CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Energy efficient buildings are those which consume less energy while maintaining the comfort conditions for their occupants compared to standard buildings. Energy efficient buildings result not only in less negative environmental impact but are also economically sustainable.

Building belongs to the most fundamental human preferences together with food, water and clothes. The more a financial system grows, the more people spend time within buildings (approximately 90% of their time in developed parts of the world) (Camp, 2005). The construction industry has significant influences to the natural environment. It is the main energy consumer of all end-use industries, comprising a third of total energy demand and for a huge part of greenhouse gases (GHG) emissions in all economies (Koeppel &Ürge-Vorsatz, 2007).

Koeppel and Ürge-Vorsatz (2007) stated that when it comes to solutions to lower energy consumption, buildings provide the biggest possibility of greenhouse gases GHG reductions. As they represent the immediate environment to humankind, buildings will additionally be a crucial area for climate change adaptation. Amazingly little consideration continues to be given to affirming energy efficiency in buildings, in spite of the remarkable impact buildings posse on costs and the environment. With high-energy prices likely for the foreseeable future, the world may have little choice but to make a concerted effort to use energy in buildings more efficiently globally.

Cities have a central role to play in the reduction of carbon dioxide (CO_2) emissions and the fight against climate change, the historic challenge now facing our society. According to Akindoyeni (2012) buildings are the largest energy consuming sector in most developed countries, and offer the largest cost-effective opportunity for savings. Cities can mitigate climate change by reducing energy consumption in the construction, maintenance and refurbishment of buildings. Retrofitting existing buildings with energy efficiency technologies can at the same time offer important economic and employment opportunities, improve energy security, and save more than it costs (Akindoyeni, 2012).

For this to happen, countries need to ensure the implementation of stable, long-term policies and legislation, which will provide certainty to the market and transform the building sector. The use of energy in buildings has increased in recent years due to the growing demand in energy used for heating and cooling in buildings. Without energy, buildings could not be operated or inhabited. Improvements have been made in insulation, plant, lighting and controls and these are significant features that help towards achieving an energy efficient building (Wilkinson, Kirk, Sean, Cathryn &Tadj, 2007).

Fasakin (2009) stated that energy used in buildings (residential and commercial) account for a significant percentage of a country‘s total energy consumption. This percentage depends greatly on the degree of electrification, the level of urbanization, the amount of building area per capital, the prevailing climate, as well as national and local policies to promote efficiency. Space heating, space cooling and lighting, which together account for a majority of building energy use in industrialized countries, depend not only on the energy efficiency of temperature control and lighting systems, but also on the efficiency of the buildings in which they operate. Building designs (in terms of orientation) and materials have a significant effect on the energy consumed for a select set of end users

Wong& Li (2007) stated that the energy efficiency of a building is the extent to which the energy consumption per square metre of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions. These benchmarks are applied mainly to heating, cooling, air conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity consumption for external lighting. The benchmarks used vary with the country and type of building.

According to Cheung, Fuller & Luther,(2005) a building is made up of a wall (which is the frame work or support) to which other components such as windows, doors, ceiling etc are attached to. The walls of different patterns or design are made up of different materials such as clay, cement, stones or wood. The measure of heat loss through a material, referred to as the heat transfer co-efficient U-Value, is used as a way of describing the energy performance of a building. The U-value refers to how well an element conducts heat from one side to the other by rating how much the heat the component allows to pass through it. U-values also rate the energy efficiency of the combined materials in a building component or section. A low U-value indicates good energy efficiency. Windows, doors, walls and skylights can gain or lose heat, thereby increasing the energy required for cooling or heating. They are the standard used in building codes for specifying the minimum energy efficiency values for windows, doors, walls and other exterior building components.

Frequent power disruption and load shedding in Nigeria, over ten hours a day, amid hot and humid conditions have made the life of city people miserable. Recently, residents have alleged that they are experiencing three to five-hour long power cuts, three to four times a day on an average (The Daily Star,2009). The load-shedding situation continues to worsen as the excessive heat drives people to use more electricity at homes and offices.

In addition, local energy sustainability action is closely related with issues of energy injustice associated with mainstream systems of energy service provision. As such, urban sustainable energy initiatives can tackle distributional socio-economic impacts of the current energy regime by fostering energy affordability and the wellbeing of disadvantaged social groups (Dubois, 2012).

In the last decade a large number of residential energy building programs have been established in cities across developed nations. These programs can be said to have revolutionized the sustainable development movement across the nations. Numerous cities have enacted ordinances promoting such programs. These programs are seen by scholars who study urban affairs as an indicator of how well cities are doing in their goal to promote sustainability. As the process of energy efficiency in building development becomes more of a mainstream phenomenon, it is important to research its progression and the diversity of implementation that has occurred in Nigeria and hence identify a best approach for development.

1.2 Statement of the Problem

Developed and developing countries are increasingly instituting energy efficient building programs for city owned buildings. The problem for municipalities looking to institute a municipal energy efficient building program is that there are few resources available and no widely recognized strategy or process for developing an energy efficiency in buildings.

When we think about Abuja's future, no long-term liability presents as great a danger to the citizen's well being as the building of carbon dioxide and there greenhouse gases in the atmosphere within the city. Energy efficiency in buildings is one important element of an integrated change and will compliment sustainability effort of the government, alternative transportation modes and technologies , and land use planning.

