and multidimensional, and that different aspects of reality may require different methods of inquiry to fully capture and understand them.

Furthermore, the success of the SDGs will require the understanding of both the experience and objective perspectives of individuals and communities. This can assist to develop policies and programmes that will be effective and sustainable. Energy consumption and reduction can be viewed objectively as measurable quantities(positivism) although their effectiveness in achieving the SDGs depends on subjective factors such as attitude, accessibility to energy sources and the willingness of individuals to adopt sustainable practices, thus pragmatism was adopted.

### 4.4.2 Epistemology

Epistemology is also a field of philosophy that studies the theory of knowledge. Epistemology ranges from the sources of knowledge to the extent of knowledge (what are the limits of what we know) and how we can share knowledge with others (Saunder, 2016). In academic research, the epistemological assumption of the researcher informs their ontology, although the study of epistemology (knowledge) has raised a lot of misconceptions about what is 'true knowledge'. The two most prevalent approaches in epistemology are empiricism, which is experience-based and idealism, which is based on innate understanding (Potter, 2016). However, the major epistemological assumptions are positivism and interpretivism, which revolve around innate knowledge (Irshaidat, 2019).

### 4.4.3 Positivism

Auguste Comte (Bourdeau and Pickering (2018) established positivism as a philosophical idea and movement. He explained that the social world, like the natural world, must be explained by the laws that govern it, and identified observation and experimentation as ways to understand human behaviour. There are many definitions of positivism, some of which indicate its negativity, while others emphasise its descriptive potential (Bryman, 2016). Positivists consider that reality is stable and can be described and observed objectively. This is occasionally called the scientific method or science research (Tashakkori & Teddlie, 2010a) (Creswell, 2014), although it has been argued as erroneous to consider positivism as synonymous with scientific methods (Bryman, 2016). Nevertheless, it incorporates the assumptions of natural science, and social reality is considered as external to the researcher and social actors. This means that positivism incorporates realism, and takes into account social entities as physical entities of natural world, believing in just one true reality (Saunder, 2016). Most positivists formulate hypotheses, conduct quantitative data collections and carry out statistical testing. The key features of positivism are as follows:

a) That existence and knowledge is regarded as reality, which can only be verified by the senses through a scientific method (techniques based on data collection by observation, measurement, and calculation);
b) It advocates deductive reasoning, the development of hypotheses which can either be confirmed or refuted, and that data is pure and not influenced by the researchers' interpretation and bias (Saunder, 2016).

According to Boehm et al. (2013), there is an assumption among social policy makers that the most reputable work is unbiased, neutral and scientific, indicating a preference for positivist approaches. However, social science research addresses human behaviour, which shows that people cannot be addressed as objects and theories that result in laws as people are influenced by other less tangible factors such as feelings and perceptions (Easterby-Smith et al., 2012). However, this research tries to bring to the front the complexities of energy use by individuals, so positivism would imply viewing energy consumption as an independent practice and not influenced by the identified social and cultural factors. Therefore, a strictly positivist approach would be unable to yield much meaningful results in terms of the research objective and the questions that the study sought to answer. Therefore, the researcher adopts a pragmatic philosophy in the research. This is because it enables the researcher to acknowledge the existence of reality and that there are different ways to interpret the world and undertaking research.

#### 4.4.4 Interpretivism

Interpretivism as a philosophical view contests the use of positivism as an ideology in social science with the belief that the social world is fundamentally different to the natural world. They consider that the world is based on social constructions in which people create and interact (Saunders et al., 2018). As such, the study of the social world would require a rational research method that differs from the scientific method. Interpretivists believe that social reality is subjective and can only be fully understood through a subjective interpretation of reality. In their view, people determine the real world rather than objects and externally observed factors (Gray, 2013). It is expected here that the researcher is immersed in the study from the beginning to the end (Holloway & Galvin, 2016) meaning that their values and beliefs play an important role in the research process (Saunders et al., 2018). Indeed, proponents of interpretivism argue that the researcher is part of the study and therefore deals with social reality. As such, interpretivism is a subjective ontological view, rationalistic epistemology, whereby social reality is distinguished from scientific truth, and explored via inductive methods. It emphasises the significance of culture, language and history in shaping participants' meanings and experiences of the social world (Crotty, 1998). Therefore, interpretivism is highly suitable in for energy research because of the nature of the research questions, which focus on developing a new and better understanding of energy consumption in residential buildings. An interpretivist research philosophy will adopt a socially constructed reality by enabling residential occupants, energy providers and other stakeholders to express their opinions about energy consumption behaviour. However, locating the research within an interpretivist philosophy coincided with the objective to identify factors that influence occupants' behaviours and attitudes towards energy consumption. This enabled the use of other techniques, such as a survey.

#### 4.4.5 Pragmatism

Pragmatism attempts to offer an alternative to 'pure' objectivism and subjectivism and their associated assumptions regarding facts, values, knowledge, and different experiences (Saunder, 2016). A pragmatist paradigm focuses on the "research question" and applies all appropriate methods (what works) to understand the question (Saunders et al., 2009; Tashakkori & Teddlie, 1998). Thus, as research questions are central to the study, the data collection methods and analysis are chosen to elicit answers rather than to ensure allegiance to a philosophical paradigm (Creswell & Clark, 2017; Mackenzie & Knipe, 2006). Pragmatism acknowledges the use of mixed methods in a research study and recognises the role the researcher plays in the interpretation of the results (Tashakkori & Teddlie, 2010a). The researcher must decide through inquiry process what they think is right or wrong (Morgan, 2007).

In this case, pragmatism was adopted to build bridges across the approaches to order to understand residential energy consumption in building sciences and the behavioural orientation of occupants. As this study answered research questions that could be best approached through a combination of interpretivist and positivist philosophies, the use of pragmatism was appropriate. This research paradigm allowed the presentation of both philosophical assumptions within the thesis and an investigation of knowledge connected to the field of energy saving behavioural research. Thus, the research design involved an interplay of ontology, epistemology and practical considerations in relation to residential buildings. This philosophical stand linked pragmatism with the research objectives and literature on energy consumption behaviour. The following were the objectives of this research:

a. To critically review literature on energy saving behaviour and energy culture element that influence occupant's residential energy consumption behaviour
b. To identify factors that influence occupant's behaviour and attitude towards energy consumption in residential buildings in Nigeria
c. To explore the use of drivers to facilitate adoption of energy saving practices against existing barriers for stakeholders
d. To assess the role of relevant stakeholders in energy saving practices and the future of sustainable energy technology and policies in Nigeria
e. To develop an energy-saving behavioural model to reduce energy consumption in Nigeria.

The first objective focused on the influences on the energy consumption behaviour amongst occupants in residential buildings. In Southern Italy,(Prete et al., 2017) concluded that the major determinant to prompt households to adopt and pay for Energy Efficient Methods (EEMs) is attitude as this influences residents' intentions to adopt and pay for EEMs. Factors like environmental concerns and social norms are minor determinants and based on the subcategories of education, level of income and age of household. Furthermore, the family unit in China is getting smaller but houses are getting bigger in size as well as energy consumption (Hu et al., 2017). Energy usage is growing because of the increased use of electronics in houses. Indeed, Prete et al. (2017) found that the attitude to pay for EEM is the major determinant of households. This is a similar finding to Dubois et al. (2019) who concluded that attitudinal change towards household energy consumption (travel, diary consumption, heating), the demography of household members, and the dynamism of the family (childhood, adulthood, and illness) influence energy usage in the house. Therefore, energy saving behaviour is subjective (the usage of energy for all appliances in a bigger house), behavioural (social norms – bigger houses with electronic appliances) and requires a greater understanding of the need for energy saving amongst society. Yet, environmental concerns, income level, and the level of education in the household might provide an objective view of the concept of energy saving. Thus, the literature explained that energy saving can be an objective and subjective philosophical view (Geerts, 2017). While energy savings can have objective views, which are physical in nature due to the facts on the ground influenced by technology or economic factors, it is also similar to energy transition which goes beyond objective views with component of epistemological, metaphysical and cultural factors amongst others (Heurtebise, 2020) . This is considering that energy saving, or efficiency may be influenced by other views with biases including attitude, cultural and human behavioural components which are subjective in nature.

The second objective was to identify factors that influence occupants' behaviours and attitudes towards energy consumption in residential buildings in Nigeria. Metred customers are more likely to use energy sustainably than unmetered customers (Aramowo, 2017). Akintan et al. (2018) identified that wood fuel is also used traditionally as a household energy source. However, smoke pollutes the environment, is a health hazard and means cutting trees for wood fuel which causes deforestation. Yet the adoption of energy saving practices is hindered by high capital costs and a lack of access to finance, and minimal awareness of the availability of solar photovoltaic (PV) (Ugulu, 2019). Furthermore, Aliu (2020) argued that the provision of prepaid metres to households in Nigeria will facilitate the adoption of energy saving practices. Pragmatically, this literature gathered the facts and experiences of research participants whereby the participants had the facts (prepaid metres, smoke in the atmosphere, and lack of access to finance) and experiences (wood for fuel, affordable fuelwood) to prompt them to adopt energy saving practices.

The third objective was to explore the use of drivers to facilitate adoption of energy saving practices against existing barriers for stakeholders. Based on the socio-demographic characteristics of people, their dwellings and environmental factors, a better understanding was required to determine an appropriate approach towards energy savings which facilitates design effective energy policies and promotes energy-responsible lifestyles (Trotta, 2018a). Furthermore, (Khan, 2019) concluded that metred households will better support energy saving practices than unmetered households.

It was essential to consider several factors when addressing the fourth objective which was to assess the role of relevant stakeholders in energy saving practices and the future of sustainable energy technology and policies in Nigeria. For example, (Mohammed et al., 2017) analysed energy technologies and considered a mixed system involving hybrid energy mechanisms alongside other energy generation methods including hydropower, solar, biomass and wind energy generation. The results suggested that the effective development of renewable energy is critical to development of a country. This could be achieved through the effective pursuance and implementation of technology, socio-political, investment polices, and legislature. Oyedepo et al. (2019) concluded that Nigeria has available renewable energy sources but needs a strong political will and a full utilization of available renewable resources (solar and wind), to enable a future with sustainable energy. Adewuyi et al. (2020) concluded that "until the reliability and cost-effectiveness of renewable energy technologies are well-proven, the reliance of Nigeria and other SSA country on energy from conventional fuels for electricity and locomotion may remain unchanged".

The last objective was to develop an energy consumption behavioural model to help to support the reduction of energy consumption in Nigeria. In addition to Singh and Yassine (2018), all cited literature recommended a comprehensive database of behaviour of energy users in the country irrespective of the sector using the energy. It was through an existing database that the data analysis Singh and Yassine recommended could be analysed and an energy behavioural model produced in accordance with the fifth objective of this study.

Conclusively, understanding energy use behaviour in residential houses in Nigeria involved collecting quantitative and qualitative data. Quantitative data helped to understand the quantity consumed, where it was consumed and when it was consumed most. In comparison, qualitative data helped to understand the views of energy users in residential homes in a developing country like Nigeria. Therefore, gathering users' experiences was paramount for energy suppliers to comprehend their understanding and enable optimal service provision. Hence, pragmatism was justifiably adopted as this study's philosophical stand. In summary, pragmatism is the philosophy adopted in this research based on its flexibility in adopting mixed research method of both qualitative and quantitative methods bearing the objective as well as subjective nature of energy saving behaviours to meet the research objectives as highlighted earlier.

### 4.4.6 Axiology

Axiology, the third branch of philosophy, is also considered at each stage of the research process. Axiology examines the role of values and ethics in the research process (Saunder, 2016). The axiological consideration of each research is located along a continuum, which is defined as either value-free at one end, in the case of positivist research, or value laden at the other end, as in interpretivism. In the case of value free research, the researcher separates themself from the research data and perceived as unbiased. This research is value laden (biased) (see Figure 4.3) as the researcher cannot be isolated from the research while the study is data rich requiring the employment of mixed methods (Jaya, 2014). The research is initiated from and its progress is based on the researcher's doubts and beliefs, alongside the role the researchers value play throughout the research (Saunder, 2016).

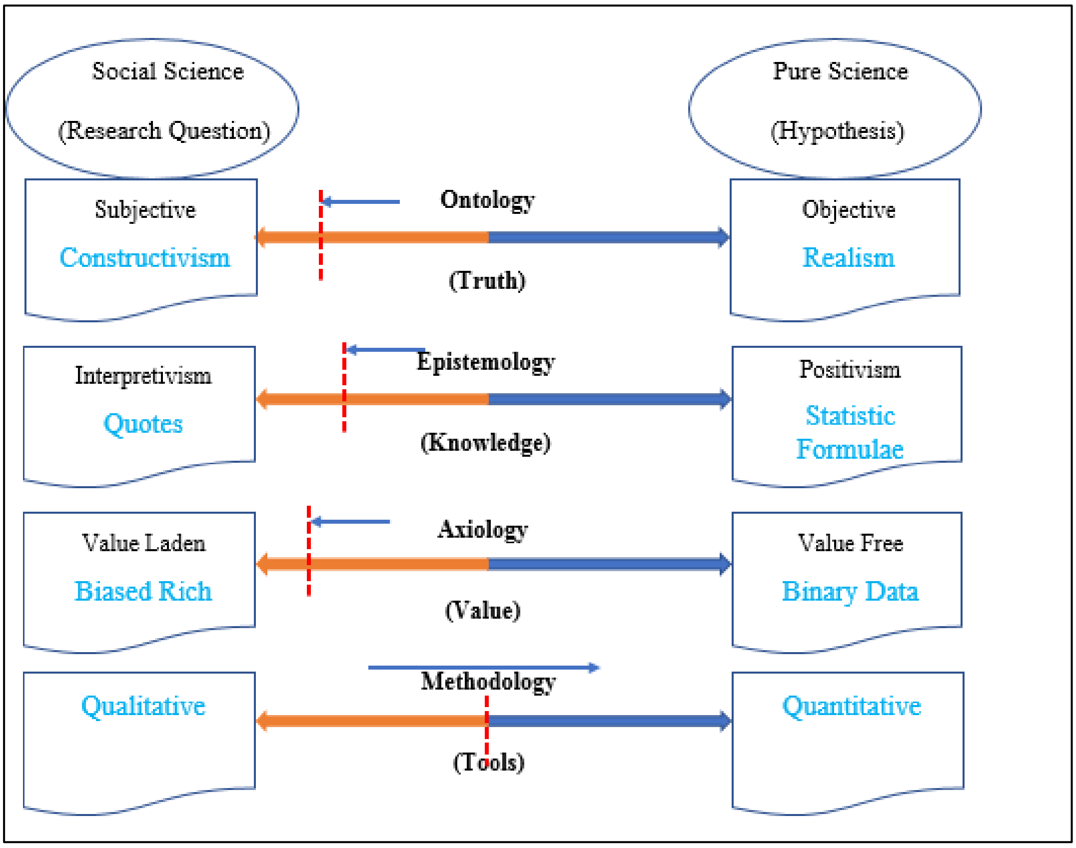



Figure 4.3. Philosophical Stance and Research Position (Lecture notes: LEAP 2018/19 Class).

### 4.4.7 Philosophical Stance

The chosen world view, pragmatism, recognises different ways of interpreting and undertaking research, and that no single viewpoint gives the entire picture, leading to the multiple realities (Saunders et al., 2019). The pragmatist adopts both positivism and interpretivism and the research question is the most important determinant of the research philosophy (Creswell and Clark, 2007). Therefore, the adoption of both quantitative and qualitative methods to assist in answering the research question, as mixed methods research is only a "method," designed to allow researchers to use any number of philosophical foundations to in their justification and application (Ma, 2012).

Secondly, as this study adopted mixed methods research (involving both qualitative and quantitative methods), the ontology of the research tended towards a subjective approach as interviews were undertaken with experts which gave rise to multiple realities. The epistemology involved the use of both quotes and statistics. Therefore, mixed methods research does not necessarily represent a single research paradigm, but is founded within several paradigms (Johnson et al., 2007; Morgan, 2007; Denscombe, 2008). The axiology of the research was value laden. This was because value plays an important role in the interpretation of the results.

### 4.5 Approach to Theory Development

Within the second layer of the Research Onion is the research approach that guides as well as directs procedures in the research design. It is necessary for researchers to determine which research approach suits their study after defining their research philosophy (Saunder, 2016). The use of theory is necessary in research as it provides a background for the research (Bryman, 2016). Theory further offers a framework through which social interactions can be best understood. Thus, when conducting research, data are collected either to test or develop theories towards the end of the research. Three main types of approach exist in research: deductive, inductive and abductive reasoning (Bryman, 2016; Creswell & Clark, 2017).

**4.5.1 Inductive Approach** (Theory building): Inductive reasoning aims to create a general overview, which can be used to identify patterns of descriptions: first, by collecting data to enable generalisations which are then used as patterns to further explain observations. An inductive approach means going from the specific to the general or rather from practice to theory. When using an inductive approach, a small sample can suffice to induce theories from the evidence. Inductive reasoning is commonly associated with interpretivism, and often open-ended and exploratory research. This research applies an inductive approach in the first phase of the study where qualitative results combines with theory from literature to inform the second phase.

**4.5.2 Deductive Approach** (Theory testing): Deductive reasoning aims to test existing theories, construct a theory and or deduce a hypothesis which is further tested by aligning it with empirical results (Blaikie, 2007). It begins with a generalized statement and ends with specific outcomes; it is thus often referred to as a top-down approach and commonly associated with positivism. The use of a deductive approach can help to quantitatively evaluate facts to explain the relationships between variables including cause and effect. The second phase of the research employed a deductive approach where the outcome from the qualitative phase of the research was tested to develop the outcome of the research (model).

### 4.6 Methodological Choice

The research methodology addresses the whole research process. It concerns the development and nature of the study's epistemology. All possible methods are utilised to answer the research question. Furthermore, the selection of the research methodology is affected by the aim of the research, the epistemological considerations and previous work in the area (Buchanan & Bryman, 2007). Traditional research methodologies have long shown a conflict between quantitative and qualitative research (Bell et al., 2018). It has been argued that a quantitative approach (survey and experiments) fails to take into account the disparities that may exist between people and objects within the natural sciences (Wilkinson, 2015). However, the combination of quantitative and qualitative research makes it possible for researchers to understand different viewpoints, positions and perspectives (Johnson et al. 2007). Indeed, Tashakkori and Teddlie (2003) argued that the use of mixed methods combines techniques from quantitative and qualitative research practises and in doing so can address research questions that cannot be answered by using a single method. Furthermore, qualitative research is mostly used synonymously with data collection techniques such as interviews and data analysis, such as data categorisation which produces non-numerical data. Thus, quantitative research is used for data collection techniques that generate numerical data, like surveys. The research method in this thesis integrates qualitative and quantitative approaches in a 'mixed method' approach.

#### 4.6.1 Quantitative Methodology

Quantitative research typically relates to natural science and the quantification of data and analysis (Bryman, 2016). Quantitative research is guided by an objective ontological stance, positivist epistemology and often a deductive approach (testing of theory). Data here is collected and analysed in order to change theory. This data collected is highly structured and results are statistically analysed using descriptive or other forms of complex statistics like regression analysis and correlations (Wilkinson, 2015). Quantitative research is used to examine relationships between variables that are measured numerically. Since data is collected in a uniform way, questions must be framed in a way that convey the same meaning to all participants. The researcher is viewed as independent from respondents. Quantitative research can use a single data collection technique, such as a questionnaire survey, which is referred to a 'mono methods quantitative study'. Moreover, in a situation where more than one quantitative data collection method is employed, this is known as a 'multi-method qualitative study'. In this situation, more than one data collection tool is used, like structured observations and questionnaire, while data is analysed statistically (Saunder, 2016). Proponents of multiple methods believe it can overcome the shortfalls of mono methods.

#### 4.6.2 Qualitative Methodology

Qualitative research is basically exploratory and typically associated with the social sciences and humanities. It is important to note that qualitative research has often been based on a subjective ontological stance with an interpretivist epistemology and an inductive approach (Denzin & Lincoln, 2018). Furthermore, this method is seen to provide meanings from words and images to represent societal phenomena (Creswell, 2014). The researcher, in this case, is not seen as independent from those researched. Qualitative research employs a relatively small of participants, it generates narrow but extensive data showing the narratives of participants (Clarke & Braun, 2018). Data collected in this case are non-standardised, unstructured and require non-probability sampling techniques (Saunder, 2016). Qualitative data collection methods include interviews, focus groups, participant observation/ethnography (Creswell & Clark, 2017) . A single method qualitative research design is referred to as mono method qualitative research. Multi methods qualitative research uses more than one method and can include interviews as well as diary accounts; however, data analysis in all cases uses a qualitative procedure.

Table 4.2: Differences between qualitative and quantitative approaches

| Orientation | Quantitative Approach | Qualitative Approach |
|---|---|---|
| **Paradigm/World view** | Positivism/Realism | Interpretivism/Idealism |
| **Research Purpose** | Confirmatory scientific (Hypothesis and theory testing) | Exploratory scientific method (Hypothesis and theory generation) |
| **Methodology** | Experimental/Manipulative | Hermeneutical/Dialectical |
| **Role of theory** | Deductive approach | Inductive approach |
| **Focus** | Narrow angle lens | Wider and deeper lens |
| **Epistemology** | Objectivity-one single reality, | Subjective, reality is socially constructed, empathetic understanding |
| **Axiology** | Value free | Value Laden |
| **Bias** | Avoid bias | Based on human interpretation |
| **Types of result** | Statistical results, generalizable findings | Descriptive narrative, Pluralistic findings |
| **Research methods** | Questionnaire, survey and experiments, empirical examination, measurements, Structure protocol randomization | Ethnography, Case study, Narrative Interviews, observation Focus group, Recording and Filming |
| **Data Analysis** | Statistical relationship between variable | Use of descriptive data, search for patterns, themes and appreciate variations |
| **Report** | Statistical report-Correlations, Comparism, Statistical significance | Informal narrative Report |
| **Data Type** | Numerical | Non-numerical (words and pictures) |
| **Data instrument** | Variables, Structured and validated data collection instrument | Word, Images participant observation, Field note, Audio recordings |

Although there exist differences, some similarities do exist between the two methods (see Table 4.2). First, both methods address research questions by using empirical observation. They describe data, provide justifications and explain results (Onwuegbuzie & Leech, 2005). Secondly, both methods follow some measures in their study to mitigate possible bias and lack of rigour (Johnson & Onwuegbuzie, 2004). Given the differences between quantitative and qualitative research, some researchers argue that both methods can be combined within research projects, commonly referred to as mixed methods research.

### 4.6.3 Mixed Methods

Mixed methods research is defined as a research strategy that combines qualitative and quantitative research strategies across multiple phases in a research process and underpinned by a distinct philosophical position and method of enquiry (Creswell & Clark, 2017) . Furthermore, two philosophical positions - pragmatism and critical realism - are often associated with mixed methods design (Saunder, 2016). Mixed methods adopt either the inductive, deductive or abductive role in their approach to theory development. The theory aims to provide more focus on research and to develop boundaries in relation to scope (Tashakkori & Teddlie, 2010a). Additionally, the justification for a mixed methods research design is based on a pragmatic approach that reconciles the extremes of qualitative and quantitative data to produce a third paradigm (Gunasekare, 2015). Lopez et al. (2011) provide an in-depth examination of the mixed-methods research design application in behavioural science. Qualitative and quantitative methods "should be combined in such a way that their strengths complement one another, and their weaknesses do not overlap" (Johnson & Turner, 2003). A triangulated approach anticipates that combining methods will result in more valid results than using a single method (Lopez et al., 2011). Qualitative data can help to interpret quantitative results, while quantitative results can corroborate or refute exploratory findings from qualitative research.

Quantitative and qualitative techniques are combined in different ways to form complex and sequential forms. The extent to which these techniques combine produce different types of mixed methods (Creswell et al., 2011). Concurrent mixed methods involve the use of both quantitative and qualitative methods within a single phase. This allows for a more robust response or reaction to the research questions compared to a mono research design. Sequential mixed methods however involve more than a single phase of data collection and analysis; thus, one method’s results and analysis is elaborated in the next. Sequential exploratory mixed methods design has an initial qualitative phase followed by a quantitative phase while sequential descriptive research design starts with a quantitative phase and follows on with a qualitative phase. Mixed method research has certain advantages that include: reducing the weakness of both qualitative and quantitative research, giving the researcher the ability to be flexible, and integrating results to produce generalisable outcomes(Creswell & Clark, 2017) .

### 4.6.4 Rationale for the Choice of Mixed Method

Previous studies have not adequately examined the trends and nuances of energy saving behaviour in Nigeria. Most research on energy saving in Nigeria has been dominated by quantitative approaches (Arawomo, 2017; Eluwa & Siong, 2013; Madugba et al., 2020; Olatunji et al., 2019; Rim-Rukeh & Ogbemi, 2014). The key exception is the study by Hussaini and Abdul Majid (2014) whose mixed methods research was conducted in Bauchi and focused on human behaviour and its implications in the delivery of energy efficiency. The nature of occupant behavioural research in energy requires a mix of social sciences and pure science, suggesting that a mixed methods design will be useful (Sovacool, 2014a). No study has explored energy saving behaviour research from the perspectives of energy and construction experts as well as households in Nigeria. According to Creswell (2014), the most noteworthy justification for adopting mixed methods is the need for multiple viewpoints to provide a broad understanding of a phenomenon by combining qualitative and quantitative measures. In the context of this study, few quantitative and qualitative studies have been conducted in Nigeria, thus adopting this approach allowed a better understanding of the building energy performance gap in which the occupant behaviour has been identified as a contributor (Zou et al., 2018). Specifically, a mixed methods in this study was based on pragmatism as most occupant behaviour research applies a objectivist philosophy and employs quantitative methods, thereby suggesting a gap in knowledge.

## 4.7 Research Strategy

A research strategy describes the methods and procedures involved in conducting research and the various methods used in the data collection, analysis and interpretation (Bryman, 2016). It also refers to the way or approach the research questions are answered by the researcher (Denzin & Lincoln, 2011; Saunder, 2016). The choice of strategy for a research depends largely on the research questions and objectives, which must reflect the outlined approach and philosophy of the researcher (Saunder, 2016). Saunders et al. (2019) suggested eight types research strategy: Archival/documentary research, experiment, survey, case study (often linked to quantitative research but could be used for quantitative, qualitative or mixed methods), ethnography, action research, narrative inquiry and grounded theory (exclusively linked to qualitative design). However, Yin (2014) discusses three criteria for deciding when to apply any of these strategies: the types of research question posed, the degree of researcher influence over the specific behavioural events, and extent of the emphasis on current - as opposed to purely historical - events. In this research, a case study research strategy will be adopted based on the pragmatism that underpins and informs the research. This will allow the use of qualitative, quantitative or a mixed design.

### 4.7.1 Case Study Strategy

According to Robson (2002), a case study is described as a 'research strategy,' which includes an empirical investigation of a contemporary phenomenon in the context of its real-life setting using various sources of evidence. Case studies have been used in multiple situations to contribute to knowledge in situations that relate to individuals, communities, organisations, groups and other phenomena and are often bounded by certain criteria Yin (2003, 2018). It is appropriate to use a case study if the researcher wants to obtain a rich understanding of the research context and processes (Tham et al., 1991). Furthermore, a case study approach can accommodate the use of a variety of evidence, such as interviews, artefacts, questionnaires, documents and observations, and will give an in-depth understanding of the research problem but, as pointed out by Yin (2018), the strategy is closer to qualitative approach.

This research employed a case study design through a mixed methods approach and aimed to explore energy use within the residential buildings of Abuja municipal area council. This allowed for the incorporation of multiple sources of data to address the various aspects of the research questions (Tashakkori & Teddlie, 2010b) and ensure the research is designed with rigour (Onwuegbuzie et al., 2009). It further applied the three types of case study approach suggested by (Yin, 2009): exploratory, explanatory and descriptive. It was exploratory because it explored the attitude to energy consumption in residential buildings in the context of (municipal) Abuja, Nigeria, and because there was no existing research on residential buildings in Nigeria that focused on a municipal area and considered residential energy behaviour. It was also descriptive in its review of household attitude to energy consumption, and explanatory as it used a conceptual framework developed from the findings of the qualitative research to provide useful explanations as to energy consumption in residential buildings including how the variables affected each other.

The choice of case study is particularly useful in exploring the social phenomena that occur in a particular context (Yin, 2018). Also it has been confirmed that a case study is an appropriate when studying unique phenomenon within its setting (Denscombe, 2014). Moreover, for this case study the researcher had good access to the stakeholders within the energy sector which made it easier to acquire the required information for the research.

#### *4.7.1.1 Justification for the Case Study*

The aim of the research was to develop a model for the reduction of energy consumption within residential buildings in Nigeria from an end use perspective in order to inform understanding. The outcome from the research intended to provide an enhanced understanding and awareness of energy saving practices at the household level through the collection of diverse sources of data. This led to the adoption of a mixed methods case study design whereby both qualitative and quantitative data were collected and integrated, and the results used to provide a deeper insight into the case (Creswell and Clark, 2018).

The phenomenon under consideration in this research required the understanding of expert stakeholders (energy providers, energy consultants, energy regulators and construction expert) to enable detailed background information on the case. The adoption of a case study strategy enabled the researcher to address both the phenomenon under consideration and the related contextual factors. Furthermore, it explored the key drivers and barriers to the adoption of energy saving practices and conservation. The adoption of a mixed methods case study design met the need to use both qualitative and quantitative information to provide better insights into the case and the research problem.

Since the research had some “what” research questions, it was deemed an exploratory study as it led to the development of a hypothesis and propositions for further inquiry. Moreover, the “how” research question meant it was also an explanatory case study and would require the documentation of changes over time rather than the study of pure patterns or occurrences. The adoption of a case study in this research enabled a better understanding of the context, particularly with the use of a pragmatic approach.  However, the case was expected to evolve throughout the research.

The other alternative strategy that may have been considered is the grounded theory. A Grounded Theory methodology can referred to as a methodological approach, which comprises a method of inquiry and the result of the analysis (Bryant & Charmaz, 2010; Saunders et al., 2016).  It was further noted that a Grounded Theory strategy uses data collection techniques and analytical procedures that contribute to the development of a theory that describes social relationships and processes in a wide variety of ways (Saunders et al., 2018). This conflicts with main aim of this research as the theory to be produced is this study will not be grounded in the data.

#### *4.7.1.2 Justification for a Single Case*

There are various approaches to the design of a case study depending on the researcher's epistemological experience (Crowe et al., 2011). For instance, a case study may be designed to fulfil certain research requirements; thus, it may be a single or multiple cases. The choice of design is the first step before the collection of data. A single case design involves a meticulous and thorough study into the case through access to case study data. A single case is adopted in situations which require a critical, extreme or otherwise unique case. Dyer Jr and Wilkins (1991) stated that single case studies are safer when the researcher is trying to create a high-quality theory as it can produce an even better theory (Gustafsson, 2017). This also illustrates the needs for the researcher to have an in-depth knowledge of the specific topic.

It is pertinent to note that the selection of a vital case, which represents the typical assessment of an already existing and popular theory or theoretical assertion, is a key rationale for the selection of a single case study. Furthermore, a single case can be exploited when the study deviates from the norms or usual practice, thereby presenting a unique circumstance in the research study. The single case is also relevant where the study aims to capture a situation concerning routine daily activities. Another rationale for a single case study is when the researcher has the advantage to study previous research in which the data were difficult to obtain. Finally, a single case study could be considered when the case is longitudinal in nature and conducted concurrently in two or more diverse points in time (Creswell & Clark, 2017). Also, one of the benefits of selecting a single case study is that the researcher can explore and challenge existing and new theoretical relationships, which is based on the conduct of a more cautious study (Dyer Jr & Wilkins, 1991).

A case study plan may also include several cases meaning it is not narrowed to a single case. The rationale for the use of a number of cases is whether the outcomes can be reproduced across cases (Saunder, 2016). Cases will be carefully selected since similar results are likely to be obtained from each, which - once known - is referred to as literal repetition Yin (2014).

### 4.7.2 Reflexivity

Researcher reflexivity relates to the ways that researchers assess their own identity, positionality and subjectivity. It acknowledges and analyses the researcher's role in the development of the research and how they contribute to the advancement of meaning of the research topic (Anderson, 2008; Guba & Lincoln, 2008; Steedman, 1991). This includes: the need of self-reflection on bias principles, the process of participant selection, theoretical preferences, connections with participants, and different analytical perspectives (Schwandt, 2015). Researcher reflexivity is vital to the overall research process in order to ensure authenticity; it is a quality control technique for qualitative research studies. It is commonly assumed that any individual (the researcher) commences a study with various pre-existing opinions and expectations. Therefore, reflexivity enables a researcher to analyse their own perceptions and the ways they may prove influential upon the data collection, interpretation and analysis (Berger, 2015). Hence, there is a need to outline the reflexivity particular to this research.

As advocated by Finlay (2002), researcher reflexivity was incorporated to the data collection process for this research. Subsequently, the researcher included her perceptions and individual reactions to different situations within the research, which also considered the aspect of cultural bias identified in the literature (Atkinson & Hammersley, 1983). Accordingly, qualitative studies are arguably more likely to be affected by researcher bias than quantitative studies, as a researcher's interests and preferences can prove influential on how a study is undertaken, which can ultimately affect the research findings (Bryman, 2006). Similarly, a researcher's personal demographics and individuality may also affect qualitative research (i.e. with interviews), which include gender, age, race, personal experiences, education and political and professional beliefs. However, it is expected that the researcher is not separate from the research, which is contrary to is contrary to positivist research studies (Hammersley & Atkinson, 2007). Furthermore, researchers need to exert minimal influence upon their participants' attitudes and opinions, whilst remaining aware of the occurrence of potential influences and demonstrating that they understand the field of study (Blaxter et al., 2006). Hence, during an interview process, the researcher is either viewed as an individual who is inside or outside of the discussed topic (Berger (2015).

In the current study, as the researcher is Nigerian and speaks the regional local dialect of Hausa, this made it easier to facilitate the interview process with participants, as access to interviewees and data collection was easier. The researcher could, thus, personally arrange the interview times and venues to best suit individual participants' schedules and religious worship times. This reduced the difficulties in gaining access to interviewees and collecting the data. Furthermore, as the researcher is female, it was easier to gain access to participants, as people showed a high level of courtesy and respect, whilst also acknowledging the family time of the researcher. Separately, the researcher practised reflexivity throughout the study, especially with regard to the literature review, as she read and reviewed different papers that were similar in context to the current study to improve her comprehension of the topic. Indeed, Kurtz (1989) stated that people often fail to observe opposing perspectives or opinions, as prior knowledge can often block new concepts and ideas. Furthermore, to ensure reflexivity and rigour, after the interviews were transcribed, certain interviewees were invited to review the interview transcript. This helped to clarify, correct errors and thereby ensure the quality of the transcription and construct validity (Yin, 2018). Also, multiple sources of evidence were also collected from the case study area involving experts in the qualitative study and the households in the quantitative study.

During this research, a pragmatic approach to reflexivity was important. Three individual forms of reflexivity concerning the researcher's social position were considered (Berger (2015): firstly, when the researcher shared the participants' individual experiences; secondly, when the researcher moved to a position that was inside the research focus instead of remaining outside; and thirdly, when the researcher had no personal experience of the topic. Meanwhile, describing and presenting themed data from the findings was a challenging process, as it was difficult to work with big data to provide descriptions of these themes, especially for the main themes. Originally, with the initial research drafts, the themes were briefly stated with the inclusion of long quotations, although through the support and advice of the supervisor, the researcher was able to balance the themes' descriptions, whilst providing effective and concise quotations.

### 4.7.3 Survey

The survey design is generally linked with the deductive approach to research and often used to address 'who,' 'what,' 'where,' 'how much' and 'how many' research questions (Saunders et al., 2009). A survey strategy quantitatively identifies the views, patterns or attitudes of the population after analysing a sample. A survey allows the collection of uniform data in a highly economical manner (Fellows & Liu, 2015). Questionnaires, structured interviews and structured observations allow for the collection of data which can be analysed quantitatively using inferential and descriptive statistics (Saunder, 2016). This can explain the reason for a possible relationship between variables and produce models of possible relationships. However, one weakness of a survey strategy is that the data are unlikely to be as wide ranging as those collected by others. Finally, it is important to spend time on the design and piloting of data collection methods when using a survey analysis technique to avoid the need to collect another set of data (Saunder, 2016).

#### 4.7.4 Experiment

Experimentation has its roots in natural science and laboratory research although it features strongly in psychology and social science (Saunder, 2016). Experimentation seeks to confirm a hypothesis rather than a research question. Such research appears to be largely dependent on laboratory-based experiments than field experiments (Bryman, 2016). Experimentation studies the probability of change in an independent variable causing a change in a dependent variable. This can help the researcher to examine the existence of relationships between variables. An experimental research strategy can also be used to answer 'how' and 'why' questions in exploratory and explanatory research (Saunder, 2016).

#### 4.7.5 Action Research

Action Research is an iterative investigative method designed to create solutions to specific organisational challenges through a participatory and collaborative approach (Saunder, 2016). Action research contributes to the rapid resolution of practical problems and brings about change in a particular context (Koshy, 2010). In carrying out an action research project, researchers need to develop and use a variety of skills to achieve their goals, such as careful preparation, good observation, and objectively listening, assessing and analysing. Action research is participatory in nature, which has led Kemmis and McTaggart (2000) to classify it as participatory research. They explained that it involves the process of acting and observing the process and consequences of a transition, and reflect on the mechanisms and consequences in order to re-plan, observe and reflect (Kemmis & McTaggart, 2000). Finally, action research draws strength from its emphasis on change, and its recognition of the need to devote time to the analysis, preparation, intervention, assessment and engagement of participants in the research process (Saunder, 2016).

### 4.7.6 Ethnography

Ethnography involves observing an individual or community in their natural setting, rather than in an artificial setting, such as laboratory in science-based research. Ethnography involves collecting data using interviews and observations over a long period of time within a social/cultural community in a natural setting (Creswell & Clark, 2017) . The researcher is thoroughly immersed in the examined social world as much as possible to allow for detailed observation and interpretation as well as an understanding of the phenomenon being studied (Saunder, 2016). When using an ethnographic research strategy, it is important for the researcher to define an appropriate setting, trust the participants, and to plan to spend time on the research problems that need to be properly answered (Saunder, 2016). However, ethnography was not a suitable approach for energy research, or the context of this particular research, namely residential buildings.

## 4.8 Time Horizon

This is the second to last layer in the Research Onion. Consideration of time horizons in research design determines whether the research is conducted at a particular time or over a given period. The research questions are very important when the researcher is trying to determine the amount of time available, irrespective of the methods chosen for the research. A time horizon may be considered cross sectional or longitudinal (Saunders et al., 2009). A cross-sectional time horizon means the research is carried out at a given point in time. Nonetheless, this type of approach does not provide actual information on why circumstances evolve over time and how certain practices occur at the time of the study. A longitudinal time horizon, conversely, could study such developments if the study is conducted over a specific period. This research was carried out for academic purposes and concerns energy saving in Nigerian residential buildings. It also tried to understand the factors affecting energy saving at a particular time; therefore, the time horizon for this research is cross-sectional.

## 4.9 Techniques and Procedures: Data Collection and Data Analysis

Within the central part of the Research Onion is the data collection and analysis. This section explains the methods used to collect and analyse data during a study.  There are several techniques and tools to collect and analyse data, depending on the scope of the problem and nature of the research questions to be answered (Saunders et al., 2009). Techniques used in the data collection include questionnaire surveys, interviews, observations, focus groups, and experiments. The selection of data analysis tools usually depends on the research question and data required (quantitative or qualitative data). The data for this research programme has been obtained from two key research phases. The first of these is a series of semi-structured interviews with energy and building stakeholders while the second phase involves the use of a questionnaire with households.

#### 4.9.1 Interviews

Qualitative data is small, descriptive in nature and requires the collection of detailed and in-depth data (Tashakkori & Teddlie, 2010a). Interviews allow for the collection of relevant, reliable and valid data which are consistent with the research objectives and questions (see Figure 4.4 for a breakdown of considerations regarding interviews). Bourdieu (1977) emphasises the importance of data collection, which requires an understanding of the meanings behind actions. Interviews are seen as social interactions with interviewers and interviewees who share in the construction of a story and its meanings, meaning that both are participants in the process of making progress (Holstein & Gubrium, 1994). Interviews are important when the purpose is to have an understanding behind the experience of the interviewees. Interviews encourage researchers to explore the motivations, beliefs, views and experiences of subjects in relation to the investigated phenomenon (King et al., 2018). They tend to be more interactive and personal in terms of the data collection compared to questionnaires. Additionally they provide the researcher with an opportunity for follow-up questions (Saunders et al., 2016). Nonetheless, interviews are time consuming and resource intensive. They may be conducted face to face, by telephone or through video conferencing. Telephone and video-conference interviews enable the interviewer to gather data quickly and within a short period of time. Based on the level of structure and formality, Saunders et al. (2018) mentioned three major types of interviews:

1. **Structured interviews**: Characterised by the use of questionnaires and based on a prearranged set of questions which are verbally administered, questions are read out and then recorded, and rarely involve follow up questions. Furthermore, this type of interview is more straight forward as the interviewer adheres to the outlined questions for the research with the aim of understanding the responses of interviewees. Although there is social interplay between the interviewer and

interviewee, questions should offer an initial guideline. Data gathered from this type of interview are quantifiable and often referred to as 'quantitative research interviews.'

2. **Semi-structured interviews**: A list of main questions that will guide and structure the discussion and areas to be explored. Depending on the type of background of the interviewee and flow of discussion, certain questions may be omitted but the goal to answer the research question remains in the background of the discussion. This type of interview offers an opportunity for the researcher to ask further or follow-up questions, change the questions based on the interviewee's answers and seek more detail. This approach helps the interviewer to explore and know more about a subject through comments and suggestions.

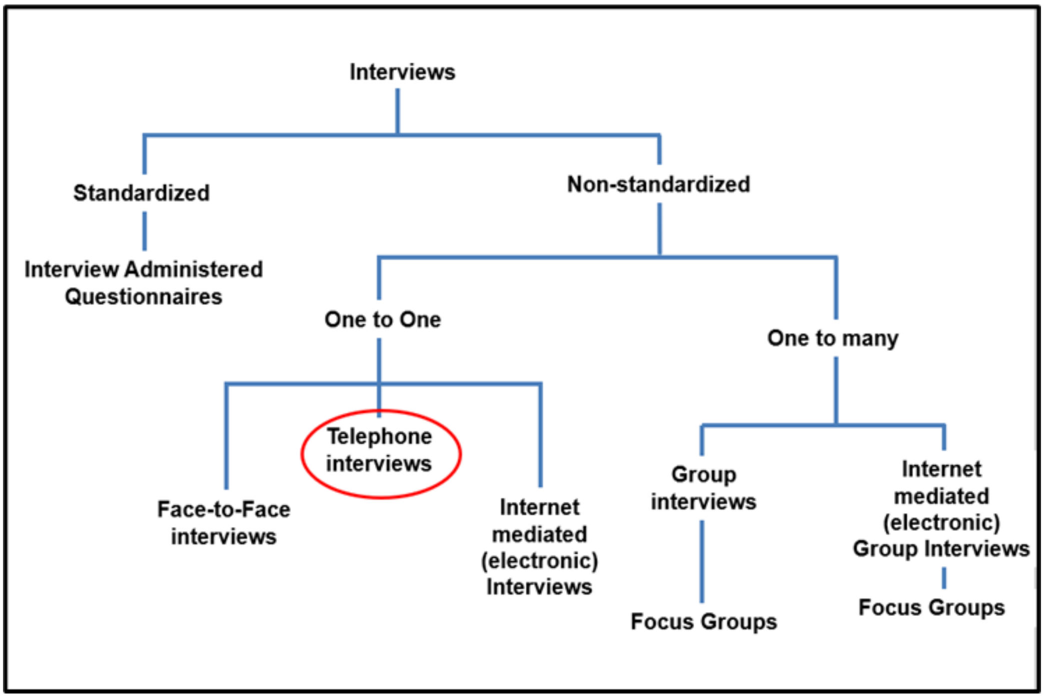



**Figure 4.4**: Interview considerations (Saunders et al., 2018).

3. **Unstructured interviews**: Classified as informal and take time, as the interviewer has no predetermined interview guide and questions to give the interview an explicit direction. In this case, the researcher has a good understanding of the subject area explored. The interviewee is encouraged to speak openly about the subject area activities, beliefs, and values, and as such is referred to as “non-directive”.

#### 4.9.2 Questionnaire

The questionnaire is one of the most commonly used data collections tools within survey research. They are structured data collection instruments in which each person is asked to answer the same set of questions in a predetermined order (de Vaus, 2014). Furthermore, the questions are answered without needing an interviewer present. Each respondent is asked the same set of questions thereby making it an easy and effective way to obtain answers from a broad sample before any subsequent quantitative analysis (Saunders, 2018). Depending on the type of the questions posed, the questionnaires can be categorised as either quantitative or qualitative in its approach to data collection. Questionnaires and interviews are primarily used in the survey but can also be used in a case study strategy. However, the use of questionnaire can be challenging as questions have to address the research question, and thereby addressing the aims of the study (Saunders et al., 2016). Furthermore, questionnaires are not suitable for exploratory studies or those involving many open-ended questions. Most questionnaires yield a better output with structured questions where the respondents can give the same interpretation (Robson & McCartan, 2016). Thus, questionnaires have been found to be most suitable for descriptive or explanatory studies.

In this research, a self-administered questionnaire is adopted, respondents record their own responses to questions in the absence of the researcher (Bell, 2014). There are three types of self-administered questionnaire.

1. Internet mediated questionnaires: Prepared by the researcher using an online survey tool and the researcher shares the links with the respondents. It can also be emailed to respondents.
2. Mail questionnaires: The researcher posts questionnaires with a prepaid stamped envelope to subjects.
3. In-house /delivery survey: Includes visiting a resident's place of work or residence in order to hand over and collect a questionnaire. A draft copy of questionnaire to be administered to households is attached as Appendix 8.