Studies continues to support the concept that energy efficiency is a critical element of energy policy that can mitigate the need for new generation (Molina, 2014). One of the greatest challenges for energy planning has been lack of good data.

Energy consumption and the associated value of efficiency savings can be difficult to measure due to imperfect metering and data availability for both tenants and owners, as well as due to uncertainty about future energy prices.

The availability and use of energy in a building are pivotal to the building's functionality within the confines of its purpose. However, if energy use in buildings is not regulated, it can steadily lead to costly waste to the building users and more importantly results to continuous release of CO_2 into the atmosphere leading to global rising temperatures and climate change. The United Nations Environmental Programme (UNEP, 2013) for Sustainable Construction and Building Initiative (SCBI) noted that 30-40% of the global energy use comes from the housing sector. This implies that achieving energy efficiency in buildings could offset the greenhouse gases (CO_2, CO, CH_4) by 30-40% which could have emanated from the housing sector thereby saving the climate from the negative effect of these gases (Nwofe, 2014). According to European Construction Technology Platform (2013), buildings constitute 40% of total European Union's energy consumption and generate 36% of greenhouse gases in Europe. This makes energy efficiency in buildings to be taken seriously by the governments in the developed world. Therefore, concerted efforts are constantly made by the governments to ensure that their countries continually tend towards buildings that use less energy while still sustaining appreciable levels of functionality for its operations and comfort for its occupants. Nigeria, with a growing population of over 160 million people is having installed electricity generating capacity of 10,400 MW but currently generating total energy below 5,000 MW.

The Power Holding Company of Nigeria (PHCN) has, over the years, provided its inhabitants with inadequate supply of electricity. This has made buildings, especially offices, to fall back on alternative sources of energy (such as generators and inverters) which increases their running cost. This also harbours other negative effects such as air pollution and noise pollution. Buildings in Nigeria are mostly poorly designed in terms of utilizing passive design strategies. For instance, some buildings lack enough illumination to be functional within the day and end up using artificial means. Also offices become too hot due to excess solar heat gain and require alternative cooling methods such as ventilation and air conditioning (HVAC) to mitigate the problems and ensure sustainable development. The concept of sustainability has been officially mentioned in the 1987 report from the World Commission of Environment and Development, "Our Common Future" (UNWCED, 1987), also known as the Brundtland report, issues related all three pillars of sustainability – economic, environmental, social – have made their way into housing sector as well. Thus achieving low energy, ecological and sustainable housing has become one of main direction in urban sustainable development.

Most Nigeria households in general and FCT households at the moment have a high-level of energy consumption leading to greenhouse gasses being released into the atmosphere and contributing to global warming. With the current situation being addressed by various initiatives, governments have indicated positive outlooks they insist that the current structures are set to change for the better in the near future. Hence, there still assist challenges towards energy efficiency in building in the town. This study examines the energy efficiency approaches for sustainable built environment in FCT Abuja

1.3 Aim and Objective

1.3.1 AIM

The aim of this study is to develop energy efficiency approaches for a sustainable built environment in the Federal Capital Territory, (FCT), Abuja

1.3.2. Objectives

The specific objectives of the study are:

1. To ascertain the basic principles in achieving energy efficiency for sustainable built environment in FCT.
2. To ascertain sustainable practices and energy efficiency strategies in buildings in the study area.
3. To determine the major barriers militating against development of energy efficiency and sustainable built environment in FCT.

4. To identify the major environmental implications of energy inefficient buildings in the study area.
5. To develop a template for achieving energy efficiency for sustainable built environment.

Research Question

Based on the specific objective of the study the following research questions are asked

1. What are the basic principles in achieving energy efficiency for sustainable built environment in the Federal Capital Territory (FCT), Abuja. ?
2. What are sustainable practices and energy efficiency strategies in buildings in the study area?
3. What are the major barriers militating against developing energy efficiency approaches for sustainable built environment in FCT?
4. What are the major environmental implications of energy inefficient buildings in FCT?

1.5 Research Hypotheses

The following null hypotheses are postulated for the study

1. There are no significant relationship between the basic principles in achieving energy efficiency and sustainable built environment in FCT.
2. Sustainable practices and energy efficiency strategies in buildings are not statistically significant.

3. There are no significant major barriers militating against the development of energy efficiency in building and sustainable built environment in FCT.
4. There are no major environmental impacts of energy inefficient buildings towards sustainable built environment.

1.6 Research Justification/Rational of the Study

An assessment research on development of energy efficiency approaches for sustainable built environment in the Federal Capital Territory (FCT), Abuja is no doubt an important one. This is going by the notion that the outcomes of current strategies engaged by government in solving the problem of providing adequate, affordable and sustainable energy efficiency in building in this city in recent time are not known. Therefore, this study is important for several reasons.

First Emerole (2002) indicated that inadequate capacity of housing agencies to deliver housing was one of the key challenges of public housing in Nigeria. This suggests that understanding the organizational capacity and constraints of housing agencies to provide efficient housing with good living condition is necessary in judging their performance. It can also help improve on their capacity and thus enhancing the productivity of the housing sub-sector. This study is thus justified on the basis that it attempts to provide basic information that will enhance our knowledge of the strategic initiatives developed towards energy efficient buildings in the study area. This is also considered necessary in assessing the outcomes of energy efficiency approaches towards sustainable built environment and making recommendations.