Conversely, the advantage of a questionnaire is that they give respondents the opportunity to answer the questionnaires when they deem fit and to search for evidence to back up their answers. Questionnaires can also be used to collect a large amount of data over a relatively short time and can be cost effective to the researcher. There is also an added advantage with a questionnaire as there is the possibility of avoiding researcher bias. Self-completed questionnaires have the potential for a low response rate as the responder has to have a certain level of literacy to complete a questionnaire (Meadows, 2003).

### 4.10 Research Design and Methodology Adopted

The research design is an action plan to collect, analyse and interpret data in a logical sequence (Yin, 2009). Research studies have different requirements, depending on the data characteristics and information (Fellows & Liu, 2015). The case study method allows the researcher to be flexible in selecting different data collection methods (Saunder, 2016). However, it is important for the researcher to consider methods to adequately answer the research questions he wishes to investigate. In this research, the method selected has been underpinned by a pragmatic stance which allows for the adoption of mixed methods. It will use a combination of qualitative and quantitative (mixed) methods to fill the knowledge gap and understand the problem of energy saving behaviour/attitude in residential buildings.

Data was collected from two main research phases. Firstly, a semi structured telephone interview was carried out with professionals in the field of energy and buildings which covered the initial exploratory stage. It provided the researcher with a better understanding of the experience of participants. All participants were selected from the case study area, namely Abuja municipal. To get an in-depth insight into these factors, an interview schedule was created around these themes. The interview consisted of eighteen professionals from the Nigerian electricity and construction industry. A similar approach is employed to explore an area when there are few journals on the topic (Gupta et al., 2017; Trotta, 2018b).

The interviews were conducted with professionals based in Abuja, Nigeria. These participants were selected based on accessibility and contact with the researcher. Voss et al. (2014) suggested that the ideal contact for a case study is to approach the person that may be most likely to open the door. These participants had 3-24 years' experience in the energy and construction industry. Table 5.1 in the next chapter outlines a brief description of the participants, although further details were omitted for anonymity. Most participants except for "Romeo" have experience working in the electricity and building industry. As the consultants have various experience dealing with key providers around Nigeria, which positioned them as the right participant for this research. The phone interviews were recorded, transcribed, and analysed. The analysis processes involved coding and constructing themes by classifying similarities in the interview data. NVIVO software was used to carry out the thematic analysis. This provided the contextual links to explain the problems and additional detailed qualitative data that helped to generate a questionnaire for the survey. The researcher expected to conduct all semi-structure interviews within the case study area as energy service providers are regionally based.

In reviewing relevant literature on energy efficiency, energy saving behaviour in building and environment, and energy and buildings information journals has shown researches to have conducted 8 to 17 interviews (Galvin, 2015). Similarly, Yin (2014) confirmed that there is no fixed number of interviews required for qualitative research but rather the number of interviews should be determined by the researcher's requirements. Saunders et al. (2015) recommended a sample size of 10–25 interviews for qualitative research. However, the point of data saturation for the semi-structure interviews was attained at 18 interviews. Data saturation was considered critical as it enabled the researcher to curtail further sampling when no new information was generated (Glaser & Strauss, 1967). A limitation encountered was that the majority of respondents were male. This could be attributed to the under-representation of females in the construction industry (Amaratunga et al., 2006; Jimoh et al., 2016). Men have historically occupied majority of the leadership roles and majority of the work force in construction. Although there has been an influx of female students in the science, technology, engineering and math (STEM) subjects by 55% compared to 29% male (Gurjao, 2011), the gender diversity has not improved (Naoum et al., 2020). The number of women working in construction has been between 9-12% since the 1990s, with majority occupying administrative and secretarial positions (Gurjao, 2011; Naoum et al., 2020). This highlights the reason for the dominant of male and under representation of female gender in the construction industry.

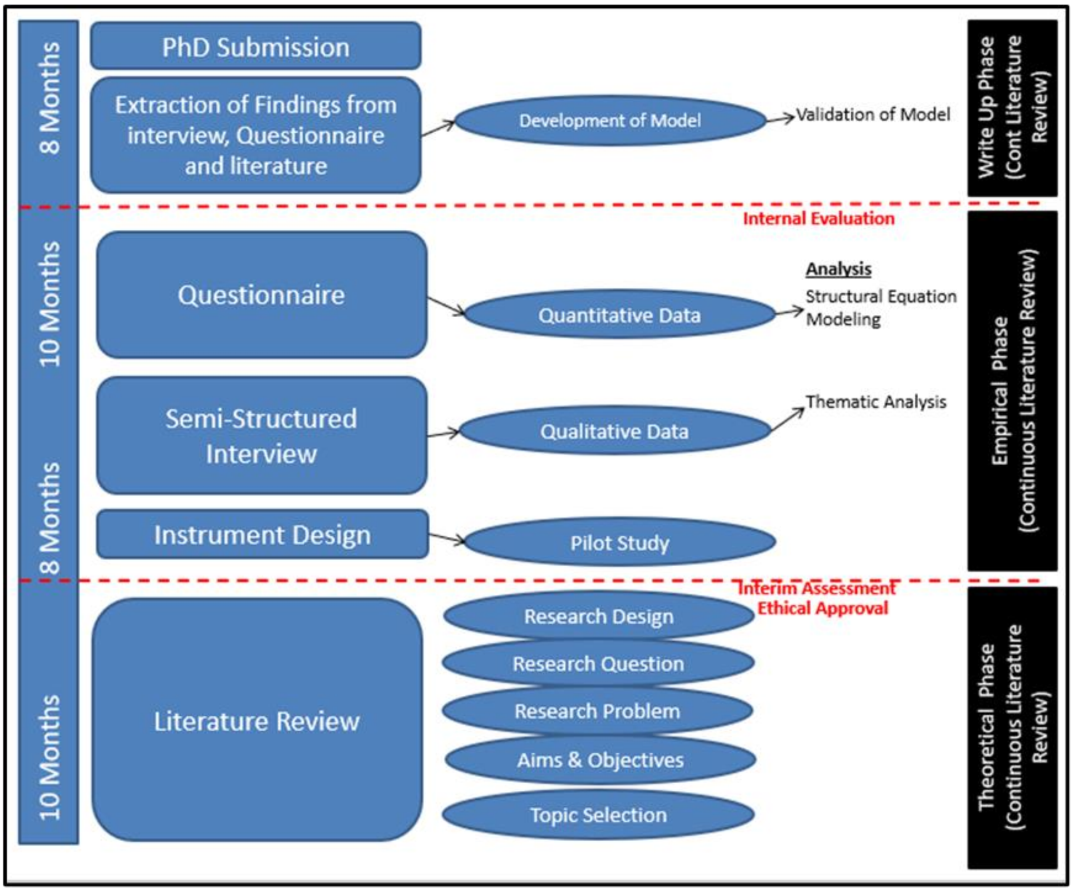



**Figure 4.5**. Research Process

### 4.10.1 Research Design

The research process can be divided into three main stages, as seen in Figure 4.5. This research began by reviewing relevant literature to gain an in-depth understanding of the research and identify key factors required in the study. The research problem, aims and objectives were identified in light of the literature reviewed. At the second stage, an exploratory and mixed methods design was adopted for the study covering two phases, the qualitative followed by the quantitative. These phases of research design were adequately accommodated throughout the process of the study to facilitate the attainment of the objectives of the research as shown in Figure 4.6.

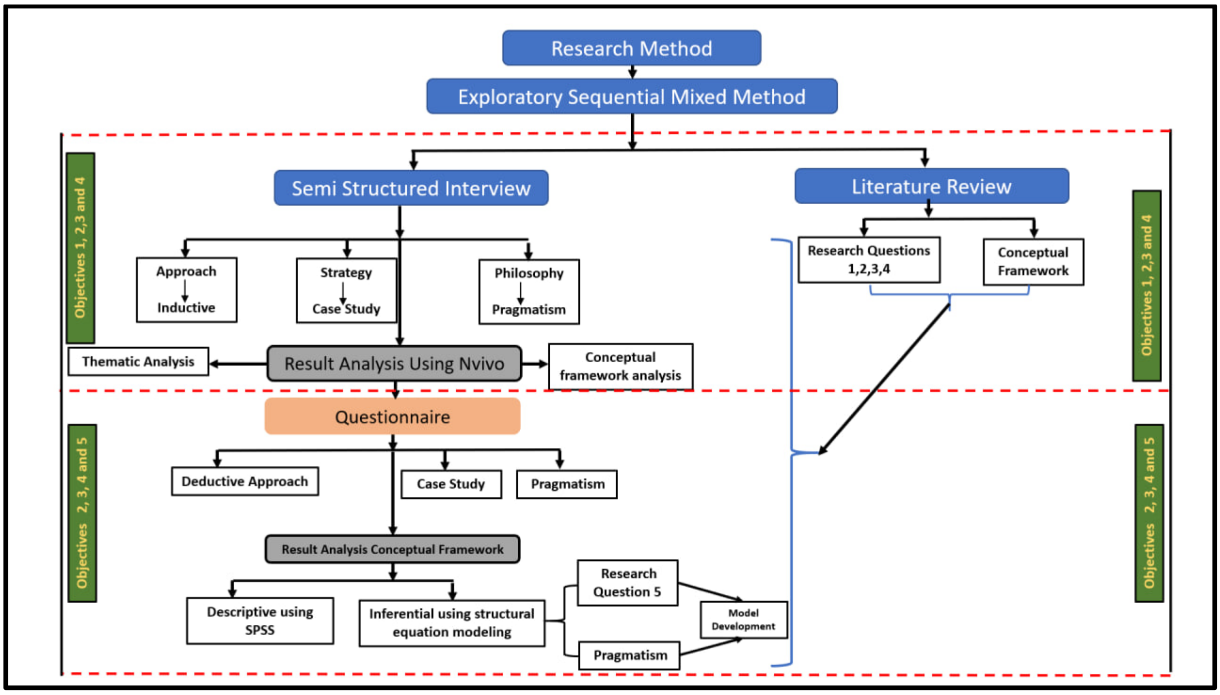



**Figure 4.6**. Research Methods Map

### *4.10.1.1 Sampling and Recruitment Method*

Qualitative researchers rarely use random and other probability sampling methods, which are required for statistical generalisations from a sample to the entire population. The primary objective in qualitative research is specific understanding rather than generalisation. Qualitative researchers frequently employ what is referred to as 'purposeful' or 'theoretical' sampling, which involves the selection of individuals, cases, and settings that are best suited to answer the researcher questions or are most relevant to the theory being developed (Maxwell & Reybold, 2015).

Purposive sampling is a non-probability sampling for identification and selections of cases with vast information that are knowledgeable and experienced with the phenomenon (Creswell et al., 2011). Purposive sampling was employed to select qualitative respondents at the beginning coupled with snowballing to facilitate and accelerate participant accessibility due to the practical limitation of time. This is consistent with the assertion by Saunders et al. (2016) that the majority of conventional research projects find that a combination of sampling techniques is necessary to achieve the desired objectives. Berndt (2020) described snowball sampling as a strategy in which current participants recruit new participants through personal connections. This type of sampling is often used to recruit difficult-to-recruit populations. Respondents assisted in the identification and access to other individuals within and outside their organisation who had the knowledge and provided the in-depth information required (Creswell et al., 2011). At the end of each interview, the researcher requested that the respondent recruited another participant through the snowballing process. The researcher further contacted the respondents through email communication and telephone calls. Additionally, information sheets about the qualitative study were shared with various organisations. Gatekeepers recommended specific individuals, departments, or units to contact in order to capture the contextual relevance of the study. Contact information for participants who received an information sheet (see Appendix three) and agreed to participate was collected with their permission for future correspondence and appointments.

However, for the quantitative element of the study, the targeted population were households with access to electricity in Abuja municipal area (Figure 4.7 showing the research area) who were registered and with a pre-paid meter. Hence, some households in the Abuja municipal area council of Nigeria made up the sampling frame that reflected the phenomenon under investigation. The rationale for the selection of this area resulted from the high consumption of domestic energy from that supplied (Dahiru et al., 2019). Participants were recruited through the energy supplier's database who were involved in the qualitative section of the study. The researcher requested the database of households within the case study area. The research however considered only samples who were given third party permission to access their data. Details of the respondents were then obtained and contacted through a WhatsApp message to inform them of the study. Respondents were sent an open invitation along with survey questionnaires (see Appendix two), to indicate their interest in taking part in the study. To further boost response rates, message reminders were sent at the end of the third, sixth, and eighth weeks following the distribution of the questionnaire. Out of 750 papers and web-link invitations, about 450 expressed an interest in participating in the study. While incomplete questionnaires provided some data, they were excluded from further analysis to minimize the occurrence of missing data and thus increase the reliability of the results.

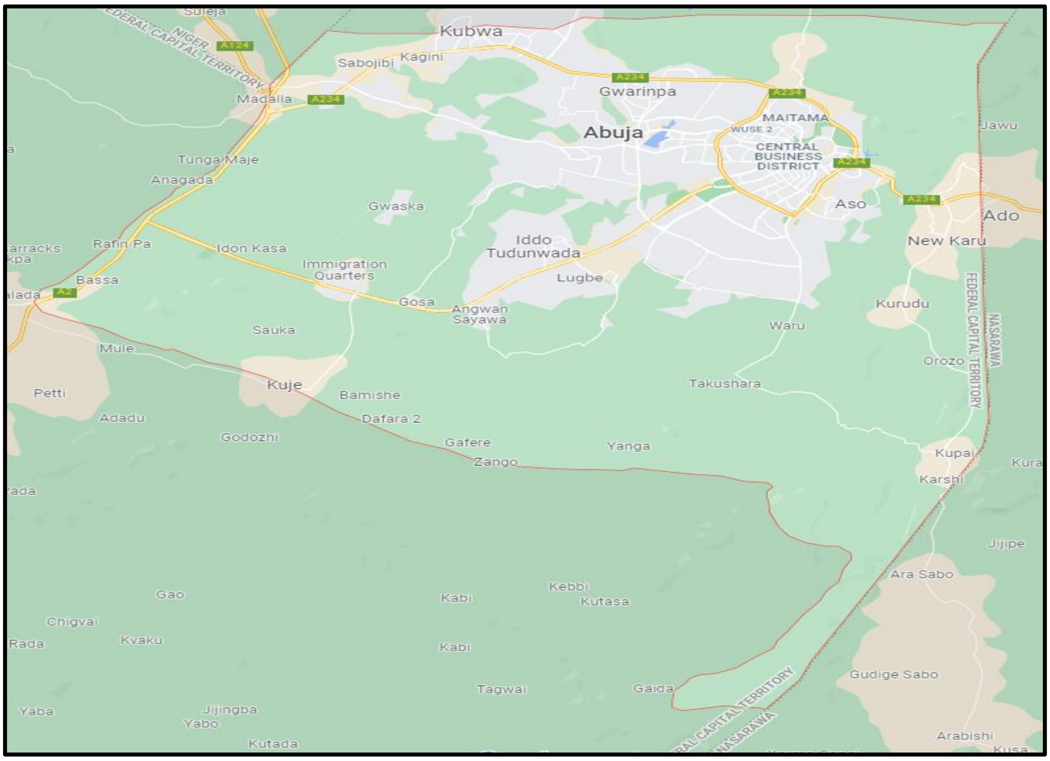



Figure 4.7: Google map of Abuja Municipal area council showing the selected study area.

### 4.10.2 Qualitative Pilot Study

Pilot studies are a key phase of the research process. The aim of the pilot study is to explore the feasibility of an approach intended for use on a larger scale. As stated by Bell and Waters (2014, cited in (Saunder, 2016), ‘however pressed for time you are, do your best to give the questionnaire a trial run’ as this will ensure the success of the questions asked. Prior to the conduct of the interviews, a pilot study was conducted in March 2020. The interviews were conducted with experts from the energy company and building industry. The pilot study was conducted over the telephone as a result of travel restrictions. Access to participants was enabled through personal contacts. The study included four semi-structured interviews with energy providers and building experts. The researcher gathered field notes and the audio recordings of interviews which were later transcribed and analysed.

The pilot study informed the main research in several key aspects. Firstly, interactions between the researcher and participants were seen as more complex and required greater reflexivity and guidance. Furthermore, more ideas to improve the interview guide, line of questioning, and introduction of the issues were gained. As energy expert and building experts were interviewed, conducting the pilot study allowed the researcher to realise that certain questions have to be redirected based on the expertise of the respondent. This led to the creation of two separate interview guides for energy as well as building experts.

Secondly, the feasibility of conducting a lengthy interview over the telephone was considered. Most telephone interviews had a limited length of interview time to make them more accessible for the respondent (Brick et al., 2007). Another issue that was clarified was the possibility of being able to record the telephone interview successfully with no problems encountered with regards to voice clarity. Also, the questions were reviewed, and checked for clarity in order to avoid leading questions and bias.

Another challenge that was identified during the interview was the problem of network signals as well as participants receiving incoming calls which disrupted the interview for some time. This led to the scheduling of some interviews out of work hours for a smooth conversation and without the disruption of incoming calls. Finally, the pilot study provided more clarity to the researcher on the method of interview adopted (semi-structured interview), to enable the researcher to adjust the interview guide and give the respondent the freedom to express their views and opinions. Findings from the semi-structed interview (pilot study), were used to refine the interview guideline and improved the overall clarity, validity and reliability of the study.

#### *4.10.2.1 Interview Guide*

An interview guide was developed to direct the conversation during the semi-structured interview (see Appendix four and five). The design of an interview guide was advocated by Oppenheim (2000), who suggested the guide should be as adaptable as possible while still ensuring that pertinent topics were discussed during the conversation.

The introductory part was about the study, then it discussed the background of the respondents, organisation and involvement with energy efficiency and energy saving relating to the participant's and researcher's background. The second section discussed the organisation's energy efficiency approach, the nature of their involvement with end users and customers, and the success of energy saving initiatives introduced. The third section discussed cultural behaviour, practices, and motivations for energy saving behaviour amongst others. The final section provided an insight into the relationship between stakeholders in the energy and building industry and residential occupants, the challenges faced to the adoption of alternative energy sources as well as the tool for incentives and rewards (see Appendix. Four and five for the interview guide).

As part of the qualitative data collection phase, participants contributed to discussions and expressed their views. Prompts were used to facilitate discussions about energy saving. Finally, at the end of the interview, an opportunity was also given for participants to offer any additional opinions.

### 4.11 Semi-Structured Interview: Empirical Studies

An interview is a conversation usually involving two people, the interviewer, who seeks answers for a particular purpose and the interviewee, the responder. The qualitative interview guide developed was flexible and iterative, meaning it was redesigned continuously (Herbert and Rubin 1995).

As part of the interview efforts, purposive sampling was used to identify and consult energy and construction experts for the qualitative interview. These energy and construction experts included energy consultants, energy providers, construction contractors and energy providers. Purposive sampling is a technique in which individuals with the expertise and information are invited to participate in an interview (Etikan et al., 2016) . These individuals were chosen as they have a relatively high level of knowledge and experience in energy consumption and energy management practices. The identified experts were sent a consent letter and several semi-structured interviews were conducted with them. The interviews were arranged and scheduled at the convenience of the participants. The interviews were conducted informally and were conversational in nature in order to further enhance transparency and integrity. It made the interviewees feel more at ease. A semi-structured interview method was employed, which means the interview guideline was formulated in advance. Appendices 4 and 5 are interview guidelines for energy and construction experts respectively.

The interviews were digitally recorded with the consent of the participants. To enhance the reliability of the interview results, the researcher took field notes during the interviews. The interviews were transcribed by the researcher after the interviews had been completed. Table 5.1 in the next chapter gives a description of the participants' job descriptions, genders and locations, however further details were omitted to protect and anonymise the participants. All participants were engaged on a voluntary basis and as such signed a consent form indicating their understanding of the study and their voluntary participation.

### 4.11.1 Telephone Interviews

Although methodological textbooks indicate that the telephone interview is not well suited to qualitative interviewing (Legard et al., 2003; Rubin & Rubin, 2011), there are circumstances whereby it is considered the most appropriate option. The most frequent argument cited are limitations in the establishment of a rapport and natural interaction (Gillham, 2005; Shuy, 2003). A lack of visual cues is often known to affect the scope of meaning that can subsequently be communicated (Fielding & Thomas, 2008; Gillham, 2005). Authors have proposed that telephone interviews are shorter because they are more exhausting and more difficult to sustain focus (Gillham, 2005; Shuy, 2003). However, despite the stated disadvantages, there are specific circumstances that pose challenges such as when interviewees are in different geographical locations and where delaying the interview to enable face to face contact might be a disadvantage. Telephone interviews have been advocated as relatively inexpensive, convenient and easy to generate a substantial amount of data (Quinlan et al., 2015). Researchers often adopt telephone interviews in a situation where the research is sensitive, where greater anonymity is required or the study is conducted areas with civil unrest or pandemics (Self, 2021); the latter was the case for the researcher at the time of the data collection.

Semi-structured interviews were then conducted on the telephone with experts and sector representatives to elicit expert opinions and insights on energy saving behaviour, including the barriers and motivational factors to energy saving behaviour. However, before the interview was conducted, preliminary contacts were gathered through an introductory phone call, and an email to explain the research, why participation would be appreciated and to arrange a time to set up an interview. Eighteen experts, representing government departments and other private construction firms responsible for household energy and residential building projects were interviewed. The conversations lasted between 45 minutes and one hour 20 minutes.

At the beginning of the interview, the researcher thanked the respondent and explained the purpose of the interview. The respondent’s signed consent form was retrieved and the information on the consent form (see Appendix 3) was reiterated before the recording and interview was commenced.

### 4.12 Quantitative Stage

#### 4.12.1 Quantitative Pilot Study

The significance of a pilot study in quantitative research as a way to test methods and study processes (Pritchard & Whiting, 2012) is well-established. Pilot studies are conducted to allow researchers to practice and evaluate the effectiveness of their planned data collection and analysis techniques. This can help a novice researcher to predict potential problems with methods leading to changes to a large-scale study. Pilots can assist in the assessment of implementation issues related to research design, questionnaire design and sampling methods such as recruitment strategies and sample availability, the adequacy of instruments, and data-collection and analysis plans. Pilot studies can be further used to gain experience and evaluate the potential risks and expenses associated with the study (Lancaster et al., 2004; Leon et al., 2011) .  This provides crucial information to the researcher before embarking on a more time-consuming and expensive investigation (Leon et al., 2011).

The decision to undertake a pilot in this research was made with the aim of ensuring that respondents understood the questions and that meaningful/reliable results were produced to address the research questions. Furthermore, the pilot helped to ensure compliance to the ethical requirements in the research.

#### 4.12.2 Structure of the Survey Questionnaire

The questionnaire was the main instrument used to collate quantitative data in this research. The aim of the questionnaire was to collect data on existing residential buildings especially in terms of energy consumption, the awareness of energy efficient technology and the benefits of an energy saving approach and behaviour. The questionnaire was titled, ‘A survey of energy efficiency and energy saving behaviour in residential buildings. The instrument was presented clearly and included instructions on how to complete it. (Bryman, 2012), suggested avoiding ambiguous, lengthy questions, and double-barrelled questions.

After obtaining results from the interview process and qualitative analysis, as outlined in Chapter 5, the questionnaire was designed in three sections comprising 23 items. The questionnaire design involved consulting several key texts regarding the structure of the questionnaire. (Callegaro et al., 2015) and (Bernard, 2017) addressed forms of bias, Presser & Krosnick (2010) described the re-wording of questions, while elements from the energy culture framework were identified from a number of sources (Stephenson et al., 2010; Stephenson, Hopkins, et al., 2015). The questionnaire mostly comprised closed ended questions to which the respondent was expected to choose their answer from several options. Some of the survey questions captured attitudinal data using relative scores on a 1-5 Likert scale (Oppenheim, 2000). For the questions, 1 stood for "strongly disagree", 3 represented "neutral", whilst 5 meant "strongly agree". A five-point scale was chosen over a seven-point scale in this research for a variety of reasons that included the ease of preparing the item, speed of administration, and lower administration costs. According to previous research, a five-point scale is easily understood by respondents and enables them to express their opinions. Meanwhile, the interviewer could easily read the entire list of scale descriptors (Brzovska et al., 2018). Google forms was utilised as a tool to generate the questionnaire. The questionnaire sections included:

a. **Section A** – General Questions: This section contains questions relating to socio-demographic factors and background information like gender, age, family size employment status, level of education, ownership of appliances, electricity bills per month, building location and dwelling type.

b. **Section B** – Awareness of energy efficient technologies, this section addressed questions relating to psychological factors that included establishing knowledge and problem awareness, values, attitudes and beliefs, norms and practices. Another area covered in this section was barriers to energy saving. This section also included some Likert-scale questions relating to attitude and behaviour.

c. **Section C** – Benefits of using an energy efficient approach and energy saving behaviour. Questions in this section related to the benefits of pro-environmental behaviour. Likert-scale questions were also asked relating to the benefits of energy efficient appliances.

### 4.12.3 Pilot Testing of Questionnaire

This phase of the mixed method research presented the researcher with an insight into the feasibility of the survey and was conducted with households within the case study to acquire more information. A survey enables the researcher to collect large samples of data (Guba &

Lincoln, 2008), providing an in-depth understanding of the current energy savings, establishing the barriers and drivers and exploring the attitudes to energy saving behaviour in residential buildings.

The questionnaire designed for this study adopted both closed-ended, open-ended and a five-point, Likert-style rating scale on importance. This range of question types is attributed to the fact that attitudes, behaviours and opinions do not have absolute values, hence a Likert scales was deemed appropriate for this study. Similar to the qualitative phase of the research, a small sample of respondents in the pilot study were administered the questionnaire that was adapted and modified to collect data from the research respondents. However, in contrast to the qualitative phase, where data from the pilot study was included in the final analysis, the quantitative pilot data was excluded from the analysis because the goal of the pilot was to validate the revised questionnaires.

Having obtained ethical approval (a requirement to conduct the research work with integrity and transparency) earlier, before the qualitative study (see Appendix one), a total of 60 questionnaire web-links were sent out to the targeted respondents a month prior to the actual study. The role of the respondents was to provide feedback on the challenges that could affect the completion of the survey. The feedback received was utilised to improve the question phrasing of the final questionnaire. Participants were free to withdraw from the study at any time and could refuse to answer certain questions if they were not comfortable to do so. It was made clear to participants that agreeing to complete the questionnaire and submission of their response signified consent for their data to be used by the researcher. After a couple of weeks, the data collection link was closed, and 45 valid questionnaire responses were received. The following were some of the difficulties encountered during the pilot study that were used to improve the final instrument:

1) Response rate to the pilot study was low. The researcher had to send follow up reminders prompting the participants to complete the pilot study. However, the respondents complained about the clarity and that the questionnaire was too lengthy. This was addressed in the main study by reducing the numbers of questions and rewording some to ensure clarity.

2) Other respondents complained about the web-link being inactive. The researcher addressed this in the main study by engaging an assistant to distribute paper copies of the questionnaire which were retrieved once completed.

In accordance with the suggestions, the questionnaire was updated after the pilot study for the next phase of the data collection.

#### 4.12.4 Preliminary Analysis of the Pilot Study

After collecting the data from Google Forms, they were converted to a Microsoft Excel spreadsheet and checked for incomplete responses, missing data and inconsistencies. The identified errors were corrected, deleted, or left unchanged according to the gravity of the error, (extreme or normal) in accordance with the suggestions by Van den Broeck et al. (2005). Analysis was expected to give a better understanding of the attitude and behaviour of stakeholders towards energy saving in practice. Since there is no standard for size of questionnaire (Butler et al., 2016), about 750 questionnaires were sent out to households in the case study area to identify their knowledge of energy saving in the built environment. This enabled adequate access to information to provide sample representativeness. The pilot study was also conducted to determine the scale reliability and to validate the instrument. Additionally, the pilot test was used to ensure the survey's effectiveness and sufficiency. Furthermore, by adopting survey research, the researcher was able to sample opinions from relevant actors. All respondents for the study were drawn from urban areas, as these places had access to electricity and other forms of energy. Finally, as English is the official language spoken in Nigeria, the questionnaire was provided in English (see Appendix two)

#### 4.12.5 Assessment of Normality

The most fundamental assumption in statistical analysis is normality. Hair et al. (2014) defined normality as the shape of the data distribution for an individual metric variable and its correspondence to the normal distribution, and the benchmarking for statistical methods. Normality was assessed using kurtosis and skewness, Kolmogorov-Smirnov, and Shapiro-Wilk, and histograms (see Figures 4.8, 4.9 and 4.10). The results showed that the score for each variable was normally distributed. Other methods used were linearity and homoscedasticity, normal and detrended Q-Q plots, normal P-P plot, and scatter plot, which all indicate that the data were normally distributed.

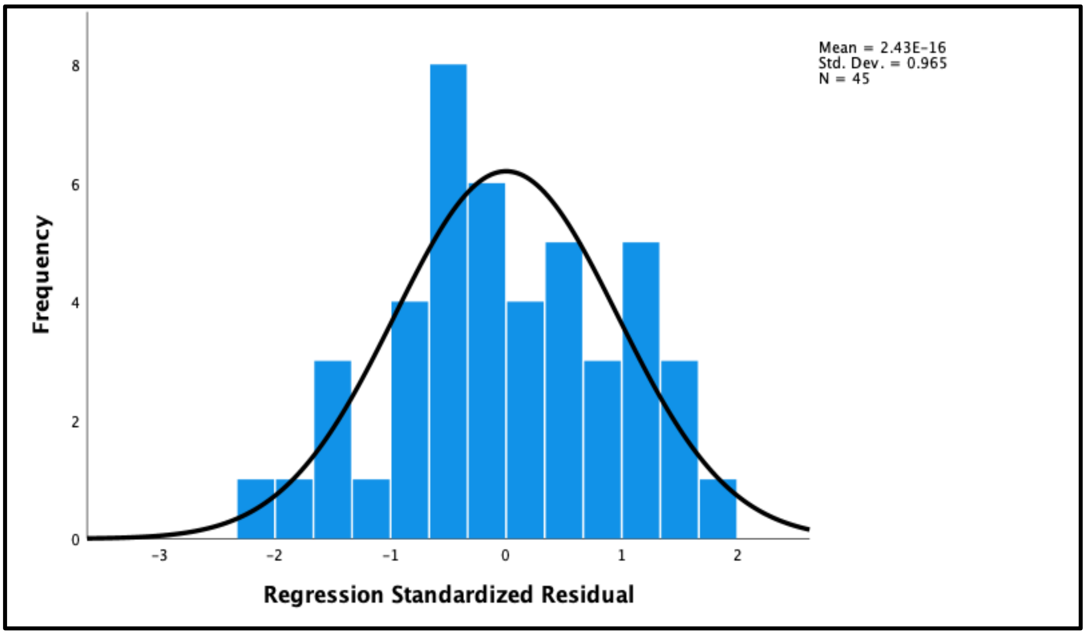



Figure 4.8:  Dependent Variable: Total Sustainable Development Goals.

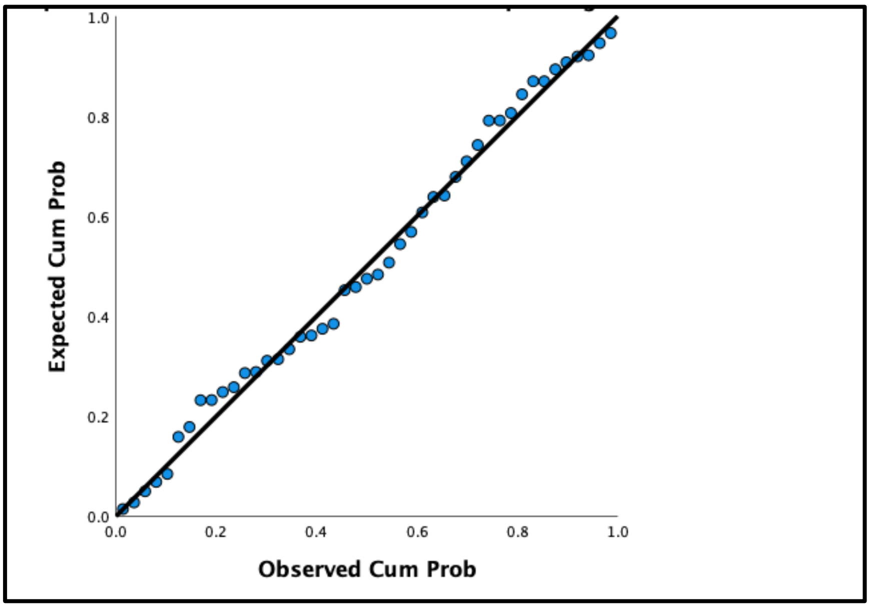



Figure 4.9: Normal P-P Plot of Regression Standard Residual Dependent Variable: Total Sustainable Goals.

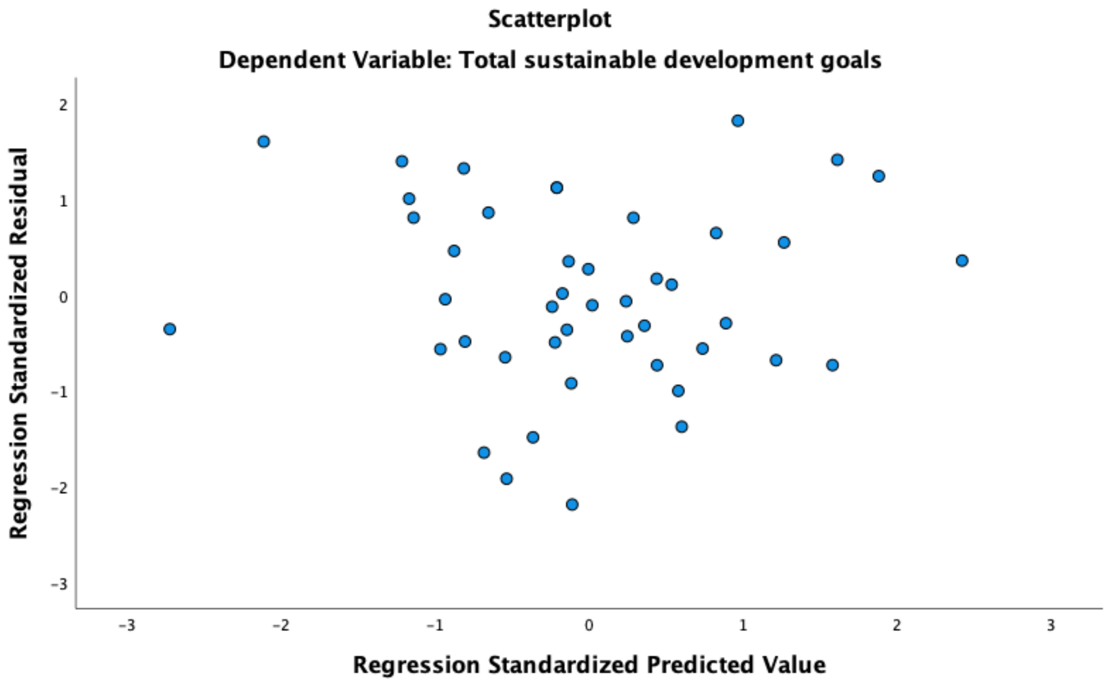



Figure 4.10: Histogram, normal P-P plot, and scatter plot.

### 4.12.6 Assessment of Reliability of Pilot Scale

Reliability is an assessment of the degree of consistency between multiple measurements of a variable. The measure of reliability is internal consistency, which applies to the consistency among the variables in the summated constructs. Cronbach's alpha is the best way to examine a construct's internal consistency, which should normally be equal to or greater than 0.7, while a value of 0.6 is sometimes acceptable (Sest & March, 2017). In this pilot study, the value of Cronbach's alpha coefficient was above 0.7, indicating good internal consistency and thus reliability (see Table 4.3).

Table 4.3. The reliability of the pilot test.

| Constructs | Cronbach's Alpha based on standardized items |
|---|---|
| Obstacles to energy efficiency strategies and saving habit | 0.841 |
| Energy saving behaviour | 0.754 |
| Energy efficiency approaches | 0.890 |
| Sustainable development goals | 0.847 |

### 4.12.8 Validity

With regards to the questionnaire, internal validity refers to the ability of the questionnaire to measure what it is intended to measure, which entails the accuracy of measurement (Saunders et al., 2019). Although different writers use different labels to characterise the techniques used to assess validity, there are two widely utilised methods. Content validity and construct validity are the terms used to describe these two concepts. The validity of a questionnaire is often discussed in relation to content validity, criterion-related validity and construct validity.

**Content or face validity** reflects the subjective agreement among experts that a scale logically reflects the concept that is the focus of attention (Zikmund et al., 2010). Content validity can be determined by asking other experts whether the scale appears to capture the concept being measured (Bryman, 2012), in this case questions in the questionnaire (Saunders et al., 2018). In this research, content validity was ensured by designing and refining the questionnaire with the research supervisor.

**Criterion validity** is assessed by statistically testing a new measurement technique against an independent criterion or standard (concurrent validity) or against a future standard (predictive validity) (Bellamy, 2015). Each item forming the scale must reflect the construct correlate with the other items within a scale (Churchill et al., 2010). Convergent, discriminant, and nomological are the three categories of construct validity. In this research, criterion validity was the degree to which variables from an energy culture framework, as well as the sociodemographic factors which explained household energy savings in real-life scenarios.

**Construct validity** is the experimental evidence that a test measures the construct it purported to measure. It is often used in constructs of attitudinal scale. Construct validity was also applied in the identification of variables from the earlier chapters.

### 4.12.9 Correlation and Regression Analysis

The analysis of the pilot study indicated a strong correlation among the constructs under investigation. Also, the correlation between energy efficiency, energy saving, and sustainable development goals was strong, which was not surprising given the existing body of work that already indicated relationships of that nature (see Table 4.4).

Table 4.4: Correlation coefficient of the main constructs.

**Correlations**

| | | Total energy saving behaviour | Total energy efficiency strategies | Total challenges of energy efficiency strategies | Total sustainable development goals |
|---|---|---|---|---|---|
| Total energy saving behaviour | Pearson Correlation | 1 | .004 | .116 | .330* |
| | Sig. (2-tailed) | | .980 | .447 | .027 |
| | N | 45 | 45 | 45 | 45 |
| Total energy efficiency strategies | Pearson Correlation | .004 | 1 | .322* | .155 |
| | Sig. (2-tailed) | .980 | | .031 | .311 |
| | N | 45 | 45 | 45 | 45 |
| Total challenges of energy efficiency strategies | Pearson Correlation | .116 | .322* | 1 | .474** |
| | Sig. (2-tailed) | .447 | .031 | | .001 |
| | N | 45 | 45 | 45 | 45 |
| Total sustainable development goals | Pearson Correlation | .330* | .155 | .474** | 1 |
| | Sig. (2-tailed) | .027 | .311 | .001 | |
| | N | 45 | 45 | 45 | 45 |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

### 4.13 Technique and Procedures (Data Analysis)

Several techniques were recommended in academic literature when analysing the results; these depended on the type of data available to the researcher. This research generated both qualitative and quantitative data. However, quantitative data were analysed through structural equation modelling as the research contained unobservable latent variables (attitude, norms, behaviour) which were best analysed using that method. It would also allow for the analysis of structural relations between the latent and measure variables.

### 4.14 Justification for the Thematic Analysis

Thematic analysis is a qualitative approach to data analysis that is descriptive in nature. It is also described as a method for identifying, analysing and reporting patterns within the data (Clarke & Braun, 2018). Thematic analysis involves finding common threads and understanding underlying patterns and relationships that exist across a set of interviews to help draw valid conclusion about a phenomenon. It provides a purely qualitative, comprehensive and distinct account of a set of data. This process enables an understanding by the reader of the results from the raw data that culminates in useful information.

Although it is primarily desirable for a thematic analysis researcher to consider both latent and manifest content in data analysis, the content analyst may choose between manifest (developing categories) and latent content (developing themes) before proceeding to the next data analysis level. The choice of thematic analysis for qualitative data analysis in this research meant that the risk of missing context was eliminated (Vaismoradi, Turunen, & Bondas, 2013). Furthermore, the decision was influenced by the researchers' pragmatic position, which focused on best answered the research questions. A classic thematic analysis was used that was guided by the research questions. Although thematic analysis has been criticised for not being robust and lacking sophistication (Smith & Firth, 2011), it is broadly used, and new researchers find it beneficial for developing "core skills that will be useful for conducting many other forms of qualitative analysis" (Braun & Clarke, 2006) in (Nowell et al., 2017, p. 2). Thematic analysis is also employed in multiple methodological approaches (S. M. Ravitch & M. N. Carl, 2019). Furthermore, the approach can be used when using inductive research without affecting the research scope, as is in the case of this research.

#### 4.14.1 Analysis of the Data

The analysis started with the transcription of the interviews that took about three days for each one-hour interview. The process involved listening to the recorded audio, and transcribing and clarifying with some of the participants. Qualitative data was analysed using thematic analysis, with the computer assisted data analysis software, NVivo. The software has several features that allows for the management of complex and unstructured data. Important themes were identified and analysed using a non-linear, step-by-step reiterative process. A theme was the categorisation of areas of focus based on data relating to the research interests of the analyst. Furthermore, these themes were identified in the transcript notes which provided a foundation for understanding the theories behind the data which could contribute to literature on the research focus (Maguire & Delahunt, 2017). Themes and codes can be easily identified with the aid of software. The process of coding and creating themes started with the categorising the similarities and differences in the interview data (Matthews & Ross, 2010; Yin, 2018). It was observed that some feedback from the interviews were difficult to group because they were lengthy and could have been the influenced by the experiences, perceptions and opinions of the respondents. Consequently, more focus was given to the research questions, without neglecting the valuable further knowledge obtained during the interview sessions. Furthermore, the participants were labelled from alphabetically (using NATO phonetic alphabets) to ensure the confidentiality of the results without compromising the interview data. The analysis of the themes was conducted using a six-phase thematic analysis format adopted from Braun and Clarke (2012), as shown in Figure 4.11.

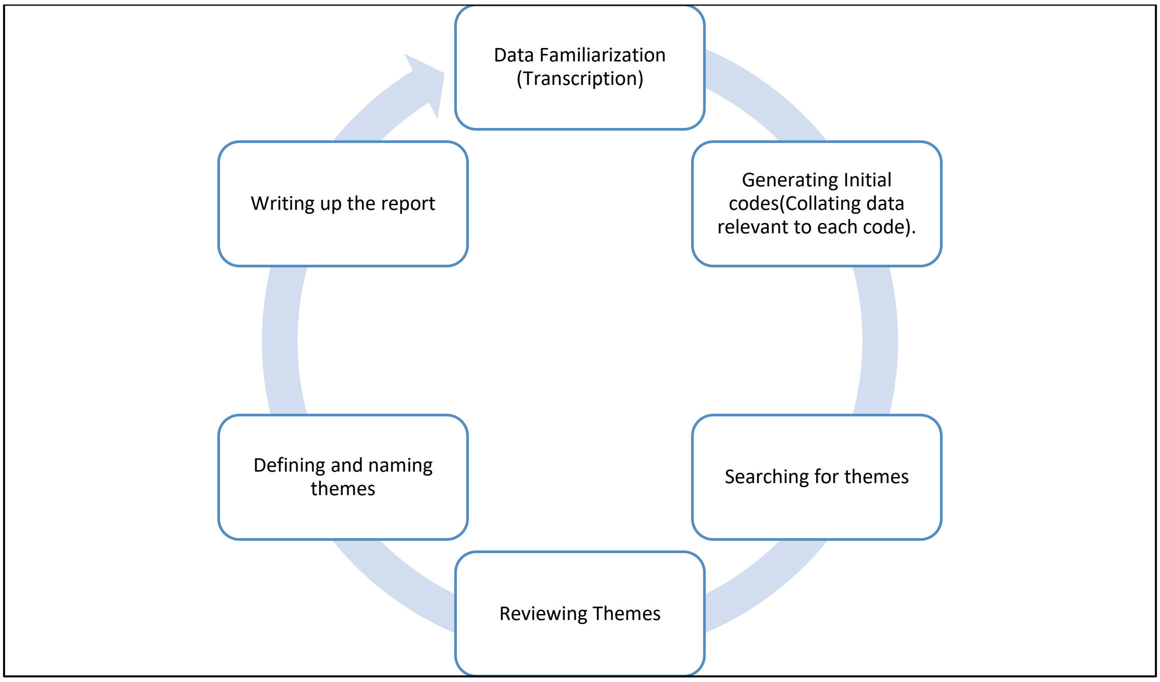



Figure 4:11: Thematic Analysis format adopted from (Braun & Clarke, 2012).

#### 4.14.2 Justification of SEM

Structural Equation Modelling (SEM) is a quantitative analysis technique frequently used in social-psychological research to determine the applicability of the predetermined theories to the datasets. This technique is used to investigate possible causal relationships between hypothesised constructs, which are composed of variable groups. These variables typically correspond to question items in questionnaire surveys. The SEM is achieved through a series of multiple regression calculations. Covariance and/or correlations between variables are critical because they enable the researcher to incorporate both causal and non-causal relationships between variables. Correlation estimates between variables enables the researcher to estimate the direct and indirect effects of other variables more accurately, especially in complex models with a large number of estimated parameters. Typically, the constructs under consideration are unobservable and are quantified indirectly through a variety of indicators. Thus, SEM was an appropriate data analysis technique because it was capable of accounting for measurement error and producing unbiased estimates of the relationships between constructs (Hair et al., 2021). Data was input into SPSS AMOS using the raw data file as input. This calculated the test statistics that corrected against inflated chi-square statistics and bias in the critical values when determining coefficient significance and standard errors.

### 4.14.3 Unit of Analysis/Case

The unit of analysis refers to the subject from which the researcher collects information. This can focus on people, structures, organisations, initiatives, perspectives, geography, activity and time (Patton, 2015). It represents the major entity the researcher is analysing within the research, namely the “who” and “what” (S. M. Ravitch & N. M. Carl, 2019). Determining the unit of analysis is important when selecting participants and conducting the analysis as it enables the researcher to make sense of the data. The research question determines the unit of analysis. It is important to understand the unit of analysis is as it guides the development of codes and the coding process as the research progresses (Bengtsson, 2016). Based on the above, the unit of analysis in this research was households as it is the unit to be analysed in terms of energy saving behaviour and sustainability practices.