Second, Mukhija (2004) noted that there is little consensus on the strategies and approaches governments should follow in addressing the housing need of their citizens. This suggests that research works are yet to focus attention on comparing outcomes of the various housing delivery development strategies used in residential and commercial housing provisions to identify which strategies work best and under what conditions for energy efficient buildings. This situation accounts for continuous engagement of inefficient and dysfunctional housing delivery development strategies, which Emerole (2002), Oladapo (2002) and African Ministerial Council in Urban Development (2008) noted was responsible for increasing building supply deficit in Nigeria. By assessing the outcomes of housing delivery development strategies on energy efficiency in building in FCT Abuja, this study is also justified on the ground that it attempts to identify development strategy(ies) with greater potentials for sustainable solution to energy efficiency in building challenges in the study area in particular and Nigeria in general.

Thirdly, this study is also justified on the ground that unlike previous research works (Olatubara and Fatoye, 2007; Jiboye, 2010) which evaluated housing in Nigeria without recourse to the underlying retrofitting theories, it provides an opportunity to assess validity of the underlying retrofitting theories by examining the extent developed initiatives on energy efficiency in buildings can be used to bring down energy cost for resident and businesses in FCT Abuja. This is very important for factual judgment on the performance of energy efficiency in building and in validating underlying assumptions in energy efficiency in building provisions in the study area.

This research was able to identify the strategies to a cost effective commercial and residential building in the tropics as a means to know the percentage reduction realized from intended cost of building construction. This in so doing will serve as a means to help owners and design teams to consider energy efficient measures and sustainable strategies from the moment the decision to construct a commercial or residential building is made.

The need to reduce cost in office building's energy consumption rate is a big issue due to the fact that it helps reduce energy bills, it frees up money that can be spent elsewhere in the economy. Hence, this research is set to lay down standards for cost-effective measures and some major sustainable strategies to an advance residential or commercial design. This was done to contribute to educational practice which can be revised, extend and create new knowledge.

Finally, apart from contributing to development of approaches for energy efficiency in building policy formulation and methods of evaluating energy efficiency in building schemes, this study is also important in bridging gaps in existing literature on the concept of development of initiatives for energy efficiency in buildings in FCT Abuja. In all, this study is justified due to the need for formal assessment of the different energy efficiency approaches in building development delivery strategies that will ensure sustainable built environment in FCT, Abuja.

With increasing urban population and economic activity, energy use in urban areas is expected to increase significantly. For example, International Energy Agency (IEA) predicts that over 80% of expected increases in global annual energy demand in future will be driven by cities in non-Organization for Economic Co-operation Development countries (IEA, 2014). At present, the bulk of energy service provision in urban areas is fossil-fuel based, hence, associated with certain social-economic and environmental implications that pose risks to the prosperity of urban communities and environmental protection. In addition, energy consumption in urban areas is a large contributor to global climate change (Jollands, 2008).

Urban cities are, thus, an integral part of the current energy regime, and central to any efforts of shifting society away from fossil-fuel sources towards more sustainable systems of energy service provision.

The rationale for this study is that modern cities use a large share of global energy consumption to provide development and services to their urban communities. Much of the existing residential buildings in FCT, Abuja do not provide an acceptable living environment as their internal temperature ranges are beyond the range that promote their occupants' well-being.

This study is based on the premise that development of initiatives for energy efficiency in building, sustainable approach to new design and retrofitting of the existing buildings could result to improvement of the living environment, reduce energy demand and the running costs for the occupants and consequently safeguard the built environment in FCT, Abuja Nigeria.

1.7 Significance of the Study

This study is significant to construction professionals, construction companies, government, future researchers, policy makers and the society as a whole. The findings from this study would be useful in developing and recommending sustainable approach for better design, refurbishment and future resilience of Nigeria's built environment.

This research will also add to and consolidate knowledge the government has relating to development of approaches for energy efficient buildings in the built environment at the FCT, Nigeria. Further, the results will have the potential for incorporation in energy efficiency regulations for buildings. Nigeria is currently making efforts to improve its energy efficiency status. In order to meet future demand, an effective energy efficient building development strategy is likely to be a cost effective alternative to developing new power plants. This study is in line with Nigerian need for long term solutions towards attaining sufficiency and sustainability in the energy sector.

This research will contribute immensely to academics, especially to undergraduate, who intend to study on development of initiatives for energy efficient buildings in other state. This research is of vital importance to the society at large; the study findings should enable the society have information on the constraints of development of initiatives for energy efficient buildings. This will help the society as beneficiaries of the projects, and other energy stakeholders in the preparations and implementations of the energy projects. It would however serve as a catalyst in the mind-set change and pave the way for policy makers to think of the alternative source of energy; and in this case the renewable energy for urban and rural community livelihood transformation.

1.8 Scope/Delimitation of the study

The research took place around the hot and dry tropical region of Nigeria, this is a climate that is portrayed by a long dry season (and subsequently a brief rainy season) accompanied with cold and dry harmattan wind, high temperature range (due to hot afternoons and cold nights) and intense sunlight. This region covers the savannah region (grassland), highland region (plateau) and semi-desert region. The study concentrated on residential and commercial buildings especially hotels in Abuja. The areas are accompanied with cold nights and hot days alternate for six to ten months of the year, and characterized by moderate or low amount of rainfall. Hot and humid conditions are experienced during one or two months.

The research was delimited to the development of energy efficiency approaches for sustainable built environment in FCT, Abuja capital of Nigeria with particular reference to residential and commercial buildings such as hotel buildings at FCT Abuja.

1.9 Limitation of the Study

The research did not cover the broader environmental or social-economic issues relating to life cycle assessment of buildings, especially, embodied energy associated with building material sourcing, extraction, manufacturing and deconstruction. Also the study did not evaluate energy efficiency of appliances, their labelling and effectiveness regarding energy savings. It solely focused on the processes and procedures of development of energy efficiency approaches during the operational stage of the buildings necessary to achieve sustainable built environment,

1.10 Plan of the Study

This research is arranged into six chapters namely introduction, literature review (two chapters), study area, research methodology, data presentation and analysis, summary, recommendations and conclusion.

Chapter one covered the introduction, giving a background to the study and the core issues (like objectives, research questions and scope) underpinning the research. Chapter two presented the literature review it also explored the objectives of the study through document reviewed. Chapter three outlined the study area by discussing the location, physical characteristics and human characteristics of the area. Chapter four covered the methodology. The chapter presented selected methods and the methodological framework used in the study. Chapter five presented the findings; it gave a summarized outcome of the field studies, it discussed the findings arising from the previous chapters interpreting the meanings associated with the various issues raised during the study. Chapter six summarised the work, it also gave the conclusions and recommendations of the research. It summarized the study findings, suggested implications and made recommendations. The Sections containing references and appendices appear at the end of the dissertation .

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL/THEORETICAL FRAMEWORK

In this chapter, review of literature related to this study is presented and discussed under the following sub headings:

2.1 Conceptual Framework

- Concept of Energy Efficiency in Building
- Concept of Retrofitting on Energy Efficiency in Building
- Sustainable Energy Efficiency Strategies for Retrofitting of Buildings
- The Basic Principles/ Strategies in Achieving Energy Efficiency in Buildings toward Offsetting Cost
- The Factors Militating on Energy Efficiency in Building
- Environmental impacts of electricity generation
- Level of Sustainable Approach that can be adopted towards Developing Energy Efficiency in Buildings.

2.2Theoretical Framework

- Behavioral Model Theory
- Building Information Model Technology Theory
- Retrofitting Existing Building Theory

2.3 Empirical Reviewed

2.4 Gap in Literature

2.1 Conceptual Framework

2.1.1 Meaning and Concept of Energy Efficiency in Building

According to European Union (2000) energy efficiency in building is the moderation of energy-end use in buildings which helps in reducing greenhouse gas emissions and pollution produced by the combustion of fossil fuels energy which is used in buildings for various purposes: heating and cooling, ventilation, lighting and the preparation of hot sanitary water among them. In residences and commercial buildings, installed equipment and appliances require energy, as do removable devices like mobile phone chargers and portable computers. However, identification of fixed and fluctuating demand for energy rarely appears in a building’s consumption metric, as most measurement consider only the total amount consumed by the whole building.

Subdivision of energy consumption can be particularly difficult in the cases of electricity, where air-conditioners, appliances, lights, pumps and heating installations all draw electricity and often from the same metering. Natural gas, too, can serve several end uses at once, including heating, cooking, and the provision of sanitary hot water. Given the difficulty in subdividing buildings' energy requirements and the use of different fuel types, most analysis examines energy use in building as defined by end-use: space heating, cooling, cooking, etc. The split in use of energy will be due to uncertainties and it will vary with different types of building and also with the age and use of the buildings.

Bassioni, Price and Hassan (2005) noted that the differences in the use of energy in different countries can best be illustrated by a subdivision of energy consumption in residential buildings, which is the most homogenous type of buildings. Building-related end-uses - heating, cooling, ventilation and the preparation of hot sanitary water - require approximately 75% of a residential building's energy demand. Building codes generally address these drivers of building-related consumption. Only more occasionally, codes cover other end-uses like lighting in service buildings, though this varies by country. For service buildings, the share of energy use for other purposes will often be larger and for some types of service buildings it can be more than 50%.

Furthermore Bassioni *et al*. (2005) confirmed that energy consumption in buildings is a large share of the world's total end use of energy. In member states of the Organization for Economic Co-operation and Development (OECD), residential and commercial buildings require approximately 35% of the end use of energy. Globally, buildings account for close to 40% of total end use of energy. Given the many possibilities to substantially reduce buildings' energy requirements, the potential savings of energy efficiency in the building sector would greatly contribute to a society wide reduction of energy consumption. The implications of such potential reduction should not be underestimated, as the scale of energy efficiency in buildings is large enough to influence security policy, climate preservation and public health on a national and global scale.

By reducing buildings' energy consumption, a nation can reduce dependency on imported energy and strengthen its strategic position. In the 2000 Green Paper setting forth a strategy to secure energy supply (European Union, 2000), the European Union named energy efficiency as the best way to establish energy security over a longer term. This environmental benefit appears on two scales, local and global. Because much of buildings' demand for energy requires local energy combustion in individual heating systems or district heating, reduced energy demand improves air quality at the local level. In particular in developing countries a reduced demand for energy requires fewer power plants, thereby delaying or obviating the construction of new generation and grid capacity and enabling communities to devote public funds elsewhere.