## 4.15. Ethical Considerations

The concept of ethical considerations and their relationship to research procedures are an important aspect of any study involving human respondents (Bryman, 2016). It is concerned with giving direction to researchers in a particular discipline about how to undertake their research in a morally defensible manner (Forrester & Sullivan, 2018). Saunders et al. (2019) refers to ethics in the research context as the appropriateness of behaviour in relation to the rights of those who become the subject of the research or are affected by the research. With particular reference to social science, ethics is defined as moral deliberation, choice and accountability on the part of the researcher during the research process (Joungtrakul & Allen, 2012). Research ethics also involve the formulation and clarification of the research topic, including the research design, access to subjects, data collection process, storage and the reporting of research findings in a moral and ethical manner. Research ethics is also a function of responsibility. This requires decision making and responsibility, such as the social and moral responsibilities of the researcher (N. K. Denzin & Y. S. Lincoln, 2011). Other duties include the responsibilities related to individual researchers, research subjects, professional peers and the learning community, and to research sponsors (Hitchcock et al., 1995).

Ethical concerns were considered by the researcher and in accordance with the research ethics framework presented by the University of Salford. The recommended training on ethics were attended and ethical approval forms were filled, submitted, and approved by the University of Salford's research ethics committee before the data collection was started (see Appendix 2 for the approval letter). The University of Salford's policy in relation to human participant and personal data were strictly followed. Also, a non-disclosure agreement was signed with the interviewees in the form of consent forms to maintain confidentiality and anonymity. Password-protected portable external hard drives were used to store the research data and relevant information about the study participants. Using this method ensured that sensitive data was stored without fear of unauthorised access or disclosure, and the responses of participants remained completely private and anonymous.

Below are three frequently raised questions in ethical research guidelines formulated by professional associations.

**Informed Consent-** In this situation, research participants have the right to know that they are being investigated, the right to be informed of the nature of the research and the right to withdraw at any time (Silverman, 2016). For this study, participants were given information on what their participation entailed, the potential risks, how their data would be handled, who would have access to their data, and the goals and purpose of the research (S. M. Ravitch & N. M. Carl, 2019). In certain cases, the researcher would need to follow a complex and long process for approval of the theoretical sample and for permission to contact the research participants. Attached in Appendix 3 is a consent letter to the research participants. For the qualitative phase of the study, informed consent was sought by email and returned before the interview. At the beginning of interviews, it was read to the respondent to ensure their approval before a recording was started. However, in the quantitative phase, access to follow-on questions could not be continued unless the inform questions were accepted.

**Confidentiality-** The concept of confidentiality is based on the principle of respect for autonomy and is taken to mean that personal information collected during the research process will not be disclosed without permission (British Sociological Association BSA, 2004). The concept of confidentiality is strongly related to anonymity in that anonymity is one way to maintaining confidentiality (Wiles et al., 2008). Nevertheless, the anonymisation of data will not address all problems posed by concerns regarding confidentiality. Confidentiality often means not deliberately revealing any details collected from the interviewee that could lead to the recognisation of the interviewee. This means that a researcher is obliged to protect each participant's identity, place and research location. All participants in the qualitative and quantitative studies were anonymised.

**Trust-** Trust mostly concerns the relationship between the researcher and participants and it is the responsibility of the researcher to carry out the research in a responsible manner so as to enable future researchers access to the subjects (Silverman, 2016). Trust is seen as key to a good field relationship, which is a continuous challenge throughout the research process. As mentioned by Lincoln and Guba (1986), the primary methods of assessment in qualitative research should centre on the study's trustworthiness and authenticity. In qualitative studies, researchers focus on trustworthiness and authenticity as opposed to reliability and validity in quantitative studies.

### 4.16 Strategies Adopted for the Reliability and Validity of Research Data

Qualitative research is frequently criticised as biased, small-scale, subjective, and lacking in rigour; however, when conducted properly, it is unbiased, systematic, accurate, in-depth, reliable and rigorous (Anderson, 2010). Brinks, Van Der Wall and Rensburg (2006) suggest that these critiques centre on the assumption that the methods used to establish reliability and validity in qualitative and quantitative research are the same whereas, in reality, qualitative researchers appear to reject this terminology in favour of consistency, reliability and the recurrence of trustworthy patterns and transferability. It has further been shown that directness, depth and observation details in qualitative research afford better validity than quantitative research (Rubin & Babbie, 2016). Although the terms reliability and validity have predominantly been related to quantitative research, they are increasingly seen as vital elements in qualitative research (Aspers & Corte, 2019). Investigating the data for reliability and validity means evaluating the objectivity and quality of the research. Also, validity relates to the credibility and accuracy of the data, while reliability relates to the reproducibility and consistency of the data (Guest et al., 2012).

The validity of the research findings considers the degree to which the findings reflect a true representation of the phenomena they are designed to portray. The reliability of the study relates to the reproducibility of the results (Anderson, 2010). Validity may be based on various techniques, such as the triangulation of contradictory evidence, validation with the respondents and constant comparisons. Also, in this study a pilot study was first conducted which enabled the researcher to modify the interview guideline and procedure before the main data collection. Certain strategies were developed to reduce bias in the data collection and analysis. As the data for this research study were collected via web-based and print survey questionnaires, it was difficult to ensure that participants' views, opinions, and responses to sensitive questions were not biased. The research was also not influenced by or prevented from reporting findings that showed respondents' use of energy in a negative light due to the support for energy conservation and the reduction of carbon emissions. Rather, the researcher assumed that participants would not be biased in their responses to the survey questions. As a result, this was one of the study's limitations.

Finally, the interviews were recorded, and notes were taken that allowed the researcher to be able to quote the interviewees verbatim to support some findings.

**Conclusion**

This chapter presented and discussed the philosophical allegiance, research design, methodology, methods and pilot study (both qualitative and quantitative). Also, information concerning the study's validity, reliability, sampling and recruitment, data collection and analysis, instrumentation, safeguarding, and bias were discussed. The next chapter discuss the results and findings from the qualitative phase of the research.

# Chapter 5: Result of Qualitative Data

### 5.1 Introduction

This chapter discusses the qualitative data generated through semi-structured interview with expert stakeholders from energy and building industry. The chapter also discusses the themes, sub-themes and third level lower themes generated from the Nvivo codes used to analyse the results. Additionally, an analysis of the various themes, sub-themes and sub-sub-themes is given, while also highlighting relevant statements from the respondents. Finally, the chapter discusses the findings from the study in relation to key sub questions on energy saving behaviour.

### 5.2. Towards Energy Saving in Residential Buildings in Nigeria

Stephenson et al. (2010, p. 1)submits that "achieving a 'step-change' in energy saving behaviours will require enhanced knowledge of behavioural drivers, and translation of this knowledge into successful intervention programmes". Using the 'Energy Cultures framework', they provided an understanding of the factors that influence energy consumption behaviour, which helped to identify opportunities for behaviour change. This study extends their work by providing perspectives from different energy practitioners on key factors related to energy saving in residential buildings in Nigeria.

This qualitative study contributes to a mixed-method approach aimed at developing an energy consumption behavioural model to reduce energy consumption in Nigeria. The research objectives/questions that framed this qualitative inquiry thus focus on identifying the factors that influence occupants' behaviours and attitudes towards energy consumption in residential buildings in Nigeria. This includes the use of drivers to facilitate the adoption of energy-saving practices and existing barriers for stakeholders, assessing the roles of relevant stakeholders in energy-saving practices and determining the future of sustainable energy technology and policies in Nigeria.

In addition, the qualitative research focuses on addressing the broad question: "What factors and practices related to behavioural change are relevant in reducing energy consumption and how can the existing cultural framework contribute to developing a suitable model for energy saving in Nigerian residential buildings?”. The factors address the drivers and barriers of energy-saving while practices relate to behavioural patterns.

### 5.2 Feedback from the Qualitative Inquiry

This report is based on transcribed data from one-on-one, oral interviews with 18 energy practitioners including four energy service providers (SPs), four energy regulators (Reg), four construction experts (CE), and six energy consultants (Con). Details of the respondents are provided in Table 5.1.

Table 5.1: Details of Interview Respondents

| Transcript Code | Gender | Qual | Work Exp (Yr) | Job Title | Organization Size | Relationship with Energy |
|---|---|---|---|---|---|---|
| Alfa | Male | M.Sc, Dip | 10 | Ex. Director | 100 (ad hoc) | CE |
| Delta | Female | MSc. | 8 | Lecturer | Students | CE |
| Oscar | Female | M.Sc. | 10 years | CEO | Students | CE |
| Papa | Male | B.Sc., MSc. | 11 | Director | 15+ (ad-hoc) | CE |
| Bravo | Male | MBA | 6 | C. PRO | 2700 | SP |
| Foxtrot | Male | B.Eng., Msc. | 15 | MD | 258 (ad hoc); 27 (Perm) | SP |
| Hotel | Male | B.Eng., Msc. | 24 | GM (Tech. Services) | 3000 | SP |
| Juliet | Male | B.Eng., MBA | 24 | GM | 480 | SP |
| Charlie | Male | M.Sc. PhD | 8 | Snr. Res. Fellow | 80-100 | Con |
| Echo | Male | M.Sc. | 11 | R&D (Energy Sys) | 80-100 | Con |
| Kilo | Male | B,Eng | 12 | Pr. Engr. (Renewable Energy) | 400 | Con |
| Lima | Male | MSc. | 12 | System Analyst IoT | 100 | Con |
| Quebec | Male | PhD | 10 | Principal Partner | 6 | Con |
| Romeo | Male | BSc., M.Sc. | 3 | Seismic Interpreter | 50 | Con |
| Gulf | Male | B.Eng., Msc. | 6 | Snr Manager | 200 | Reg |
| India | Male | B.Eng., Msc. | 11 | HSE Manager | 200 | Reg |
| Mike | Male | B.Eng. | 6 | Snr. Mgr (Regulation & Standard) | 160 | Reg |
| November | Male | MBA | 5 | Regulation & Standard | 165 | Reg |

## 5.3 Themes and Sub-Themes in Energy-Saving Processes and Practices

The initial analysis of the transcribed data resulted in the generation of several codes that were further analysed to yield two main themes and four sub-themes. There were also several sub-sub-themes associated with the sub-themes, as shown in Table 5.2. Codes and themes generated from the analysis of the data focused on contributing to the generation of a behavioural model to reduce energy consumption. Themes were thus captured as energy-saving processes and practices. The analysis was based on a definition of energy-saving as consisting partly of energy efficiency and partly of other energy-saving approaches. While efficiency addresses technology-related approaches, all other approaches are grouped together as 'other ES approaches'. There are two main themes: energy-saving strategies and energy saving factors. Together, these main themes address four sub-themes and 11 third-level themes, as shown in Table 5.2 and the Nvivo Screenshot that generated the grouping is shown as Figure 5.1. These themes and their lower-level sub-themes are discussed in the following sections in relation to the main focus.

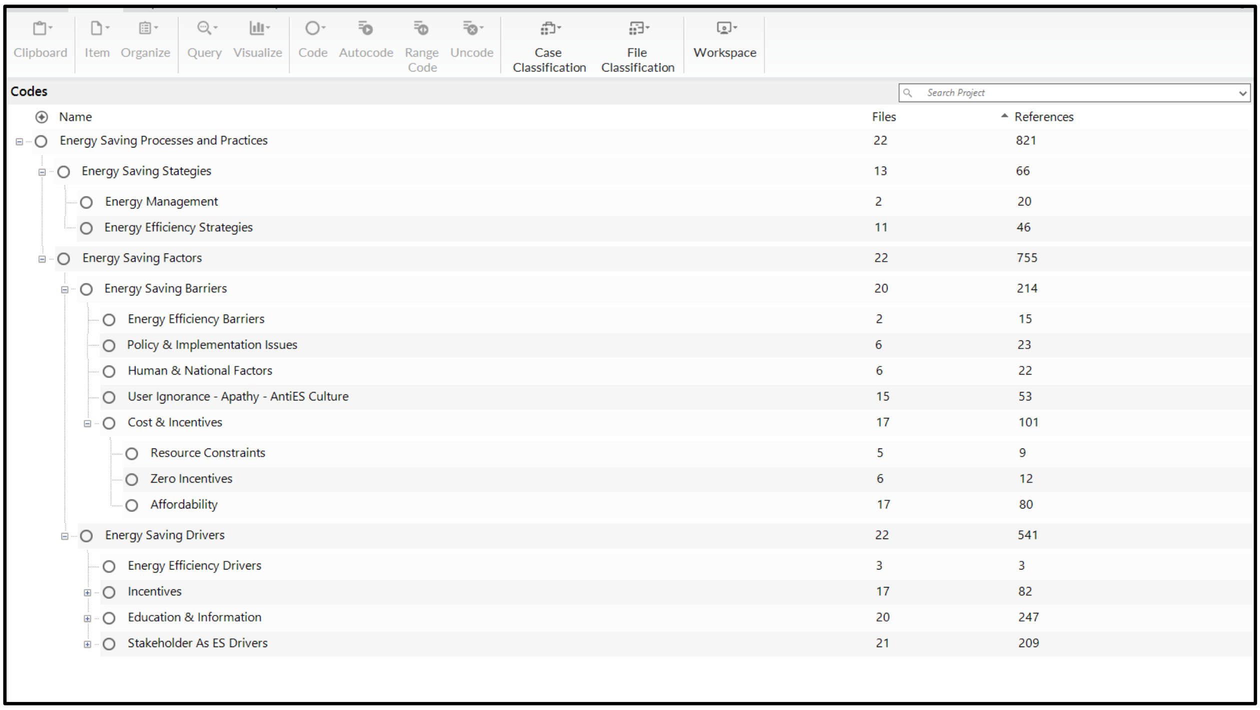



Figure 5.1. NVivo screenshot for the themes and sub-themes.

Table 5.2: Themes and Sub-themes of Energy Saving (ES) Processes and Practices.

| **Theme** | **Sub-theme** | **Sub-sub-theme** |
|---|---|---|
| ES Strategies | Energy Efficiency Strategies | Promoting Energy Efficiency |
| | | Energy Eff. Measurement |
| | Energy Management | energy policing, lighting strategies and load management |
| ES Factors | ES Barriers | Energy Efficiency Barriers |
| | | User Ignorance-Apathy-Culture |
| | | Policy & Implementation |
| | | Human & National Factors |
| | | Cost & Incentives |
| | ES Drivers (ESD) | Energy Efficiency Drivers |
| | | Education & Information<br>› Research<br>› Sustainability Focus<br>› Client & Peer Education<br>› User Education & Awareness<br>› User-SP Psychology |
| | | Incentives<br>› Punishment<br>› Subsidies<br>› Rewards<br>› Unattractive Alternatives |
| | | Stakeholders as ES Drivers<br>› Stakeholder Involvement<br>› Proactive Public Policies-Standards-Approaches<br>› Proactive Occupant Culture & Individual Actions<br>› Corporate Actions & Standards |

### 5.3.1 Energy-Saving Strategies

This theme captures codes related to energy efficiency strategies and energy management. They include factors and practices that determine or limit energy-saving behaviours.

#### 5.3.1.1 Energy Efficiency Strategies

This group of codes include those related to technological approaches to energy saving. Respondents identified energy efficiency measurement and other strategies as promoting energy efficiency. While only a few participants submit that measuring energy efficiency is a clear strategy for energy efficiency, all respondents agree that the use of energy-saving appliances is an important ES strategy. The NVivo screenshot in this regard is shown in Figure 5.2, while the relevant extracts from responses are outlined subsequently.

> *We measure in terms of consumption. Exactly! Yeah, when people's consumption is going high, then there… Ohm, especially where there's [the] same requirement but high increase in energy consumption, then you have an issue, maybe the customers are using appliances that are not energy savers, so the consumption would really the efficiency of energy usage.* [Bravo; SP]
>
> *Encourage the use of energy-saving bulbs to replace halogen bulbs. Encourage the use of sounds and motion sensors that would immediately switch off lights and appliances when not in use* [Papa; CE]
>
> *One tries to make sure that you select equipment that is efficient in terms of operation in energy savings. So, you select the equipment that has better… I mean better efficiency compared to the conventional ones that are already in existence* [Quebec; Con]
>
> *Also, the commission err is working tirelessly to see that every customer is connected to the network through the meter erh prepaid meter. So it's one of the commission's ahh ahh priorities now to see that everyone is connected through the meter.* [November; Reg]

odes

Search Project

| Name | Files | References | Created on | Created by | Modified on | Modified by |
|---|---|---|---|---|---|---|
| Energy Saving Processes and Practices | 22 | 821 | 15/06/2021 14:53 | BIE | 10/11/2021 00:36 | BIE |
| Energy Saving Factors | 22 | 755 | 29/10/2021 06:15 | BIE | 29/10/2021 06:15 | BIE |
| Energy Saving Stategies | 13 | 66 | 08/06/2021 04:10 | BIE | 29/10/2021 06:06 | BIE |
| Energy Efficiency Strategies | 11 | 46 | 09/08/2021 03:19 | BIE | 10/11/2021 17:01 | BIE |
| Energy Management | 2 | 20 | 16/06/2021 13:40 | BIE | 10/11/2021 17:01 | BIE |

**Figure 5.2**: NVivo Screenshot of Energy Efficient Strategy.

However, an exploration of the codes captured under the energy efficiency strategies shows greater emphasis by energy consultants and regulators, as shown in Figure 5.3. This observation may be related to their roles in relation to energy, although the feedback does not necessarily confirm this. At least one file was coded at this node for every relationship with energy, although three and four files were coded for regulators and consultants respectively.

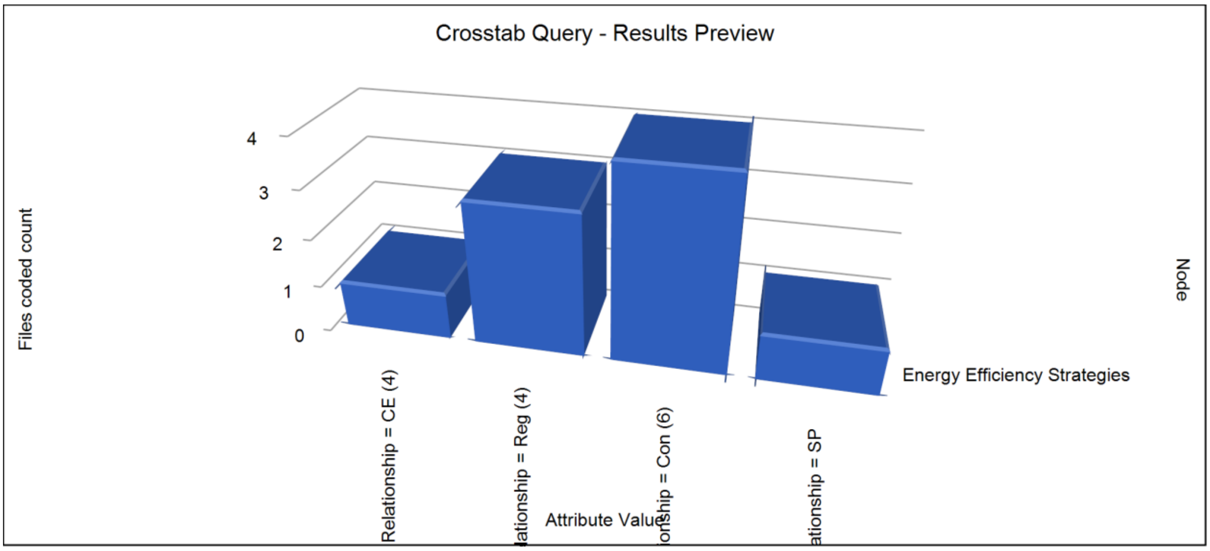



**Figure 5.3**: Comparison of Feedback from Energy Consultants, Regulators Construction experts and service providers.

### *5.3.1.2 Energy Management*

The energy management strategies identified include energy policing, lighting strategies and load management. Energy policing involves the assignment of an individual, the 'energy police' in an organisation, whose duty includes 'patrolling' the office environment after closing hours to switching off the power directly from the distribution board thus promoting zero overnight consumption. Figure 5.4 shows the NVivo screenshot depicting energy management.

> *there is somebody mandated in the organisation by the time it's around 8 o'clock in the evening or so; almost all the office will close. He goes office by office switching off from the distribution board so the distribution board switch off completely this, the office that DB is controlling so you see in that process everything is switched off so you don't you have zero consumption up to the morning time* [India; Reg]

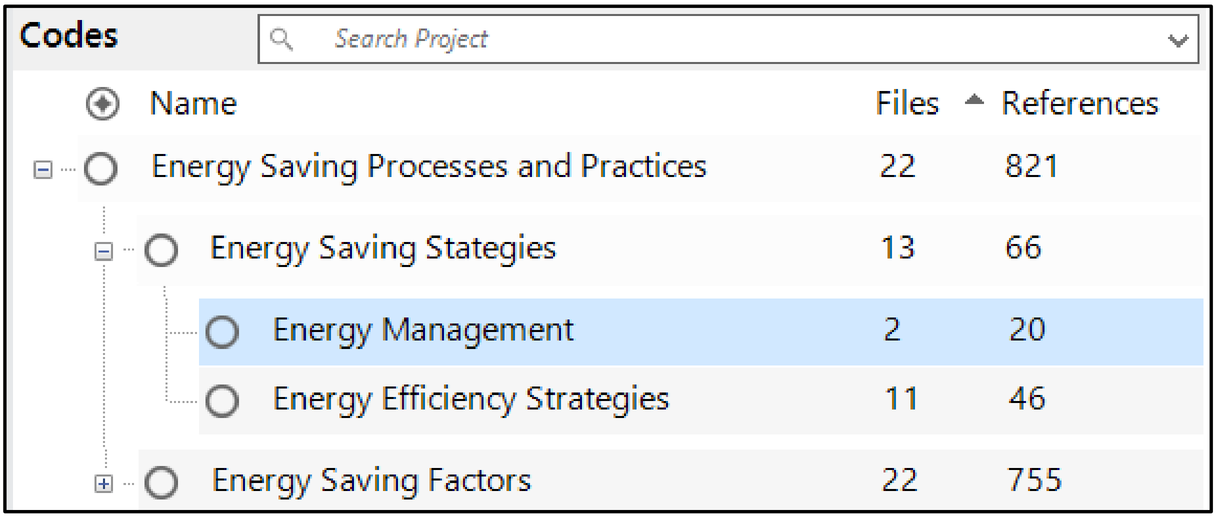



**Figure 5.4**: NVivo Screenshot for Energy Management.

Lighting strategies are various approaches directly related to how users implement procedures that help to reduce energy use. ES keys, the use of energy-efficient appliances and the installation of systems like pre-paid meters, inverters, sensors and motion detectors and timers can significantly help to reduce energy consumption by users.

> *energy saving key, what that key implies is that the switch points of your electrical equipment is controlled by a key…automatically all your electrical equipment goes off. Controlling the energy using the entrance key to the door.* [Juliet; SP]

Government and non-government organisations can contribute to these strategies by providing practical support through the availability and accessibility of ES appliances. Many of these strategies are directly linked. When government ensures (through the use of prepaid meters) that people only pay for the energy consumed, it will serve as an incentive to manage personal, family or corporate energy use. This will in turn inform practices to support such management, which can capture the lighting strategies. Load management is a corporate practice that involves the allocation of energy services based on need. Reduced consumption at one end, and at the other, the availability of energy that can be routed to other areas of need. In this way, available energy, as well as allocation, can be maximised. The process can also be automated for maximum benefits. It is not surprising that this strategy was highlighted in feedback from a respondent in the energy distribution company.

*here we installed those errh… those inverter systems errh… so we tried to see how… how… how… we can reduce those wattages of the building…by the time your house consumes less energy, that particular energy will also be routed to some other places that they really need it…For instance if Kaduna or Kano has been allocated let's assume 100 megawatts and let's assume due to lack of energy efficiency let's assume the whole of Kaduna as errh..total, it's about 110 or 120. So but by the time you times this energy efficiency. Let's say averagely so house, 50 percent of the houses, so I am assuring you that, that particular consumption of that 100 mega watts might drop as low as like 50 or 60. I have already explored, you predict it, by that 80% of Nigeria start using prepaid meters and I am assuring you the energy efficiency in Nigeria will also go as high as 90-100%* [India; Reg]

Although the implementation is reported in a corporate setting, the same practice can be adopted in residential buildings. Energy management can be automated by the use of a smart distribution board (SDB) which can correctly model the energy usage pattern of users to inform load distribution (Olakanmi et al., 2018) amongst other intervention programmes (Stephenson et al., 2010).

### 5.3.2 Energy-Saving Factors

This theme incorporates drivers and barriers. The drivers are discussed in terms of positive factors, including energy efficiency drivers (technology-related factors) and the other drivers of ES behaviour. Energy saving barriers are grouped into five themes: energy efficiency barriers (technology-related), user ignorance-apathy-culture, policy & implementation issues, human & national factors and cost & incentives. Section 1.2.1 discusses the energy-saving drivers while the barriers are discussed in 1.2.2.

#### *5.3.2.1 Energy Saving Drivers*

Multiple factors relate to the adoption of ES practices, such as energy efficiency drivers, benefits or incentive-based strategies, design-, education-, policy-, and psychology-based strategies, which were all noted by the respondents. The NVivo screenshot for the energy saving drivers is shown in Figure 5.5.

#### 5.3.2.1.1 Energy Efficiency Drivers

These are technology-powered solutions, approaches and strategies. All methods involving the use of technology to drive, encourage, promote or implement energy-saving fall into this category.

> *for clients, we encourage them to use solar panels. We try to educate them to minimise or to have the optimum use of energy they have from the solar panels* [Oscar, CE]

This group of strategies are also closely related to proactive occupant culture and individual actions in the sense that many technology-powered solutions to drive energy efficiency include many individual actions that can be grouped under occupant culture. Together, these strategies can be regarded as energy-efficient occupant culture.

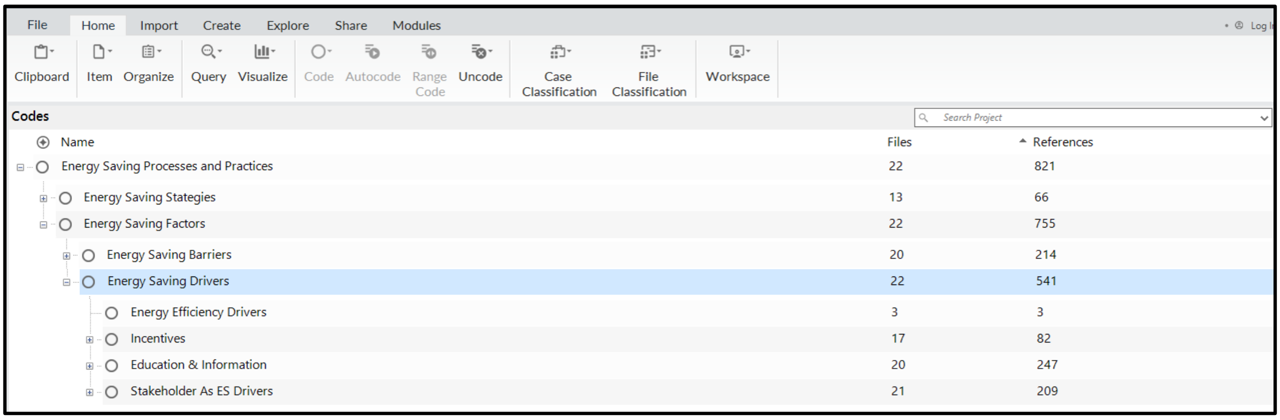



Figure 5.5: The NVivo Screenshot of Energy Saving Drivers.

#### 5.3.2.1.2 Education and Information

Respondents noted that energy-saving approaches, insights and education are communicated indirectly to clients during the initial engagement periods. They acknowledged the cost of electricity, public education, awareness campaigns through radio, or corporate awareness through sustainability forums as drivers of ES practices. Education-based approaches leverage peer and public education as well as stakeholder dialogues. Peer education occurs at the corporate level and can involve the use of many communication media including emails, meetings, discussions or bigger forums, like general or focused conferences (e.g. sustainability conference), with a focus on ES practices and related issues.

These serve both to inform and keep energy practitioners abreast of information within the field. Information is also related to the public so that energy practitioners can help to educate the general public (or public officers).

> *So we have meetings and we go to conferences, that's how we get to know about them.* [India; Reg]

Research contributes to the identification of new problems and solutions, including the identification of novel energy-saving strategies, and energy efficiency strategies and tools.

> *…for instance, like we did research, we did a sensitization to carry out ahh ahh energy audit free of charge infact we started with the university after doing the energy audit of all offices in the university. We came up with a report to the university management that looks, this is what every office, every department is consuming in terms of light…we are here at the university to do research in the essence…locating the research centre within the university to build in what student capacity will be encouraged to come and carry out their project in some of the areas* [Lima; Con]

Research also addresses individual or corporate user efforts to assess energy consumption with a view to encouraging energy saving:

> *Yeah, depends on… yeah, by the time you put ohm…. you calculate all the appliances that you have and their rating and hours of supply, you can come up with the consumptions of your appliances and then you can compare [the] same with your neighbour if you know his appliances. So you can know whether you are using electricity more than your neighbour. You know…because you are comparing your consumption with your neighbour, so can really see whether you are doing really good or really bad…it is an area that we can really explore and see how can tap the benefits of that.* [Bravo; SP]

> *Yes, that time when I conducted the energy auditing in a particular secretariat…I was able to come up with, because…at the time the government was paying the PHCN on no bill because the PHCN would just quote any amount, so in that case, when I conducted that survey, I was able to come up with the reality that the government is paying an outrageous bill*

*which has not supposed to been paid to PHCN. And we came up with measures that if the government could conduct such measures within its framework, the government at least could have saved a lot of money...* [Echo; Con]

Creating awareness of the advantages of a sustainable environment is another effective means of leveraging education to promote ES practices. Design-based strategies for example consider integrated approaches whereby energy saving is planned in the design of buildings, which are designed to optimize user comfort right from the planning stages. Known as passive design, it employs the use of several features that promote ES. 'Larger windows', 'roof overhang', 'landscaping', 'water bodies in and around buildings' are all features that may be incorporated to 'ensure energy saving by making the microclimate of the building conducive for its inhabitant'. The idea is promoted through client education to encourage the adoption of passive designs in building designs with the basis being that,

*if the environment is conducive, you don't need to put on electricity, you don't need to put on heaters or in our case air conditioners to cool the buildings*. [Oscar; CE]

Practitioners believe this can be among the undisputable ways to energy-saving since, if a building is comfortable (e.g. well ventilated), users will not seek artificial means to create a comfortable environment in the form of air conditioning/heating systems, thereby reducing energy consumption. It is not surprising that this approach to energy saving was emphasised by CEs who are directly involved with building design and construction. One of the respondents submits that this approach is the most sustainable and most effective ES strategy:

*Still under the passive design strategy, we also have windows for daylight, the choice of the materials, their sizes and numbers also plays a vital role in energy saving strategies. When windows are adequate, one requires no artificial lighting in the daytime. Windows also contribute to energy saving by either trapping the air within when closed or by either allowing a free flow of air when opened.* [Papa; CE]

*Ohm, well, not the energy use. Passive, is more into improving the comfort of the occupants. But in the real sense it reduces the energy use because if the place is comfortable the occupants won't go the extra mile to put on the AC (air conditioner) for more comfort.* [Oscar; CE]

*The architect designs to increase the energy efficiency of the building using both active and passive design strategies…I will consider the passive measures as more sustainable methods…because no machine or electricity is involved or required* [Papa, CE]

The previous excerpts suggest that ES strategies are energy relationship-dependent, which is expected. Indeed, individuals see within their setting what others from different settings may not be able to see or may not consider important. The data is further explored to confirm this by examining how different professionals responded to ES strategies and drivers, as shown in Table 5.3.

Table 5.3: Patterns of Responses to ES Strategies and Drivers by Different Professionals

| Energy Relationship = | CE (4) | Reg (4) | Con (6) | SP (4) | Total (18) |
|---|---|---|---|---|---|
| Education & Information | 4 | 4 | 6 | 3 | 17 |
| Client & Peer Education | 4 | 3 | 5 | 3 | 15 |
| Research | 1 | 0 | 2 | 1 | 4 |
| Sustainability Focus | 3 | 1 | 3 | 1 | 8 |
| User Education-Awareness | 4 | 4 | 5 | 3 | 16 |
| User-SP Psychology | 0 | 1 | 2 | 1 | 4 |
| Energy Efficiency Drivers | 2 | 0 | 0 | 1 | 3 |
| Incentives | 4 | 4 | 5 | 3 | 16 |
| Punishment | 0 | 2 | 1 | 1 | 4 |
| Rewards | 2 | 4 | 4 | 3 | 13 |
| Subsidies | 1 | 1 | 1 | 1 | 4 |
| Unattractive Alternatives | 2 | 1 | 1 | 1 | 5 |
| Stakeholder As ES Drivers | 4 | 4 | 6 | 4 | 18 |
| Corporate Actions & Standards | 4 | 4 | 6 | 3 | 17 |
| Proactive Occupant Culture & Individual Actions | 2 | 2 | 5 | 1 | 10 |
| Proactive Public Policies-Standards-Approaches | 3 | 4 | 6 | 4 | 17 |
| Stakeholder Involvement | 0 | 2 | 1 | 1 | 4 |
| Energy Saving Strategies | 2 | 4 | 4 | 2 | 12 |
| Energy Efficiency Strategies | 2 | 3 | 4 | 1 | 10 |
| Energy Management | 0 | 1 | 0 | 1 | 2 |

Patterns in the table show contributions to sustainability as ES drivers were cited more by construction experts than other professionals while research was a solution proposed more by consultants. This observation matches the expectations from such professionals. The role of stakeholders, including corporates, as ES drivers were emphasised by all professional groups. Although the use of incentives was listed by all professional groups as an ES driver, only energy regulators appear to strongly consider punishment as an incentive while subsidy was an equally weak recommendation by all.

Energy efficiency strategies (technological solutions) were also emphasised more by construction experts than other professionals. It could be concluded that some (e.g. service providers and regulators) may benefit from energy inefficiency - as noted by a respondent - which might have contributed to this position.

Only two unique contributions were offered on energy management; one from each of the energy regulators and service providers. Patterns across the table suggest a biased approach to energy saving based on the participants' relationship with energy; however, more exploration will be required to further confirm this.

Psychology-based strategies can apply to both end-users and energy service providers. Such strategies employ several approaches that target non-tangible reward systems which deliver appealing immediate or future, long-term benefits. Cost-saving, long-term benefits, and other advantages can be applied to encourage users to adopt ES practices. Showcases, demonstrations, media adverts and more are means through which such messages can be passed. According to Juliet, a staff in the energy regulation sector,

> *When you look at somebody what one person would have consumed and you talk to the person and the person to talk to another person when you aggregate it…I was spending averagely before now 20,000 naira but now after your visits, I am spending 15,000 naira* [Juliet; SP]

On the part of corporate bodies, the desire to be seen as an environmentally friendly company or one that promotes a sustainable environment is becoming a key desire amongst organisations. This can be explored to promote ES approaches and strategies.

> *No company would want to erhm be viewed as an environment panicking (sic) company in terms of its erhmm operations and the other one is the*

*utilization of new technologies and also branding*

*…lot of companies are trying to position themselves as erhm an eco-company or green companies and try to use all energy efficiency and energy-saving approaches in all their operations* [Romeo, Con]

Active design on the other hand:

*…usually consist of cooling and heating systems through electrical or mechanical means* [Papa; CE]

*We consider all things like umm when you are doing the design you need to consider err energy efficiency so that at times you know from design to implementation…whatever you are putting [in] they are going to be in conformity with the design in order to achieve that particular energy; for instance I am doing a two-bedroom installations so I know if am going to implement the efficiency you know what to put how to achieve it right from the wiring connection to the fittings you know those times we do that, we do it...yes* [Foxtrot; SP]

Designers and CEs thus have to factor in the natural or regional environment to make design decisions that are in line with energy-saving approaches. For example,

*Let's take a region where you have for instance, in Plateau State where you know the temperature is very low and they don't need much ACs because the temperature is very low. So what we consider that particular region is like you don't put ACs in their structures in most of their houses because they don't even make use of it. And umm the only thing that consumes the energy is during the winter period the temperature goes down to like 11°c so maybe that's when people use room heaters so whenever you are doing the regional design you use so if you are doing the design in that area you know what to put and ignore, what to add...if you are designing a house in Maiduguri where their region the temperature is very high so you need to put all the facilities like the ACs, provision of fans and everything. So it* *depends on where you are doing the design … you need to provide maybe lots of cross ventilation* [Foxtrot; SP]

#### *5.3.2.1.3 Incentives*

Incentives are benefit-based drivers. Personal benefits, rewards and incentives have always proven to be effective in motivating positive behaviour and can be exploited with occupant behaviour. This theme is linked to others, like education, psychology, design and occupant culture. When users understand the benefits of ES practices, they are more inclined to adopt them. Long- and short-term benefits, immediate cost benefits, less consumption, reduced cost with the same or reduced usage are all factors that can be explored. This theme also relates to the concept that users take full responsibility for their consumption, for example, through energy efficiency strategies like the use of prepaid meters. This may increase costs at the initial stage, but will increase user awareness of their personal consumption which will directly affect their attitude, and eventually, overall occupant culture.

> *so the more people are installing prepaid meters, they are now seeing that …their consumption is going high that is rolling they are, people are now realising that oh I need to remove this one need to remove this one, I need to remove this* [India; Reg]

Punishment, subsidies and rewards are all linked under incentives. By subsidising the cost of ES appliances, energy efficiency can be promoted as more citizens are encouraged to adopt their use resulting in improvements to occupant culture. Rewarding users for choosing ES approaches by cutting down on energy charges will also be a deterrent to choosing non-ES approaches.

> *key motivation is to make you pay less… if you ask for the cost of that old model it might tell you that this might (be) 30,000, but if you ask for the cost of this new modern they would say that it is like 80,000…the energy that this old modern would be drawing for a period of year right? You would see that you would have paid that 50,000 times two…anything that you are going to do that would make people to save money for their pockets you would see people love doing it because we have scarce resources* [Juliet; SP]

*I would say, the first one is cost, cause energy-saving practices saves a lot of cost for the companies* [Romeo; Con]

Punishment and sanctions, as a negative reward, or the loss of reward are the means by which incentivisation can be used to encourage ES practices or discourage non-ES practices. Respondents identified the importance of regulations or rules and the role of penalties for violators of the energy commission's order or regulations for all the industry players (DISCO, GENCO, transmission company ). Monitoring by the commission, customers would result in higher bills at the end of every billing circle that would serve as a disincentive. Anti-ES activities, like by-passing meters to connect to the electricity, can be ascertained through random checks thus discouraging such attitudes. With proper monitoring, users would also be charged more for using non-energy-efficient appliances, thus indirectly promoting or encouraging the use of ES appliances. On the part of the DISCOS, employee benefits and key performance indicators tied to revenue generation work to discourage anti-ES activities, thus preventing wastage and leakages [Gulf; Reg].

Unattractive alternatives are similar to negative incentives. By making non-ES alternatives more expensive (or making ES options cheaper), consumers will have to (re)consider ES options. Cost is always an incentive or disincentive for the larger population, and cost savings can be an excellent approach to promote ES. According to participants:

*And with the changes, even in metering, people are gradually knowing that they have this new regime to take measures so that they would be able to demand less and have more…in their pockets by adopting alternative sources like solar and inverters* [Mike; Reg]

*…as in we have err it's not comfortable for example when you installed err virtually it looks like turn on the generators just the noise just the pollution and it's very inconvenient* [Delta; CE]

*Whatever I'm saying, I am just giving examples of what is happening within our region err… first of all we don't even have energy in excess so whether you like it or not you don't have any choice but to manage what you have. So if you don't have it how can you manage it.... So just what you have you manage it* [Foxtrot; SP]

#### *5.3.2.1.4 Occupant Culture*

There are two sub-themes in the direct strategies: corporate action and occupant culture. These sub-themes represent stakeholder practices or strategies that translate directly to energy conservation as opposed to those which may facilitate, promote or encourage energy-saving practices. These are captured as indirect approaches and directly relate to, and are discussed in relation to the drivers of ES practices.

#### *5.3.2.1.5 Stakeholders as ES Drivers*

*Stakeholder Involvement*

Stakeholders play a central roles in ES culture and the consumption behaviour of occupants, who themselves represent another group of stakeholders. They are responsible for education, motivation, policy-making, public support, the provision of incentives and more. The key stakeholders identified include energy organisations (service providers, consultants, regulators, and construction experts), investors, and the government. Organisations like the Energy Commission of Nigeria has a mandate to ensure energy efficiency in the country while others like Nigerian energy regulatory commission are regulators and others are into distribution. All these organisations deal directly with each other and some with users. In such cases, they lead by example which becomes a critical way to achieve energy conservation. Stakeholder choices in terms of appliances, building design, are all ways which that energy can be conserved. In addition, the significance of ES-promoting policies in place puts a huge responsibility on the government as a major factor in facilitating user behavioural and culture change. Although investors are involved for profit, it is important that they ensure that their…

> *attention should not just be that the customer should pay me; you should be able to charge customer what they can afford and that will (promote) harmony between you and the customer*. [Juliet; SP]

Education is one of the key routes to promote positive energy consumption behaviour; the duty rests on all stakeholders and multiple means should be exploited to achieve the purpose. It is not enough to educate the user; self-education, peer education, and corporate client education are all ways by which knowledge can be promoted. Awareness campaigns, regular public education through various media, in-house learning opportunities and intentional learning through forums like conferences, meetings and public dialogues are all central. The government as a central factor also requires education by other stakeholders; there is a need to connect with other energy stakeholders in order to keep abreast of global changes and adopt updated policies in relation to design, construction, distribution, regulation, and the promotion of user culture change.

In terms of residential buildings, users are the most important stakeholders, while other stakeholders connect directly or indirectly with them. Energy conservation in residential buildings is only possible when the user is on board with whatever approaches are being leveraged, which must therefore be the goal of all other stakeholders.

*Proactive Occupant Culture and Individual Actions*

*Alternative energy sources*: Generated power is non-renewable and an expensive energy source. Over-dependence on this is a major challenge in energy management and conservation. With a switch to renewable energy sources, like solar power as alternative energy sources, the load demand on non-renewable sources can be greatly reduced. While individuals have much to contribute to this respect, access and affordability to promote user interest may remain the duty of the government.

*Proactive ES culture* takes into consideration several factors including the use of ES appliances, socio-cultural practices that are intrinsically ES-focused, and the exploitation of nature, for example in the use of natural ventilation rather than air-conditioning.

*Responsible use* is the major factor in energy management and ES practices in both residential and non-residential buildings. The day-to-day activities of individuals and groups regarding responsible lighting (switching on and off), management of security lights, constant use of air conditioning, and electrical appliances permanently left on are some common non-ES practices. More use of sunlight, and the reduced use of air conditioners - especially on solar-powered systems that automatically switch on and off to power boreholes and pump machines - are all ways to promote responsible energy use. In a similar manner, energy policing is employed in corporate settings, while individuals and families can also adopt such responsible practices in residential premises. In essence, encouraging users to be conscious of switching lights and appliances when they are not in use, and promoting and adopting the use of solar energy can directly encourage ES. Making useful information on novel sources (like solar energy) available to the public will also go a long way to promote its use.

*Proactive Public Policies, Standards and Approaches*

*Policy-based strategies* directly relate to the government. Much of user culture revolves around issues that are based on government policies; hence, when policies change, user culture is also bound to change. It is also not enough to set up agencies, such government agencies need to operate and meeting their responsibilities and achieving targets. If something as simple as prepaid meters remain a problem that cannot be solved, there is very little else that can be addressed. So, the government represents a major driver of ES practices, through direct and indirect approaches, alongside the public's choice like the use of energy-efficient appliances.

> *I think most of the work will come from the government side, and from the government side one of the things they need to start is [to] convert their meters to erhm pre-paid, buildings and other parastatals that are under their direct control to energy saving organisations or buildings that will give the customers more*. [Romeo; Con]

Housing laws and policies, building construction policies, and policies that will encourage investment in the energy sector are all required to drive culture change or shift. Government support, such as subsidies for energy-efficient appliances and alternative energy sources like solar energy, will go a long way to make them affordable, and the cost could in turn drive a large percentage of the public towards adoption. When combined with public education and awareness campaigns, adoption could increase.

> *The consumer will (eventually) realise it is actually cheaper to go for the solar than energy from the grid I think a lot of consumers will move towards that direction.* [Romeo; Con]

#### ***5.3.2.2 Energy Saving Barriers***

The barriers identified are broadly captured under five third-level themes: energy efficiency barriers, user ignorance-apathy-culture, policy & implementation, human & national factors as well as cost & incentives. The Nvivo screenshot for the energy saving barriers is shown in Figure 5.6.

### 5.3.2.2.1 Energy Efficiency Barriers

*Technical barriers* to ES practices are outside the control of the user and may include 'hot spots', referring to excess energy that is not distributed, thereby causing an imbalance whereby the customer pays less than the value of the energy consumed because there is a difference in the energy supplied from the source and that measured at the user end. Poor networking, a failure to adhere to standard formats including connections, equipment, sockets, switches and fusing result in partial contacts, etc. Moreover, heat energy loss resulting from such hot spots is accounted for in distribution but not in utility.

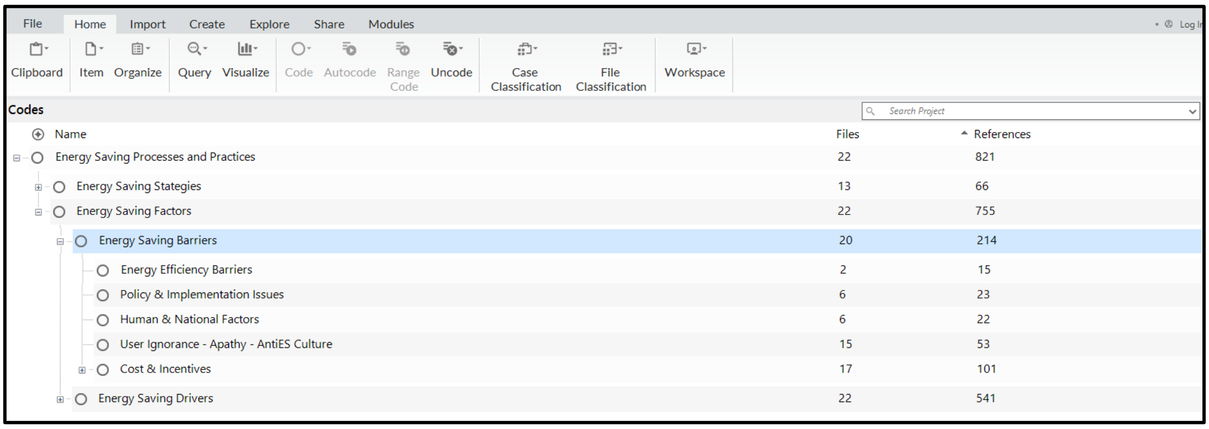



Figure 5.6: The NVivo Screenshot of Energy Saving Barriers.

### 5.3.2.2.2 User Ignorance-Apathy-Anti-ES Culture

Users' lack of knowledge directly relates to the advantages of education. When user knowledge increases, attitude and culture change. When users lack the adequate knowledge, it is reflected in their choices, actions and energy use as well as negative ES practices. The understanding of immediate cost versus overall cost, and savings on long-term costs through initial higher costs are all issues that require understanding.

> *So, for the fact that they don't look at it, they are just looking at the immediate cost but when they look at the long term cost they can easily appreciate that it is better to spend more money to acquire this, because I am going to save the extra money I am adding now; I am going to save it from daily consumption that would be in use. So, it is about knowledge.* [Juliet; SP].

*Absence of user responsibility*: If users are not made to take responsibility for energy use, it will be difficult to encourage them to use energy responsibly. Furthermore, indirect billing is a concept that will continue to make responsible energy use and ES practices elusive.

> *As far as people are on estimated billing you know as far as they are concerned it's none of their business*. [India; Reg]

Over the years, when people have been made to pay an estimated rather than the actual cost of their consumption, an unfair culture has emerged that promotes irresponsible use; furthermore, breaking such a culture is challenging. Even with continuous education and awareness raising, it will take a lot of time for cultural change to take effect. This is doubly challenging when users are not interested in such awareness.

Over the years, other negative cultural behaviours were based on a foundation of irresponsible service.

> *Some have a particular bulb 'on' for the whole period - nobody will switch off his bulbs. That is the point that we use to identify whether energy is back or is not back…you would see some bulbs are [on] in the daytime and its doing nothing so those are also part of our cultural behaviour that we don't know how to change and those kinds of things a(r)e very hard to change yeah.... Our culture, the way we do thing if…You are not paying things compared something from your pocket you don't care.* [India; Reg].

Inevitable situations sometimes necessitate extra energy use. Unexpected situations like the pandemic lockdown forced people to spend more despite having less because,

> *people stay more in the house and stay more; they consume more energy and they must pay for more…So paying more under an economic situation that is less because of the pandemic, you can see people are already agitated and having that interaction/engagement has made [them] understand what they need to know to do to cut down cost*...*with this economic meltdown everybody can manage little resources; [this] is the key motivating factor*... [Juliet, SP].

However, with the current global pandemic challenge, the culture of waste that previously characterised energy use faces a challenge and is inspiring a change that has the potential to encourage more responsible energy use in the future.

#### *5.3.2.2.3 Policy and Implementation Issues*

National policymaking is usually never a challenge globally; policy implementation is the main issue that renders policies impractical, no matter how great. This issue has been identified in practically every sector of the economy. The same applies to energy management. Some practitioners are not sure if there are any policies in place:

> *not [policy] at the moment, not that I know at the moment yeah. No, I think at the moment there is none because…even…in the government… no, no, no, yes, yes is just about persuasion at the moment* [Alfa; CE]

> *Perhaps there is no building law or regulations to encourage the use of energy efficiency material, to encourage the use of energy efficient appliances, to ban totally the use of…. Ohm, for example halogen bulbs* [Papa; CE]

> *for example, let's say for example Cuba, Ghana where there is a government policy that ban the use of incandescent lamp or stuffs like that, we don't have any here in this country* [Charlie; Con]

Sometimes, efforts are met with resistance in the form of a lack of user willingness to change, even when change is the better option. An example is the challenge of switching to prepaid meters which has been extremely difficult for several years due to the interests of those who benefit from such negative conditions. Strong policies with deliberate efforts at implementation are the key solutions to drive the necessary change.

> *also in the area of metering, you remember I told you on energy efficiency? They been doing very poor, so the commission has to intervene by developing regulations to be able to encourage, to incentivise meters. Like the meter acceptance providers regulations, which was developed to take away metering from their operators but allowing investors to come in and*

*then fund metering so that the metering gap is closed to further drive energy efficiency in the sector* [Mike; Reg]

It is not enough to have excellent policies or master plans as well as implementation plans that are workable, such plans must also be relevant to the times and must change, be reviewed, and updated from time to time to meet the needs they are meant to address. Within the context of the study, respondents noted that sometimes, policies are too old and outdated to be of any use in driving required change.

*So in a way, but the government want of course we generate data like we contribute a lot in the development of [an] energy master plan but we all know that it is due for revision and the implementation is very low so if you are talking about that angle I think the implementation is not encouraging* [Charlie; Con]

#### *5.3.2.2.4 Cost & Incentives*

The codes captured under this sub-theme are categorised into three groups: Zero incentives, resource constraints and affordability. Zero incentives directly contradict the positive effects of incentivisation previously discussed as energy saving drivers. Without incentives, people reject and resist the necessary changes which can facilitate energy saving. Examples include the continued use of estimated bills whereby people will not naturally be willing to take responsibility for energy saving since they have nothing to lose in the arrangement. There is no incentive for responsible use, and no reward for energy saving:

*if you know you are not, what you are consuming is not measured and whatever you consumed you pay at a specified value, you have no incentive to be able to reduce your consumption or demand* [Mike; Reg]

Resource constraints are availability issues. In many cases, the required resources for facilitating energy saving are just not available, or not available in the right quality or quantity:

*So also, we have the issues of availability sometimes you will only see it on paper and may not find it here in the market* [Quebec; Con]

*the non-availability of the metering; a lot of the customers are hindered to the adoption of energy serving practices by the end users and the logic is very simple* [Mike; Reg]

Sometimes, resource constraints are closely tied to affordability or acceptance for a specific group; for example, rural dwellers are less receptive to technological changes than urban dwellers, and the availability of necessary resources might be closely tied to affordability:

> *Sorry what do you called it...urban areas I don't think they have [a] problem with this but the people in the rural areas, even though you are implementing something that has to do with technology whatever you called it err I don't think if it's going to have effect to those people in rural areas because err one, some of them are not even connected to the world, like I can set [an] example with the mini grid project that I have in the place that they don't even have GSM communication there* [Foxtrot; SP]

Affordability follows resource constraints by making it impossible for users to access resources even when such are available. This is mostly due to cost issues, and is especially important in a poor nation where the average citizen lives below the poverty line. While people may appreciate the wisdom of investing in energy-saving appliances for long-term benefits, the required financial resources are simply not a priority for investment in energy saving for individuals struggling to make ends meet.

## 5.4 Discussion

This section provides a discussion of the findings in relation to the main question: "What factors and practices related to behavioural change are relevant in reducing energy consumption, and how can the existing cultural framework be employed to develop a suitable model for energy saving in Nigerian residential buildings?" Exploring the related codes helps to answer a number of sub-questions:

i. To what extent is behavioural change relevant in reducing energy consumption in Nigerian residential buildings?

Figure 5.7 is a map of nodes contributing to the 'energy saving practices and processes' theme. It highlights the stronger emphasis on energy saving drivers compared with strategies, with the strongest emphasis on the role of education and information, incentives (positive or negative), and the role of stakeholders in driving positive user behaviour in relation to energy.

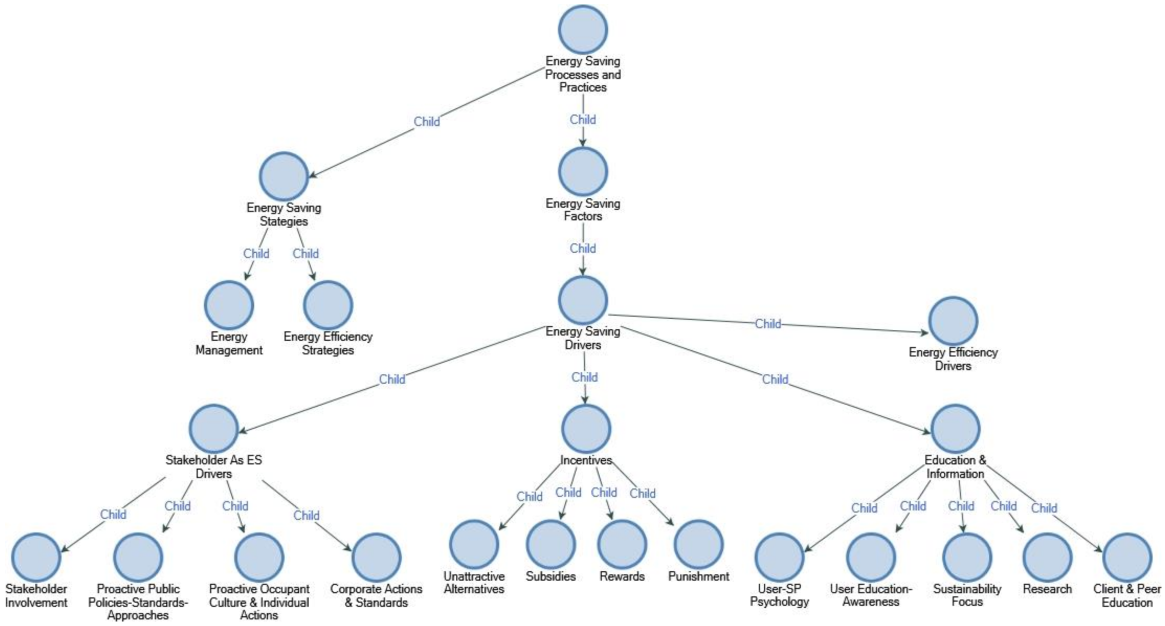



Figure 5.7: Determinants of Energy Saving Behaviour

Technology-related drivers (energy efficiency drivers) are not strongly emphasised even though they are noted as effective. This may be due to the associated cost, which constitutes a disincentive in an environment with extremely high poverty levels. This underscores the significance of user behaviour, attitudes and actions directly or indirectly related to energy saving.

Factors that limit energy saving behaviour yielded the project map in Figure 5.8. In a manner similar to the determinants of energy saving behaviour, the figure also highlights the stronger emphasis on barriers as stakeholder behaviours, with a stronger emphasis on cost and (dis)incentives.

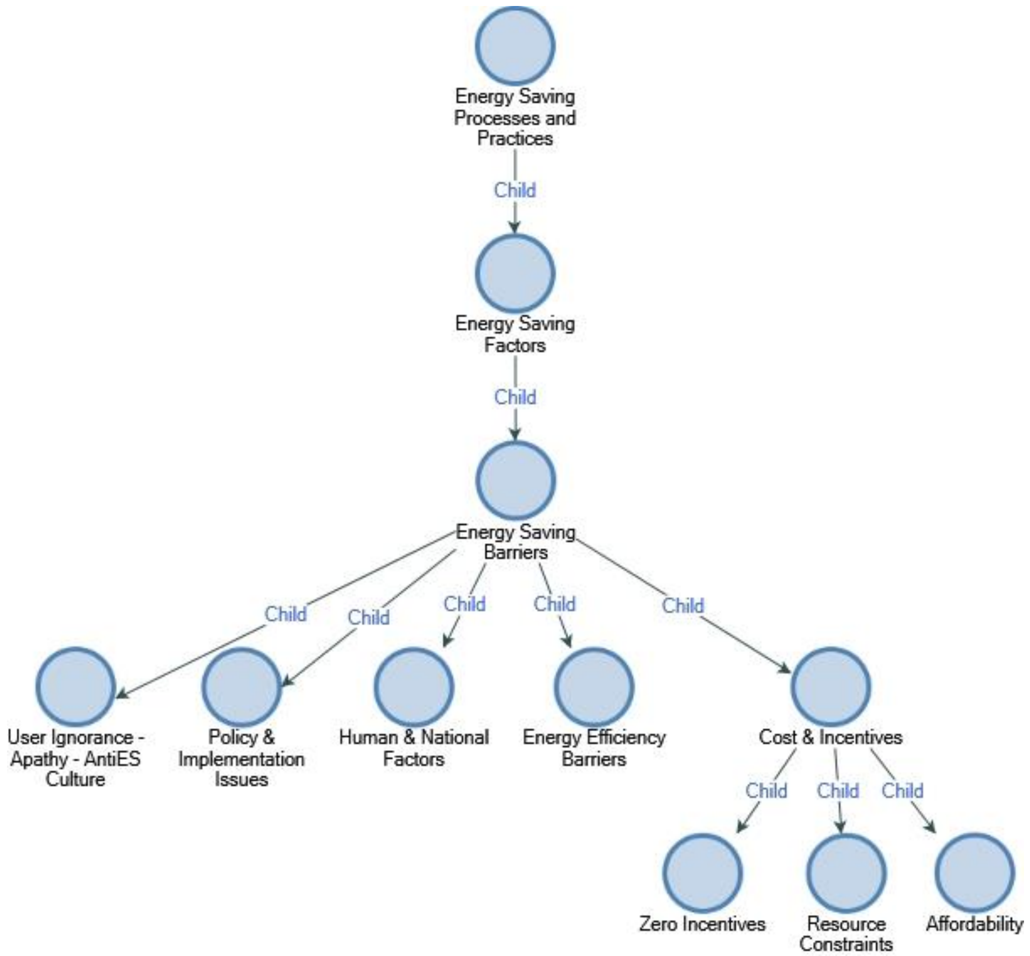



Figure 5.8: Barriers of Energy Saving Behaviour

In summary, an exploration of data confirms that behaviour plays a highly significant role as both a determinant as well as a barrier to energy saving. Incentives are highlighted in both cases as constituting potentially strong drivers of behavioural change and indicate an area of focus for implementing processes to drive the necessary change. This exploration also answers the question “What are the barriers to the adoption of energy saving practices in Nigerian residential buildings?” It does so by highlighting the challenges posed by the lack of necessary policies or implementation, user ignorance and apathy, human and national factors, and more importantly, the challenge of cost and affordability, which also directly relate to resource constraints.

i. How can the use of drivers and stakeholders input contribute to improving occupant attitude and energy consumption behaviour in residential buildings?

The ‘stakeholder as drivers’ theme incorporates four sub-themes, as shown in Figure 5.9.

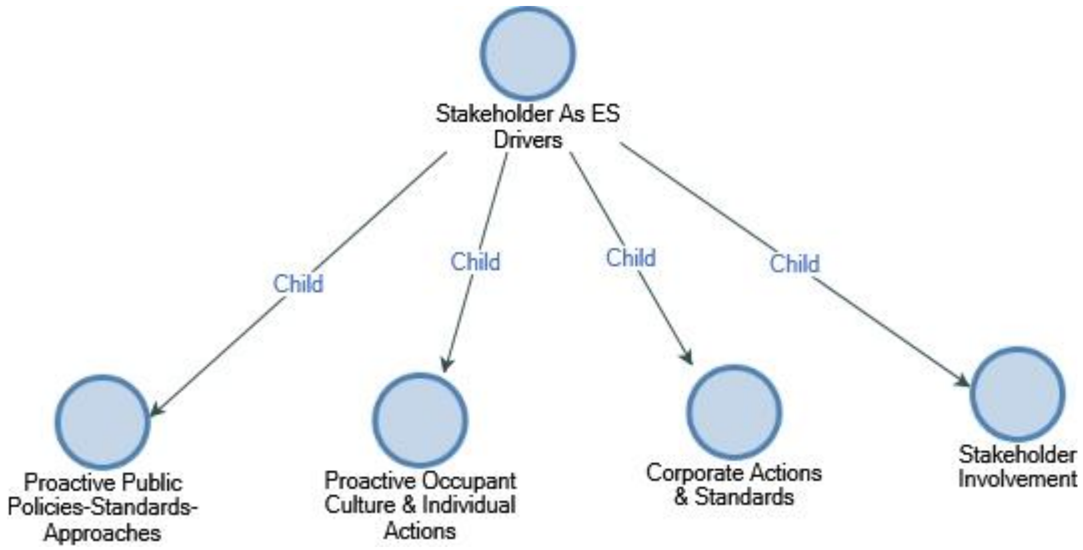



Figure 5.9: Map of ‘Stakeholder as Drivers’ Sub-theme

Stakeholder involvement addresses the range of roles that different types of energy stakeholders (CEs, Reg, etc.) can adopt in user education, energy management, creating and sponsoring incentives, etc. Corporate actions related to actions, standards and regulations (energy policing) are put in place by organisations to drive ES practices among users. Proactive occupant culture are user actions that directly support or limit energy saving. This may include switching off lights when not in use or investing in energy saving appliances; proactive public policies addressing government actions, standards, etc. aimed at developing and implementing energy saving strategies; incentives to drive adoption of ES practices; ES appliance subsidies to render non-ES options unattractive, and meting out punishments to offenders and violators of standards and rules. All highlight how stakeholder input helps to improve occupant attitudes and energy consumption behaviours.

**5.5 Stakeholders as Energy Saving Factors**

Construction experts identified construction-related techniques like 'passive designs' which ensure energy savings by making the microclimate of the building conducive for its inhabitants. Others are the use of ES appliances which promote ES by reducing overall consumption. They noted that for a nation in a temperate region, the need for thermal comfort, the presence of poverty, the absence of either policy backing or incentives, and the high cost of ES appliances represent barriers to ES. They also acknowledge that both the local and religious culture of citizens inherently promote ES, acknowledging that:

*in a typical African culture you go to bed when it is dark, you wake up once*

> *it is bright and do most of our activities outside of our courtyards...in Africa we don't stay indoors throughout the day; at some point, the men go out under the tree to have some fresh air while the women partake in their home activities in the courtyard* [Oscar; CE]

And regarding religion, he noted

> *prayer time for the Muslims may not be more than five minutes and five times a day...and the five minutes might just [be] for amplifiers and fans in the mosques. And for the churches, services might not be more than two hours on Sunday* [Oscar; CE]

From the perspective of an energy regulator, energy efficiency is viewed in terms of consumption, and reduced consumption is an effective approach to ES.

> *we try to advise people okay when you go to buy these electronics look at those electronics that are energy efficient, maybe with lesser wattage that consumes less amounts of energy to also help the whole system, to also help you as a person* [India; Reg]

He explains how the process of load allocation from the perspective of regulators is designed to ensure efficient use and consumption by redirecting excess energy to areas with higher demand. He noted that the use of prepaid meters also forces users to be aware of their consumption, and ensures they take steps to reduce it. Timers, sensors and motion detectors were identified as methods by which energy can be consumed efficiently; they help to ensure that appliances are switched off automatically when they are not in use. He noted that the high cost of ES appliances as well as anti-ES culture amongst users are the two biggest factors to hinder energy efficiency. He also pointed out users' apathetic attitudes towards ES, which can easily be linked to lack of user responsibility.

Highlighting the importance of user education, it was noted that when users understand how much cheaper it is to practice energy saving, they are more inclined to implement them in their homes. The onus thus rests on organisations to ensure energy management as they are involved in dispensing public education to ensure that people understand that energy efficiency practices benefit them and the community around them. Amongst consultants, whose jobs include promoting ES techniques to their clients, strategies involve free consultation opportunities to willing clients. Although it might seem that culture is the major barrier to ES practices, ignorance of the benefits is a stronger factor.

> *...is not mostly about the culture and tradition but it's all about awareness and perception, how we perceive such energy activities so if we embark on*

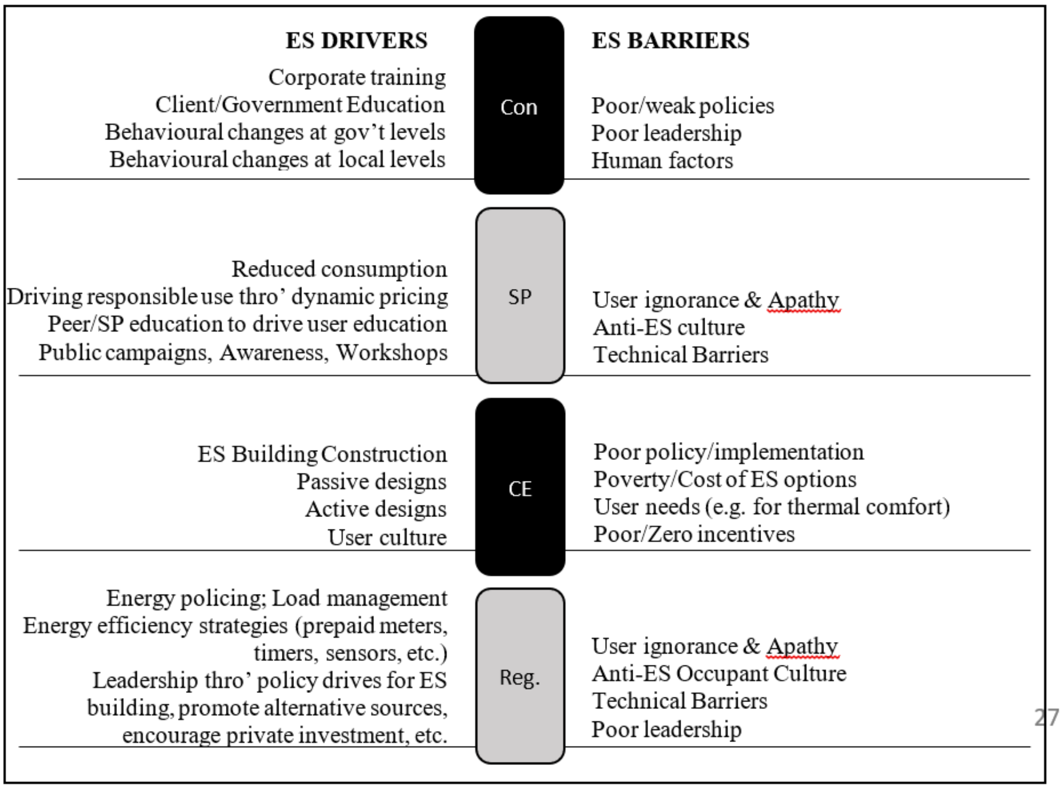
*a general nationwide awareness campaign on the dangers of actually using more fuel energy sources I think that culture will move* [Romeo; Con]

In essence, although strong energy culture has been noted as a barrier, education that focuses on promoting an understanding of the personal and communal gains that can accrue from ES practices could be a strong enough incentive to break the barriers created by culture. What the government is willing to do to facilitate this includes ways to encourage the masses to adopt ES techniques. Other important issues raised in relation to the government relate to policy drives including the use of prepaid meters in all public ministries and parastatals and the conversion of such organisation to energy saving organisations or buildings. Additionally, when the government provides leadership in ES practice through initiatives such as ES buildings, private investors in more energy efficient industries will be attracted by the access to readymade consumers, as well as reliable and stable policy backing. Strong laws and policies on ES building construction, for example, are required to plan for an ES future such that in years to come most of the houses or estates will be energy efficient. This will also open up new investment opportunities in the adoption of solar systems. Furthermore, technology improvement, the skills training of engineers and discouraging the importation of related components into Nigeria to promote local production could promote a mass shift in the direction of ES practices. A key complication noted is the fact that organisations responsible for educating users on ES practices profit from the ignorance of users; hence, they would rather energy is wasted.

*For DISCOS it's a good thing to for them, for people to consume a lot of energy because the more you consume the more they get* [India; Reg].

Energy service providers (SPs) identified education forums, like USAID workshops, as a means by which ESP staff could acquire an understanding of ways to maximise revenue and reduce expenses to provide these services to residents. Such fora can focus on efficient and effective fault identification strategies, the exploration of energy wastage, and how to curb such waste to benefit both ESPs and consumers. Maintaining a standard tariff on energy at the separate times that different areas access energy, ensuring consumers meet the energy standards required and help them avoid complications and hazards are means by which an organisation promotes energy efficiency. Staff education is thus seen as fundamental to consumer education, understanding and co-operation, as peer learning and the resulting correction of their own habits and mindset will have a ripple effect on consumers. Public education through campaigns and interpersonal relations, including one-on-one discussions with individual clients are also key. The importance of both service providers and consumers being equally educated is thus highlighted.

Various parts of the energy system require different approaches that combine in a holistic strategy to help achieve energy savings. This study provides richer insights by incorporating feedback from multiple stakeholders who in turn view energy conservation approaches differently based on their roles, thereby providing a more integrated view of energy saving approaches. Energy distributors focus more on reducing consumption, identifying load management, energy policing, alternative energy sources and the elimination of technical losses along the line or at the user's end among the important factors.




*LEGEND: Con = Consultants; SP = Service Providers; CE = Construction Experts; Reg = Energy Regulators;*

**Figure 5.10**: Multiple Stakeholder Input on Energy Saving Factors

Construction experts are more concerned with the approaches that capture energy saving from the design stage whereas energy regulators highlight the role of policies, and government practices, including the cognitive priming of users as central to the achievement of an ES user culture. Consultants deal directly with other stakeholders rather than end users, and so believe that significant changes in thinking at the local community level require changes to cultural infrastructure and practice at a national level. Educating government thus becomes a key indirect approach to achieve user culture change. This feedback illustrates the ways in which the energy behaviours of stakeholders, including end users, are influenced by interactions between multiple factors and how the understanding of these interacting components can be harnessed 'to reveal the need, the options and the staging for change strategies'.

Figure 5.10 provides a summary of stakeholder submissions that highlight the link between energy roles or relationships, their perspectives on energy saving practices, and the significance of multiple stakeholder input in defining robust, effective and meaningful approaches to behavioural changes for energy saving.

Exploring feedback from relevant nodes lends insight into how different stakeholder groups might contribute to energy saving, thus providing a new lens through which to view current cultural frameworks. Tables 5.4 and 5.5 present views and comparisons of different stakeholder inputs based on a number of characteristics captured in the study. Table 5.4 presents the overall feedback from different stakeholders for all nodes which are compared by the year of experience.

Patterns across the table present interesting feedback with the following observations identifiable:

- Most respondents belong to the 6-15 years of experience group
- Only two SP respondents have between 21-25 years of work experience
- Only one consultant respondent has between 0-5 years of work experience
- Most respondents have a medium level of work experience
- Future studies exploring the perceptions of inexperienced and highly experienced practitioners may yield more useful insights
- Cost and incentives show similar patterns across the table; this is unexpected, considering the link between both concepts
- More experienced practitioners (11 – 15 years) are more silent on suggestions like the positive and negative incentives, compared with their less experienced (6 – 10 years) counterparts, but both groups appear to agree on the significance of user

ignorance and apathy; hence, education, information, and awareness are important tools to drive positive user behaviour.

- Feedback on the significance of policies in driving ES practices are strongest from CEs
- Feedback related to stakeholders as ES factors are similar for CEs and Consultants
- Feedback from regulators and consultants on the significance of energy efficiency strategies are the strongest and most similar
- Less experienced (6 – 10 years) CEs identified energy efficiency drivers as strong approaches to ES. Considering its significance as the application of technological solutions, it is not surprising that it receives more advocacy from the younger generation.

Table 5.4: Comparison of Overall Feedback from Different stakeholders by All Nodes.

| Energy Relationship = | CE (4) | | | | | Reg (4) | | | | | Con (6) | | | | | SP (4) | | | | | **Total (18)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Work Experience = | 0-5 (0) | 6-10 (3) | 11-15 (1) | 16-20 (0) | 21-25 (0) | 0-5 (1) | 6-10 (2) | 11-15 (1) | 16-20 (0) | 21-25 (0) | 0-5 (1) | 6-10 (2) | 11-15 (3) | 16-20 (0) | 21-25 (0) | 0-5 (0) | 6-10 (1) | 11-15 (1) | 16-20 (0) | 21-25 (2) | |
| **Energy Saving Processes and Practices** | **0** | **3** | **1** | **0** | **0** | **1** | **2** | **1** | **0** | **0** | **1** | **2** | **3** | **0** | **0** | **0** | **1** | **1** | **0** | **2** | **18** |
| Cost & Incentives | 0 | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 16 |
| Affordability | 0 | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 16 |
| Resource Constraints | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 |
| Zero Incentives | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 6 |
| Energy Efficiency Barriers | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| Human & National Factors | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 6 |
| Policy & Implementation Issues | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6 |
| User Ignorance - Apathy - AntiES Culture | 0 | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 14 |
| Education & Information | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 17 |
| Client & Peer Education | 0 | 3 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 15 |
| Research | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 |
| Sustainability Focus | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 |
| User Education-Awareness | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 16 |
| User-SP Psychology | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Energy Efficiency Drivers | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| Incentives | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 16 |
| Punishment | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 |
| Rewards | 0 | 2 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 13 |
| Subsidies | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Unattractive Alternatives | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 |
| Stakeholder As ES Drivers | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 18 |
| Corporate Actions & Standards | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 17 |
| Proactive Occupant Culture & Individual Actions | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 |
| Proactive Public Policies-Standards-Approaches | 0 | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 17 |
| Stakeholder Involvement | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 |
| Energy Saving Strategies | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 12 |
| Energy Efficiency Strategies | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 10 |
| Energy Management | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |

Table 5.5 presents the overall feedback from different stakeholders for all nodes compared by their educational background. Patterns across the table highlight some important concepts that contribute to an understanding of practitioners' views of ES strategies and practices, and how they provide insights into specific strategies to drive users' adoption of ES practices, especially in relation to policy making/implementation and education approaches.

- Seven of the respondents have a background in electrical engineering while the remaining eleven are spread across various backgrounds including other engineering fields, business, and science.
- All respondents, irrespective of their background, offered clear and strong feedback across most themes, especially in relation to ES factors, barriers, cost and incentives as well as affordability.
- Feedback on research is not extensive and four unique submissions are noted, one from each of MBA holders (backgrounds in Business Administration), M.Sc holder (background in computing), and two from current PhD scholars (backgrounds in Architecture and Mechanical Engineering)
- It is noteworthy that all current research scholars and none of the PhD holders identified the significance of research (as an educational approach) in driving positive user behaviour and the adoption of ES practices. This observation may be connected to their expected passion for research as evidence-based approaches to problem-solving in most areas of human endeavour. Such enthusiasm is usually more associated with current scholars than those who have already earned their degrees and are no longer involved in active research.

Table 5.5: Overall Feedback from Different stakeholders by All Nodes.

| | Educ. Level = Bachelors (2) | | | | | | | | Educ. Level = M.Sc (9) | | | | | | | | Educ. Level = MBA (3) | | | | | | | | Educ. Level = PhD in View (2) | | | | | | | | Educ. Level = PhD (2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Educ. Backgrou nd** | | | B Adm (0) | | Chem (0) | Engr (Elect) (1) | Engr (Mech) (1) | Engr (Civil) (0) | Geo (1) | Arc (2) | B Adm (0) | | Chem (1) | Engr (Elect) (4) | Engr (Mech) (0) | Engr (Civil) (0) | | | B Adm (2) | | Chem (0) | Engr (Elect) (1) | Engr (Mech) (0) | Engr (Civil) (0) | | Arc (1) | B Adm (0) | | Chem (0) | Engr (Elect) (0) | Engr (Mech) (1) | Engr (Civil) (0) | | | B Adm (0) | | Chem (0) | Engr (Elect) (1) | Engr (Mech) (0) | Engr (Civil) (1) | |
| ES Proc & Pract | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 18 |
| ES Factors | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 18 |
| ES Barrier | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 18 |
| Cost & Incentive | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 16 |
| Affordab-ility | | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 16 |
| Resource Constr | | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 |
| Zero Incentive | | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Energy Eff'y Barriers | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Human & National Factors | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 |
| Policy & Impl. Issues | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 |
| User Ign Apathy - AntiES | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 14 |

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| ES Drivers | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 18 |
| Educ & Info | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 17 |
| Client & Peer Edu | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 15 |
| Research | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Sustainability | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 |
| User Educ & Aware | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 |
| User-SP Psych | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Energy Eff'y Drivers | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Incentives | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 |
| Punishment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Rewards | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| Subsidy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |

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| Stakeholder as Drivers | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 18 |
| Corp Act. & Standard | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 17 |
| Proactive Occ. Culture & Indiv Actions | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 10 |
| Proactive Public Policies-Etc | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 17 |
| Stakeholder Involvement | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| ES Stategies | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 12 |
| Energy Eff'y Strategies | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 10 |
| Energy Mgt | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |

**ii.** Extending existing cultural framework to develop a suitable model for energy reduction in Nigerian residential buildings

Energy literacy has been identified as central to a 'shift in the cognitive norms' towards improved user awareness and behavioural change. This is the central thrust of the energy culture framework that has been explored within non-residential buildings. This study employed a qualitative approach to explore feedback from energy stakeholders other than the user on energy saving in residential buildings. Findings also identified the consumer culture and energy practices of households. Significant changes in material culture were not noticed due to several factors even though it has great potential. One factor that stands out, and which directly parallels previous findings is the role of stakeholders, especially the government. (Stephenson et al., 2010, p. 14) noted that government subsidies effect a significant energy culture change that otherwise "would have been unlikely if the community had not been cognitively 'primed'". The same trend is noted in this study, as respondents identified government activities like the provision of incentives, public education, proper policy support and implementation to develop the cognitive priming of users, as critical to the achievement of a significant change in user culture. Other factors were noted with the potential to effect key changes in material culture, which include stakeholder education, for example the exchange of technical advice with the government and between organisations through various forums, and cooperation between all stakeholders.

Perspectives offered by different energy stakeholders differ as a result of how they view energy saving within the context of their practice. Key feedback from this work is thus how these different perspectives can be integrated in plans and programmes to promote improved user culture in energy saving. The themes identified in this qualitative study highlight the significance of user behaviour for energy saving, and the role of stakeholders, including users, in promoting energy saving practices. The significance of incentives or disincentives, as well as the roles of both government and corporate bodies in policy making, implementation, and the encouragement of energy saving practices or making non-energy saving practices unattractive alternatives were also emphasised. These drivers and barriers can extend existing cultural frameworks by emphasising what constitutes the most important approaches within these framework elements.

## 5.6 Summary

Figure 6 provides a summary of findings from this study and how the result might extend a common cultural framework.

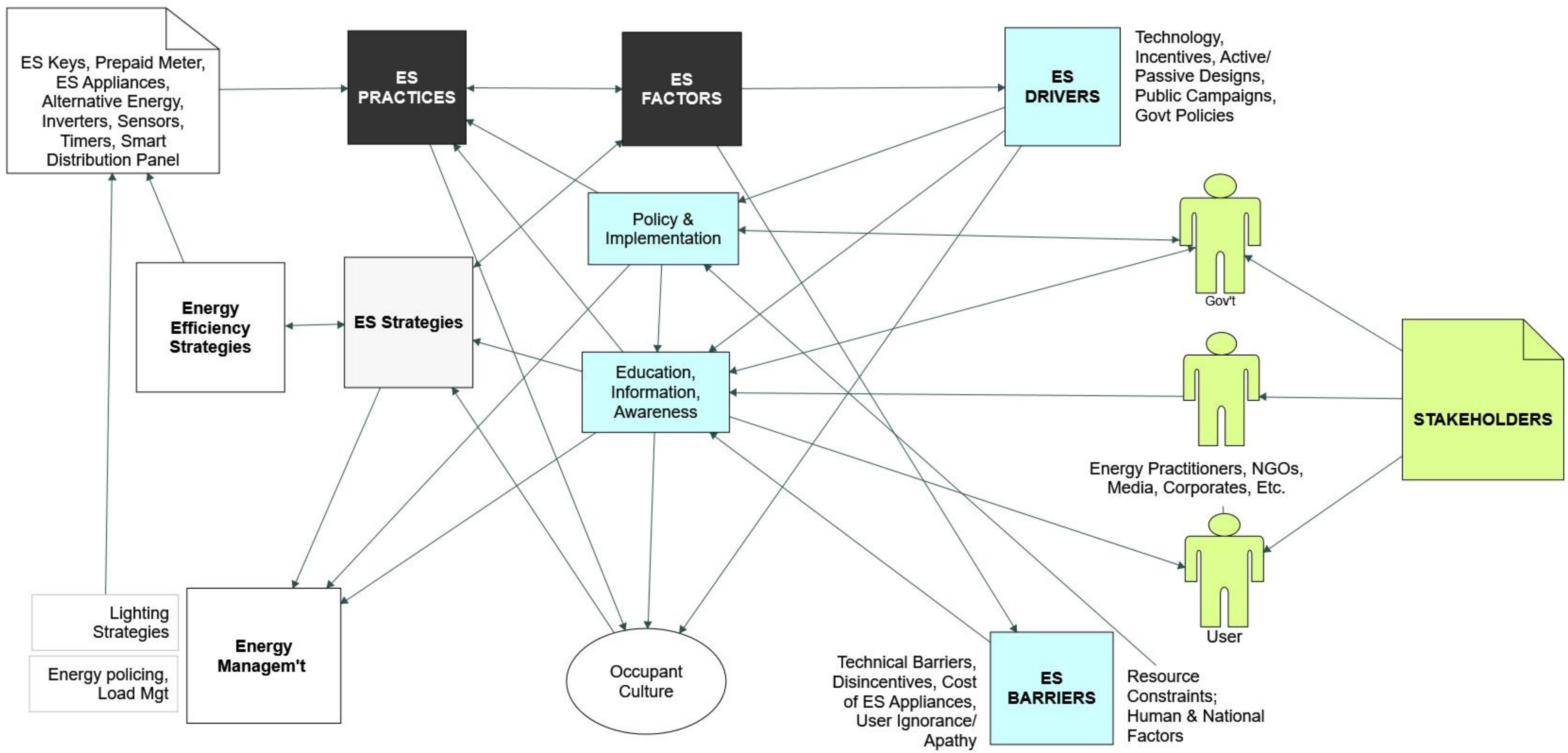


**Figure 5.6**: Graphical Summary of Findings

**Conclusion**

Feedback from stakeholder perspectives highlight the significance of an integrated view from all stakeholders as a means of defining a robust approach to ES. This will also indicate the importance of feedback from end users as a key measure. To promote ES practices among users in residential buildings, perspectives from actual users will be central to defining effective approaches and measures.

This study further confirms that energy-related behaviour is hugely complex and is shaped by multiple context-specific factors. The findings will extend the Energy Cultures framework by highlighting the complex interactions between stakeholder input and context, and the effect of this on overall energy saving and user culture. Individual consumer characteristics in terms of economy and knowledge play important roles in choices, and hence, energy behaviour. It should therefore be factored into projects and programmes to achieve the extensive adoption of energy-efficient behaviours. These are the highlights of the analysis from the results presented in this chapter. Hence, the next chapter presents the detailed discussion of the findings from these qualitative results and relating to existing literature.

# Chapter 6: Discussion of Qualitative Results

## 6.1 Introduction

This chapter summarises the findings from the qualitative phase of the study and the results from the context of the research questions outlined in Chapter 1. It begins with an overview of the main findings before proceeding to a discussion of these findings in relation to existing work, highlighting their similarities and differences. The discussion of the findings will align with the themes and sub-themes tabulated in Table 5.2. This provides an additional context for crucial points and considers how the findings from this study relate to the existing literature and theory discussed in Chapters 2 and 3.

## 6.2 Discussion of the Findings

The aim of this research was to develop a model to inform and understand the reduction of energy consumption within residential buildings in Nigeria from an end user perspective. In this section, the findings from the qualitative study (Chapter 5) are discussed in detail in the context of relevant literature. Semi structured interviews were conducted with experts to firstly, give rich and detailed feedback on the factors and practices that relate to the behavioural change relevant to reducing energy consumption in Nigerian residential buildings. Secondly, it helped to establish how existing cultural frameworks can help to develop a suitable model toward energy saving in Nigerian residential buildings.

### 6.2.1 Energy Saving Processes and Practices

The basic principle of the building energy efficiency is to use less energy for operations (heating, cooling, lighting and other appliances), without impacting the health and comfort of its occupants. The findings of the interviews suggested changes to appliances and lighting as the main strategies to support efficiency. This can be attributed to the fact that the experts recognize the need for energy efficient technologies (EETs) but are unaware or lack information on the existence of alternative EETs (Yeatts et al., 2017). This agrees with Nduka and Ogunsanmi (2015) who found this to be a barrier affecting the use of energy efficient technology by the Nigerian construction industry. However, there are five major areas to improve energy efficiency in residential buildings which includes measures for the whole building, constructing part of the building (roof, wall and ceiling, windows and shading), HVAC systems, appliances, and lighting (De Boeck et al., 2015). Most interviewees mentioned the less technical and easier to implement energy efficiency strategies. Another interviewee noted that energy efficient bulbs are usually distributed to households during town hall meetings to encourage their adoption. It was also mentioned, that in African households, most occupants (both male and female) spend the majority of their time outdoors taking advantage of the fresh air and moonlight, while others engage in more communal activities thereby reducing their energy consumption. Other interviewees suggested employing the use of motion sensor lights for corridors and security lights to save energy.

Previous studies reported that energy in residential buildings is mainly consumed by space heating (68.4%), water production (13.6%), lighting and other appliances (14.1%) (Fell, 2017; Todd & Geissler, 1999); Hunt & Ryan, 2015; Pothitou et al., 2016; Blash et al., 2017). This indicates that space heating in residential building should be an area of focus for energy consumption reduction (Trotta, 2018a); Steg et al., 2015). The study also highlighted that space heating consumes a substantial amount of energy in residential areas, especially in Europe and most parts of American which experience relatively cold weather conditions. In tropical regions with higher temperatures, air-conditioning systems to regulate the temperature level also consume higher energy compared to other appliances (IEA, 2018). Hence, it is crucial to encourage technological innovation within energy efficient appliances to enable energy efficiency and inculcate energy saving behaviours amongst occupants of residential buildings. However, it has been mentioned by an interviewee the cost of energy efficient appliances is often a deterrent to efficiency.

The use of energy efficient appliances in residential building can effectively reduce the energy consumption to enhance energy efficient practices and behavioural change in energy saving Morihsita and Ghisi, 2010 & Jareemit and Limmeechokchai, 2017). This is in consonant with the findings in this study as the responses favour the use of energy efficient appliances:

*increase in energy consumption, then you have an issue, maybe the customers are using appliances that are not energy savers;*

*use of sounds and motion sensors that would immediately switch off lights and appliances when not in use*

Responses also suggest the provision of a pre-paid metre to every consumer:

*one of the commission's ahh ahh priority now to see that everyone is connected through the meter.*

Furthermore, it was observed that the commercially available appliances for water heating, water production, and lighting are not affordable to the average household in Nigeria. The price of electric water heaters ranges from N30,000 to N120,000 (£53.76 to £215.05) (Hassan et al, 2019), in a country where having one central water heater for the house is not common. It was further noted that, with a national monthly minimum wage of N30,000 (£53.76), water production ranges from N120,000 to N600,000 (£215.05 to £1,075.26) (Johnson, 2019), while most residences depend on privately owned water boreholes for their water supply (Kumpel et al., 2016; Okpako et al., 2009; Trotta, 2018a). Fortunately, Nigeria is located in the tropics meaning that it has annual hot season between March to May that reduces the need to heat up spaces and use hot water. However, there is a higher use of air conditioning systems at this time of the year amongst those who can afford it. This indicates inequality in energy affordability, as stated by Frederiks et al. (2015), and inequity among the consumers, as discussed by Aliu (2020); Tong et al. (2021) and Cong et al. (2021). Thus, considering the different scenarios, low usage of electricity during the hot season can balance high usage during the cold season (December to February). Even though the cost of energy consumption could be higher amongst those who can afford an air-conditioning system, there is a relatively low energy consumption rate amongst the wider population that cannot afford such systems.

Pre-paid meters were also mentioned by some experts as a means to reduce most energy excesses in households (Aliyu et al., 2015; Makanjuola et al., 2015; McRae, 2015; Ogbuefi et al., 2019). However, the Nigerian Electricity Regulatory Commission confirmed that only about 45% of electricity customers have meters (Sunday, 2017). This shows that a significant number of its customers rely on estimated billing systems to pay for energy which does not encourage energy efficiency or savings. Moreover, customers have complained of inaccurate bills, while cases of meter bypasses by customers have been noted, and the subsequent refusal to pay for bills (Aribisala & Mohammed, 2021). This has resulted in service providers accruing substantial amounts of unpaid electricity and debts from the Transmission Company of Nigeria. Service providers often respond with utility service disconnection, leading to community protests (Ndujihe, 2017). However, for most households with pre-paid meters, changes have been noted in the way they use energy. This was emphasised by one of the service providers in the interviews:

> *….in the brief form, ohm, our company's approach illustrates [what] energy efficiency has to do with customers' sensitization or customer education in terms of how they use the electricity and at the same time advise them in terms [of the] best appliances that are energy efficient in terms of using appliances in their respective houses (Bravo, Energy Provider).*

Although a study of pre-paid meters by Tuffour et al. (2018) in Ghana showed that customers have complete control over their energy consumption, the inaccurate reading of post-paid metres that earned the service provider a bad reputation among consumers is also a thing of the past. However, customers still complain of technical faults in prepaid meters. Furthermore, the use of passive design strategies, daylight and the choice of materials were highlighted by one of the interviewees who is a construction expert

> *we encouraged our clients to go for passive designs. Passive designs are designs that ensure energy savings by making the microclimate of the building conducive for its inhabitant. It could come in [the] form of larger windows, roof overhang, and the orientation of the building on site, and vegetation that is landscaping (Oscar, Construction expert)*

> *we have a pretty small firm we are more into residential design and we usually educate our client right from the brief stage on the benefits of the passive design. The passive design helps in energy saving. If the environment is conducive, you don't need to put on electricity, you don't need to put on heaters or in our case air conditioners to cool the buildings*.