Given the potential scale of energy savings across the building sector, reduced demand for energy and fossil fuels can substantially contribute to a nation's compliance with domestic or supranational targets for the reduction of greenhouse gas emissions. When adequately ventilated, energy efficient buildings are generally healthier than traditional buildings. Relative to traditional buildings, energy efficient buildings offer a more stable indoor climate, with less draught from windows, walls, floors, and ceiling constructions. Because residents of energy efficient buildings must spend relatively less to heat and cool their homes to within the margins of acceptable comfort, energy efficient construction reduces fuel poverty across society. As households demanding less energy for building-related uses, they burn less fuel locally, thus doubling the potential to improve public health and otherwise benefit local communities.

In many countries, buildings consume more energy than transport and industry. The International Energy Agency (IEA) statistics estimate that globally, the building sector is responsible for more electricity consumption (42 percent) than any other sector (IEA, 2004).

The building sector encompasses a diverse set of end use activities, which have different energy use implications. Space heating, space cooling and lighting, which together account for a majority of building energy use in industrialized countries, depend not only on the energy efficiency of temperature control and lighting systems, but also on the efficiency of the buildings in which they operate.

Building designs and materials have a significant effect on the energy consumed for a selected set of end users. On the other hand, building design does not affect the energy use of cooking or appliances, though these end users are nonetheless attributed to the building sector. Appliance efficiency matters more for some end uses than for others. Water heating and refrigeration each account for significant shares of building energy use since they are in constant use. By contrast, cooking and small appliances (including computers and televisions) generally account for only small percentages of building energy consumption, owing to their intermittent use.

In general, energy efficiency in building consumption is higher in industrialized countries. Thus, development of initiatives for energy efficiency in building has an important effect on energy demand from the building sector, implying that building efficiency becomes more significant as countries become more prosperous. The importance of energy efficiency in building sector is especially significant in developing countries, owing to rapid new construction with opportunities to employ efficient materials and global best practices.

2.1.2 Concept of Retrofitting Energy Efficiency in Existing Buildings

Retrofitting refers to the addition of new technology or features to older systems. Praznik, Butala and Zbašnik-Senegačnik (2013) define retrofitting as newly developed or modified and upgraded technologies, as well as new design concepts, which need to be developed and their validity confirmed.

Retrofitting an existing building can often times be more cost-effective than building a new facility. Since buildings consume a significant amount of energy, particularly for heating and cooling (32 percent), and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings. But conserving energy is not the only reason for retrofitting existing buildings. The goal should be to create a high-performance building by applying the integrated, whole-building design process, to the project during the planning or clearance phase that ensures all key design objectives are met. For example, the integrated project team may discover a single design strategy that will meet multiple design objectives. Doing so will mean that the building will be less costly to operate, will increase in value, last longer, and contribute to a better, healthier, more comfortable environment for people in which to live and work. Improving indoor environmental quality, decreasing moisture penetration, and reducing mold will all result in improved occupant health and productivity. Further, when deciding on a retrofit, consider upgrading for accessibility, safety and security at the same time. The unique aspects for retrofit of historic buildings must be given special consideration. Designing major renovations and retrofits for existing buildings to include sustainability initiatives will reduce operation costs and environmental impacts, and can increase building adaptability, durability, and resiliency.

Making a building more sustainable while completing the retrofit could attract more higher-paying tenants, which would cause a greater appreciation by the time the owners plan to sell. Properties with Energy Star certification have sold for 2-5% more than buildings without such certification (Praznik, Butala & Zbašnik-Senegačnik, 2013).

Existing buildings account for most of the energy used in the building sector, whereas new buildings use only a small percentage of energy. The energy use in commercial buildings is predicted to increase every year for at least two decades. Therefore, it is important to retrofit existing buildings to increase energy savings. This endeavor is very complicated with many considerations, such as maintaining historic features to controlling costs.

Energy efficiency building planning depends on the scale of opportunity for energy efficiency improvements in existing buildings. A typical building can cut energy use by up to 15% by implementing low cost measures and over 45% by implementing deeper retrofit measures. Such retrofit projects will reduce operating costs, and improve occupant comfort with a host of other benefits.

A building doesn’t have to be new to be efficient. Building owners are retrofitting buildings, converting them into archetypes of sustainability. While most building owners still follow individual technology improvements, smart owners package energy saving technologies to get serious savings through lower energy consumption and operating costs. Fundamentally, the improvements are paid for through energy savings over time.

According to Praznik*et al*. (2013) a building can often be retrofitted for a lower cost than a new building. To accomplish this it's important to review the heating and air conditioning system, as well as lighting. The goal should be to create a high-performance building that ensures all of the design concepts are met. By accomplishing the design objectives, the building will be less costly to operate, increase in value, last longer and contribute to a healthier and more productive environment for the workers.

2.1.3 Sustainable Energy Efficiency Strategies for Retrofitting of Existing Buildings

A definition of Building Energy Efficiency Retrofit (BEER) is the reduction of building energy use through certain approaches to improvement of the building envelope and the equipment systems, while maintaining the comfort of the building’s indoor environment (Shanghai Construction and Transportation Commission, 2008). Besides retrofitting of building envelopes and equipment systems, improvement of operating and management practices should also be considered. Improvements to building energy efficiency typically include the envelope structure, the equipment systems, as well as more precise control systems, and conversion to renewable energy where appropriate. Staff training and new management and monitoring strategies ensure continued optimal operation and savings.