Interviewees also suggested the adoption of renewable energy technology, like the solar panels with sun-tracking devices, which can provide electricity and hot water to households, while energy storage batteries would be a viable option to save energy and thereby ensure efficiency and energy saving measures in residential buildings.

Furthermore, as highlighted by the interviewees, energy companies and other experts can adopt occupant centred conservation initiatives like townhall engagements and simple campaigns that work within time and lack of funding from the government. The regulator embarks on public enlightenment to enable the safe use of electricity through a pre-recorded radio enlightenment program called 'Electricity Update'. This is delivered across 12 states and the Federal Capital Territory (FCT) with the aim of enlightening electricity consumers on various issues (NERC, 2020). However, radio programmes in less than half of the states in Nigeria do not cover the whole nation, and further barriers are encountered if the language adopted is English. The NERC report also did not mention the amount budgeted for these public enlightenment campaigns.

In addition, these simple strategic messages (switching off lights when not in use, using energy efficient appliances and lighting) which can be tailored to occupants can result in significant savings through behavioural change. Although energy providers mentioned that within their office environment, the energy police ensure that lights and other appliances are switched off after closing hours, these actions are more habitual in character; in comparison, require more strict routines and discipline are required in residential environments. Abrahamse et al. (2005) state that this is challenging because even with enlightenment and monetary rewards, the behaviours of many households do not change towards energy efficiency. However, Ubale and Abdul Majid (2014) believe that public enlightenment on how to efficiently use energy coupled with energy saving appliances can influence change in the behaviour of households. This agreed with the results from some of the interviewees that creating awareness and using energy saving appliances would facilitate the attainment of more sustainable energy practices in residential homes.

The afore-mentioned campaigns should be mostly centre on households. Finally, government contributions should not be overlooked when trying to improve energy saving behaviour, particularly with respect to appliances and the import of renewable energy equipment. This will require more action on the standards of appliances as well as policy enforcement. Globally, governments are making policies and taking action on climate change as prescribed in the Paris Agreement. These actions involve accounting for energy efficiency (Hesselink & Chappin, 2019; Podgornik et al., 2016); energy savings through tariffs (Eyre, 2013; Prasanna et al., 2018), implementing an energy efficiency building code (Atanda & Olukoya, 2019; Geissler et al., 2018; Prasanna et al., 2018), and using incentives (Atanda & Olukoya, 2019; Geissler et al., 2018; Kaufman & Palmer, 2012; Prasanna et al., 2018; Xu & Chen, 2019). Other policies also focus on ensuring the importation of good quality energy efficient lighting and appliances (Mills & Schleich, 2014; Singh et al., 2019); research and development in energy efficiency (Mayer, 2018; United Nations, 2015); energy conservation activities (Broad et al., 2020; Flores-Larsen et al., 2019) awareness of the potential benefits of adopting energy efficient behaviour (Wei et al., 2017), and improving energy efficiency with regard to the distribution of electricity by energy providers (Emodi & Yusuf, 2015; Oikonomou et al., 2009). Although, these government strategies are advantageous to all concerned, the priority for the sector is to meter every electricity consumer:

> *Also, the commission err is working tirelessly to see that every customer is connected to the network through the meter erh prepaid meter. So it's one of the commission's ahh ahh priority now to see that everyone is connected through the meter. [November, Regulator]*

However, before these measures are implemented, a better understanding of how to reduce residential energy consumption is required (Csoknyai et al., 2019). Moreover, Nigeria is grappling with challenge of providing stable energy for its growing population (Adewuyi et al., 2020), and the whole of Sub-Saharan Africa contributes about 30% of the total emissions to global warming (Fleurbaey et al., 2014) meaning that these countries are not enthusiastic about meeting up their climate change targets. Additionally, the NVivo analysis illustrates that energy efficiency strategies have a stronger emphasis amongst energy consultants and regulators. This supports the existing study which observed that increasing the diffusion of best practices, technologies and innovation is regarded as one of the strategies to reduce energy consumption and carbon dioxide ($CO_2$) emissions (Hong et al. (2017). Best practice and appropriate technologies are introduced to the built industry by consultants who know the advantages of these appliances.

There are divergent views on the technologies which would facilitate the adoption of greater efficient energy saving approaches in residential building. Rather there were convergences in agreement that technological changes to buildings, such as fabric or system upgrades, would offer the potential for technical energy savings. Some interviewees also expect that behavioural changes to the way that individuals interact with technologies could enable energy savings. It was observed that another emerging concept of social potential aimed to shift attention from individuals in the building energy efficiency industry towards a more creative and contextual orientation. This recognises the importance of social relationships in changing the orientation or mindset of people in energy saving behaviour.

#### *6.2.1.1 Energy Management*

The findings from the qualitative study on energy management strategies include energy policing, lighting strategies, the use of smart meters, energy storage systems and load management. However, literature has categorised energy management into three forms including direct load reduction demand response management, demand side management (DSM), and (more precisely) residential energy management (REM)(Trotta, 2018b). It was noted that the majority of interviewees had the requisite knowledge and experience in energy saving or energy management. However, the use of designated 'Energy Police' by energy regulators to switch off all appliances after the close of work every day indicates deficits in energy saving practices amongst regulators. In addition, literature also supports the views of some interviewees on the adoption of energy management strategies through the use of smart meters and innovations in energy storage systems (Hong et al., 2019; Nagy et al., 2015).

It was further noted that the use of smart meters in more advance societies are confronted with the challenge of privacy and big data (Wang et al., 2018) and social problems like household vulnerability, poverty, exclusion and resistance from society (Sovacool et al., 2017). Additionally, inverters, lighting based on motion detectors, and timers are all products of energy storage systems and lighting strategies. However, these products are only used by households that can afford these items (Isola & Mesagan, 2017). It was noted that lighting based on motion detectors are also more efficient if operated in a smart home through the Internet of Things (IoT) (Firdaus & Mulyana, 2018; Isola & Mesagan, 2017; Motlagh et al., 2018). This may be difficult to implement in Nigeria as the country's broadband penetration is low, at 40.88% as of December 2021 (Nigerian Communications Commission NCC, 2022). It is also vital to note that the affordability of these energy saving innovations hinges upon the government reducing tariffs (if imported), reducing production costs (if locally produced) to manufacturers or incentives to producers and dealers to make their appliances affordable to Nigerians. These measures therefore intend to achieve multiple goals that range from low costs to the consumer, energy saving within electricity usage, and climate change mitigation. This is further confirmed by the interviewees:

> *by the time your house consumes less energy, that particular energy will also be routed to some other places that they really need it* (India, Regulator).

> *we do give them that kind of sensitszation or education and at the same time also to ensure we reduce the level of technical losses that we have. We also have an approach by operating most of our dilapidated networks so we can at least reduce some of the technical losses that we have (Bravo, Energy provider).*

> *…connected to the network so that at least you would have them to your cascade, then equally you make that your network is technically healthy to make sure that you don't [have] much energy loss… through wrong connections and creating faults in the line. So, apart from ensuring that you have a clean network to minimise the technical losses in the line, what we do again is to advice our customers from the use of incandescence lamps to energy saving bulbs (Juliet, Energy Provider).*

### 6.3.2 Energy Saving Factors

This theme incorporates energy saving barriers and drivers, as illustrated in Table 5.2. Energy saving barriers are grouped into five, which are energy efficiency barriers (technology-related), user ignorance-apathy-culture, policy & implementation issues, human & national factors, and cost & incentives. The energy drivers, discussed as positive factors, are: energy efficiency drivers (technology-related factors), education and information, incentives, and stakeholders.

#### *6.3.2.1 Energy Saving Barriers*

Barriers to energy saving can be technical, financial, policy, and regulatory in nature which can be resolved if governments take appropriate action (UNIDO, 2017b). The International Energy Agency IEA (2014) noted that the lack of attention to energy efficient investment opportunities amongst stakeholders in both the industrial and government sectors are a barrier to energy saving behaviour. However, the major barrier mentioned by interviewees is technical, namely: excess energy that is not distributed to consumers, poor distribution networks, and a failure to adhere to standard formats (including connections, equipment, sockets, switches, and fusing). Thus, the energy generated is accounted for during transmission but lost in distribution and in household utility. The major barriers identified in the semi-structured interviews are captured under five third-level themes (as illustrated in Table 5.3): Energy efficiency barriers, user ignorance-apathy-culture, policy & implementation, human & national factors, and cost & incentives. These barriers are further discussed below:

*a.* ***Technical (Energy Efficiency) barriers.*** Currently, Nigeria's construction industry is underdeveloped in terms of energy efficiency, due to a lack of standards, technological guidance, and established information channels which results in high costs and low product credibility (Lützkendorf & Lorenz, 2005). Technical barriers, as identified in this research, were mainly noted in relation to electricity providers and described as 'hotspots' which lead to a difference in the energy supplied and used (technical losses). Distribution companies are licenced to manage and reduce losses along the electricity value chain (Odje et al., 2021). However, they still experience energy loss because the national grid has insufficient capacity to transmit the power generated (Edomah et al., 2016). This challenge is responsible for insufficient energy to end users, amongst others.

Energy loss is also experienced at the distribution end where interviewees further discussed a failure to adhere to the standard formats of connection, switches, and the partial contacts of fuses in transformers; these were identified as the leading technical barriers they face. Furthermore, nonadherence to industry and construction standards, low quality switches and fuses, and poor technical skills are factors that the government needs to enforce through existing regulations by implementing an energy efficiency building code (Geissler et al., 2018; Atanda & Olukoya, 2019). This would ensure the importation of high quality energy efficient lighting and appliances (Mills & Schleich, 2014; Singh et al., 2019) and would create awareness about the potential benefits of adopting energy efficient behaviour (Change, 2007; Wei et al., 2017). Distribution companies should be held responsible by the regulator for substandard appliances along the value chain, particularly relating to energy metering.

Engineers and technicians could be sanctioned for the supply and installation of substandard electrical equipment, while appliances imported into or manufactured in Nigeria must meet the required international standard and best practice meaning that suppliers and manufacturer should be held culpable for any defects. Additionally, the government should encourage generation and distribution companies to set up local electrical equipment industries to produce relevant appliances in line with international standards and best practice.

Meanwhile, a lack of knowledge amongst investors and developers about products may increase the risk of investment failure resulting in the rejection of new technologies. Odje et al. (2021) noted that private investors are selected based on a proposal that aims at limiting aggregate technical, commercial and collection losses over a five-year period. Thus, investors won the bid to own 60% equity in generation and distribution companies because of their expertise and competence in the electricity sector. However, Papaefstratiou (2019) stated that electricity privatisation programmes faced difficulties during implementation. These difficulties included the lack of available audited accounts which detailed the liabilities of the businesses to be privatised. Furthermore, GENCOs and DISCOs were purchased with minimal due diligence, little visibility, and minimal information relating to the assets and businesses in their portfolios and their operational capabilities. Furthermore, some of the privatised assets deteriorated throughout the privatisation process as scarce resources were no longer directed towards the continued operation and maintenance of those assets. Hence, new investors focus on rehabilitating and reviving dilapidated and obsolete equipment and not on introducing new technologies. Additionally, the regulator needs to enforce standards of equipment for uniformity across all DISCOs and GENCOs. This is because, over time, differences in technical skills and equipment across the Distribution and Generation Companies might create problems in synergy and integration.

Furthermore, there is a lack of professional staff and entrepreneurship when implementing energy conservation measures (Wang et al., 2016). There is also a lack of testing of appliances imported into the country due to poor standard practices. Rikko and Gwatau (2011) stated that Nigerian's architecture is shaped by the introduction of new building materials which are mainly imported from abroad and the building materials are not produced for local climatic conditions meaning they incur more energy to operate such buildings (Todd & Geissler, 1999). To achieve maximum impact, energy saving will require the delivery of best value, including higher quality, wealth generation and productivity levels that consider appropriate social issues. A lack of integration of new technology is considered one of the most important barrier groups for energy efficiency implementation.

b. **User ignorance-apathy and anti-energy saving culture.** It was observed that users lack the requisite knowledge that relates directly to the advantages of education. When user knowledge increases, attitude and culture changes. When users lack adequate knowledge, it is reflected in their choices, actions and energy use as well as negative ES practices. When making decisions, homeowners may prioritise other factors than energy efficiency, be oblivious of energy efficiency, or simply be unwilling to change (Ferrari & Beccali, 2017; Schleich et al., 2016). This assertion was confirmed by one of the respondents, noting that homeowners do not look at cost on a long-term basis but rather on a short term when choosing building materials or appliances; this can be remedied with more knowledge of the advantages. However, Abrahamse et al. (2005) acknowledged that a household's information on energy efficiency and conservation has led to more enlightenment about the topic but no behavioural change. Yet, households' energy consumption could be influenced by the number of people in the household (Leahy & Lyons, 2010), their age range (McLoughlin et al., 2012) and behaviour (Brounen et al., 2012). Additionally, stakeholders in both industry and government sectors need to invest in an energy saving culture through enlightenment and the provision of appliances before it can be accepted by the end users (International Energy Agency IEA, 2014).

Responses from the interviewees stated that users are not made to take responsibility for their energy usage due to estimated billing (India; Regulator), which encourages a culture of not switching off bulbs when not in use (India; Regulator), while '*unexpected situations like the pandemic lockdown forced people to use more energy*' (Juliet, Service Provider). Most of these user behaviours are cultures that are ingrained following years of low to no enlightenment. Nevertheless, with evolving knowledge and understanding of how to design energy saving houses and encourage low energy usage, behaviours might change prompting users to conform to energy saving practices (Olaniyan et al., 2018; Paone & Bacher, 2018). In addition, it was noted that higher income earners may consider a more sustainable energy source even if it is expensive, when compared to medium or low-income earners (Frederiks et al., 2015). Furthermore, high income earners may not consider the importance of energy efficiency because they can afford to pay for energy (Brown et al., 2020); therefore, they may not be bothered if the bulbs are not switched off during the day or if they stay at home for months.

*c.* ***Policy and implementation issues*****.** Globally, challenges arise during the implementation of government policies and Nigeria is not an exception (Isaksson et al., 2017; Peidong et al., 2009). The Nigerian power sector are experiencing a similar challenge in implementing their current policies (Ajayi & Ajanaku, 2009; Dialoke & Veronica, 2017; Effiong, 2013; Oyewo et al., 2018), and particularly in implementing energy saving policies in residences (Coyne et al., 2018). However, responses from some of the research participants (two construction experts and one energy consultant) confirmed there is no law or regulation to guide the usage of energy saving appliances. The Nigerian Building Energy Efficient Code (BEEC) was launched in 2017 (Federal Republic of Nigeria, 2017), and Section 34 of the National Environmental (Electrical/Electronic Sector) Regulations, 2011 set the standard for power generation, transmission and distribution, and for household electrical appliances. Therefore, Nigeria has laws and standards guiding the electricity sector; moreover, electricity consumers do not want a change in the culture they are used to (Hussaini & Abdul Majid, 2015). Hence, for personal reasons there is a challenge to switching to prepaid meters, and this could negatively impact those who benefit from the approach. Interviewee Charlie, an energy consultant, stated that

> *we contribute a lot in the development of [an] energy master plan but we all know that it is due for revision and the implementation is very low so if you are talking about that angle, I think the implementation is not encouraging.*

Dialoke and Veronica (2017) and Oyedepo et al. (2018) stated that implementing policies in Nigeria is challenging, even for the policy implementors and decision makers; indeed, delays to the review of existing policy based on recent data is one of the issues that the sector needs to address.

d. **Inconsistent standards and compliance requirements**. This is attributed to a lack of adequate standards, codes, net metering guidelines and utility interconnection standards, a lack of cost reflectivity in electricity tariffs, policy uncertainty regarding renewable energy buyback schemes and future feed-in tariff. There is also policy uncertainty on technical requirements for residential feed-in, as well as residential feed-in tariff, and a lack of clear national energy efficiency standards where clear energy efficiency targets are defined. It was noted that no clear air emission regulation existed nor clear national standards for electrical appliances alongside the inadequate implementation of national building codes.

e. **Human and national factors.** The human factor in energy saving barriers manifests in different forms including the abuse of power by government officials (Imhonopi & Ugochukwu, 2013; Mohammed, 2013) and private organisations (Imhonopi & Ugochukwu, 2013; Mohammed, 2013; Okeshola, 2012; Osemeke & Osemeke, 2017) alongside misconduct on the part of public officers (Abomaye-Nimenibo & Samuel, 2020; Gundu, 2011). In such cases, they become national factors because every sector of the economy faces these issues. This is confirmed by the interviewees

> *I forgot to mention another major factor that is a barrier to energy saving practices in Nigeria. That is corruption!* [Papa, Construction Expert].

Apart from the exploitation perpetrated by private and public officials, another human factor is the innate quality of self-interest before public interest. This manifests in switching off appliances when not in use;

> *the habit of leaving systems on even when they are away* [Echo, Energy Consultant],

It also appears in low quality imported appliances, tools, and equipment through the deliberate import of low quality items to make high profits*:*

> *the appliances there are a lot of fake products in the market so a lot of people tend not to have confidence in them* [Charlie; Energy Consultant];
>
> *Another thing that I noticed is the fact that energy saving doesn't last due to the substandard technology. You put in a lot of money but the output [is] due to substandard technology sometimes and we are not able to gain, as I said I invested* [Delta; Construction Expert].

The need to change the culture and behaviour of Nigerians towards saving energy was emphasised by Brandon & Lewis (1999), Abrahamse et al. (2005), and Yohanis (2012). Furthermore, Slupik and Trzesiok (2021) stated that the study of energy consumption and energy saving behaviour is new, thus, behavioural change in energy usage might take a while especially in Nigeria where 24-hour power supply is a luxury rather than a necessity. However, technology-based up-grades towards energy efficiency is strongly influenced by human behaviour (Ubale & Abdul Majid, 2014) and the rush for the latest innovation in the sector has led to the importation (or manufacture) of substandard products. Recent trends have shown that technological improvements alone will not achieve low energy and improved comfort in buildings but rather demand the inclusion of human factors (D'Oca et al., 2018). Additionally, the energy consultants and the construction expert acknowledged the failure of importation checks and low manufacturing standards in Nigeria. It also illustrates the impact of misconduct by public officials (Abomaye-Nimenibo & Samuel, 2020; Ukeje et al., 2020) and by private sector organisations (Okeshola, 2012; Osemeke & Osemeke, 2017). Therefore, approving the importation and local manufacture of substandard electrical appliances illustrates the connivance of public and private sector officials which negatively impacts Nigeria's energy saving ambitions.

f. **<u>Cost</u>.** The findings from this sub-theme highlighted resource constraints and the problems of affordability in energy efficiency appliances (amongst other measures) amongst the masses**.** Financial/economic barriers include the investment required to implement energy-efficient technologies in buildings (Travezan et al., 2013; Wang et al., 2016; Zhang et al., 2018). Energy-efficient and renewable energy technologies, such as energy-efficient air conditioners and inverters, and solar energy, require a larger upfront cost than standard equipment. Investments in the adoption of such technologies are greater than those in conventional technologies, affecting the rate of BEE adoption. This finding agrees with the literature (Durdyev et al. (2018); Goodier and Chmutina (2014); Shukla et al. (2018) . The adoption of technologies, such as HVAC systems, more energy-efficient lighting systems, photovoltaic devices, and geothermal heat pumps increases the cost of investment (Kangas et al., 2018; Robichaud & Anantatmula, 2011). Another barrier mentioned in the interview is occupants' financial constraints; in many cases, owners lack the capital necessary to invest in technologies or to implement the necessary reforms (Li & Colombier, 2009). Others mention they are averse to the risk of investing in energy saving and renewable energy technology (Djokoto et al., 2014) and narrated instances where solar energy resources did not measure up as expected. There is also the difficulty in accessing funding bodies. Having access to such funding bodies requires knowledge of the right people to guide households in the funding process. Financial barriers are still seen today as one of the main barriers to energy efficiency and energy saving behaviour. The challenges to energy efficiency and, more broadly, sustainability is accelerated among households, because of financial constraints, although the willingness to provide financial support to households can help boost their energy efficiency. This was noted when analysing the contributions of some interviewees.

g. **Lack of incentives.** During the interview, most experts mentioned a lack of incentives (with the exception of a few energy providers and the energy consultants). The energy providers mentioned the distribution of the energy saving bulb to households as a form of incentive to encourage energy saving. Also, energy consultants mentioned they provide individuals with free advice on the adoption of energy efficient technology and renewable energy. Economic incentives are crucial for energy saving behaviour change. Several studies, however, indicated the persistent lack of economic incentives to implement energy-efficient technologies (Chmutina et al., 2013; Durdyev et al., 2018; Yeatts et al., 2017). This barrier can be explained by the government's refusal to provide financial assistance or economic incentives to building owners to adopt such technologies (Addy et al., 2014; Zhikun Ding et al., 2018; Gupta et al., 2017). It is important for the government to develop economic incentives which lead to tax reductions and financial rewards (Adeyeye et al., 2007; Wang et al., 2016). However, it is important that this form of incentive is available to project investors

(Zhang & Zhou, 2015). This underscores the importance of incentives in achieving energy efficiency and energy saving behaviours.

### **6*.2.2.2 Energy Saving Drivers***

This subsection discusses the factors that drive energy saving among the stakeholders of the electricity sector. The factors identified by the research respondents are energy efficiency drivers.

a. **Technology Related Factors**. These are technology-powered solutions, approaches, strategies, and methods involving the use of technology to drive, encourage, promote or implement energy-saving. The Fourth Assessment Report of Intergovernmental Panel on Climate Change (2007) emphasised some technological drivers of energy saving: the use of technology to save energy; whole house refurbishment and retrofit in line with the Building Code (Jia et al., 2021; Thomas et al., 2009); the energy labelling of residential buildings (Jiang & Zhang, 2017); the integration of household appliances and energy supply through the Internet of Things (Arshad et al., 2017), and socio-technical issues based on the occupier of the house whether homeowner or tenant (Nie et al., 2020). However, a Oscar – Construction Expert stated that they *"for clients, we encourage them to use solar panels. We try to educate them to minimise or to have the optimum use of energy they have from the solar panels".* Accordingly, this illustrates other technological strategies to enable household energy saving, not only solar power. However, if this is the only available strategy and technology in Nigeria, the introduction of more solutions should be fast tracked through research and development and technology transfer. Furthermore, Diesendorf & Diesendorf (2007), Iris & Lam (2019), and Tanaka (2011) stated the advantages that technology plays in saving energy. However, Santin et al. (2007), (Gram-Hanssen, 2014; Morley & Hazas, 2011; Santin et al., 2009) emphasised the importance of occupant behaviour including whether the technology will be accepted (like pre-paid meters) rejected, or abused (like leaving bulbs on during the day).

b. **Education and information**. Through enlightenment and sensitisation the research participants have knowledge of energy saving approaches:

> *we have meetings, and we go to conferences, that's how we get to know about them.* [India; Regulator].

They also rely on research data to identify problems and solutions, and test energy efficiency strategies and tools:

> *we started with the university after doing the energy audit of all offices in the university, we came up with a report to the university management that looks, this is what every office, every department is consuming in terms of light* [Lima; Energy Consultant].

The need for education and information was also reiterated by an energy service provider (Bravo) and an energy consultant (Echo). An understanding of why and how energy can be saved can convince users on energy saving (Nakamura, 2013). However, the larger a household the greater the energy consumption (McLoughlin et al., 2012). Thus, even if parents understand why and how energy can be saved, they will not be able to do so because of the size of the family and the use of numerous appliances (Brounen et al., 2012). Although some households might have all the information and education needed on energy saving no behavioural change will be achieved (Abrahamse et al., 2005). Moreover, others might change if they know the amount of money they are saving, accept that saving energy is their responsibility, know how to save energy, and compare a current energy bill with that of the previous months (Leelakulthanit, 2017). While research and information can drive energy saving, Trotta (2018) and Gupta et al., (2017) stated that without an information drive energy savings cannot be achieved. Therefore, regardless of negative receptions and attitudes amongst household energy users after receiving all necessary information, it is still more advantageous to provide such details. It should be noted that information on energy saving is not only based on technologies but also on the passive designs of houses. It also implies that such buildings that are designed with large windows, high ceilings, landscaping with garden and trees to make the house airy, using natural lighting and encouraging cool temperatures. The idea is promoted through client education to encourage the adoption of passive design in building designs. This is in line with Nigerian Building Energy Efficient Code (2017) that encourages the incorporation of biophysical elements in building design to enable energy saving. Because Nigerian's architecture is influenced by designs and building materials from abroad (Rikko & Gwatau, 2011), the design often does not consider the local climatic conditions and building standards, which incur more energy to operate such buildings (Todd & Geissler, 1999). As stated by Oscar, a construction expert,

> *if the environment is conducive, you don't need to put on electricity, you don't need to put on heaters or in our case air conditioners to cool the buildings.*

The interviewees expressed different views on energy saving strategies and drivers. The construction experts believe that energy saving strategies that contribute to sustainability are positive, while research was a solution proposed more by consultants. However, all the professional groups indicate that all stakeholders, including corporate bodies, are drivers. Incentives to encourage the acceptance of energy saving strategies are supported by all respondents except the regulators who suggest that punishment should be the consequence. Energy efficiency strategies (technological solutions) were also emphasised more by construction experts than other professionals. It cannot be concluded whether the fact that some (e.g. service providers and regulators) may benefit from energy inefficiency as noted by a respondent might have contributed to this position. Construction experts who participated in this research believe energy saving strategies that contribute to sustainability represent a positive strategy, which coincide with the findings of Ahn et al. (2013). It should be noted that energy management education and training are scarce in the Gaza Strip, and local contractors have no formal energy management education and training. As buildings are now required to have building ratings based on the Nigerian Building Energy Efficient Code (2017), corporate organisations are also making their performance and operations environmentally friendly (Elkington, 2001). Therefore, the desire to be seen as an environmentally friendly company is a positive indicator for organisational performance and assessment, both publicly and globally. Thus, an energy consultant (Romeo) stated that:

> *[a] lot of companies are trying to position themselves as erhm an eco-company or green companies and try to use all energy efficiency and energy-saving approaches in all their operations.*

Conclusively, architects must factor in the natural or regional environment to make design decisions that align with energy-saving approaches. As stated by an energy service provider interviewee (Foxtrot), when designing a house in Jos which is in Plateau State, Nigeria, wiring and fittings for room heaters are required unlike in Maiduguri in Borno State, Nigeria where an air conditioner, ceiling fan and large windows would be preferable. Thus because of the weather conditions different considerations are required– Jos has mild conditions during the hot season and cold during harmattan while Maiduguri has high temperatures in the hot season. However, empirical evidence on changing energy behaviour through public campaigns or increased exposure is limited (Owens and Driffill, 2008; Sorrell *et al.*, 2000; Sweeney *et al.*, 2013). These authors rather recommend co-operating with specialised research centers to adopt a transdisciplinary approach and to forego traditional governmental subsidy policies. Research has highlighted that people sustain changes in behaviour if they have been given tailored information (Iweka et al., 2019; Lo, 2011)). Hence, the critical nature of education and information in energy efficiency and energy saving behaviour cannot be overemphasised.

c. **Incentives:** Lack of or inadequate incentives might discourage energy consumers to think of saving energy in their households (Trotta, 2018; IEA, 2014). Also, split incentives can be a disadvantage to energy saving drivers (Nie et al., 2020; Sorrell, 2015); such incentives are based on the differences that arise between those who pay (landlords) and those who enjoy the benefits (tenants) of the adoption of energy-efficient technology and energy-saving behaviour. Household energy users will accept energy saving strategies and technologies if there is an incentive for them in the short and long terms. Moreover, (Leelakulthanit, 2017) stated that users will save energy if they know the amount of money they are saving, they accept that saving energy is their responsibility, and compare their current energy bill with that of the previous months (Leelakulthanit, 2017). As the respondent from the regulator (India) stated:

> *so … more people are installing prepaid meters; they are now seeing that …t their consumption is going high that is rolling; people are now realising that oh I need to remove this one need to remove this one, I need to remove this*.

Trotta (2018) stated that energy-saving behaviours drive energy efficiency investment. Thus, households will invest in long term energy saving appliances if they change their behaviour to understand the energy and cost they are saving. Hence, research participant Juliet (energy service provider) stated that:

> *key motivation is to makes you pay less… if you ask for the cost of that old model it might tell you that this might (be) 30,000 naira, but if you ask for the cost of this new model they would say that it is like 80,000 …the energy that this old modern [one] would be drawing for a period of year right? You would see that you would have paid that 50,000 times two…anything that you are going to do that would make people to save money for their pockets you would see people love doing it because we have scarce resources.*

Incentives can be positive or negative to the consumer. They can be positive if they save costs and energy, and negative if they are not enlightening and violate electricity regulations which result in punishment and sanctions. The respondent from the regulator (Gulf) said this is applicable to consumers, DISCOs, GENCOs, and the transmission company. For the consumer, anti-energy saving activities like by-passing meters to connect to electricity sources will be discouraged and higher charges will be applied for using non-energy-efficient appliances, thus promoting, or encouraging the use of ES appliances. DISCOs offer employee benefits and Key Performance Indicators (KPIs) are tied to revenue generation, meaning they work hard to discourage anti-energy saving activities, and thus prevent wastages and leakages. However, Han et al., (2013) stated that incentives for energy saving should be tailored to fit individual households by their preference: cost driven residents, conscious residents, ease driven residents and environment minded residents. Furthermore, cost is always an incentive in energy saving. Hence, Mike (regulator) states that*:*

> *with the changes, even in metering, people are gradually knowing that they have this new regime to take measures so that they would be able to demand less and have much [more] [money] in their pocket by adopting alternative sources like solar and inverters.*

d. **Stakeholders as Energy Saving Drivers.** Stakeholders play a central role in the energy saving culture and consumption behaviour of occupants. They are responsible for education, motivation, policymaking, public support, the provision of incentives and more. The key stakeholders identified include energy organisations (service providers, consultants, regulators, and construction experts), investors and the government. Organisations like the

Energy Commission of Nigeria has a mandate to ensure energy efficiency in the country while some, like NERC, are regulators and others are into generation, transmission, and distribution.

- **Stakeholder Involvement**: The IEA (2014) states there is lack of attention to energy efficiency investment opportunities by stakeholders in both the industrial and government sectors. To reduce energy consumption and enhance the modelling of energy consumption in buildings, occupants' behaviours toward building energy consumption need to improve through the involvement of professional stakeholders (Yu et al., 2011). Juliet, from an energy service provider, states that:

  > *attention should not just be that the customer should pay me, you should be able to what customer can afford and that will (promote) harmony between you and the customer.*

  Therefore, households listen to the professional stakeholder because they provide information that is beneficial to the consumer which allows for mutual understanding. Di Foggia (2018) states that an effective energy policy provides consumers with reliable information and project developers with a stable regulatory environment that encourages investment while investors are responsive to reliable information. Thus, a harmonious relationship arises between the regulator and investor/service provider/consumer. However, Díaz-López et al. (2021) state that, from a stakeholder point of view, a sustainable building is driven by fiscal (rebates and deductions in property tax, building and construction tax, value-added tax for construction companies and developers, and fees for habitability and first occupancy licences), and government interventions (technical support mechanisms, the implementation of housing design support tools, the facilitating of access to databases, and the provision of subsidies to finance public services), in that order. Thus, all stakeholders, excluding the government, needs some incentives to provide energy saving (and sustainable) energy consumption.

- **Proactive Occupant Culture and Individual Actions**: Globally, there has been a continuous increase in energy consumption from coal, oil, and gas with a negligible consumption of other renewable, solar, wind and hydropower in the last decade (BP

Statistical Review of World Energy, 2020; International Energy Agency IEA, 2021b). This undermines the efforts towards sustainable alternative energy. In terms of policy, Nigeria is ready to provide alternative energy sources through the Energy Commission of Nigeria; the Commission is charged with the diversification of energy resources by developing and maximising the use of all available sources, including the introduction of new and alternative energy sources such as solar, wind, biomass, and nuclear energy (Usman & Abbasoglu, 2014). With the development of the Renewable Energy Master Plan (REMP), Nigeria should call on all stakeholders (policymakers, businesses, non-governmental organisations) to identify opportunities and best practice to develop and invest in renewable energy (Williams et al., 2019). Renewable energy includes solar, wind and biomass, however, there is low awareness of the importance of biogas production from a range of feedstock as an alternative energy source in Nigeria (Ajieh et al., 2021). Therefore, providing information on available alternative energy sources and investment opportunities for these energy sources will encourage consumers to use these alternatives.

As cited previously, a proactive energy saving culture is driven by user behaviour that will lead to a change in the usual culture of energy mismanagement (Shuangjie, 2021). A culture of energy saving behaviour enhances productivity, lowers operating costs, and minimises environmental impact in a building (Baatz, Relf, et al., 2018; International Energy Agency IEA, 2014; Weinsziehr & Skumatz, 2016). Behaviours are one's values, beliefs or attitudes, and social norms towards energy efficiency activities (Gardener & Stern, 2002; Bergquist, 2020), and behaviour differs among socio-economic and demographic groups (Poortinga et al., 2005; Chen, Xua & Day, 2017). Household designs (D'Oca et al., 2018) and the use of energy efficient appliances help to save energy Trotta, 2018).

Responsible use is the major factor in energy management and ES practices in both residential and non-residential buildings. The day-to-day activities of individuals and groups regarding responsible lighting (switching on and off), the management of security lights, the use of all-day and all-night air conditioning and electrical appliances permanently left on are some very common non-ES practices. More use of sunlight, and the reduced use of air conditioners especially through solar-powered systems that automatically switch on and off to power borehole and pump machines are all ways of promoting responsible energy use. In a similar manner, energy policing is employed in corporate settings, while individuals and families can also adopt such responsible practices in residential premises. In essence, encouraging users to be conscious of switching off lights and appliances when they are not in use, and promoting and adopting the use of solar energy can directly promote ES. Making useful information about novel sources like solar energy available to the public will also promote its use.

The issue of policy was not highlighted in the interviews mainly due to the lack of policy enforcement:

> *I think, the drives come [from] the board of the company because of the importance of energy efficiency, down to the staff and down to the customers (Bravo-Energy provider).*

Authors have argued that behaviours can be transferred from one environment to another and have described this as 'spill-over' behaviours (Thøgersen & Grønhøj, 2010; Whitmarsh & O'Neill, 2010). The distinct energy practices of the individual, which can be examined by the energy culture framework (Stephenson et al., 2010, 2015) may 'spill-over' from the home environment to the work environment. The behaviour spill-over may also move from work to home, with workplace energy practices moving into the home environment where appropriate.

How can the use of drivers and stakeholders help to improve occupant attitude and energy consumption behaviour in residential buildings?

e. **Stakeholder input.** The role of stakeholders in the improvement of occupants' attitudes and energy consumption behaviour in Nigerian residential building is crucial to the objectives of this study. There are some critical organisations in Nigeria that could influence the attitudes and behaviour of residents towards more sustainable energy consumption. Some of the major stakeholder organisations are discussed as follows:

- ***National Center for Energy Efficiency and Conservation***. This is one of one of the six centres under the Energy Commission of Nigeria responsible for conducting research and implementing energy efficiency and conservation in the residential commercial, industrial and transport sectors. The centre's main area of focus include research into energy efficiency and conservation, energy policies, energy audits, public awareness of energy efficiency and conservation. Through targeted and planned programmes, the effective implementation of the objectives of this centre would influence the attitude and behaviours of residents towards energy reduction, energy efficiency and more sustainable approaches to energy consumption in Nigerian residential buildings. One of the important research works promotes the use of energy efficient appliances and light bulbs with the aim of reducing energy consumption.
- ***Energy Commission of Nigeria***. The Energy Commission of Nigeria is the statutory body responsible for the overall planning, development and implementation of policies on energy matters in Nigeria. Some of the major objectives of the Commission include the implementation of energy policies, the promotion of diversified energy resources, the introduction of new and alternative energy sources, the development of sustainable and more realistic approaches to energy use and management, and collaboration with relevant international organisations on all matters related to energy efficiency and management. To achieve its objectives, the Commission established six centres, including the National Centre for Energy Efficiency and Conservation, to facilitate the implementation of its programmes through several initiatives. The Energy Commission of Nigeria is a major partner of the UN on the implementation of the UN SDG and other key initiatives including climate action. In view of the aforementioned, a deliberate policy or strategy to facilitate behavioural change towards the attainment of sustainable development goals can achieved through the Energy Commission.
- ***Federal Ministry of Environments Renewable Energy Unit***. The Federal Ministry of Environment is mandated to ensure environmental protection, the conservation of

natural resources and sustainable development. One of the major areas of focus of the Ministry in relation to this research is promoting the sustainable use of natural resources, preserving biodiversity and raising public awareness. Considering that the Ministry is responsible for strategic planning and the execution of the protection of the environment towards sustainable development, the effective implementation of their objectives would facilitate behavioural change to reduce energy consumption, enable energy efficiency and promote energy savings. Furthermore, key recommendations and interventions from this work, if adopted by the Department, would enhance the attitude and behaviour to reduce energy consumption in Nigerian residential buildings. Two such initiatives by the unit were the production and distribution of a biomass stove, and the distribution of energy efficient LED bulbs and solar kits.

- ***GIZ-Nigerian Energy Support Program***- The GIZ Nigerian Energy Support Program is in the Nigerian electricity sector; it is co-funded by the European Union (EU) and commissioned by the German Federal Ministry for Economic Cooperation and Development. The programme was influenced by the challenges of inadequate production, transmission and distribution of electricity across the country. There were also challenges associated with the slow reform process and poor implementation government policies. It was observed that the Nigerian population requires a minimum of 13,700 MW but the sector was only able to provide 4,500 MW in 2018. The challenges also persist as over 75% of the rural population did not have access to electricity. Consequently, the GIZ Nigerian Energy Programme II was conceptualised to address all the challenges hindering progress in the electricity sector. The objective of the programme was to ensure better and more reliable electricity supply as well as more sustainable and environmentally friendly electricity to facilitate economic and social development in Nigeria. The first phase of the programme was implemented between 2013 and 2018, while the second phase was completed between the Nigerian Energy Support Programme II (NESP II) and was earmarked from 2018 to date. At the end of the first phase of the project, over 3,147 households in rural areas gained electricity, over 100,000 people were provided with environmentally friendly electricity and several other achievements. Additionally, the programme facilitated the development of over 11 laws and regulations for Nigeria in the electricity sector including the building efficiency code and efficiency label for household appliances (Ezeamama, 2020). On this premise, NESP II is a viable platform that can be utilised to influence behavioural change to facilitate the reduction in energy, energy efficiency and savings.

## 6.4 Summary of Findings

As part of major findings from the qualitative analysis, it was revealed that behaviour plays a significant and vital role in energy savings in the Nigerian residential buildings. Furthermore, some of the identified barriers as highlighted above are likely to affect the behaviour of residents in embracing energy saving practices. The study also shows that incentive is a critical and strong driver for behavioural change in energy savings and indicates an area of focus for implementation to drive the necessary change. The analysis of the qualitative result also shows that stakeholder involvement, user education, and implementation of energy saving practices are factors to assist in the improvement of energy consumption behaviour. Even though important, technology related drivers are not strongly emphasised to influence energy saving behaviour. Other areas of major contributions to energy saving include staff education for regulators, consumer education and awareness as well as understanding and cooperation of critical stakeholders. Finally, it was noted that energy saving cultures should be included at the design stage of the development of energy saving framework, while efficient implementation of government policy, strategies and consistency in energy practices were recognised as vital.

**Conclusion**

The result from this chapter revealed that there 2 major factors affecting energy efficiency and energy saving behaviours which includes energy saving barriers and drivers. It was observed that the capacity of building sector to adequately ensure effective energy saving building is a major technical barrier to energy efficiency. Furthermore, human and national factor, ignorance, poor policy implementation and lack incentives are also major barriers to energy efficiency and energy saving practices. This chapter also presented findings on essential components that facilitate the energy saving measures known as energy savings drivers. While education and information are important to influence measures towards energy saving and energy efficiency, incentives and technology related factors are also vital energy saving drivers. Furthermore, the importance of stakeholders amongst other factors were discussed in this chapter. The next chapter presents the results and discussions on quantitative data generate from this research.

# Chapter 7: Quantitative Data Analysis

## 7.1 Introduction

This chapter presents the results and analysis of the quantitative data collected in this study. The first section focuses on the questionnaire administration and response rate. It further discusses the reliability test of the instrument as well as the socio-demographic characteristics of the respondents, and other factors that influence occupants' behaviours and attitudes towards energy consumption in residential buildings in Nigeria. Personal data from the respondents enables an understanding of which demographics were included during the completion of the questionnaire and helps to identify any potential issues with the responses provided. The demographic data collection also helps the researcher to ascertain whether user groups are underrepresented within the respondent group. The second section involves the inferential analysis and the use of structural equation model to develop a framework for the reduction of energy use in Nigeria.

## 7.2 Questionnaire Administration and Response Rate

In this research, the survey was conducted to understand the energy consumption of households in Nigerian residential buildings. This ensures the extension and generalisability of findings to include a higher percentage of households in the population. Thus, this study collected data on the monthly energy consumption of households in Abuja Municipal Area Council in Nigeria.

The online questionnaire distribution technique was utilised in this study since it is faster and more cost effective than a manual printed survey (Huang, 2006; Lefever et al., 2007; Weible & Wallace, 1998). Snowball sampling (Biernacki & Waldorf, 1981) was employed to distribute questionnaires on a large scale in the study area in Nigeria. The link to the questionnaire was distributed via email and WhatsApp. The web link enables the wide distribution of questionnaires using the snowballing technique (Biernacki & Waldorf, 1981).

From 750 paper-based and web-link invitations, about 450 expressed an interest in participating in the study. The survey targeted respondents (mainly households) within the study area.

Consequently, a total of 400 questionnaires were administered and 329 questionnaires were returned, which gives a response rate of 82.2%. Of the 329 questionnaires returned, a total of 317 were fully completed and considered valid for analysis while the remaining 12 were rejected because of missing data. Although incomplete questionnaires provide some data, they were excluded from further analysis to minimise the occurrence of missing data and therefore increase the reliability of the results. Table 7.1 shows the total response rate of the questionnaires.

Table 7.1: Total questionnaire response rate

| **Total questionnaire distributed** | **Total respondents that expressed interest in participating in the study** | **Total questionnaires that were administered** | **Total questionnaires returned** | **Total questionnaires fully completed** |
|---|---|---|---|---|
| **750** | 450 | 400 | 329 | 317 |

### 7.3 Procedure Adopted in Analysing the Quantitative Data

The data collected from the survey were coded and entered in SPSS software for the purpose of conducting statistical analysis. This enables the computation of descriptive statistics including standard deviations, mean scores, frequencies, as well as inferential analyses such as multiple regression analysis. In addition, SPSS Amos software was used to perform structural equation modelling to develop an energy-saving behavioural model to reduce energy consumption.

#### 7.3.1 Non-Response Bias Analysis

In this study, t-tests were carried out on the first and second waves of responses from participants to assess the non-response bias. The result of the t-test shows that there were no statistically significant variations amongst the survey items examined. For all measured variables, the two-tailed significance values are above 0.05. Consequently, the survey instrument is deemed to be valid meaning this study was not affected by non-response bias.

### 7.3.2 Reliability and Validity Analysis

Reliability is an important and fundamental feature in evaluating any research measurement instrument. Reliability refers to the consistency of the research instrument each time it is used in the same setting and with the same respondents (Sullivan, 2011). Reliability tests were conducted to ascertain the internal consistency of the instruments used to measure the concepts. To be reliable, instruments measuring a concept must be highly correlated. Cronbach's coefficient alpha is the most frequently used test of internal consistency because it computes the average of all possible split-half estimates (Green et al., 2016).

**Table 7.2**: Reliability test results

| Variable | Cronbach's Alpha | Number of items |
|---|---|---|
| Energy Efficiency Approaches | 0.861 | 11 |
| Energy Saving Approaches | 0.767 | 10 |
| Barriers/Obstacles to Energy Efficiency and Saving Approaches | 0.881 | 11 |
| Material Culture | 0.745 | 5 |
| Physical Environment | 0.701 | 4 |
| Energy Practices | 0.988 | 5 |
| APCA | 0.986 | 3 |
| Sustainable Development Goals | 0.896 | 12 |
| Reliability of the Entire Constructs | 0.905 | 44 |

Reliability tests were carried out for the main elements of the research instruments, namely: energy efficiency approaches, obstacles to energy saving, sustainable development goals and the entire constructs of the research. The reliability test results are shown in Table 7.2. Cronbach's alpha for all constructs was measured at 0.905. Furthermore, for each of the sub-constructs of the research instrument, the coefficient of the alphas was above 0.70, thus the scale shows a strong internal consistency. The reliability of all the other constructs in Table 7.2 is within the accepted value for reliability.

### 7.3.4 Socio Demographic Characteristic of the Respondents

Information collected from the survey was analysed for descriptive statistics. In doing so, the variables of the study, their maximum and minimum scores, frequencies, and percentages were recorded and presented in Table 7.3. The demographic characteristics of the survey participants are discussed in greater detail in the subsequent sections.

***Position of Respondents within the Household***

Table 7.3 presents the socio demographic characteristic of the respondents. In the table, the position of the respondent shows that 211 (66.6%) were heads of the house, 90 (28.4%) were children, 9 (2.8%) were grandparents and 7 (2.2%) indicated 'other'.

***Gender and Age***

Gender in this context refers to an individual's identity either as a male or female. The gender responses indicate that 229 respondents (72.2%) from the total sample were male and 88 respondents (27.8%) were female. The number of male respondents were more than twice that of female respondents.

Most of the respondents were aged between 26-40 years, which is 175 of the total respondents, representing 55.2%. The next group is 18-25 years at 65, representing 20.5% of the sample. Moreover, 49 respondents (15.5%) were between the age of 41-55 years while the remaining respondents (14), at 4.4% were between the age of 56-65 years.