Retrofitting existing buildings and replacing energy consuming equipment are critical for improving energy efficiency in cities where building stock turnover is low. Cities need to be opportunistic in order to capture this potential by incentivizing and/or requiring energy efficiency upgrades as part of all significant renovations and equipment-replacement activities. For this to happen, an enabling environment and effective project financing and delivery mechanisms must be in place.

In cities where the building stock is stable or growing slowly, the retrofitting of existing structures and the replacement of old energy-consuming equipment is often the best means to achieve EE gains. The equipment inside an existing building can generally be replaced over periods ranging from 10 to 20 years, whereas a building’s shell, or envelope, is often unchanged for decades except for basic maintenance. Renovating a building’s envelope is often necessary to reduce heating and cooling loads. Technical approaches to buildings renovations need to be guided by specific climate conditions and sound economic justifications.

Whole building design guide WBDG (2012), wrote on the essential sustainable and energy efficient strategies for the retrofitting of existing buildings, they are:

a) Work-out a plan to enhance the recycling and re-use of demolition remains and waste from construction to minimize the waste sent to landfills

b) Assess occupancy patterns, and then apply daylight, heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable. Integrate energy into the project suitable for the tasks and functions of the spaces.

c) Re-commission all energy and water systems to verify if they are functioning at optimum performance; then renovate energy and water systems to minimize consumption.

d) Find out if natural ventilation and fresh air intake are possible substitutes to lessen heating and cooling loads.

e) Look into renewable options that can counter balance the purchase of fossil fuel-based energy.

f) Consider solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices.

g) Change existing windows with windows suitable for climate and exposure.

h) Examine the benefits of distributed generation if the building is in a campus cluster or can share the on-site energy produced with neighboring buildings.

i) Some specific site can improve the energy performance of the building including reducing the heat island effect.

j) Decide if a cool roof or green roofs are cost-effective ways to lessen heat island effect and storm water runoff.

k) Employ Energy Star and/or a green building rating system for existing buildings like Leadership in Energy and Environmental Design(LEED) for Existing Buildings: Operations and Maintenance (EBOM) or Green Globes for Existing Buildings to gage the building's level of performance.

l) Update systems appropriately to maintain a balance between the need for energy and water savings with the character of the original building fabric especially for historic buildings.

m) Use the chance given by the building renovation to integrate sustainable practices and switch to green cleaning products and methods.

n) In order to make sure that a newly renovated building continues to function as designed, measure the performance of the building frequently.

o) If not already metered, plan on installing meters for electric, gas, water and other utilities. Smart meters and sub meters are preferable to monitor real-time usage, control demand and increase tenant accountability (cost control).

Chappell and Shove (2005) stated that the aim of improving the situation of boosting the significance of energy conservation as one of the set-up of goals of decision makers in retrofit projects must be realized by increasing the knowledge of energy-efficient retrofit technologies and their intelligent application. One of the best ways to do that is to present best practice examples to show that the improvement of the comfort as the primary aim can be achieved together with measures for energy savings. Another promising way is to give the decision makers and their technical staff simple-to-use tools at hand that will support them in the first planning phase to make the right decisions towards energy saving retrofit measures.

Building Energy Efficiency Retrofit (BEER) provides excellent opportunities for reducing energy consumption in buildings as well as for promoting environmental protection, rational resource use, and better health for the occupants. Although there are many benefits and large potential energy savings in existing buildings, not many have undergone energy efficiency retrofits.

To reach optimum retrofit goals many factors must be considered. Energy and water systems should be upgraded to minimize consumption. During the retrofit, evaluation of where the employees work must be made, natural ventilation and fresh air are alternatives that would reduce heating and air conditioning. Solar shading devices for windows will help reduce energy consumption, or replace existing windows with insulated windows. Insulated windows work well in high noise areas.

Breedt (2007) asserted that a cool or green roof could be cost-effective and help with rain runoff. A cool roof's surface is painted with material that reflects part of solar radiation. As it can also reflect solar reflection in winter, heating energy consumption is decreased.

A green roof is covered by soil, which increases heat insulation through photosynthesis, transpiration, and shade against solar radiation. The soil itself provides thermal storage and retains water, allowing heat to be carried away through water evaporation. High-quality roof materials are needed to prevent structural failure and water permeation, which will increase the initial cost. Non-soil plant roofs replace soil with sawdust, rock wool or silica. This kind of roof reduces roof load and also significantly improves heat-insulation performance, reaching three times of that of soil plant roof (Breedt, 2007)).

To ensure that a newly retrofitted building continues to perform as designed, the operation of the building needs to be tracked on a methodical basis. To help with this, smart meters and sub-meters are used to monitor real-time consumption, demand and accountability. Sub-meters help to monitor the electrical consumption of individual pieces of equipment within a building. Green cleaning products and methods should also be used.

The use of exterior insulation is an effective way to enhance the overall thermal resistance of wall construction. Exterior insulation has other advantages, such as enhanced water management and increased air tightness of the building. Exterior insulation of 50mm-100mm will be needed on existing masonry walls, while wood furring strips should be used on wood framed walls.

In the past, retrofits of buildings typically involved the filling of framed cavity walls with insulation. The amount of insulation that could be used was limited by the depth of the existing stud cavity in wood framed walls. For masonry walls, the insulation material, usually fiberglass, mineral fiber or cellulose, is determined by the strapping depth (Voss, 2008).

To overcome these limitations, Druckman (2004) noted that contractors add insulation to the exterior of existing buildings and achieve higher effective R-values. The benefits of this approach go beyond the added thermal resistance by increasing the building's durability and air tightness. Some of the materials used are expanded polystyrene (EPS) board thin plaster, EPS powder particle, EPS board in-situ concrete, EPS steel wire frame plate in-situ concrete, mechanical fixed EPS steel wire frame plate, EPS board thin plaster, polyurethane spray, or rock wool board. Among these systems, the greatest advantage of EPS board's external thermal insulation system is its low water absorption, which is around 3 percent and its long life

2.1.3.1 Energy Performance Contracting (EPC) Mechanism

Energy Performance Contracting (EPC) is a market mechanism to deliver energy efficiency projects. The EPC mechanism emerged in the U.S. during the 1970s and was introduced into China in 1998 (Shen, 2007). Energy Performance Contracting (EPC) is a financing package provided by Energy Service Companies (ESCOs) that includes energy savings guarantees and the associated design and installation services for energy efficiency projects. The EPC mechanism has great advantages for building owners wishing to implement energy efficiency retrofit projects and improve the sustainability of existing buildings.

Energy Performance Contracting is a mechanism for procuring and implementing capital improvements today that are self-funding over time through guaranteed operational savings. Performance contracting uses operational savings and avoided capital expenditure to fund repayment of capital for building/infrastructure improvements.

However, the EPC principle is not limited to being a financing tool. An Energy Performance Contract in the ESCO business may be broadly defined as a contract between an ESCO and the owner of the building consuming the energy, involving an energy efficiency investment in the owner's facilities, the performance of which is somehow guaranteed by the ESCO, with financial consequences for the ESCO (Taylor *et al.*, 2007). Under an energy performance contract, the ESCO will provide financing for a specified set of energy efficiency retrofit measures, along with the associated design, engineering, and installation services. The owner or user can obtain facilities that are highly energy efficient and make potential savings with little or even no initial investment.

The basic concept of energy performance contracting is shown in Fig. 1. The first bar represents the total utility costs of one facility before the introduction of the performance contract. In the second bar, after retrofitting, the energy savings are shared between the owner and the ESCO during the performance contract period. After the performance contract period, all the cost savings belong to the owner, which is shown in the third bar.

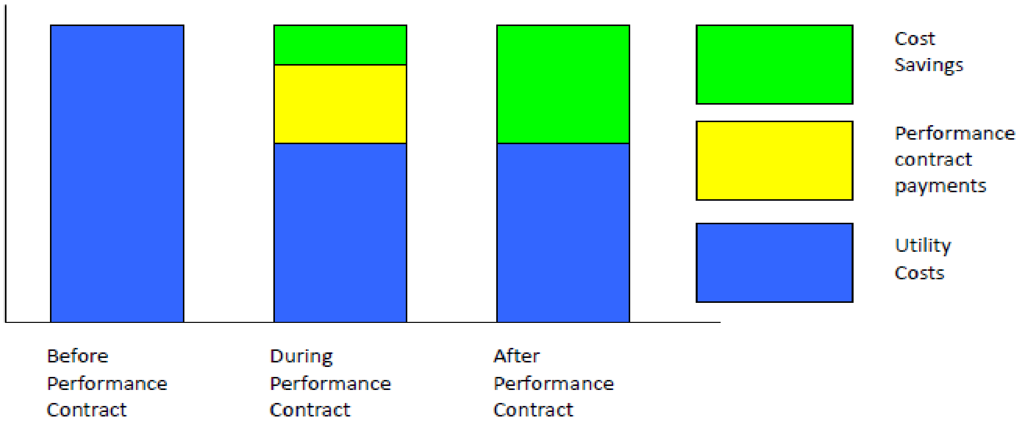


Fig.2.1 Basic Concept of Energy Performance Contract

2.1.4 The Basic Principles / Strategies in Achieving Energy Efficiency in Buildings towards Offsetting Cost

A) The Basic Principles

According to Kornelis, Luis, Danny, Siwei, Geoffery, Anthony, Sevastian, Aleksandra, Jacques & Hiroshi(2007), in order to achieve an energy efficient building, an integrated design approach is a prerequisite to guarantee that the architectural elements and the engineering systems work effectively together. The following are the principles of energy efficiency;

a) Reduce heating, cooling and lighting loads. **Strategy**: -use the building as filter to selectively accept or reject solar radiation and outside air depending on the need for heating, ventilation and air conditioning (HVAC).

b) Utilize active solar energy and other environmental heat sources and sinks. **Strategy**: - generate electricity (renewable energy) and apply space cooling methods that dissipate heat directly to natural heat sink without the use of refrigeration cycles (evaporative cooling, radioactive cooling to the night sky, earth pipe cooling can be used).

c) Increase the efficiency of appliances, heating and cooling equipment and ventilation. **Strategy**: - increase the efficiency and where possible reduce the number and size of appliances.

d) Implement commissioning and improve operations and maintenance

e) Utilize system approaches to building design. **Strategy**: -1.Select a high performance envelop and high efficient equipment. 2. Incorporate a building energy management system that optimizes the equipment operation and human behavior. 3. Fully commission and maintain the equipment.

f) Consider building form, orientation and other related attributes. **Strategy**: - employ strategies to improve passive ventilation and cooling.