***Number of Occupants in the Household***

The number of occupants in the household shows that 34 (10.7%) had 1-2 occupants, 122 respondents (38.5%) had 3-4, 82 respondents (25.9%) had 5-6 and 37 respondents (11.7%) had 9. Results indicate that the majority of households had 3-4 occupants.

Table 7.3: Socio demographic characteristics of the respondents

| Variable | Categories | Frequency | Percent (%) |
|---|---|---|---|
| **Position of the respondent** | Head of the house | 211 | 66.6 |
| | Child | 90 | 28.4 |
| | Grandparent | 9 | 2.8 |
| | others | 7 | 2.2 |
| **Gender** | Male | 229 | 72.2 |
| | Female | 88 | 27.8 |
| **Average age of occupants** | 18-25 | 65 | 20.5 |
| | 26-40 | 175 | 55.2 |
| | 41-55 | 49 | 15.5 |
| | 56-65 | 14 | 4.4 |
| | others | 14 | 4.4 |
| **No of occupants in household (Including the respondent)** | 1-2 | 34 | 10.7 |
| | 3-4 | 122 | 38.5 |
| | 5-6 | 82 | 25.9 |
| | 7-8 | 42 | 13.2 |
| | 9 | 37 | 11.7 |
| **Occupants' employment status** | Employed | 240 | 75.7 |
| | Unemployed | 30 | 9.5 |
| | Retired | 47 | 14.8 |

***Employment Status of Respondents***

The employment status of respondents shows that 240 (75.5%) were employed, 30 (9.5%) were unemployed, and 47 (14.8%) were retired. The results revealed that the majority of respondents were from the working class as revealed by their ages.

***7.3.4.1 Type of Property of the Respondents***

Figure 7.1 presents the type of property among the participants. In the figure, 54 (17.0%) indicate a multi-storey building, 61 (19.2%) indicate a bungalow, 38 (12.0%) indicate a bungalow-semi-detached, 13 (4.1%) indicate a bungalow-end-terraced, 15 (4.7%) indicate a bungalow-mid-terraced and 136 (42.9%) indicate an apartment/flat.

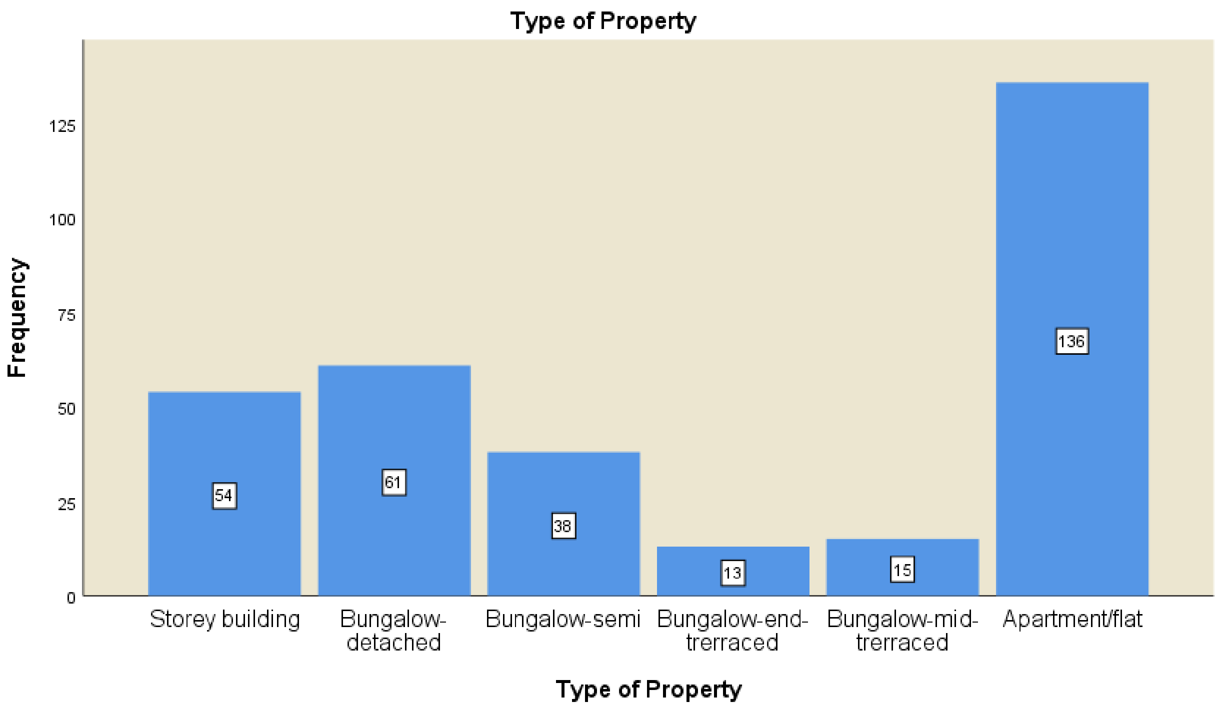


**Figure 7.1**: Type of property of participants in the study.

### *7.3.4.2 Type of Energy Used Among the Participants*

Figure 7.2 presents the type of energy utilised among the participants. In Figure 7.1, 74 (23.3%) indicate electricity, 13 (4.1%) use gas, 223 (70.3%) use gas and electricity and 7 (2.2%) indicate 'other'. The majority of respondents use both gas and electricity while 'others' refer to other sources that may include renewable energy sources and inverters.

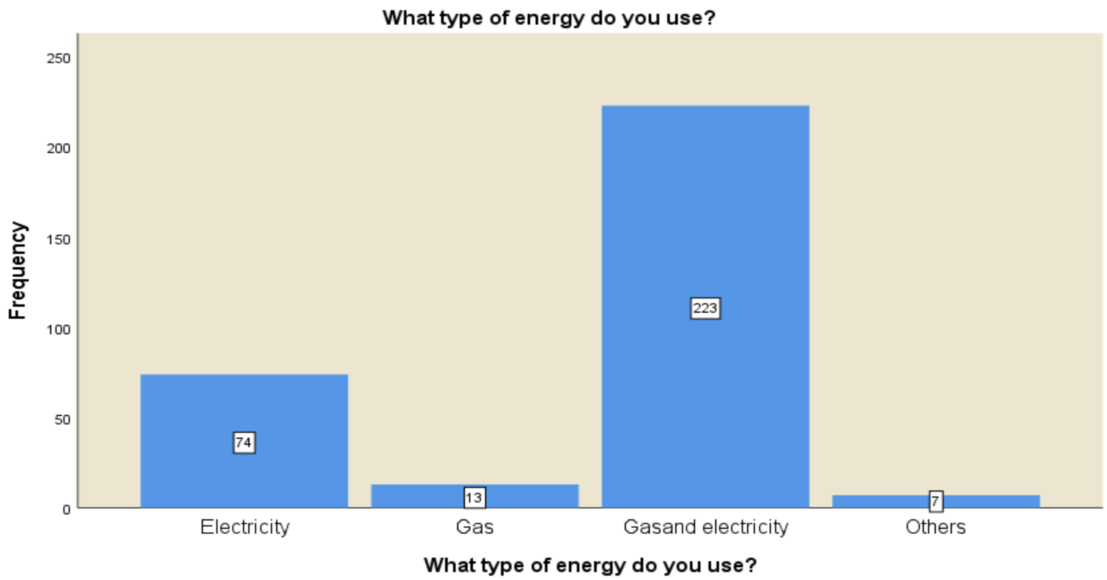


**Figure 7.2**: Type of energy used among the participants

### *7.3.4.3 Type of Energy Used for Cooking*

Figure 7.3 presents the type of energy used for cooking. In the Figure 6.3, 8 (2.5%) use electricity, 128 (40.4%) use gas, 150 (47.3%) use gas and electricity and 31 (9.8%) indicate 'other'. This shows that most respondents use both energy types for cooking while 'other' may refer to fuelwood (charcoal, firewood and sawdust).

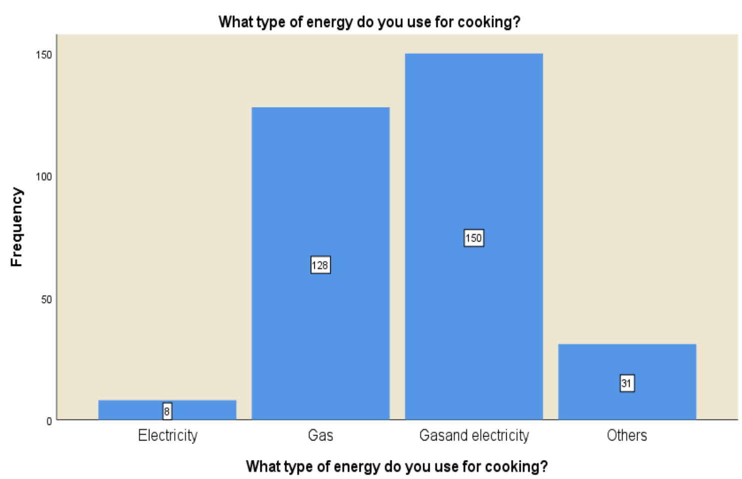


**Figure 7.3**: The type of energy used for cooking

### *7.3.4.4 Monthly Electricity Bill*

The highest energy bill was 50,000 naira, as indicated by seven of the respondents. The majority of the respondents pay between less than 5,000 naira to less than 20,000 naira while 29.7% pay less than 5,000 naira, 28.7% pay less than 10,000 naira and 26.8% pay less than 20,000 naira. Table 7.4 illustrates the monthly cost of electricity in naira.

**Table 7.4**: Monthly cost of electricity (Naira)

| | (₦) | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 50000 | 94 | 9.4 | 29.7 | 29.7 |
| | 10000 | 91 | 9.1 | 28.7 | 58.4 |
| | 10000-20000 | 85 | 8.5 | 26.8 | 85.2 |
| | 20000 | 40 | 4.0 | 12.6 | 97.8 |
| | 500000 | 7 | .7 | 2.2 | 100.0 |
| | Total | 317 | 31.7 | 100.0 | |
| Missing | System | 682 | 68.3 | | |
| Total | | 999 | 100.0 | | |

### *6.3.4.5 Knowledge of Energy Efficient Appliances*

Figure 7.4 presents the knowledge of energy-efficient appliances among the respondents. In Figure 7.4, 22 (6.9%) indicate not at all, 68 (21.5%) had less knowledge, 76 (24.0%) indicate very important and 87 (27.4%) indicate extremely important. This indicates that about 48% of the respondents have good knowledge of energy efficient appliances.

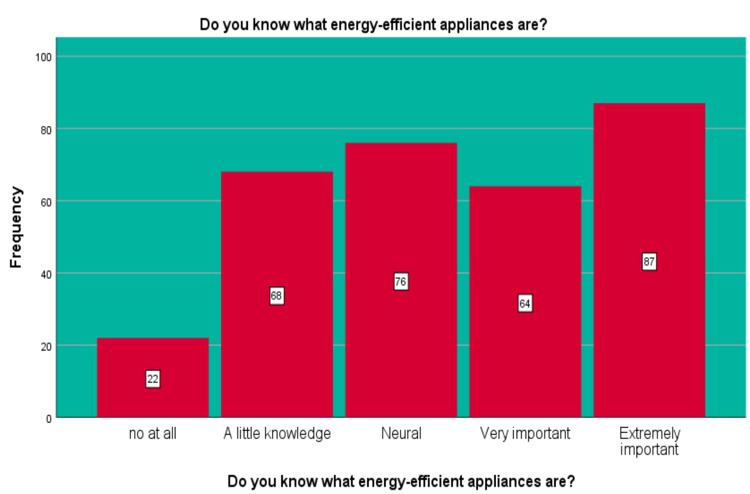


**Figure 7.4**: Knowledge of energy efficient appliances

*__7.3.4.6 Overall Energy Efficiency Approaches amongst Respondents__*

Figure 7.5 presents the overall energy efficiency approaches; in the figure, 300 (95%) had good energy efficiency approaches and 17 (5%) had poor energy efficiency approaches.

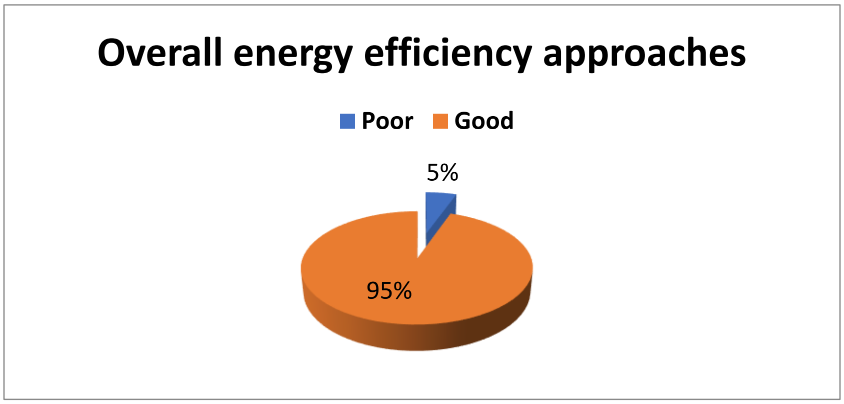


**Figure 7.5**: Overall energy efficiency approaches

The results from Table 7.5.1 presents the association between the socio demographic and overall energy efficiency approaches. The table indicates that the socio demographic variable based on the position of the respondent shows a significant association with energy efficiency and saving behaviours at ($\chi2=11.883$, $p=0.008$), and non-significant association with gender, the average age of occupants, the number of occupants per household and the occupants' employment status at ($\chi2=2.292$, $p=0.130$), ($\chi2=3.641$, $p=0.457$), ($\chi2=7.736$, $p=0.102$), ($\chi2=0.259$, $p=0.878$), ($\chi2=0.052$, $p=0.974$) and($\chi2=0.445$, $p=0.801$) respectively as $p>0.05$ in each case. This highlights the impact of energy saving behaviour in residential within the Abuja Municipal.

**Table 7.5**: Association between the socio demographic and overall energy efficiency approaches

| Variable | Categories | Poor | Good | Total | Pearson Chi-Square ($\chi^2$) | df | P-value |
|---|---|---|---|---|---|---|---|
| **Position of the respondent** | Head of the house | 7(2.2%) | 204(64.4%) | 211(66.6%) | 11.883 | 3 | 0.008 |
| | Child | 8(2.5%) | 82(25.9%) | 90(28.4%) | | | |
| | Grandparent | 0(0.0%) | 9(2.8%) | 9(2.8%) | | | |
| | others | 2(0.6%) | 5(1.6%) | 7(2.2%) | | | |
| **Gender** | Male | 15(4.7%) | 214(67.5%) | 229(72.2%) | 2.292 | 1 | 0.130 |
| | Female | 2(0.6%) | 86(27.1%) | 88(27.8%) | | | |
| **Average age of occupants** | 18-25 | 5(1.6%) | 60(18.9%) | 65(20.5%) | 3.641 | 4 | 0.457 |
| | 26-40 | 11(3.5%) | 164(51.7%) | 175(55.2%) | | | |
| | 41-55 | 1(0.3%) | 48(15.1%) | 49(15.5%) | | | |
| | 56-65 | 0(0.0%) | 14(4.4%) | 14(4.4%) | | | |
| | others | 0(0.0%) | 14(4.4%) | 14(4.4%) | | | |
| **No of occupants in household (Including the respondent)** | 1-2 | 4(1.3%) | 30(9.5%) | 34(10.7%) | 7.736 | 4 | 0.102 |
| | 3-4 | 2(0.6%) | 120(37.9%) | 122(38.5%) | | | |
| | 5-6 | 7(2.2%) | 75(23.7%) | 82(25.9%) | | | |
| | 7-8 | 2(0.6%) | 40(12.6%) | 42(13.2%) | | | |
| | 9 | 2(0.6%) | 35(11.0%) | 37(11.7%) | | | |
| **Occupants' employment status** | Employed | 12(3.8%) | 228(71.9%) | 240(75.7%) | 0.259 | 2 | 0.878 |
| | Unemployed | 2(0.6%) | 28(8.8%) | 30(9.5%) | | | |
| | Retired | 3(0.9%) | 44(13.9%) | 47(14.8%) | | | |
| **Occupants' employment status** | Employed | 9(2.8%) | 162(51.1%) | 171(53.9%) | 0.052 | 2 | 0.974 |
| | Unemployed | 7(2.2%) | 117(36.9%) | 124(39.1%) | | | |
| | Retired | 1(0.3%) | 21(6.6%) | 22(6.9%) | | | |
| **Occupants' employment status** | Employed | 6(1.9%) | 106(33.4%) | 112(35.3%) | 0.445 | 2 | 0.801 |
| | Unemployed | 10(3.2%) | 185(58.4%) | 195(61.5%) | | | |
| | Retired | 1(0.3%) | 9(2.8%) | 10(3.2%) | | | |

### *6.3.4.7 Overview of Electrical Appliances in Residences*

Figure 7.6 presents an overview of the electrical appliances in residences; in the figure, 75 (23.7%) had high energy consumption appliances, 204 (64.4%) had moderate energy consumption appliances and 38 (12.0%) had low energy consumption appliances.

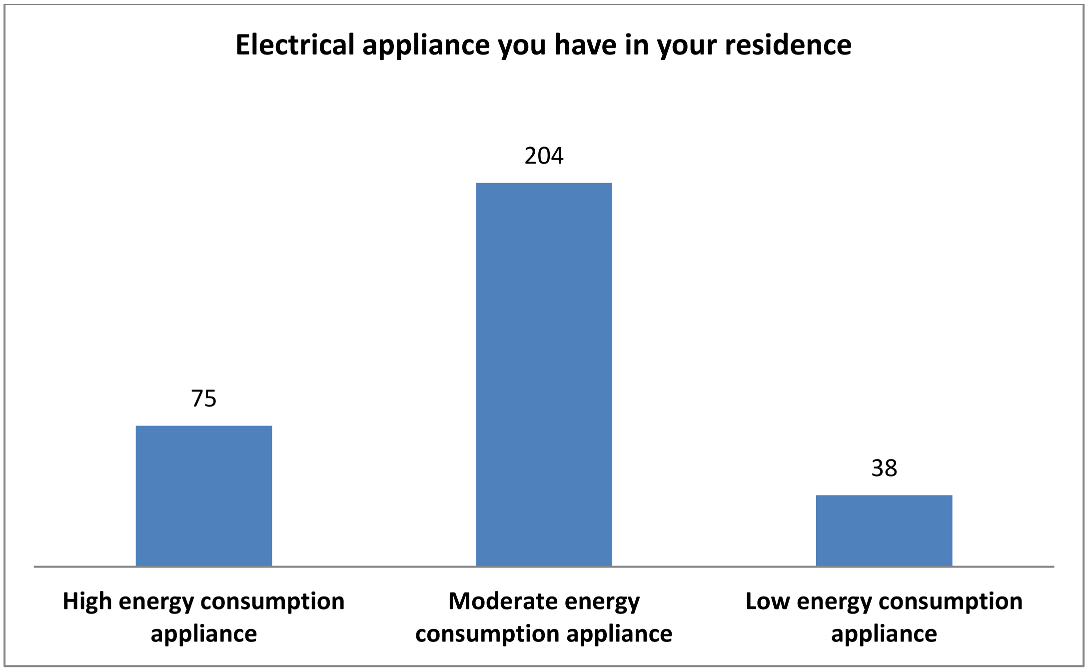


**Figure 7.6**: Overview of the electrical appliance in residences

### *7.3.4.8 Perception of Respondents to Energy-Efficient Appliances*

Figure 7.7 presents the perception of participants to the use of energy-efficient appliances; in the figure, 177 (55.8%) had a good perception as they indicated yes, while 140 (44.2%) had a poor perception.

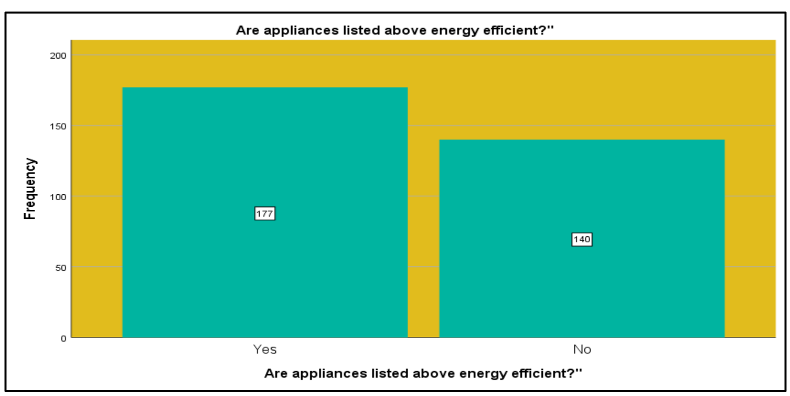


**Figure 7.7**: Perception of energy-efficient appliances

*7.3.4.9 Total Energy Saving Behaviours of Respondents*

Figure 7.8 showed the total energy saving behaviours of respondents based on the questions answered. In the figure, 241 (76%) had good energy saving behaviours and 76 (24%) had poor energy saving behaviours.

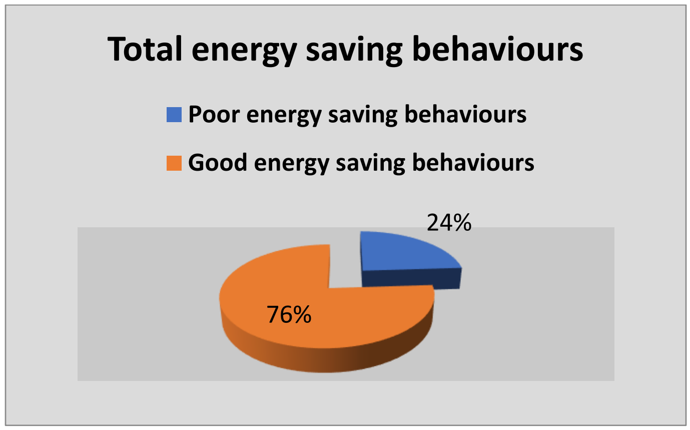


**Figure 7.8**: Total energy saving behaviours of respondents.

*7.3.4.10 Energy Efficiency and Saving Behaviours among the Respondents*

Figure 7.9 presents the energy efficiency and saving behaviours among the respondents; in the figure, 286 (90.2%) had good energy saving behaviours while 31 (9.8%) had poor energy saving behaviours.

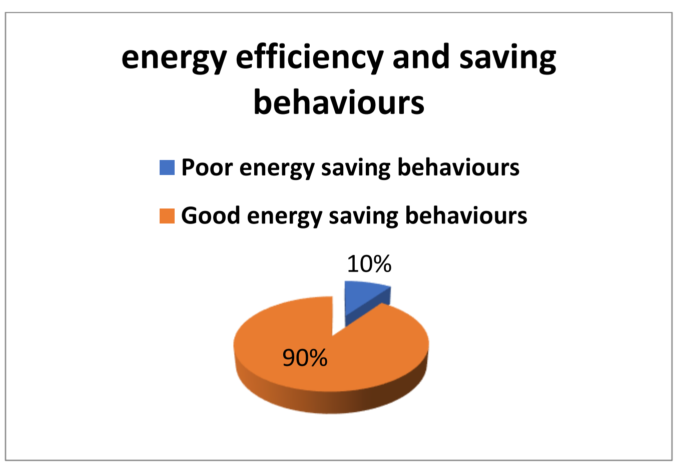


**Figure 7.9**: Energy efficiency and saving behaviours among the participants.

**Table 7.6**: Association between the socio demographic and energy efficiency and saving behaviours.

| Variable | Categories | Poor energy saving behaviours | Good energy saving behaviours | Total | Pearson Chi-Square ($\chi^2$) | df | P-value |
|---|---|---|---|---|---|---|---|
| **Position of the respondent** | Head of the house | 20(6.3%) | 191(60.3%) | 211(66.6%) | 2.365 | 3 | 0.500 |
| | Child | 9(2.8%) | 81(25.6%) | 90(28.4%) | | | |
| | Grandparent | 2(0.6%) | 7(2.2%) | 9(2.8%) | | | |
| | others | 0(0.0%) | 7(2.2%) | 7(2.2%) | | | |
| **Gender** | Male | 21(6.6%) | 208(65.6%) | 229(72.2%) | 0.347 | 1 | 0.556 |
| | Female | 10(3.2%) | 78(24.6%) | 88(27.8%) | | | |
| **Average age of occupants** | 18-25 | 5(1.6%) | 60(18.9%) | 65(20.5%) | 2.401 | 4 | 0.662 |
| | 26-40 | 19(6.0%) | 156(49.2%) | 175(55.2%) | | | |
| | 41-55 | 5(1.6%) | 44(13.9%) | 49(15.5%) | | | |
| | 56-65 | 0(0.0%) | 14(4.4%) | 14(4.4%) | | | |
| | others | 2(0.6%) | 12(3.8%) | 14(4.4%) | | | |
| **No of occupants in household (including the respondent)** | 1-2 | 2(0.6%) | 32(10.1%) | 34(10.7%) | 1.677 | 4 | 0.795 |
| | 3-4 | 11(3.5%) | 111(35.0%) | 122(38.5%) | | | |
| | 5-6 | 8(2.5%) | 74(23.3%) | 82(25.9%) | | | |
| | 7-8 | 6(1.9%) | 36(11.4%) | 42(13.2%) | | | |
| | 9 | 4(1.3%) | 33(10.4%) | 37(11.7%) | | | |
| **Occupants' employment status** | Employed | 23(7.3%) | 217(68.5%) | 240(75.7%) | 0.526 | 2 | 0.769 |
| | Unemployed | 4(1.3%) | 26(8.2%) | 30(9.5%) | | | |
| | Retired | 4(1.3%) | 43(13.6%) | 47(14.8%) | | | |
| **Occupants' employment status** | Employed | 18(5.7%) | 153(48.3%) | 171(53.9%) | 0.236 | 2 | 0.889 |
| | Unemployed | 11(3.5%) | 113(35.6%) | 124(39.1%) | | | |
| | Retired | 2(0.6%) | 20(6.3%) | 22(6.9%) | | | |
| **Occupants' employment status** | Employed | 14(4.4%) | 98(30.9%) | 112(35.3%) | 2.273 | 2 | 0.321 |
| | Unemployed | 17(5.4%) | 178(56.2%) | 195(61.5%) | | | |
| | Retired | 0(0.0%) | 10(3.2%) | 10(3.2%) | | | |

Table 7.6 presents the association between socio demographic and overall energy efficiency and saving behaviours. In the table, the socio demographic variable was based on the position of the

respondent, their gender, the average age of occupants, the number of occupants per household and the occupants' employment status shows a non-significant association with energy efficiency and saving behaviours at ($\chi^2$=2.365, p=0.500), ($\chi^2$=0.347, p=0.556), ($\chi^2$=2.401, p=0.662), ($\chi^2$=1.677, p=0.795) and ($\chi^2$=0.526, p=0.769) respectively as p>0.05.

**Table 7.7**: Barriers to energy efficiency among the respondents

| Variables | Strongly disagree | Disagree | Neural | Agree | Strongly agree |
|---|---|---|---|---|---|
| **Poor government support** | 25(7.9) | 34(10.7) | 77(24.3) | 70(22.1) | 111(35.0) |
| **Inadequate use of new energy technology** | 11(3.5) | 28(8.8) | 96(30.3) | 98(30.9) | 84(26.5) |
| **Lack of awareness and training on energy-efficient tools** | 19(6.0) | 30(9.5) | 61(19.2) | 109(34.4) | 98(30.9) |
| **Poor financial support** | 12(3.8) | 26(8.2) | 79(24.9) | 95(30.0) | 105(33.1) |
| **Lack of cultural change** | 12(3.8) | 26(8.2) | 91(28.7) | 100(31.5) | 88(27.8) |
| **Problems with the installation process** | 16(5.0) | 46(14.5) | 120(37.9) | 76(24.0) | 59(18.6) |
| **Public resistance** | 25(7.9) | 26(8.2) | 113(35.6) | 94(29.7) | 59(18.6) |
| **Cost of training** | 18(5.7) | 27(8.5) | 116(36.6) | 99(31.2) | 57(18.0) |
| **Initial energy efficient technology (huge investment** | 10(3.2) | 37(11.7) | 107(33.8) | 103(32.5) | 60(18.9) |
| **Lack of support from policy makers** | 15(4.7) | 18(5.7) | 89(28.1) | 110(34.7) | 85(26.8) |
| **Lack of enabling environment** | 12(3.8) | 20(6.3) | 77(24.3) | 120(37.9) | 88(27.8) |

As illustrated in Table 7.7, which shows the barriers to energy efficiency among the respondents: 111 (35.0) indicate strongly agree to poor government support; 84 (26.5) indicate strongly agree to the inadequate use of new energy technology; 98(30.9) indicate strongly agree to a lack of awareness of and training on energy-efficient tools; 105(33.1) indicate strongly agree to poor financial support; 88(27.8) indicate strongly agree to a lack of cultural change; 59(18.6) indicate strongly agree to problems with the installation process; 59(18.6) indicate strongly agree to public resistance; 57(18.0) indicate strongly agree to the cost of training; 60(18.9) indicate strongly agree to initial energy-efficient technology (huge investment); 85(26.8) indicate strongly agree to a lack of support from policymakers, and 88(27.8) indicate strongly agree to the lack of an enabling environment.

Table 7.8 below present practices that determine or limit energy saving behaviours in Nigerian residential buildings. The Table observed that more than two third of the participants had good practice on energy saving behaviours in Nigerian residential buildings as 180 (56.8%) indicate strongly agree to turn off the lights when not in use. On the other hand, 159 (50.2%) strong agreement to unplug your charger when not in use, 197(62.1%) strongly agree to switch off your television, computer, radio and fan when not in use. The data also shows that 75(23.7%) strongly agree to move furniture away from radiator 77(24.3%) to close the curtains when the sun goes down and 51(16.1%) strongly agree to fully load your dishwasher/washing machine.  The survey also indicated 48(15.1%) indicate strong agreement to dial down the degrees on your clothes wash, 140(44.2%) shows strong agreement to hang your clothes out to dry, 114(36.0%) indicate strong agreement to clean and defrost your fridge-freezer and adjust the settings of temperature on the heating or air conditioner and 88(27.8%) strongly agree to bulk ironing at once. The result shows significant agreement in the awareness to manage energy in households more efficiently.

**Table 7.8:** Practices that determine or limit energy saving behaviours in Nigerian residential buildings.

| Variable | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| **Turn off the lights when not in use"** | 31(9.8) | 13(4.1) | 39(12.3) | 54(17.0) | 180(56.8) |
| **Unplug your charger when not in use** | 15(4.7) | 15(4.7) | 52(16.4) | 76(24.0) | 159(50.2) |
| **Switch off your television, computer, radio and fan when not in use** | 16(5.0) | 5(1.6) | 40(12.6) | 59(18.6) | 197(62.1) |
| **Move furniture away from radiator** | 21(6.6) | 13(4.1) | 111(35.0) | 97(30.6) | 75(23.7) |
| **Close the curtains when the sun goes down** | 19(6.0) | 24(7.6) | 112(35.3) | 85(26.8) | 77(24.3) |
| **Fully load your dishwasher/washing machine** | 23(7.3) | 60(18.9) | 126(39.7) | 57(18.0) | 51(16.1) |
| **Dial down the degrees on your clothes wash** | 12(3.8) | 29(9.1) | 145(45.7) | 83(26.2) | 48(15.1) |
| **Hang your clothes out to dry** | 17(5.4) | 6(1.9) | 55(17.4) | 99(31.2) | 140(44.2) |
| **Clean and defrost your fridge-freezer** | 16(5.0) | 9(2.8) | 63(19.9) | 115(36.3) | 114(36.0) |
| **Adjust the settings of temperature on the heating or air conditioner** | 14(4.4) | 7(2.2) | 59(18.6) | 123(38.8) | 114(36.0) |
| **Bulk ironing at once** | 25(7.9) | 31(9.8) | 99(31.2) | 74(23.3) | 88(27.8) |

**Table 7.9**: Drivers for energy efficient approaches and energy saving behaviours.

| Variable | Strongly disagree | Disagree | Neural | Agree | Strongly agree |
|---|---|---|---|---|---|
| **Benefit of energy efficiency approach** | 12(3.8) | 19(6.0) | 86(27.1) | 107(33.8) | 93(29.3) |
| **Improved productivity** | 5(1.6) | 13(4.1) | 78(24.6) | 125(39.4) | 96(30.3) |
| **Lower cost** | 15(4.7) | 29(9.1) | 80(25.2) | 87(27.4) | 106(33.4) |
| **Enhanced profitability** | 5(1.6) | 15(4.7) | 90(28.4) | 108(34.1) | 99(31.2) |
| **Reduced carbon footprint** | 6(1.9) | 20(6.3) | 97(30.6) | 88(27.8) | 106(33.4) |
| **Improved product quality** | 1(0.3) | 23(7.3) | 100(31.5) | 104(32.8) | 89(28.1) |
| **Minimized air pollution** | 8(2.5) | 16(5.0) | 85(26.8) | 103(32.5) | 105(33.1) |
| **Promoted health and well-being** | 6(1.9) | 17(5.4) | 83(26.2) | 117(36.9) | 94(29.7) |
| **Lowered energy use** | 8(2.5) | 21(6.6) | 86(27.1) | 93(29.3) | 109(34.4) |
| **Created employment** | 33(10.4) | 30(9.5) | 115(36.3) | 83(26.2) | 56(17.7) |
| **Improved working environment** | 9(2.8) | 15(4.7) | 84(26.5) | 122(38.5) | 87(27.4) |
| **Save money** | 18(5.7) | 16(5.0) | 81(25.6) | 82(25.9) | 120(37.9) |

Table 7.9 presents the benefits of using an energy efficient approach and engaging in energy saving behaviours. In the table, 93 (29.3) strongly agree to the benefits of an energy efficiency approach; 96 (30.3) indicate strongly agree to improved productivity; 106 (33.4) strongly agree to lower costs; 99 (31.2) strongly agree to enhanced profitability; 106 (33.4) indicate strongly agree to a reduced carbon footprint; 89 (28.1) indicate strong agreement to improved product quality; 105 (33.1) indicate strong agreement to minimised air pollution; 94 (29.7) indicate strongly agree to improved health and well-being; 109 (34.4) strongly agree to lowered energy use; 56 (17.7) indicate strongly agree to the creation of employment; 87 (27.4) strongly agree to an improved working environment, and 120 (37.9) indicate strong agreement to save money.

**Table 7.10:** Drivers and stakeholder effect on occupants' attitudes and energy consumption behaviours in residential buildings

| Variable | Strongly disagree | Disagree | Neural | Agree | Strongly agree |
|---|---|---|---|---|---|
| **Provision of door to door energy saving awareness/ town hall meetings** | 9(2.8) | 7(2.2) | 95(30.0) | 55(17.4) | 151(47.6) |
| **Training and workshop on energy efficient equipment use** | 10(3.2) | 7(2.2) | 95(30.0) | 55(17.4) | 150(47.3) |
| **Availability/affordability of energy efficient appliances** | 2(0.6) | 12(3.8) | 87(27.4) | 101(31.9) | 115(36.3) |
| **Awareness through billboards, radio and Tv advertisements** | 10(3.2) | 28(8.8) | 90(28.4) | 76(24.0) | 113(35.6) |
| **Provision of door to door energy saving awareness/ townhall meetings** | 1(0.3) | 10(3.2) | 104(32.8) | 85(26.8) | 117(36.9) |
| **Financial motivation to save money from utility bills** | 3(0.9) | 18(5.7) | 109(34.4) | 66(20.8) | 121(38.2) |
| **Financial tariff increase** | 142(44.8) | 20(6.3) | 94(29.7) | 21(6.6) | 40(12.6) |
| **Inspiration through real life saving** | 5(1.6) | 11(3.5) | 93(29.3) | 82(25.9) | 126(39.7) |
| **Fine and penalties** | 4(1.3) | 12(3.8) | 93(29.3) | 86(27.1) | 122(38.5) |
| **Competitive tariff** | 4(1.3) | 15(4.7) | 110(34.7) | 64(20.2) | 124(39.1) |
| **Inspiration through practical cases by neighbors** | 18(5.7) | 18(5.7) | 121(38.2) | 65(20.5) | 95(30.0) |
| **Inspired to save electricity for environmental protection** | 2(0.6) | 12(3.8) | 91(28.7) | 98(30.9) | 114(36.0) |
| **Inspired to save electricity as a social responsibility** | 12(3.8) | 13(4.1) | 94(29.7) | 62(19.6) | 136(42.9) |

The table above (Table 7.10) depict the Driving factors to stakeholder effect on occupants' attitudes and energy consumption behaviours in residential buildings. In the table, majority of the participants indicate positive responses to Driving factors to stakeholder effect on occupants' attitudes and energy consumption behaviours in residential buildings as 151 (47.6%) indicate strong agreement for the Provision of door to door energy saving awareness/town hall meetings, 150(47.3%) strongly agree for training and workshop on energy efficient equipment use and 115(36.3%)indicate strong agreement to availability/ affordability of energy efficient appliances, 113(35.6%) strongly agreement to install awareness through billboards, radio and Tv advertisements. Furthermore, 117(36.9%) indicate strong agreement to Provision of door-to-door energy saving awareness/ townhall meetings, 117(36.9%) strongly agree to financial motivation to save money from utility bills, 121(38.2%) strongly agree to financial motivation to save money from utility bills, 40(12.6%) strongly agree to financial tariff increase, while 126(39.7%) strongly agree to Inspiration through real life saving. The table also shows that 126(39.7%) strongly agree to Inspiration through real life saving, 122(38.5%) indicate strong agreement for fine and penalties, 124(39.1%) supports the need for competitive tariff, 95(30.0%) indicate strong agreement for Inspiration through practical cases by neighbours, 114(36.0%) indicate strong agreement for Inspiration to save electricity for environmental protection and 136(42.9%) indicate strong agreement for inspiration to save electricity as a social responsibility.

Table 7.11 The result of drivers to energy savings in residential buildings

| Item | Scale items | Standardised item loadings | $R^2$ | t-value |
|---|---|---|---|---|
| | **Drivers and stakeholder effect on occupants' DF Cronbach's α = (0.826) (Constant=4.720)** | | | |
| | **Education and information** | | | |
| DF1 | Provision of door to door energy saving awareness/ townhall meetings | 0.016 | 0.858 | -0.179 |
| DF2 | Training and workshop on energy efficient equipment use | 0.007 | 0.941 | 0.074 |
| DF3 | Availability/affordability of energy efficient appliances | -0.044 | 0.583 | -0.550 |
| DF4 | Awareness through billboards, radio and Tv advertisements | 0.016 | 0.846 | 0.194 |
| | **Incentives** | | | |
| DF5 | Provision of door to door energy saving awareness/ townhall meetings | 0.042 | 0.622 | 0.494 |
| DF6 | Financial motivation to save money from utility bills | 0.007 | 0.926 | 0.093 |
| DF7 | Financial tariff increase | 0.113 | 0.054 | 1.938 |
| DF8 | Inspiration through real life saving | -0.082 | 0.320 | -0.996 |
| DF9 | Fine and penalties | 0.088 | 0.364 | 0.910 |
| | **Stakeholder as a driver** | | | |
| DF10 | Competitive tariff | 0.015 | 0.877 | 0.155 |
| DF11 | Inspiration through practical cases by neighbours | 0.014 | 0.861 | 0.175 |
| DF12 | Inspired to save electricity for environmental protection | -0.029 | 0.743 | -0.328 |
| DF13 | Inspired to save electricity as a social responsibility | -0.114 | 0.179 | -1.347 |

### 7.3.5 Factors which Influence Occupant Behaviours and Attitudes Towards Energy Consumption

The questionnaire sample was completed by 88 females and 229 male respondents. Isnin et al. (2018) and do Paço et al. (2015) assert that women express a positive attitude to energy saving and perform more energy-saving behaviours than their male counterparts. Additionally, Vainio and Paloniemi (2014) identified that women in Nordic countries engage more in energy-saving actions. Nevertheless, Thøgersen and Grønhøj (2010) revealed that gender influences on household energy consumption are ambiguous and could be either directly or indirectly influenced by interactions with other factors. Moreover, both genders' attitudes toward energy conservation are influenced by their willingness to alter social norms, which influences how much electricity they consume. Furthermore, women have also been found to be more optimistic about energy conservation and environmental issues than their male counterparts, and are more likely to partake in efficiency activities (Huang & Chao, 2017). However, at ($\chi^2$=2.292, P=0.130), there has been no association between saving behaviour and the 'gender of respondents' in this study. Other socio demographic variables based on 'gender' and 'number of occupants in the household' shows a significant association with the total energy saving behaviours at ($\chi^2$=7.143, p=0.008) and ($\chi^2$=10.556, p=0.032) respectively at $p<0.05$; moreover, it shows a non-significant association with the 'position of the respondent', 'average age of occupants' and 'occupant's employment status' at ($\chi^2$=2.311, p=0.510), ($\chi^2$=2.605, p=0.626) and ($\chi^2$=1.234, p=0.540) respectively (at $p>0.05$).

With improvements in living standards in the country, there has been an increasing need to use electrical appliances which vary from electric cookers, fridge–freezers, dishwashers, microwaves, electric ovens, microwave ovens, electric kettles, washing machines and tumble driers in homes, as indicated by the majority of respondents in this study. Multiple television sets, DVD players, and laptops have become more prevalent in households. At the time of the survey, there appeared to be a rise in the number of appliances utilised in households, although a large proportion of the participants confirmed the appliances were energy efficient. Also, the findings concerning their awareness of energy-efficient knowledge were moderately positive while the significance of appliances was high. This may be associated with syncretic decisions from the household and may eventually result in a rebound effect. Therefore, policies in the country should address the performance standards of appliances to reduce inefficient consumption. Participants involved in the interview affirmed the problems with the standards of appliances. Many significant policies, like carbon or energy taxes, can modify the rebound effect and enhance the effect of regulations. It has therefore become important to understand the response of energy demand to important economic variables such as personal income and energy prices (Ewald et al., 2021).

If all buildings were privately owned, price elasticity would almost certainly be greater (Broberg & Egüez, 2018; Gillingham & Palmer, 2014). Furthermore, split incentives and energy poverty also suggest a reluctance to use excessive or aggressive energy pricing due to the possibly impact on low-income tenants. This suggests the need for parallel regulations that promote or compel building owners to maximise their efficiency and may imply that energy prices are augmented by subsidies that reduce the cost of energy-efficient investments. In addition, carbon taxes allow for dividends to be dispersed or targeted in socially responsible ways.

Another finding from this study shows that more than one-third of the respondents have an average socioeconomic status with 136 (42.9%) indicating they live in an apartment/flat, 38 (12.0%) indicating bungalow-semi-detached, and 13 (4.1%) indicating bungalow-end-terrace. However, research has shown that energy consumption increases with the degree of dwelling detachment, meaning that detached houses consume more energy compared to apartments (Leahy & Lyons, 2010). Furthermore, Belaid and Garcia (2016) found out that respondents' work conditions and types of dwelling effect their energy-saving behaviour, as people who stay longer at home (retired people and homemakers) and those who live in high-energy-consumption buildings (such as rural dwellings) tend to behave more energy-efficiently. Although, Jones and Lomas (2015) found that excessive energy usage in household buildings in the United Kingdom relates to a combination of the residents' socioeconomic factors and the characteristics of the dwelling in which they live, Murtagh et al. (2014) noted that householders may struggle to reduce their domestic electricity consumption because it is not only effectively invisible but also billed in aggregate, at long intervals, and retrospectively (Burgess & Nye, 2008). The expectation is that providing exact current and frequently disaggregated feedback through the in-home display would enable more energy efficient utilization and a decrease in the total consumption (Faruqui et al., 2010) which may vary, as observed in this study.

Another economic variable that was considered was the employment status of respondents. The results identified that more than 75% of the respondents were employed, 14.8% were retired while only about 9.4% were unemployed. Sánchez et al. (2016) found out that good employment status had a positive influence on pro-environmental purchase behaviour but not consumption behaviour.

Many households understand the financial benefits of saving energy, and as a result, the cost of electricity appeared to be a motivating factor for energy saving behaviour. Furthermore, in terms of finance, savings appeared to serve both symbolic and monetary purposes, and for many participants, any savings would be significant. However, monetary gain-driven motivation was restricted by complex social factors, which was consistent with previous findings on energy consumption (Ferraro & Miranda, 2013) and on consumption generally (Schleich et al., 2013). Each home had a different sense of acceptable conservation activities, highlighting the difficulty of defining what constitutes inefficient energy behaviour or the 'energy-efficiency gap'.

In this study, residents were aware of numerous energy-saving strategies. The results indicate that while householders were generally aware of energy efficiency measures, applying them seems unilateral and based on the household. This adds another element of complexity to the government's task of introducing and promoting efficiency measures aimed at achieving energy independence and reducing carbon emissions. Jorgensen et al. (2021) found that the following were theoretically associated with behaviour: the need to acknowledge one's responsibility for energy demand; to know and understand the consequences of energy use; to be environmentally conscious and shun environmental indifference. Furthermore, based on the type of energy utilised, 74 (23.3%) indicated electricity, 13 (4.1%) used gas, 223 (70.3%) used gas and electricity and 7 (2.2%) indicated ‘other’.  Meanwhile, for the type of energy used for cooking 8 (2.5%) used electricity, 128 (40.4%) used gas, 150 (47.3%) used gas and electricity and 31 (9.8%) indicated ‘other’ while only 41% possessed standard meters among the participants surveyed.

This study showed that 300 (94.6%) had good energy efficient approaches although there is synergetic responses to energy saving behaviours among the respondents. As a result, relevant departments must increase their efforts to disseminate energy-saving knowledge.

Simultaneously, greater emphasis should be placed on energy-saving behaviours and awareness. Although previous research demonstrated that increased awareness of energy conservation has a limited effect on behaviour (Wang et al., 2011), this study found that the position of the respondent in the household had a significant association with the overall energy efficiency approaches. In addition, Zhao et al. (2019) asserted that consumers' belief about their commitment to saving energy indicated environmental concerns. These findings suggest that energy-saving education is a necessary component to increasing energy-saving awareness. As a first step towards improving energy efficiency, the government should implement effective energy-saving education in schools in order to create a more diverse energy-saving future population. Furthermore, the government must disseminate behavioural knowledge, standardise social norms, and establish reward and punishment mechanisms to encourage people to purchase and use more energy-efficient equipment, and to design and build low-energy homes. Additionally, governments and societies could create additional opportunities and locations for university research experience.

The correlations between energy efficiency approaches within this study shows that turning off lights when not in use, unplugging a charger when not in use, switching off the television, computer, radio and fan when not in use, moving furniture away from radiators, closing the curtains when the sun goes down, fully loading a dishwasher/washing machine, dialling down the degrees on your clothes wash, hanging your clothes out to dry, adjusting the temperature settings of the heating or air conditioning, and bulk ironing at once shows a linear association with each other. This implies the attitude and practice of individuals to energy efficiency approaches is directly proportional to their energy saving behaviours; a similar finding was reported by (Yue et al., 2019) in their study on energy-conservation behaviour who also observer a linear relationship between behaviour intention and energy conservation and its influencing factors. However this finding is in contrast to the work of Zainudin et al. (2014) who found that the energy efficiency label negatively correlated with green purchasing behaviour, and the energy efficiency label had no effect on encouraging consumers to consider such information in their purchasing decisions (Zainudin et al., 2014).

Energy efficiency barriers are numerous and complex, and overcoming them is a critical component in effectively implementing energy efficiency policies (Abrahamse & Steg, 2011). Findings from this study also shows that energy efficiency and energy saving practices show a significant association with each other at $p<0.05$. Findings by Ghofrani et al. (2021) reported that demographic and socioeconomic characteristics have a significant influence on residential energy efficiency. He also noted that human characteristics, such as gender, ethnic origin, and income level, are associated with the influence of financial drivers on residential energy consumption, which is consistent with this study's findings. Human-centred actions such as targeted electricity pricing, community awareness and education, incentives to promote building energy efficiency, forming new social/personal norms and values, and increasing a sense of accountability must be considered by decision-makers. Legislators must overcome regulatory barriers to energy pricing and subsidy. Taxation and enforcement in the region's real estate markets must be re-evaluated to ascertain the impact of marketing efforts, such as utility bill deferment offers on residential energy use.

Understanding consumers' perceptions of energy use and savings can help curtailment and the development of energy efficiency policies. Moreover, smart technology and associated services, such as in-home displays, mobile applications, and other information and communication technology-related services, may enable improved measurement and feedback to consumers (Geelen et al., 2019). However, caution should be exercised in presenting feedback, which needs to be offered in a manner that consumers can utilise and comprehend (White et al., 2019). In this study, 55.8% had a good perception of energy efficient use; this indicated that more than two third of respondents had a good energy efficient use, as most gave a positive answer to: the inadequate use of new energy technology, a lack of awareness and training on energy efficient tools, poor financial support, problems with the installation process, initial energy efficient technology (huge investment, gender and number of occupants in household showed a significant association with overall total energy saving behaviours). This study corroborate the findings of Lesic et al. (2019) who revealed that, while participants could identify the three most and least energy-consuming devices in their homes, they were unable to accurately quantify the energy consumption or order of these devices beyond the most energy-consuming device. Furthermore, participants appeared to understand the difference in energy consumption between low-energy dishwashers, ovens, and clothes washers, although their perceptions of the energy consumed were overestimated. They also emphasised the duration of time appliances in operation rather than the total amount of time in operation. This is consistent with the findings of (Attari et al., 2010), who discovered that people associated energy savings more with reductions to the duration of device operation than with replacing the device with a more efficient version. Both findings indicate that consumers underestimate the impact of device power on energy consumption.

According to finding from studies, more than two-thirds of the respondents in the case study area use energy-saving methods in their residences. The majority of participants indicate that they turn off their electrical devices when not in use, which may suggest that they were aware and conscious of their consumption. This approach may result in significant energy savings in homes, companies, and public structures. On the contrary, for those residents who are not conscious of their electricity consumption, it is likely that they fall into the class of residents who evade payment of electricity bills they use (Oyedepo, 2012). This highlights the need to be more conscious of energy usage for better energy efficiency.

It was also noted that people's actions and desires have a significant influence on predictions of energy utilization (Iqbal et al., 2022). Furthermore, overall energy efficiency approaches from this study shows significant association with position of the respondents, which indicates that the pattern of energy utilization had impact on energy efficiency and method to influence it. However, the pattern of consumption of energy shows that large utilization of energy with head of the family and grandparents being the least. This may be due to self-adoptive behaviour of the participants such as practices that determine or limit energy saving behaviours among which include switching off the lights when not in use, unplugging the charger when not in use and switching off television, computer, radio, and fan when not in use, flexible behaviour towards energy efficiency approaches amongst others (Liu et al., 2012). This pattern may be influenced by a variety of exterior factors which could be consciousness or lack of awareness.

In this study, the data noted that among the main driving factors, financial tariff increase, and competitive tariff has the highest weight of standardised item loadings. This implies that applying forceful factors through financial tariff increase to save energy efficiency will have high weightage to achieve energy efficiency in buildings. It is also an inspiration to save electricity as a social responsibility among the stakeholders. It is imperative that the government ensures provision of prompt and adequate information towards energy consumption behaviours in residential buildings by utilizing the driving force. Some critical factors like incentives could be considered amongst other drivers as the main driving force will have a deep impact on energy efficiency in homes. Furthermore, findings from the literature have also shown that motivational subfactors and occupant behavioural factors have deep impact and act as key drivers for energy efficiency in homes (Qarnain et. al, 2021). This underscores the importance of drivers and other incentives to influence behavioural change for the achievement of energy efficiency in residential buildings.

**Section Two**

## 7.4 Inferential Statistics

In this study, multiple regression analysis and a structural equation modelling technique were used to establish the links between the main research constructs. Specifically, multiple regression analysis was employed to examine the influence of three independent variables on the dependent variable, while the structural equation modelling technique was utilised to simultaneously test and assess the research constructs to develop a model of causal relationships.

### 7.4.1 Multiple Regression Analysis

Multiple regression analysis is one of the multivariate statistical methods employed to assess associations between several independent variables and one dependent variable. It is considered a straightforward technique to examine the connection between many variables. Multiple regression analysis is among the most adopted statistical techniques for analysing data comprised of various factors. This technique is different from correlation analysis because it offers explanations and predictions of the variables examined, which can help researchers to understand the cause and effect among research variables.

Some assumptions should be met before conducting regression analysis. One of the requirements of regression analysis is that multicollinearity must not be present between the variables. Multicollinearity refers to high correlation coefficient among the variables examined. In this study, the correlation coefficients recorded between the research variables were very low. According to Saunders et al. (2015), when correlation scores are within the range of 0.7 – 0.9, there is a concern of multicollinearity. Therefore, multicollinearity is not an issue in the regression model of this study.

The results of the multiple regression analysis are reported in Tables 7.12 – 7.14. The regression analysis was performed to examine the influence of three independent variables (aggregate obstacles to energy efficiency and saving behaviours, aggregate energy efficiency approaches, and aggregate energy saving behaviours) on the dependent variable, which is the aggregate sustainable development goals. Table 7.8 shows that ‘obstacles to energy efficiency and saving behaviours’ account for 23.2% of the variance between the ‘sustainable development goals’; ‘energy efficiency approaches’ account for 24.3% of the variance in ‘sustainable development goals’, while ‘energy saving behaviours’ account for 25% of variance in the ‘sustainable development goals’.

The results of the regression model indicate that ‘obstacles to energy efficiency and saving behaviours’ and ‘energy efficiency approaches’ recorded significant associations with ‘sustainable development goals’ at a 1% level, while the relationship between ‘energy saving behaviours’ and ‘sustainable development goals’ was found to be insignificant.

**Table 7.12**: Model summary

| | | | | | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .482[a] | .232 | .230 | 7.43788 | .232 | 95.285 | 1 | 315 | <.001 |
| 2 | .493[b] | .243 | .238 | 7.39801 | .011 | 4.405 | 1 | 314 | .037 |
| 3 | .500[c] | .250 | .243 | 7.37407 | .007 | 3.042 | 1 | 313 | .082 |

a. Predictors: (Constant), Total obstacles to energy efficiency and saving behaviours

b. Predictors: (Constant), Total obstacles to energy efficiency and saving behaviours, Total energy efficiency approaches

c. Predictors: (Constant), Total obstacles to energy efficiency and saving behaviours, Total energy efficiency approaches, Total energy saving behaviours

d. Dependent Variable: Total sustainable development goals

To assess the different variables and predictors, a robust statistical analysis using One Way Analysis of Variance (ANOVA) was performed. The ANOVA test result in Table 7.13 validates the earlier result indicating whether there is significant difference between the variables that were found to be significant. Table 7.13 shows that the characteristics of the regression model are: 22697.8 sum of squares, 55.3 mean square, 95.285 F-statistic (.001) for obstacles to energy efficiency and saving behaviours; 22697.8 sum of squares, 54.7 mean square, 50.360 F-statistic (.001) for energy efficiency approaches; 22697.8 sum of squares, 54.3 mean square, and 34.806 F-statistic (.001) for energy saving behaviours. The result of the ANOVA test shows that the observed variables were significant at 1% level.

**Table 7.13**: ANOVA

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 5271.364 | 1 | 5271.364 | 95.285 | <.001[b] |
| | Residual | 17426.453 | 315 | 55.322 | | |
| | Total | 22697.817 | 316 | | | |
| 2 | Regression | 5512.445 | 2 | 2756.222 | 50.360 | <.001[c] |
| | Residual | 17185.372 | 314 | 54.730 | | |
| | Total | 22697.817 | 316 | | | |
| 3 | Regression | 5677.861 | 3 | 1892.620 | 34.806 | <.001[d] |
| | Residual | 17019.956 | 313 | 54.377 | | |
| | Total | 22697.817 | 316 | | | |
| a. Dependent Variable: Total sustainable development goals | | | | | | |

Table 7.14 shows that obstacles to energy efficiency and saving behaviours, energy efficiency approaches, and energy saving behaviours recorded Beta of 0.422, 0.097, 0.095, t-values of 7.714, 1.924, 1.744, and significance values of 0.001, 0.055, 0.082, respectively. These statistics further confirm the impacts of these factors when predicting the outcome variables

**Table 7.14**: Model coefficients

| Model | | Unstandardised Coefficients | | Standardised Coefficients | t | Sig. | Correlations | | |
|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Zero-order | Partial | Part |
| 1 | (Constant) | 25.655 | 2.089 | | 12.283 | <.001 | | | |
| | Total obstacles to energy efficiency and saving behaviours | .500 | .051 | .482 | 9.761 | <.001 | .482 | .482 | .482 |
| 2 | (Constant) | 21.844 | 2.759 | | 7.917 | <.001 | | | |
| | Total obstacles to energy efficiency and saving behaviours | .478 | .052 | .460 | 9.179 | <.001 | .482 | .460 | .451 |
| | Total energy efficiency approaches | .113 | .054 | .105 | 2.099 | .037 | .199 | .118 | .103 |
| 3 | (Constant) | 19.688 | 3.015 | | 6.530 | <.001 | | | |
| | Total obstacles to energy efficiency and saving behaviours | .438 | .057 | .422 | 7.714 | <.001 | .482 | .400 | .378 |
| | Total energy efficiency approaches | .103 | .054 | .097 | 1.924 | .055 | .199 | .108 | .094 |
| | Total energy saving behaviours | .124 | .071 | .095 | 1.744 | .082 | .291 | .098 | .085 |
| a. Dependent Variable: Total sustainable development goals | | | | | | | | | |

### 7.4.2 Structural Equation Modelling

One of the primary objectives of a statistical technique is to expand the researcher's explanatory capabilities and efficiency. Unlike multiple regression and other techniques that can examine only a single relationship between the dependent and independent variables, these techniques do not test an entire theory with a technique that considers all possible information. Instead, structural equation modelling (SEM) is an extension of several multivariate techniques such as factor analysis and multiple regression analysis.

SEM is used to simultaneously examine a series of dependent relationships (Hair Jr et al., 2014). It is useful in testing theories that contain multiple equations involving dependent relationships. Thus, a hypothesised dependent variable becomes an independent variable in a subsequent dependent association. Multiple regression techniques cannot assess both measurement properties and test the theoretical relationships in one technique. Thus, SEM will help address the limitation of multiple regression techniques.

Therefore, SEM is a family of statistical models that seeks to explain the relations among multiple variables. It examines the structure of the interrelationships expressed in a series of equations, like a series of multiple regression equations. These equations depict all the relationships among constructs (dependent and independent variables) involved in the analysis. Constructs here are either unobservable or latent factors represented by multiple variables. Each technique has been classified either as an interdependent or dependent technique. SEM can be thought of as a unique combination of both types of techniques because its foundation lies in factor analysis and multiple regression analysis. SEM models can be tested in different ways, including by estimating multiple and interrelated dependence relationships. It has the ability to represent unobserved concepts in these relationships and account for measurement error in the estimation process meaning it can define a model to explain the entire set of relationships (Hair Jr et al., 2014).

A model is a representation of a theory. A theory reflects a systematic set of relationships that provides a consistent and comprehensive explanation of the phenomenon. From this view, a theory is not the exclusive domain of academia, but can be rooted in experience and practice, and obtained through observation of real-world behaviour. A conventional model in SEM consists of two models - the measurement model, which represents how measured variables come together to represent constructs, and the structural model, which shows how constructs are associated with each other.

Latent constructs are related to measured variables with a measurement relationship. This is a type of dependent relationship (depicted by a straight arrow) between the measured variables and constructs. In SEM, the arrow is drawn from the latent constructs to the variables associated with the constructs. These variables are referred to as indicators because no single variable can represent a construct, but rather can be used as an indication of the construct. Hair et al. (2014) identified three principles when constructing a measurement model, which are:

i) constructs are represented by ovals or circles, and measured variables are represented by squares or rectangles.
ii) it helps to distinguish the indicators for endogenous versus exogenous constructs (measured variables (indicators) for exogenous constructs are referred to as X variables, whereas endogenous construct indicators are referred to as Y variables);
iii) the X and Y measured variables are associated with respective constructs by a straight arrow from the constructs to the measured variable.

Figure 7.10, bullet (a) shows the measurement relationship between a construct and one of its measured variables. Because constructs will be indicated by multiple measured variables, the more common depiction is shown in Figure 7.10, bullet (b). Here the indicators are labelled as either X or Y.

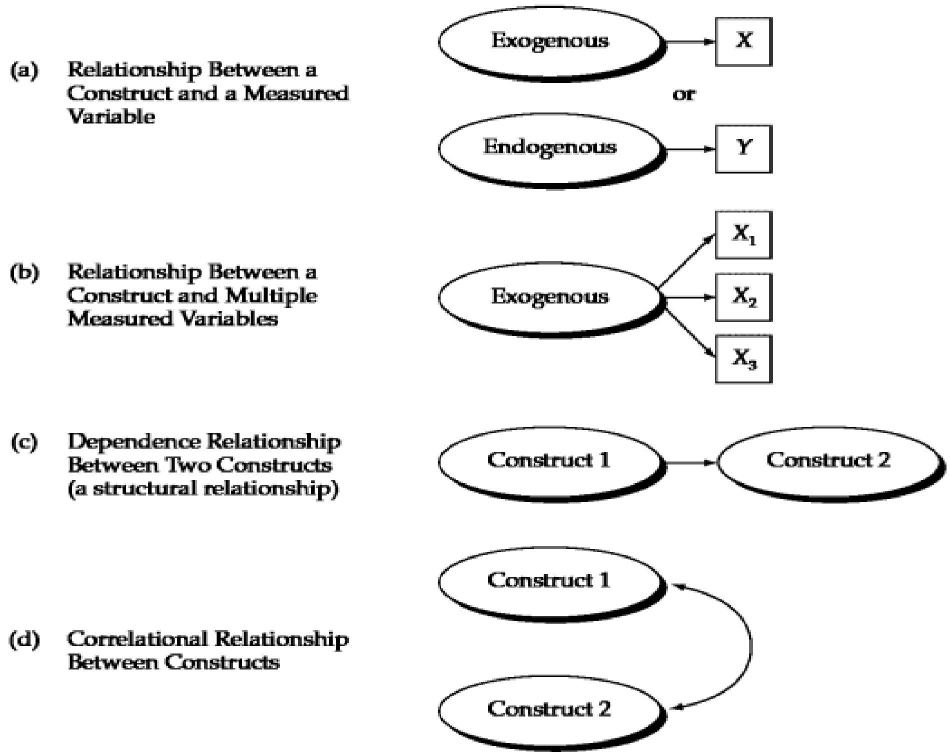


**Figure 7.10**: Common type of theoretical relationships in an SEM model (bullets a to d)

A structural model involves specifying structural relationships between latent constructs. Specifying a relationship means that one either specifies that a relationship exists or that it does not exists, from which an arrow is drawn; if no relationship is expected, then no arrow is drawn. Specification also means a particular value is specified for a relationship. Two types of relationship are possible among the constructs: dependence relationships and correlational relationships.

Measurement relationships are one form of dependence relationship between constructs to variables, the other form is a dependence relationship between constructs. Here the arrows point from the antecedent (independent variable) to the subsequent effect or outcome (dependent variable). This relationship is depicted in Figure 7.10, bullet (c).

Figure 7.11 shows the SEM model incorporating both the measurement and structural relationships of two constructs with four indictors each. In Figure 7.11, image (a), there is a correlational relationship between the two constructs, as indicated by the curved arrow. The indicators are labelled $X_1$ to $X_8$. Figure 7.11, image (b) depicts a dependent relationship between the exogenous and endogenous constructs. The two constructs retain their same indicators, but two changes distinguish this connection from a correlational relationship. The indicators of the exogenous constructs are denoted by $X_1$ to $X_4$, whereas the endogenous indicators are $Y_1$ to $Y_4$. The single dependent relationship between the exogenous construct and the endogenous construct is depicted by a straight arrow between the constructs that replaces the curved arrow.

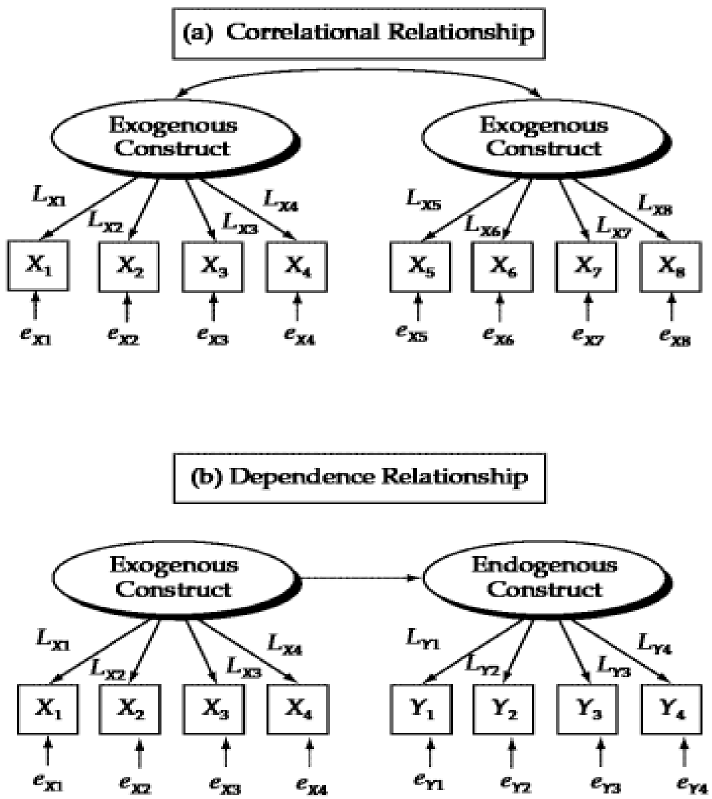


**Figure 7.11**: Measurement and structural model relationships in SEM model (images a and b)

### *7.4.2.1 Assessing the Measurement Model Fit*

In an SEM analysis, the major factor of a good model involves calculating an estimated covariance matrix and assessing the degree of fit to the observed covariance model. The estimated covariance matrix is derived from the path estimates of the model. These estimates allow the researcher to calculate the covariances in the observed covariance matrix using the principles of path analysis. By comparing the matrices, SEM can help test the fit of the model. Models that produce an estimated covariance matrix within a sampling variation of the observed covariance matrix are thought of as a good model fit (Hair et al., 2014).

The model fit was tested using confirmatory factor analysis (CFA) via the AMOS 28 version. The model exhibits good fit: $X^2$ = 440.814; DF = 2.725, $p < 0.001$; CFI = 0.943; TLI = 0.938; IFI = 0.943; RFI = 0.905; NFI = 0.913; RMSEA = 0.043, thus supporting the fitness of the model. The fit indices were equal to, or exceeded, the minimum threshold value of 0.90 suggested by Dangelico et al. (2017). The standardised loadings were also above 0.70 in all cases. Figure 7.12 illustrates that the standardised loadings among the constructs were statistically significant at $p < 0.001$, with energy efficiency policies = 0.75, energy saving policies = 0.59, and behavioural change = 0,23.

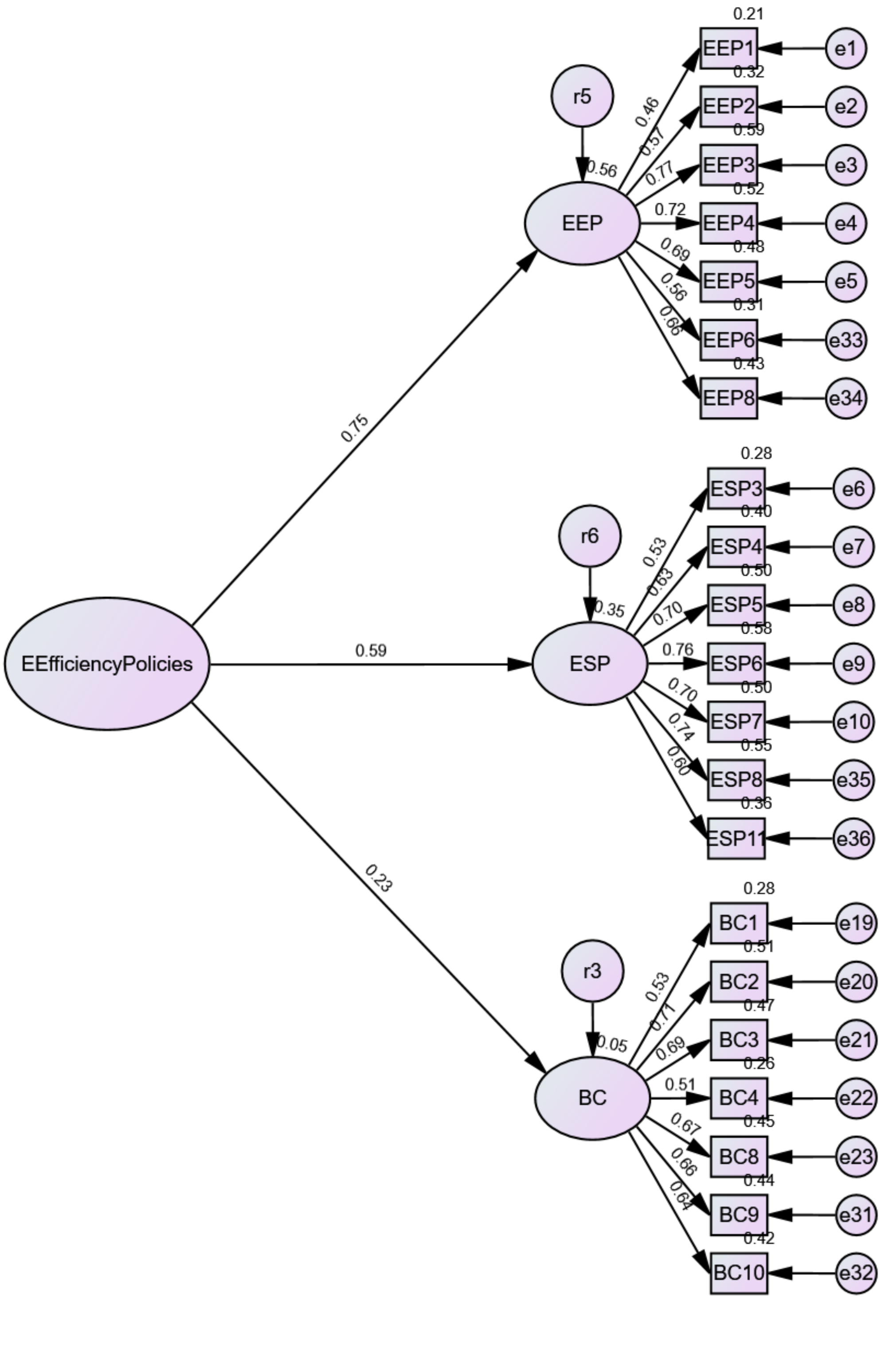


**Figure 7.12**. Measurement model energy efficiency and saving policies

### *7.4.2.2 Assessing Measurement Model for the Entire Construct*

Table 7.14 Shows the results of the model fit for all constructs, including the standardised path coefficients, significance levels and model fit indices. The fit indices are all within a good range ($X^2$ = 203.183; DF = 2.629, p < 0.001; CFI = 0.941; TLI = 0.873; IFI = 0.942; RFI = 0.866; NFI = 0.938; RMSEA = 0.046), suggesting a good fit between the model - implied covariance matrix - and the data. The eight factors provide a better structure to conduct the structural equation modelling. Table 7.14 depicts the standardised item loadings, R square and t-value for the entire scale items.

**Table 7.14**. Results of the confirmatory factor analysis

| Item # | Scale items | Standardised item loadings | $R^2$ | t-value |
|---|---|---|---|---|
| Energy efficiency policies (EEP) Cronbach's α = (0.863), CR = (0.901), AVE = (0.534) | | | | |
| EEP1 | Turn off the lights when not in use" | .755 | .155 | 9.509 |
| EEP2 | Unplug your charger when not in use | .568 | .087 | 9.121 |
| EEP3 | Switch off your television, computer, radio, and fan when not in use | .770 | .086 | 7.339 |
| EEP4 | Move furniture away from radiator | .719 | .078 | 8.030 |
| EEP5 | Close the curtains when the sun goes down | .695 | .078 | 8.288 |
| EEP6 | Fully load your dishwasher/washing machine | .556 | .087 | 9.176 |
| EEP7 | Dial down the degrees on your clothes wash | .656 | .083 | 8.610 |
| EEP8 | Hang your clothes out to dry | .754 | .088 | 9.119 |
| Energy saving policies (ESP) Cronbach's α = (0.773), CR = (0.825), AVE = (0.405) | | | | |
| ESP1 | Bulk ironing at once | .525 | .097 | 9.378 |
| ESP2 | Space heating | .630 | .061 | 8.936 |
| ESP3 | Space cooling | .704 | .060 | 8.419 |
| ESP4 | Lighting | .764 | .045 | 7.743 |
| ESP5 | Water Cooling | .704 | .055 | 8.417 |
| ESP6 | The use of appliances | .740 | .047 | 8.059 |
| ESP7 | Water Heating | .604 | .058 | 9.073 |

| | | | | |
|---|---|---|---|---|
| Behavioural changes | | | | |
| Physical environment (PE) Cronbach's α = (0.700), CR = (0.705), AVE = (0.379) | | | | |
| PE1 | Building type | .531 | .143 | 9.183 |
| PE2 | Construction experts | .711 | .075 | 7.894 |
| PE3 | Building design and aesthetics | .686 | .055 | 8.162 |
| PE4 | Climate condition | .509 | .097 | 9.272 |
| Material cultural (MC) Cronbach's α = (0.755), CR = (0.875), AVE = (0.590) | | | | |
| MC1 | Available technology | .624 | .080 | 8.382 |
| MC2 | Building regulation | .701 | .098 | 9.367 |
| MC3 | Energy rating scheme | .766 | .062 | 8.939 |
| MC4 | Household income | .708 | .061 | 8.397 |
| MC5 | Household/residents | .991 | .045 | 7.647 |
| Energy practices (EP) Cronbach's α = (0.989), CR = (0.982), AVE = (0.914) | | | | |
| EP1 | Building price structure | .995 | .055 | 8.331 |
| EP2 | Social marketing | .957 | .003 | 5.607 |
| EP3 | Energy distribution | .933 | .003 | 3.851 |
| EP4 | Consumer | .938 | .008 | 9.342 |
| EP5 | Cost and benefit | .957 | .011 | 9.586 |
| Attitude, perception, cognitive, and social norms (APCS) Cronbach's α = (0.986), CR = (0.783), AVE = (0.548) | | | | |
| APCS1 | Demography | .670 | .077 | 8.319 |
| APCS2 | Upbringing | .661 | .066 | 8.396 |
| APCS3 | Education | .644 | .063 | 8.534 |
| Sustainable development goals (SDGs) Cronbach's α = (0.900), CR = (0.905), AVE = (0.516) | | | | |
| SDGs1 | Promoted health and well-being | .954 | .009 | 8.725 |
| SDGs2 | Lowered energy use | .957 | .009 | 8.624 |
| SDGs3 | Created employment | .968 | .007 | 8.090 |
| SDGs4 | Enhanced profitability | .959 | .009 | 8.527 |
| SDGs5 | Reduced carbon footprint | .957 | .009 | 8.627 |
| SDGs6 | Improved product quality | .956 | .009 | 8.634 |
| SDGs7 | Minimised air pollution | .925 | .014 | 9.233 |
| SDGs8 | Lower cost | .922 | .015 | 9.273 |
| Note: $X^2$ = 203.183; DF = 2.629, p < 0.001; CFI = 0.941; TLI = 0.873; IFI = 0.942; RFI = 0.866; NFI = 0.938; RMSEA = 0.046 | | | | |

#### *7.4.2.3 Assessing the Structural Model Fit*

According to Hair et al. (2014), before testing a hypothesis, it is important to validate the structural model. As a structural model denotes the structural relationships between latent constructs through path estimates (Hair et al., 2014), this was explained in AMOS, as depicted in Figure 7.13. Although, there is evidence for the hypothesised model, post hoc model adjustments were performed to create a better fitting model. In this case, many residual covariances were estimated. The model was enhanced with the addition of these paths. The evaluation of the model fit indicates that $X^2 = 440.814$; DF = 2.463, $p < 0.001$; CFI = 0.967; TLI = 0.962; IFI = 0.967; RFI = 0.937; NFI = 0.946; RMSEA = 0.036. These demonstrated adequate fit.

As shown in Figure: 7.13, the theoretical framework of this research incorporates the physical environment, material culture, energy practices, energy efficiency and saving policies with sustainable development goals. The proposed hypotheses were outlined in Chapter 3 for individual association among the eight constructs. In accordance with Oakshott (2020), three ratios were used to assess the hypotheses: 0.05, 0.01, and 0.001. The following section presents the results of the hypotheses testing.

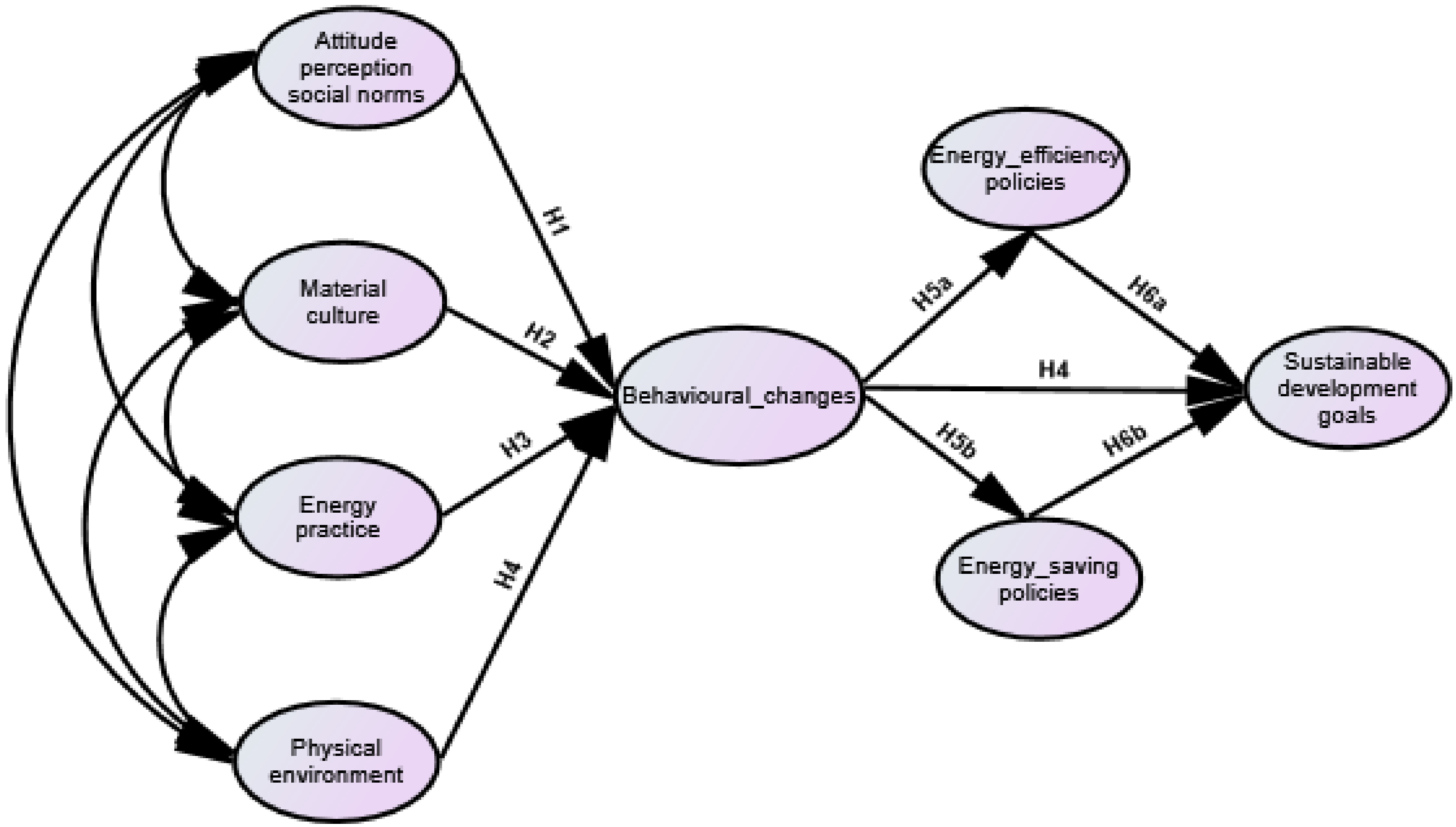


**Figure 7.13**: Structural model

#### *7.4.2.4 Testing the Hypotheses*

**Assessing the direct effects**

Table: 7.15 presents the results of the direct relationships among the research constructs. Among the first four relationships (energy practices, material culture, APCS, and physical environment) with behavioural changes, the estimated coefficients are statistically significant ($\beta = 0.216$, $p < 0.007$; $\beta = 0.166$, $p < 0.027$; $\beta = 0.021$, $p > 0.786$; $\beta = 0.151$, $p < 0.055$) respectively. The effect sizes of these coefficients indicate that energy practices have the biggest impact on behavioural change, whereas material culture is somewhat moderate, the physical environment has less impact, and APCS has the smallest impact, thus supporting H1 to H4. However, this path is not significant for attitude, perception, cognitive and social norms. The results also suggest that the causal path for behavioural changes have a substantial impact on both energy efficiency and energy saving policies ($\beta = 0.298$, $p < 0.001$; $\beta = 0.670$, $p < 0.001$) respectively, supporting H5a and H5b. Moreover, the results also indicate that the causal path EEP ⍰ SDGs and ESP ⍰ SDGs are statistically significant ($\beta = 0.517$, $p < 0.001$; $\beta = 0.156$, $p < 0.038$), supporting H6a and H6b. Meanwhile, the BC ⍰ SDGs path is not significant ($\beta = 0.099$, $p > 0.200$), thus H6c is not supported. The lack of support for the causal path linking behavioural change and sustainable development goals suggests a mediation model. The next section looks at the mediating effects of energy efficiency and saving policies on the association between behavioural change and sustainable development goals.

**Table 7.15**: Assessing the direct effects

| Correlations among constructs | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| Behavioural changes | <--- | Energy practices | 0.216 | 0.098 | 2.680 | 0.007 | |
| Behavioural changes | <--- | Material culture | 0.166 | 0.082 | 2.211 | 0.027 | |
| Behavioural changes | <--- | Attitude, perception, and social norms | 0.021 | 0.105 | 0.271 | 0.786 | |
| Behavioural changes | <--- | Physical environment | 0.151 | 0.088 | 1.921 | 0.055 | |

| Correlations among constructs | | | Estimate | S.E. | C.R. | P | Label |
|---|---|---|---|---|---|---|---|
| Energy efficiency policies | <--- | Behavioural changes | 0.298 | 0.058 | 4.404 | 0.000 | |
| Energy saving policies | <--- | Behavioural changes | 0.670 | 0.045 | 12.728 | 0.000 | |
| Sustainable development goals | <--- | Energy efficiency policies | 0.517 | 0.055 | 8.882 | 0.000 | |
| Sustainable development goals | <--- | Behavioural changes | 0.099 | 0.062 | 1.282 | 0.200 | |
| Sustainable development goals | <--- | Energy saving policies | 0.156 | 0.071 | 2.076 | 0.038 | |

#### *7.4.2.5 Assessing the Indirect or Mediating Effects of Energy Efficiency and Saving Practices*

According to Tabachnick et al. (2007), if there is a hypothetical causal path involving three or more variables, the middle variables are considered mediators (indirect effects) that represent part of the chain leading to changes in the dependent variable. Baron and Kenny (1986)argued that a variable is confirmed as a mediator if: i) there is a significant relationship between the independent and dependent variables; ii) there is a significant relationship between the independent variable and the mediator; iii) the mediator still predicts the dependent variables after controlling for the independent variable. Here, if the relationship between the independent and dependent variables goes to zero when the mediator is included the equation, mediation is said to be perfect or full; if the relationship is diminished, but not to zero, mediation is said to be partial.

In this analysis, the first step to assessing mediation should indicate that the independent variable (behavioural changes) influences the dependent variable (sustainable development goals). This is shown in Figure 7.14. The direct effect on relationships between behavioural change and sustainable development goals were insignificant at $p > 0.200$, suggesting an indirect effect. The second step for testing mediation is to indicate that the direct effect of behavioural change on the mediators (energy efficiency and saving policies) is significant. The results are depicted in Figure 7.14, with a significant association at the $p < 0.001$ level. The last step is to indicate that the mediator variables (energy efficiency and saving policies) influence the sustainable development goals. In Figure 7.14, the results show that the mediator variables strongly correlate with the sustainable development goals at $p < 0.001$ and $p < 0.05$, respectively. The final step is to assess the original direct relationships between behavioural change and sustainable development goals. These results are shown in Figure 7.16 the associations are statistically insignificant. These results indicate strong support of full mediation of the association between behaviour changes and sustainable development goals, by the mediator variables energy efficiency and saving policies. So, hypotheses 7a and 7b are strongly supported (see details in Table 7.16 and figure below).

**Table 7.16** Hypotheses testing results.

| **Correlations among constructs** | | | **Hypo** | **Direct effect** | **Indirect effects** | **Total effects** | **Results** |
|---|---|---|---|---|---|---|---|
| Behavioural changes | | Attitude, perception, and social norms | H1 | 0.021 | 0.000 | 0.021 | Not supported |
| Behavioural changes | ? | Material culture | H2 | 0.166 | 0.000 | 0.166 | Supported |
| Behavioural changes | ? | Energy practices | H3 | 0.216 | 0.000 | 0.216 | Supported |
| Behavioural changes | ? | Physical environment | H4 | 0.151 | 0.000 | 0.151 | Supported |
| Energy efficiency policies | ? | Behavioural changes | H5a | 0.298 | 0.000 | 0.298 | Supported |
| Energy saving policies | ? | Behavioural changes | H5b | 0.670 | 0.000 | 0.670 | Supported |
| Sustainable development goals | ? | Energy efficiency policies | H6a | 0.517 | 0.000 | 0.517 | Supported |
| Sustainable development goals | ? | Energy saving policies | H6b | 0.156 | 0.000 | 0.156 | Supported |
| Sustainable development goals | | Behavioural changes | H6c | 0.099 | 0.000 | 0.099 | Not supported |
| Sustainable development goals energy efficiency policies ? behavioural changes | | | H7a | 0.099 | 0.156 | 0.255 | Supported |
| Sustainable development goals energy saving policies ? behavioural changes | | | H7b | 0.099 | 0.107 | 0.206 | Supported |

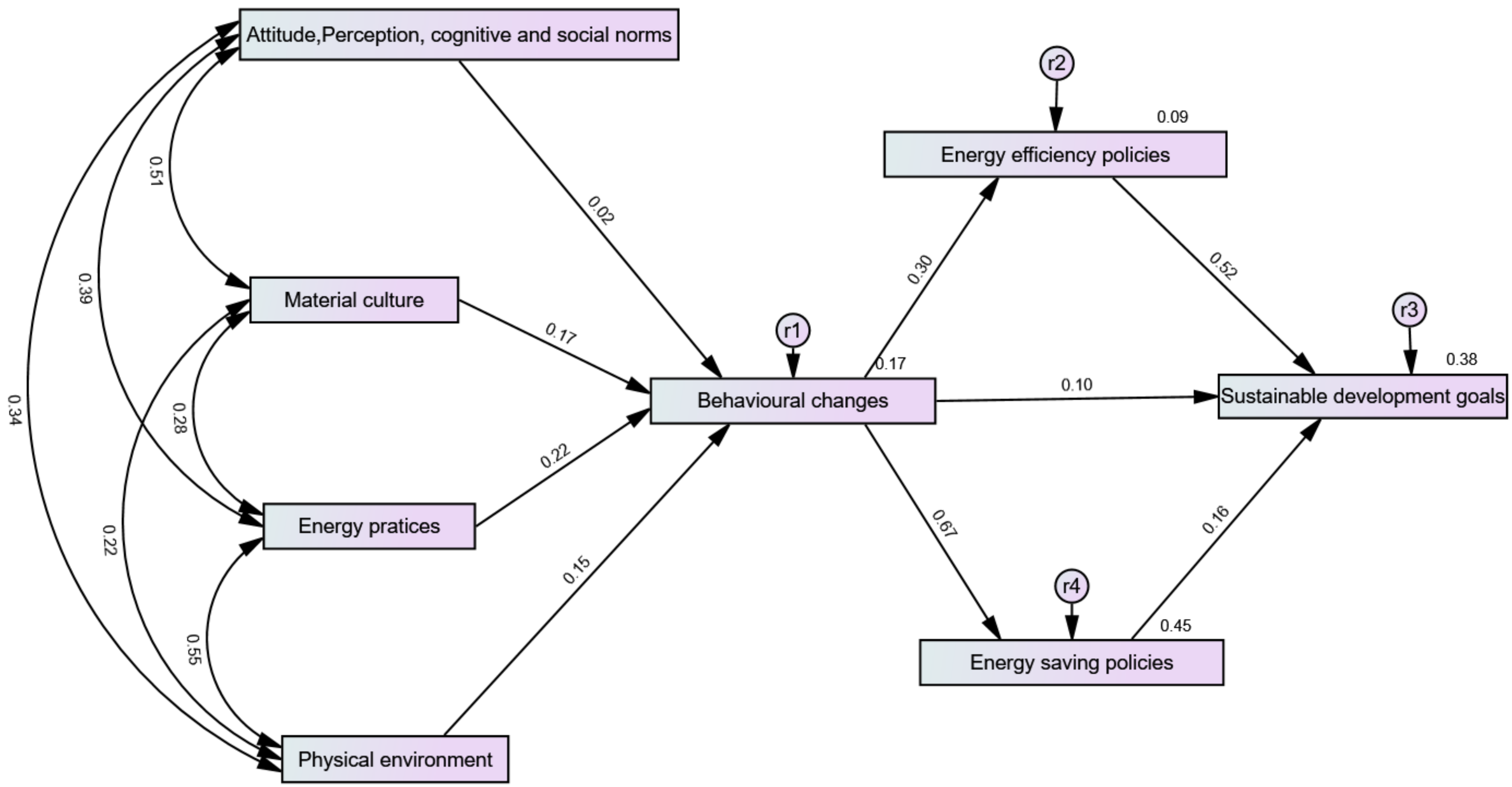


Figure 7.14 Results of direct and mediating effects

## 7.5 Summary of findings

The findings from this study shows that respondents use either electricity, gas or both. More than one third of the sample use a standard meter amongst which most are recharged monthly. Furthermore, 94.6% had good energy efficiency approaches, while the pattern of energy utilization shows that 23.7% had high energy consuming appliances, 64.4% had moderate energy consuming appliances and 12.0% had low energy consuming appliances. This also translates to positive behaviour and most demonstrated similar behaviour to energy saving, gender and the number of occupants in a household, which show significant associations with the overall energy saving behaviours, energy efficiency approaches and obstacles to energy efficiency. In addition, saving behaviours shows a significant association with energy efficiency and sustainable development goals.

Electricity monitoring should be viewed as a component of a broader strategies to promote energy saving in some residential buildings and across broader social and physical contexts. Financial benefits contribute to energy consumption reduction, but only to a certain point which vary considerably between households.

Social practices and relationships appear to impose constraints on the actions that individuals are likely to undertake. Women are particularly influential on energy use in many households due to their primary responsibility for domestic carers on behalf of the household, and their experience and concerns can help inform technical, policy, and campaigning approaches to energy consumption. Electricity monitors should be considered as only one component of encouraging energy conservation, for some households and within wider social and physical contexts. Financial savings contribute to reduction in energy use but only up to boundaries which vary radically between households. Social practices and social relationships appear to constrain the actions of households and individuals are prepared to undertake.

The developed structural equation model presented in this chapter with the model fit tested using confirmatory factor analysis via AMOS 28 and exhibited a good fit. Additionally, the correlation from the constructs shows a direct relationship with behavioural change in achieving energy efficiency and energy savings approach. It was further noted that a deliberate policy or plan to ensure energy efficiency and energy saving practices are vital tools to the achievement of sustainable development goals.

## Conclusion

The growth of a nation is dependent on its access to energy. Rising energy consumption in developing countries is influenced by urban growth and economic expansion. This study assesses energy consumption of households in Nigerian residential buildings, online questionnaire distribution technique was employed to distribute questionnaires, and each participant gave informed consent before completing standard questionnaire. The survey was divided into different sections. In the initial part of the introduction, after the data were collected, the instruments were examined to ensure they were complete and usable. In accordance with the study's objectives, the data were quantitatively evaluated. When respondents were asked closed-ended questions with a limited number of permissible responses, quantitative analysis was applied. IBM's Statistical Packages for the Social Sciences (SPSS), version 25, was used to analyze the data. All of the derived frequency distributions, percentages, mean scores, standard deviations, and charts were entered into a table. Chi square was employed in the data bivariate and regression analyses. The level of significance was set at P=0.05. These studies' findings were utilized to evaluate the hypotheses developed for the study. The findings from this study shows that predictor model based on total obstacles to energy efficiency and saving behaviours. The position of the respondents shows a significant association with energy efficiency and saving behaviours, and more than half of the participants had good perception to energy-efficient appliances. Electricity monitoring should be viewed as a component of a broader strategies to promote energy saving in some residential buildings and across broader social as well as physical contexts especially among poor energy saving behaviours and poor energy efficiency approaches.

# Chapter 8: Conclusion

## 8.1 Introduction

This research employed the use of mixed methods to address the research questions. The main aim of the research was to develop a model for the reduction of energy use in residential buildings from an end use perspective. Chapters 6 and 7 presented the findings and discussion on the qualitative and quantitative phases of the study. This chapter summarises and concludes the findings of the research. It also restates the research objectives and how they were met. In addition, this chapter emphasises the study's contribution to existing knowledge as well as its limitations. Finally, it makes recommendations for policy makers in government, end users in residential buildings, building consultants, energy regulators and providers and offers suggestions for future research.

## 8.2 Overview of the Research Problem and Objectives

Energy consumption behaviour in residential buildings amidst growing global demand for energy has been the focus of this research. This increase in demand is influenced by several factors including urbanization, population increase and over reliance on the use of fossil fuels for energy use. The growing need for energy continues to increase the rate of energy consumption at different levels amongst public and private organisations as well as residential buildings, amongst others. It was noted that any increase in energy consumption has direct or indirect environmental impacts and corresponding carbon dioxide ($CO_2$) emissions which are serious concerns for different countries.

As part of the efforts to reduce energy demand, this research considers energy efficiency, reductions to energy usage, and energy saving behaviour as vital enhancements. This work also considers residential buildings as an important component in energy conservation because of their crucial role in energy usage. The way energy is generated, transmitted, and used is important when addressing the reduction of our society's carbon footprint. This process interrelates with issues of resource depletion (energy), ecosystem loss and climate change.

Nevertheless, energy is an essential resource for life to thrive and households represent a significant consumer. Households depend on energy for functions such as cooking, water heating, space heating in colder climates and space cooling in warmer climates, lighting and other end-uses. The household’s demand for energy in urban areas is growing due to increasing incomes and improved living standards. Hence, residential buildings are a critical target sector for an energy saving culture, on which policy makers could focus energy policies and regulations. With growing urbanization and population in a developing country like Nigeria, urban household energy becomes a significant problem. Changing the habits of building occupants also has a significant effect on the quantity and pattern of energy use in households in these areas. It is on this premise that the assessment of energy saving behaviour from the perspective of households is crucial to enabling energy efficiency, enhancing climate action and facilitating the achievement of the Sustainable Development Goals (SDGs). In addition, little has been explored in this area in sub-Saharan Africa, particularly Nigeria. It was further noted that research efforts in this area are critical for occupants to identify and further acknowledge the impact of their home's energy performance, including their energy consumption expenses, and how environmental impacts can be reduced. Understanding energy consumption at home can uncover significant energy savings in all other aspects of the built environment.

Therefore, this research (stated in Chapter 1) developed a model for the reduction of energy consumption within residential buildings in Nigeria from an end user perspective in order to inform public, private and government understanding. The research explored the cultural dimensions to energy use and their key elements, whilst its aim was achieved through addressing the following objectives:

a. To critically review literature on energy saving behaviour and energy culture elements that influence occupants’ residential energy consumption behaviour.
b. To identify factors that influence occupant’s behaviour and attitude towards energy consumption in residential buildings in Nigeria.
c. To explore the use of drivers to facilitate the adoption of energy saving practices against existing barriers for stakeholders.
d. To assess the role of relevant stakeholders in energy saving practices and the future of sustainable energy technology and policies in Nigeria.
e. To develop an energy-saving behavioural model to reduce energy consumption in Nigeria.

The average household in Abuja depends on the supply of public electricity to meet their needs. The electricity supply is erratic, and not uniform across the city. This inadequate supply necessitates those who can afford it source alternative electricity through generators, solar energy, and inverters. Although DISCOs are required to supply pre-paid meters to consumers, this is being achieved at a slow pace that, in the meantime, leaves consumers frustrated with estimated billing and the loss of revenue to DISCOs. Because of these challenges, convincing households to be energy efficient when they do not have a constant electricity supply might be taxing amongst some (low to middle-income) families. Therefore, these households may not bother with energy saving strategies, especially if they do not have a pre-paid meter, and instead only care if there is supply or not.

With these challenges, it may be hard for Nigeria to achieve her national and international commitments on energy saving, energy efficiency, the Paris Agreement, and SDGs. However, while these challenges can be daunting, this researcher believes that if the recommendations proffered are implementable and the political will is required to ensure efficiency and effective management of energy in a more sustainable approach in Nigeria. For this study, household electricity consumers were considered the main stakeholders, which were confirmed by the objectives stated in Chapter 1. To achieve the objectives, the study answered the following questions:

1. What are the current factors and practices that determine or limit energy saving behaviours in Nigerian residential buildings?
2. To what extent is behavioural change relevant to reducing energy consumption in Nigerian residential buildings?
3. What are the barriers to the adoption of energy saving practices in Nigerian residential buildings?
4. How can the use of drivers and stakeholder input contribute to improving occupant attitudes and energy consumption behaviours in residential buildings?
5. How can the existing cultural framework be employed to develop a suitable model for energy reduction in Nigerian residential buildings?

The findings in relation to these objectives and research questions are detailed as follows:

**Objective 1-** To critically review state of the art literature on energy saving behaviour and energy culture elements that influence occupants' residential energy consumption behaviour.

**Research Question 1: What are the current factors and practices that determine or limit energy saving behaviours in Nigerian residential buildings?**

Barriers to energy saving can be technical, financial, policy and regulatory in nature although these can be resolved if governments take appropriate action. A lack of attention by stakeholders to energy efficient investment opportunities in both the industrial and government sectors can also be a barrier. This includes excess energy that is not distributed to consumers, poor distribution networks, and a failure to adhere to standard formats including connections, equipment, sockets, switches, and fusing. Nonadherence to industry and construction standards, low quality switches and fuses, unskilled technicians are all factors that government needs to enforce through regulation by implementing the energy efficiency building code, ensuring the import of good quality energy efficient lighting and appliances, and increasing awareness of the potential benefits of adopting energy efficient behaviour. Users lack knowledge on energy saving practices. The abuse of power by government officials and private organisations, and misconduct on the part of public officers hinder energy saving behaviours. Cost can also be a barrier to implementing energy-efficient technologies in buildings, and investments in the adoption of such technologies are greater than those in conventional technologies, affecting the rate of BEE adoption.

Technology can be a limiter and an enabler in energy saving. There are technology-powered solutions, approaches, strategies, and methods to drive, encourage, promote, or implement energy-saving. Some technological drivers of energy saving are: whole house refurbishment and retrofit in line with Building Code, energy labelling of residential buildings, integration of household appliances and energy supply through the Internet of Things, and socio-technical issues based on the occupier of the house – homeowner or tenant. Through enlightenment and sensitisation, consumers have knowledge of energy saving approaches.

**Objective 2-** To identify factors that influence occupants' behaviours and attitudes towards energy consumption in residential buildings in Nigeria

**Objective 4-**To assess the role of relevant stakeholders in energy saving practices and the future of sustainable energy technology and policies in Nigeria.

**Research Question 2: To what extent is behavioural change relevant in reducing energy consumption in Nigerian residential buildings?**

The analysis of the data collected from the study revealed that several factors affect behavioural change in relation to reducing energy consumption in residential buildings in Nigeria. Some of these factors include an unstable power supply, the lack of/poor implementation of policies, cultural norms, and the attitudes and behaviours of end users. Findings from the study showed that all these factors have significant impacts on behavioural change which could influence energy reduction. Additionally, findings from this work showed that the use of energy efficient appliances, awareness of energy efficient technology and implementation of energy efficient policies are some of the key recommendations that could influence behavioural change. Moreover, the qualitative study highlighted the significance of user behaviour for energy saving, and the role of stakeholders, including the users, in promoting energy saving practices. The significance of incentives or disincentives, as well as the roles of both government and corporate bodies in policy making, implementation, and encouragement of energy saving practices or the making of non-energy saving practices into unattractive alternatives were also emphasized. This underscores the relevance of behavioural change in reducing energy consumption in Nigerian residential buildings.

**Objective 3-** To explore the use of drivers to facilitate the adoption of energy saving practices against existing barriers for stakeholders.

**Research Question 3: What are the barriers to the adoption of energy saving practices in Nigerian residential buildings?**

The major barriers in energy saving practices are energy efficiency, user ignorance-apathy-culture, policy and implementation, human and national factors, cost, and incentives. Energy efficiency barriers include the nonadherence to standards, energy loss as the national grid has insufficient capacity to transmit the power generated, and unskilled technicians. User ignorance-apathy and anti-energy saving culture includes users lacking knowledge on energy saving strategies, and ingrained cultures in users due to years of low or no enlightenment. Policy and implementation issues included: challenges arising from the implementation of government policies, poor implementation of the Nigerian Building Energy Efficient Code (BEEC) and the enforcement of the National Environmental (Electrical/Electronic Sector)

Regulations 2011, and the overdue revision of existing policies, laws, and regulations. Human and national factors include the abuse of power by government officials and private organisations, and misconduct on the part of public officers. Cost barriers include the investment required to implement energy-efficient technologies in buildings, households' financial constraints, difficulty in accessing funding bodies, and a lack of incentives to the consumer to save energy.

**Objective 3-** To explore the use of drivers to facilitate the adoption of energy saving practices against the existing barriers for stakeholders.

**Research Question 4: How can the use of drivers and stakeholder input contribute to improving occupant attitude and energy consumption behaviour in residential buildings?**

As found in this research, energy saving drivers are broadly classed as technology, education and information, incentives, occupant culture, and stakeholders. For technology drivers, all methods involving the use of technology to drive, encourage, promote, or implement energy-saving are included. Education and information involve communicating the cost of electricity, public education, awareness campaigns through radio or corporate awareness through sustainability forums on energy saving practices. These serve both to inform and keep energy practitioners abreast of information within the field. They also provide information related to the public so that energy practitioners can help to educate the public. It also involves research on the sector to find solutions to problems and plan ahead. Incentives involve personal benefits and rewards to motivate positive behaviour. It also makes users take full responsibility for their consumption. Finally, stakeholders play central roles in energy saving culture and the consumption behaviour of occupants. They are responsible for education, motivation, policymaking, public support, the provision of incentives and more. The key stakeholders identified include energy organisations (service providers, consultants, regulators, and construction experts), investors, and the government.

**Objective 5-** To develop an energy-saving behavioural model to reduce energy consumption in Nigeria.

**Research Question 5: How can the existing cultural framework be employed to develop a suitable model for energy reduction in Nigerian residential buildings?**

The existing cultural framework was analysed based on the initial data collected from stakeholders generated from interviews. Findings from the study identified that energy literacy is central to change in the cognitive norms that improve user awareness and behavioural change. While existing change in material culture is vital in the change towards energy reduction, other factors likely to affect material culture include stakeholder education, for example the exchange of technical advice with the government and between organisations through various forums, in addition to cooperation between all stakeholders. Existing cultural frameworks were harnessed, while valuable data from the qualitative interviews of relevant stakeholders and quantitative data generated from end users were exploited to develop a suitable model to reduce energy in Nigerian residential buildings. Some factors like attitude, perception, cognitive and social norms were considered valuable inputs to influence behavioural change and achieve energy savings. Others were material culture, energy practices and the physical environment.

The generated data were subject to detailed analysis, while structural equation modelling was used to develop a model to reduce energy use in Nigerian residential buildings. The energy saving model is at Chapter 7 (Figure 7.14), showing the relationship between identified factors and behavioural change and its impact on energy efficiency towards achieving the UN SDGs. The developed model shows the direct and mediating effects of various cultural practices associated with households in residential buildings. It was shown that more than one third of the occupants use a standard metering system and are aware of their energy consumption pattern. This implies that a conscious approach towards positive energy saving behaviour and energy efficiency is likely to reduce energy consumption within residential buildings. This underscores the need for electricity monitoring as a key strategy to promote energy saving or energy efficiency in residential buildings across a broader social and physical context. The model also shows that the modification of existing cultural frameworks has a direct relationship to behavioural change. In achieving the desired sustainable development goals, it was noted that a strong relationship exists between behavioural change, energy efficient policy and energy savings. Hence, to achieve more sustainable energy efficiency and energy saving behaviour in Nigerian residential buildings, the government should utilise this model as valuable tool to achieving the set objectives through deliberate policy planning and implementation.

### 8.3 Recommendations from this Research

This case study research investigated different factors that influence energy consumption from an end user perspective using both qualitative and quantitative data to understand the barriers and drivers to energy saving in residential buildings. Further research could assess the relative importance of the different factors identified to develop an intervention tool. Due to the cross-sectional nature of the design, this means that the findings reported are limited to a specific period. Future research could employ longitudinal surveys and/or observational studies to elucidate electricity consumption over an extended period of time. Longitudinal studies could help to determine how respondents' behaviours change over time. Therefore, the following recommendations are identified from this research:

1. Governments, energy providers, researchers and other energy stakeholders should adopt the energy saving model to serve as a pathway to achieving behaviour change and sustainable development objectives.
2. Nigeria Government should develop a strategy to include the use of energy saving appliances in their energy compliance code and standards to influence energy saving behaviour.
3. The energy distribution companies should adopt energy management strategy as a cooperate energy strategy using an automated smart distribution board.
4. Government should develop a framework for the provision of incentives for energy users that adopt sustainable energy approach including the use of alternative energy sources to complement their energy usage.
5. Distribution companies should be encouraged by regulators to establish local companies to meet energy saving appliances as well as international standards and best practices.
6. Improved awareness to all stakeholders (public, professionals, regulators, GENCOs, and DISCOs) on the existence of energy efficient appliances and technology.
7. More education is required for potential residential owners and builders on the need to adopt passive houses and use of sustainable energy sources like solar energy electricity to save energy and cost. The enlightenment education should tell the

consumer why saving energy is beneficial to them because Nigeria is grappling with challenges of providing stable energy for its growing population. Although Sub-Saharan Africa, as a whole, contributes about 30% of the total emissions to global warming, Nigerians may not be concerned with this but only how energy saving affects them individually.

8. The Regulators should expand their public enlightenment campaign on the safe use of electricity to include energy saving strategies and to cover the whole country. This should also focus on school-age children.

9. The day-to-day activities of individuals and groups regarding responsible lighting (switching on and off), the management of security lights, all-day and all-night air condition usage, and electrical appliances permanently left on are some common non-energy saving practices. More use of sunlight, and the reduced use of air conditioners especially solar-powered systems that automatically switch on and off to power boreholes as well as pump machines are ways of promoting responsible energy use. In a similar manner, energy policing is employed in corporate settings, although individuals and families could also adopt such practices in residential premises. Users should be encouraged to be conscious of switching lights and appliances off when they are not in use. These strategies encourage the responsible use of energy.

10. The provision of pre-paid meters to consumers by DISCOs could help them appreciate the energy cost they can save through their use.

11. Encourage the private sector to produce pre-paid meters and other energy saving appliances and technologies locally.

12. The government should improve energy efficiency regarding appliances and renewable energy equipment imported into the country. This would require more action on the standards of appliances and policy enforcement. These actions involve accounting for energy efficiency and energy saving in tariffs, implementing an energy efficiency building code, using incentives to save energy and efficiency by households, DISCOs and GENCOs, research and development in energy efficiency and energy conservation activities, and improving energy efficiency with regards to distribution of electricity by the energy providers.

13. Technical barriers include excess energy that is not distributed to consumers, poor distribution networks, and the failure to adhere to standard formats including connections, equipment, sockets, switches, and fusing. Thus, the energy generated is accounted for during transmission but lost in distribution and thus not utilised in

households. Therefore, all technical and operational factors that result in a lack of energy saving should be addressed and resolved accordingly. DISCOs should be held responsible by the regulator for any use of substandard appliances along the value chain. Moreover, engineers and technicians who install substandard appliances in houses should be penalised by their certification body, alongside organisations which allow substandard electrical equipment and appliances to be imported into or manufactured in Nigeria.

14. When storing, managing, and analysing consumer data, DISCOs and GENCOs can identify vulnerable households and incentivize their electricity consumption to avoid electricity exclusion and poverty.

15. The affordability of energy saving innovation hinges on the government reducing tariffs (if imported) and production costs (if locally produced) to manufacturers or offering incentives to producers and dealers to make their appliances affordable to Nigerians. This is designed to achieve multiple goals which range from low cost to the consumer to energy saving to mitigate climate change if the products are used.

16. It is important for the government to develop economic incentives that lead to tax reduction and financial rewards to households, DISCOs, GENCOs, and other professionals in the sector. Furthermore, consequences should also be applied in cases of neglect or unprofessional behavior by households or professionals.

17. Public officials that allow the production or import of substandard electric appliances and equipment should be penalized. This is particularly important given the indication of connivance by public officials during this research.

18. As technologies and societies evolve, the electricity sector should endeavor to conduct periodic policy and regulation reviews to address issues that arise in a dynamic world.

19. Stakeholders play a central role in the energy saving culture and consumption behavior of occupants. They are responsible for education, motivation, policymaking, public support, and the provision of incentives. The key stakeholders identified include energy organisations (service providers, consultants, regulators, and construction experts), investors and the government. Occupants' behaviour toward building energy consumption needs to improve through the involvement of professional stakeholders to help reduce energy consumption and enhance the modelling of energy consumption in buildings. Households listen to the professional stakeholder because they are furnished with information that is beneficial to the consumer and allows for mutual understanding.

In terms of policy, Nigeria is ready to provide alternative energy sources through the Renewable Energy Master Plan (REMP). Stakeholders (policymakers, businesses, non-governmental organisations) should identify opportunities and best practice for developing and investing in renewable energy. Therefore, education on the availability of alternative energy sources and the provision of investment opportunities into these energy sources will encourage consumers to adopt them.

**8.4 Implications for this Research**

This research studied energy usage in Nigerian residential buildings. It also offered an understanding of the end user's perspective on energy saving in their households. Different behaviour patterns and electricity usage arise in residences depending on the socio-economic dynamics of the household. These distinctions and behavioural differences, alongside the challenges to electricity supply experienced in Nigeria necessitated this research.

Further research into the energy saving behaviour of households is critical for occupants to identify and further acknowledge the significance of their home's energy performance, how their energy consumption costs accumulate, and ways to reduce the environmental impact, especially in a developing country like Nigeria. Understanding energy consumption in the home can uncover significant energy saving across all other aspects of the built environment. Therefore, this research has a range of implications for household behavior on energy saving, energy cost, the operations of electricity distributors, and policy.

**8.4.1 Contributions to Knowledge**

The research generated additional empirical data on energy saving behaviour in residential buildings in Nigeria, which is significant given the current lack of data in this area particular in the sub-Saharan Africa. The research focused on the household consumer in Nigeria. This aspect of the electricity sector has not been adequately studied because the sector's focus is implementing the (Electric Power Sector Reform Act), stabilizing the sector, expanding, collecting outstanding electricity bills, and maximising profit from consumers. The behaviour of household consumers is not a priority, which is illustrated in the slow pace of pre-paid meter distribution across the country. Therefore, in as much as this research focuses on energy saving from the perspective of households, the DISCOs and regulatory bodies do not similarly focus on understanding the household consumer. The research filled this gap. In addition, the findings from this research brought to the fore the inherent challenges confronting energy efficiency and energy savings including how they affects behavioural change in residents. Some of the barriers to energy saving were highlighted stressing the peculiarities and suggesting solutions to enable a more sustainable energy saving regime. The finding identified a key research gap by assessing the cultural, social and demographic factors that affect energy consumption to facilitate energy efficiency and influence energy saving behaviour in residential buildings from an end user perspective.

This research has contributed to knowledge of the electricity consumer at the residential level in Nigeria. It has shown that there is gap in understanding that goes beyond the technical aspects of generation, transmission and distribution. Moreover, the findings also revealed that the issue is not only about regulation, or having a steady electricity supply across Nigeria, and it is not only about industries and high electricity users but about household users. Therefore, this research focused on understanding the culture, behaviour and needs concerning the electricity usage of an average household in a Nigerian city. Therefore, this study contributed to existing knowledge as this is often overlooked but necessary. Thus, the electricity usage of a household needs to be understood so that the provision of electricity can be forecasted and planned.

This research focused on the city of Abuja municipal, within Nigeria's capital city, which has a population of over one million. Other Nigerian cities have a higher population than Abuja, therefore, this study can be replicated across other cities to understand the dynamics and distinctions of household electricity users across the nation or, if possible, across communities and neighborhoods. As such, this research is a benchmark to understanding the household electricity consumer in Nigeria.

Nigeria is a signatory to the Paris Agreement on Climate Change and the Sustainable Development Goals (SDGs). The Paris Agreement focuses on mitigating climate change, and adapting to achieve energy saving is one of the strategies used. The SDGs, specifically SDG 17 ('ensure access to affordable, reliable, sustainable and modern energy for all'), focuses on energy efficiency and the use of renewable energy. However, energy loss in the Nigerian electricity value chain is huge. This begins with generation (low generation, system collapse, dilapidated equipment) includes transmission (obsolete transmission lines in the national grid, transmission line theft, energy diversion) and distribution (inadequate transformers, poor distribution network and lines, dilapidated and obsolete equipment and facilities, energy theft by consumers, overbilling or underbilling of consumers, unpaid bills, redundant electricity). This illustrates the challenges faced by Nigeria in achieving her international commitments. This research notes that these challenges must be addressed before Nigeria can hope to achieve her desired international commitments.

The most important contribution to knowledge by this research is the development of a model to reduce energy consumption in residential buildings in Nigeria. The proposed model originates from data collected from stakeholders in residences in Nigeria's municipal city of Abuja. The lack of data on energy efficiency and energy saving behaviour in residential buildings was a gap identified during the literature review. The analysis of the developed model found a direct relationship and significant influence between occupants' behaviours, energy savings and energy efficiency in residential buildings. This highlighted the need for a deliberate plan with the aim of achieving more sustainable energy saving behaviour and greater energy efficiencies in residential buildings. In addition, the research showed that the barriers or obstacles to energy saving behaviour significantly impact the country's overall energy efficiency and sustainable development goals. Even though behavioural changes show an insignificant relationship with the sustainable development goals, it has a significant effect on energy saving policies and energy efficiency policies, and a substantial impact on the sustainable development goals. Hence, a more deliberate policy or approach to encourage energy saving behaviour would reduce energy consumption with a significant impact on sustainable development goals. This is also considered a major contribution to knowledge. Hence, the outcomes from this research will contribute to the existing body of knowledge for researchers and the recommendations will be useful to Nigerian Government, other stakeholders in the energy sector in Nigeria and sub-Saharan Africa, and to academia.

### 8.4.2 Contributions to Practice

This research contributes to practice in several ways. It has found that service providers tend to focus on consumption to bring in profit while construction experts and consultants tend to focus on encouraging the adoption of energy saving appliances and equipment and renewable energy sources to consumers. However, the regulator is concerned about metering every consumer to avoid energy loss, while GENCOs and DISCOs are concerned about being paid for the services they are rendering. It was further noted that, households appreciate the advantages offered by prepaid meters because they can control the energy they use in the house. The practice of switching off appliances when not in use should be encouraged to all consumers, not only households. This research recommends assigning

Energy Police to all public and private organisations, while residents can borrow from this practice to achieve energy efficiency and better energy saving.

This study has contributed to the need for ongoing public education and awareness raising on energy saving actions and appliances that can be used by households, while workshops/conferences could be offered to professionals in the sector to share ideas. The awareness and education campaigns should be deliberate, based on the implementation plan of policies or energy saving strategies. Through awareness and the sharing of ideas, consumers will appreciate the need to build their homes using passive designs to reduce their energy usage and save cost. The main thrust for most households is directed towards how they can save their energy costs. Furthermore, further research on energy usage from the end user perspective (residences and organisations) is recommended by this research, as mentioned by one of the participating service providers and two of the energy consultants.

Due to international agreements and the inclusion of corporate bodies in mitigating climate change and achieving the SDGs, most organisations now want to be certified as environmentally friendly. Therefore, there is the need to operate energy efficient buildings and that are certified green by the Nigerian Building Energy Efficiency Code (BEEC).

This research has helped to identify the gap in practice concerning the growing need for incentives for consumers to save energy and consequences when they consume higher energy than necessary. One of the incentives is subsidising the price of energy saving appliances for households, which will boost the market for these appliances but reduce the market for other non-energy saving appliances. As mentioned by some of the research respondents, because of an inadequate electricity supply there is a growing use of solar energy and inverters by households influenced by the cost of buying and managing generators. Therefore, some cultural and behavioral change toward energy saving is happening amongst household consumers especially in urban areas.

### 8.4.3 Methodological Contributions

Methodologically, this research applied mixed methods research which involved a combination of qualitative and quantitative methods. This approach was exploited to fill the knowledge gap and address the problem associated with energy saving behaviours/attitudes in residential buildings. The usage of mixed method research allowed the researcher to be flexible in selecting different data collection methods so that the methods used would adequately answer the research questions. By using industry professionals as research participants, the researcher gained a better understanding of the industry through listening to the experience of the participants.

Data was collected in two main phases, the first phase entailed semi structured telephone interviews with professionals in the energy and building related fields and generated qualitative data. The second phase saw the collection of quantitative data from households on energy usage. All respondents for the study were residents of Abuja and considered that they had access to electricity and other forms of energy. As the second data gathering phase targeted households, this enabled the researcher to collect large samples of data, provide an in-depth understanding of current energy savings, establish the barriers and drivers, and explore attitudes with regards to energy saving behaviour in residential buildings.

Households were the focus of this study; therefore, knowing the amount of electricity respondents used in their households was paramount to achieving the aim of this research. Thus, using qualitative responses from industry professionals based on their experience and quantitative data from households based on their electricity usage informed the development of an analytical model that could subsequently be replicated or adapted across Nigeria.

Pilot study was conducted to explore the feasibility of the approach intended for used on a larger scale. The pilot study was conducted via telephone with experts from one of the DISCOs. Access to the participants was enabled through personal contact. The pilot study provided more clarity to the researcher on the method of interview adopted (semi-structured) and enabled the researcher to adjust the interview guide and give respondents the freedom to express their views and opinion. Findings from the semi-structured interviews, were used to refine the interview guideline and improve the overall clarity, validity and reliability of the study. Therefore, the pilot study became the case study for understanding and preparation for the main research study area in Abuja. Thus, the evolution of the pilot to the case study contributed to the methodological approach by illustrating that the results of pilot studies can be used to gather background information.

**8.5 Scope for Further Study**

The research considered several factors in the current study when investigating energy efficiency or energy saving behaviour in Nigerian residential buildings. While some fundamental factors - including barriers - were valuable in achieving the key objectives of the study, there were some key areas which were not fully covered by this research. Thus, the following are potential areas of future research:

a. While this research focused on the behaviour of occupants or residents towards energy saving, the direct impact of their behaviour was not covered by the research. Moreover, the negative consequences of energy saving behaviour could have a direct effect on the environment. Hence, there is the need to conduct further research on the direct impact of behavioural change as this will help to determine the contributions of various households towards a more sustainable future and facilitating the attainment of the UN SDG.
b. In the interviews, the study focused on stakeholders from the building sector, energy regulators and energy providers. However, the research did not consider the views from energy efficient technology suppliers, manufacturers of energy appliances and intermediaries or agents in the supply chain of energy or electricity appliances during the data collection process. The input from these stakeholders would have been valuable in further understanding and influencing energy saving culture and energy efficiency. It would also complete the energy stakeholders circle to allow for more robust solutions in the model in energy saving behaviour or energy efficiency in Nigerian residential buildings.
c. This research developed a model based on existing cultural frameworks and designed to encourage energy reduction in Nigerian residential buildings. However, due to the lack of time, the model could not be validated with relevant stakeholders. Hence, it is crucial that the developed model is validated to ensure its accuracy and enhance its performance.
d. In the data collection process, the Abuja municipal was selected as the case study area within the metropolitan city of Abuja. The context reflected the diverse nature of people from different cultural, education, economic and social backgrounds while the sociodemographic settings of the respondents captured and mirrored the majority of municipal cities across the country. Hence, the data obtained would be applicable to most cities across the country. Nevertheless, the data did not capture rural dwellings where the nature of electricity or energy supply is low, and where the mindsets of residents are different from those in metropolitan cities. Furthermore, other socio-demographic factors could differ in terms of education and financial capacity. There could also be a huge difference in the level of awareness of the energy saving

appliances, the use of a sustainable approach to energy usage, or the use of items with a high carbon content or fossil fuel that increase carbon emissions. There is also the likely effect of weather or climatic conditions in different parts of the country which was not taken into consideration in detail during the data collection process. All these could affect the energy efficiency or energy saving behaviours in residential buildings in Nigeria, and would thus require further research.

e. Even though the research discussed some aspects of sustainable energy, there is need for a separate study on renewable and sustainable adoption to facilitate energy efficiency in Nigerian residential buildings. This is particularly important given there is growing knowledge and increasing adoption of a renewable and more sustainable energy saving culture amongst residential buildings due to the unstable nature of energy or electricity supply and the current increase in energy or electricity tariffs.

**8.6 Limitations of the Study**

The current study has a number of contextual and methodological limitations, indicating the need for more research in the area. The study's scope is necessarily limited, as it focuses exclusively on electricity as the primary cost to households, even though energy consumption is frequently associated with electricity and gas. Despite these limitations, this study sheds light on an area where relatively little research has been conducted.

Another major strength of the qualitative phase is on the data collected from managers and other experts who were directly involved with energy saving in their organisations. This provided invaluable data and firsthand information about various practices in organisations. However, because of the pandemic and travel restrictions, the absence of face-to-face interviews limited the researcher from analysing non-verbal cues and body language that could have provided enriched text for analysis.

Furthermore, with regards to the research study area and demographics, this study was mainly conducted on households within the municipal area of Abuja city. This excluded the views of rural dwellers with access to electricity and other people in other regions of the country. As such, the results for the survey and findings were generalised to just that case study area. This meant that the results and conclusions reached could be difficult to implement in other geographical locations due to environmental, social, lifestyle and economic differences. As a result, the population for the survey may limit the generalisability of the result. However, the results can be implemented in municipal cities in Nigeria with similar population demographics, and environmental, social and lifestyle contexts.

Another limitation of the research is the lack of validation of the proposed model. This could have been conducted via focus groups as initially proposed in the research design. However, due to time constraints, this was not achieved. Nevertheless, future research could validate the model and offer greater insight into the outcome to enable additional contributions to knowledge.

**8.7 Final Note**

This chapter presented an overview of the key objectives of the research and how the objectives were achieved and presented key recommendations from the research findings. Furthermore, the study also highlighted the implications of the research, including its contributions to knowledge and practice. One of the key contributions is the addition of empirical data to the body of knowledge on energy efficiency and in the energy saving behaviour of residential buildings, which was initially identified as a research gap. The model could also enhance energy efficiency through encouraging a reduction in energy consumption amongst Nigerian households. Despite the limitations of the study, its contributions are intended to benefit the government, relevant stakeholders in the energy sector, the research community and academia.

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# Appendix 1

University of Salford
MANCHESTER

**Research, Innovation and Academic Engagement Ethical Approval Panel**

Doctoral & Research Support
Research and Knowledge Exchange,
Room 827, Maxwell Building
University of Salford
Manchester
M5 4WT

T +44(0)161 295 5278

www.salford.ac.uk/

23 September 2019

**Aisha Tilde**

Dear Aisha

**<u>RE: ETHICS APPLICATION STR1819-44 – An investigation of sustainable energy consumption for Residential buildings in Nigeria</u>**

Based on the information you provided, I am pleased to inform you that your application STR1819-44 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Dr Devi Prasad Tumula
Deputy Chair of the Science & Technology Research Ethics Panel

# Survey of energy efficiency and saving behaviour in residential buildings (Copy)

The survey will take approximately 9 minutes to complete.
All information provided will be treated in strict confidence and your identity and anonymity is guaranteed. Results will only be published in aggregate form and used strictly for this research only. Any acknowledgement of you or your institution will be made subject to your agreement. The questionnaire is estimated to take between 10 minutes to complete.
About this research: The main aim is to investigates the attitude and behaviour of occupants in residential buildings for the proposed case study in Nigeria. It is the anticipation of the researcher that the outcome will provide framework to assist users or households in reducing their energy consumption. This will support the sustainable development efforts of the residential sector by having a better understanding of energy saving behaviour/ attitude. Energy consumption in this research refers to electrical energy.
I will require a few background information about yourself, your estimated energy consumption, about appliances and energy consumption in your home.
Your contribution to this research is appreciated. I look forward to receiving your response.

* Required

## Section A:

**General Information**

1. Which State do you live in?
*

- Abia
- Adamawa
- Akwa Ibom
- Anambra
- Bauchi
- Bayelsa
- Benue
- Borno
- Cross River
- Delta
- Ebonyi
- Edo
- Ekiti
- Enugu
- FCT - Abuja
- Gombe
- Imo
- Jigawa
- Kaduna
- Kano

- Katsina
- Kebbi
- Kogi
- Kwara
- Lagos
- Nassarawa
- Niger
- Ogun
- Ondo
- Osun
- Oyo
- Plateau
- Rivers
- Sokoto
- Taraba
- Yobe
- Zamfara

2. Location?
*

*(e.g. Gwarinpa, Mushin, Sabon Gari, Kado, Gwallaga, Dakata, Ebute Metta etc.)*

3. Position of the respondent *

- Head of the house
- Child
- Grandparent
- Other

4. Gender *

- Male
- Female

5. Average age of occupants *

- 18-25
- 26-40
- 41-55
- 56-65
- >66

6. No of occupants in household (Including the respondent) *

- 1-2
- 3-4
- 5-6
- 7-8
- >9

7. Occupants employment status *

| | Employed | Unemployed | Retired |
|---|---|---|---|
| Head of the house | | | |
| Member 1 | | | |
| Member 2 | | | |
| Member 3 | | | |

8. Type of Property *

- ◯ Storey building
- ◯ Bungalow – Detached
- ◯ Bungalow – semi
- ◯ Bungalow – end -terraced
- ◯ Bungalow -mid -terraced
- ◯ Apartment/ Flat
- ◯ Other

9. What type of energy do you use? *

- ◯ Gas and Electricity
- ◯ Gas
- ◯ Electricity
- ◯ Other

10. What type of energy do you use for cooking?
*

- Gas & electricity
- Gas
- Electricity
- Charcoal
- Firewood

11. How much do you spend on cooking gas per month (in naira)?
*

- <2,000
- <4,000
- <6,000
- <8,000
- <10,000

12. What type of meter do you have?
*

- Standard
- Mutil-rate
- Smart
- No Meter

13. How much do you currently pay for your electricity bill per month (In naira ₦)?
*

- <5,000
- <10,000
- 10,000-20,000
- Above 20,000
- 50,000 and above

14. How do you currently pay your energy bill?
*

- Monthly direct debt
- Quarterly cash or cheque
- Pay As You Go

15. How much electrical energy do you use?
*

- In Naira
- I know in kWh
- I don't know

# Section B:

**Awareness of energy-efficient technologies**

16. Do you know what energy-efficient appliances are?

*

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|

Not at all — Extremely Informed

17. Please indicate how much you agree or disagree with the following energy saving habits.

*

| | Strongly disagree 1 | Disagree 2 | Neutral 3 | Agree 4 | Strongly agree 5 |
|---|---|---|---|---|---|
| Turn off the lights when not in use | ○ | ○ | ○ | ○ | ○ |
| Unplug your charger when not in use | ○ | ○ | ○ | ○ | ○ |
| Switch off your television, computer, radio and fan when not in use | ○ | ○ | ○ | ○ | ○ |
| Move furniture away from radiator | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| Close the curtains when the sun goes down | ○ | ○ | ○ | ○ | ○ |
| Fully load your dishwasher/washing machine | ○ | ○ | ○ | ○ | ○ |
| Dial down the degrees on your clothes wash | ○ | ○ | ○ | ○ | ○ |
| Hang your clothes out to dry | ○ | ○ | ○ | ○ | ○ |
| Clean and defrost your fridge-freezer | ○ | ○ | ○ | ○ | ○ |
| Adjust the settings of temperature on the heating or air conditioner | ○ | ○ | ○ | ○ | ○ |
| Bulk ironing at once | ○ | ○ | ○ | ○ | ○ |

18. Please indicate which electrical appliance you have in your residence? *

*E.g. Microwave, Kettle, TV, Dishwasher, Phone, Laptop. etc.)*

19.
Are appliances listed above energy efficient? *

- Yes
- No

20. Please indicate how the following activities drive your energy consumption *

| | Very low 1 | Low 2 | Neutral 3 | High 4 | Very high 5 |
|---|---|---|---|---|---|
| Space heating | | | | | |
| Space cooling | | | | | |
| Lighting | | | | | |
| Cooking | | | | | |
| The use of appliances | | | | | |
| Water Heating | | | | | |
| Water Cooling | | | | | |
| Charging of mobile phone | | | | | |
| Television on standby | | | | | |
| Changes other appliances | | | | | |

21. Please indicate the rate at which you agree or disagree with the following obstacles to your energy efficient strategies.
*

| | Very low 1 | Low 2 | Neutral 3 | High 4 | Very high 5 |
|---|---|---|---|---|---|
| Poor government support | ○ | ○ | ○ | ○ | ○ |
| Inadequate use of new energy technology | ○ | ○ | ○ | ○ | ○ |
| Lack of awareness and training on energy efficient tools | ○ | ○ | ○ | ○ | ○ |
| Poor financial support | ○ | ○ | ○ | ○ | ○ |
| Lack of cultural change | ○ | ○ | ○ | ○ | ○ |
| Problems with the installation process | ○ | ○ | ○ | ○ | ○ |
| Public resistance | ○ | ○ | ○ | ○ | ○ |
| Cost of training | ○ | ○ | ○ | ○ | ○ |
| Initial energy efficient technology (huge investment) | ○ | ○ | ○ | ○ | ○ |
| Lack of support from policy makers | ○ | ○ | ○ | ○ | ○ |
| Lack of enabling environment | ○ | ○ | ○ | ○ | ○ |

# Section C:

**Benefits of using energy efficient approach and energy saving behaviour**

22. What benefits do you derive from using energy-efficient tools?

*

| | Very low 1 | Low 2 | Neutral 3 | High 4 | Very high 5 |
|---|---|---|---|---|---|
| Benefit of energy efficiency approach | ○ | ○ | ○ | ○ | ○ |
| Improved productivity | ○ | ○ | ○ | ○ | ○ |
| Lower cost | ○ | ○ | ○ | ○ | ○ |
| Enhanced profitability | ○ | ○ | ○ | ○ | ○ |
| Reduced carbon footprint | ○ | ○ | ○ | ○ | ○ |
| Improved product quality | ○ | ○ | ○ | ○ | ○ |
| Minimised air pollution | ○ | ○ | ○ | ○ | ○ |
| Promoted health and well-being | ○ | ○ | ○ | ○ | ○ |
| Lowered energy use | ○ | ○ | ○ | ○ | ○ |
| Created employment | ○ | ○ | ○ | ○ | ○ |
| Improved working environment | ○ | ○ | ○ | ○ | ○ |
| Save money | ○ | ○ | ○ | ○ | ○ |

23. Anything Else?

12/20/2021

The school of Science, Engineering and Environment,
University of Salford
Manchester,
M5 4wt
Tel: +447587905155
Email:

Dear Sir,

**RE: AN INVESTIGATION OF ENERGY CONSUMPTION FOR RESIDENTIAL BUILDINGS.**

I am a PhD research student in the school of Science, Engineering and Environment, University of Salford Greater Manchester, United Kingdom. I am currently undertaking research to investigates the attitude and behaviour of occupants in residential buildings for the proposed case study in Nigeria. It is the anticipation of the researcher that the outcome will provide framework to assist users in reducing their energy consumption as well as recommend appropriate measures for intervention and policy makers to achieve efficient energy management in line with the United Nations Sustainable Development Goals. The aim of research is concerned with the application of energy framework to understand energy (electricity) consumption behaviour in residential buildings in Nigeria. The data collection method will be through a semi-structured interview and it is expected to last for an hour.

I would be very grateful if you could confirm your interest and willingness to participate in this research, as your participation will contribute immensely to this study and timely completion of the PhD programme.

This research will not disrupt your working environment and all information collected as part of the data for this research purpose will remain confidential, as your identity will be anonymous. This shall remain same both in this research and in any publications. Please kindly complete attached consent form to indicate that you grant permission for the information provided to be used for the purpose of this study.

For further inquiry or clarifications, you can contact me through the above address or my supervisor Dr Nirodha Fernando (n.g.fernando1@salford.ac.uk).

Yours faithfully,

Aisha Ibrahim Tilde

**TITLE: OCCUPANT ATTITUDE MODIFICATION: A SUSTAINABLE ENERGY CONSUMPTION MODEL FOR RESIDENTIAL BUILDINGS**

**Name of Research:** Aisha Ibrahim Tilde

**Tick as appropriate** (√)

| s/n | | Yes | No |
|---|---|---|---|
| 1 | I confirm that I have read and understood the information sheet for the above study and what my contribution will be | | |
| 2 | I have been given the opportunity to ask questions about the study | | |
| 3 | I agree to take part in the interview | | |
| 4 | I understand that the information provided will only be kept for the duration of this research | | |
| 5 | I understand that the information provided will be confidential and any information about me will not be disclosed to a third party | | |
| 6 | I agree to the interview being tape recorded | | |
| 7 | I understand that my participation is voluntary and that i can withdraw from the research at any time without giving any reason and any information provided destroyed immediately | | |
| 8 | I agree to digital images being taken during the research exercises | | |
| 9 | I agree to take part in the above study | | |

Name of participant: ………………………………………………………………………….....

Signature: ……………………………………………………………………………………….

Date: ………………………………………………………………………

## TELEPHONE INTERVIEW GUIDE A -CONSULTANT

**A. Background Information**

- What is your academic and professional qualification?
- How long have you worked here?
- Can you give a brief description of your organization and the number of employees?
- What is your job title and roles and responsibilities in your organization?
- How long have you been involved in the field of energy efficiency?
- How are you involved with residential consumers?
- What are the services you provide to residential consumers?

**B. Organisation's energy efficiency approach**

- Could you please describe your organisation's or your energy efficiency approach?
- What are the priorities at the corporate level?
- How does this initiative respond to the need of different stakeholder groups?
- Are customers involved in the formulation and implementation of energy-saving practices?
- Are there clear aims and objectives from your organisation linked with energy efficiency initiatives?
- How do you assess and manage success of these initiatives?
- Do you think consumers contribute to the reduction of energy consumption?
- Could you predict changes in the marketplace this energy consumption?

**C. Cultural behaviour**

- Are there cultural practices to energy saving within energy companies or government agencies?
- What are the key motivating factors to energy-saving behaviour in residential buildings?
- What factors will hinder consumers from using energy efficiency technologies?
- How is information about energy savings shared between different stakeholders?
- Who is responsible for energy saving practices within your operations function?
- Are individuals trained in energy saving initiatives? If yes, what is the impact, if no**,** problems?
- How do you perceive leadership support?
- Do you think that energy saving would increase if there were more individual involvement and engagement?

**D. Stakeholder's insights**

- What are the major motivating factors to including stakeholder into energy-saving policy?
- Who is included?

- How do you think energy providers perform in terms of meeting supply and operations level energy saving objectives?
- Does energy saving practice influence the choice of relying on energy from the grid or consider alternative energy sources for their energy needs?
- What are the challenges faced in considering alternative energy sources?
- What are the tools for incentives and rewards?
- Is there any support from the government to encourage energy-saving?
- Do you provide support to your client to achieve energy saving?

**Interview Guideline**
**Telephone Interview Guide B**

**A. Background Information**

- What is your academic and professional qualification?
- How long have you worked here?
- Can you give a brief description of your organization and the number of employees?
- What is your job title and roles and responsibilities in your organization?
- How long have you been involved with in the field of energy efficiency?
- How are you involved with residential consumers?
- What are the services you provides to residential consumers?

**B. Organisation's energy efficiency approach**

- Could you please describe your organisation's energy efficiency approach?
- Do you involve your client in energy-saving practice?
- What measure do you consider as sustainable energy for your client? How do you advise your client to achieve these measures?
- Are there any restrictions to the implementation of sustainable energy saving in building environment?
- What do you think could assist consumers in reducing their energy use?

**C. Drivers and barriers behaviour**

- What are the key motivating factors to energy-saving behaviour in residential buildings?
- What hinders residential building from using energy efficiency technologies?
- Have information technology systems been adapted to include awareness of energy-saving opportunities?
- Are there Government regulations imposed on energy-saving implementation? How do your organisation comply with such regulations or policies?

**D. Stakeholder's insights**

- What happens to providers who fail to meet energy efficiency expectations?
- How are energy-saving expectations communicated?
- To which extent are energy-saving initiatives included in decisions with service providers?
- What is the role of energy-saving practices in providers' development? How is it included? Gap? Problems?
- What are the tools for incentives and rewards?
- What is the contribution of the service providers?

- Is there any support from the government to encourage energy-saving?
- Do you provide incentives to your client to reach this policy?