g) Minimize greenhouse gas emissions

Kornelis *et al.*, (2007) write up on development and land use policy simply summarizes the principle of energy efficiency as follows;

i. building orientation

ii. orientation, size and shading of windows

iii. roof and wall insulation

iv. use of thermal mass (heat absorbing) material

v. cross ventilation

vi. landscaping

vii. energy efficient appliances

B) Strategies in Achieving Energy Efficiency in Buildings

Energy efficiency in building is a cost effective measure to achieving a design that saves a lot of money on energy bills, for example countries can reduce their dependency on fossil fuels, which are often imported and subject to price volatility. Community research and development centre CREDC (2009) assert that energy efficiency in building has become an important aspect of sustainable development, the use of energy efficiency in building will lead to the saving of personal income; people will not have to spend so much money paying for energy. It will help to reduce the building of more power stations, thus the money for building power stations will then be spent on other sectors of the economy. In Nigeria, the inadequate supply of energy made it necessary for energy to be portioned/rationed, but with good energy management at the residential, public and private sector, there will be no need to ration electricity supply.

A write-up by federal energy management program on “low energy building design guidelines (2010) indicated that for a particular project, the distinctive energy-saving techniques, strategies, and mechanisms to be used will vary greatly, depending on building and space type. Their choice and conformation will also be influenced by:

i. Climate
ii. Internal heat gains from occupants and their activities, lights, and electrical equipment
iii. Building size and massing

iv. Illumination (lighting) requirements

v. Hours of operation

vi. Costs for electricity and other energy sources.

Therefore, the basic energy-saving techniques below should be used to reduce building energy use.

- Sitting and organizing the building configuration and massing to reduce loads.
- Reducing cooling loads by eliminating undesirable solar heat gain.
- Reducing heating loads by using desirable solar heat gain.
- Using natural light as a substitute for (or complement to) electrical lighting.
- Using natural ventilation whenever possible.
- Using more efficient heating and cooling equipment to satisfy reduced loads.
- Using computerized building control systems.

A manual by Energy Commission of Nigeria (2013)on sustainable design and energy efficiency measures arranged the strategies for achieving energy efficiency into three groups:

- ➢ Strategies that reduces the whole energy load within the building
- ➢ Strategies that improves the efficiency of the systems
- ➢ Strategies that involves on-site generation of electricity via the use of renewable resources.

The energy efficient strategies helps to improve whole sustainable performance of a building especially in improved access to daylight and views, improved indoor air quality, improved occupant comfort.

The manual further mentions that the cost-effectiveness of an energy efficiency measures differs by region and climate, there is no single amalgamation of measures that will offer the ideal energy efficiency and therefore, project teams are to continuously evaluate completely the conceivable and suitable actions so as to make sure that the most cost-effective solutions are acquired.

2.1.4.1 Building load reduction strategies

1. **Fenestration**

This has to do with the use of high performance glazing products for window design. The use of Sun shading/light shelves, operable windows, fritted glass, and for skylights and other appropriate locations, insulated translucent composite panel. These are all part of window design strategies to achieving building load reduction.

It will present considerable operational cost savings in reduced energy. Additionally, these strategies can improve the interior environment through better access to daylight, views, and outdoor ventilation.

2. **Air barriers**

The out-come of air infiltration caused by temperature differential, wind and stack effect are heat loss/gain. The placement of air barriers accurately inside the unclear wall construction or, in suitable climatic zones, presents a combined air and vapor barrier, considerable energy can be recovered that would normally escape through the building enclosure.

The extremely meaningful costs related with enhancing the thermal performance of the envelope come from removing thermal bridging and reducing the degree of air infiltration through the façade.

3. **Walls, Roof and Slab**

In any plan or strategy, trying to lessen the use of energy in order to take advantage of thermal performance of envelope construction by minimizing heat transfer according to climate needs is a very important thing to embark on. More insulation is usually beneficial but there is a point at which additional insulation is not justified.

4. **Daylight Dimming Controls for Perimeter Areas**

The Daylight dimming lighting controls depend on photocells to maintain the essential lighting levels in the space by decreasing the lighting output from electric lighting based on the amount of daylight in the space. The photocell is placed in such a way that makes it monitors the lighting level in the space and dims the electronic lights accordingly to maintain the required foot candles, based on the natural daylight available at any given time in the space.

The cost for integrating daylight dimming controls at perimeter areas includes both the cost of the control system and the additional cost associated with dimmable fixtures. Typically the cost increase is in the range of 1 to 2 percent of the overall lighting budget. Nevertheless by limiting artificial light, the heat load is also reduced, which reduces both the initial system size and long term energy costs.

5. Variable Air Changes per Hour (ACH) Ventilation Rates

The degrees of ventilation are reduced based on occupancy and or time clock. For the occupancy sensor based controls, a space occupancy sensor identifies if the space is unoccupied, similar to lighting controls but with a longer time delay to prevent HVAC cycling. When the space is detected to be empty for 30 minutes (either by sensor or time clock) the ventilation rates to the space are reduced by 50 percent, and the fan regulated down. This in effect forces VAV(Variable Air Volume) operation for these spaces, thereby saving significant fan, cooling and reheat energy. The potential energy reductions are substantial with reductions in fan energy, heating, and cooling loads

6. Lighting and Occupancy Sensor Lighting Controls

Artificial lighting contributes to energy consumption, selecting the type of lighting wisely is important. Energy efficient fixtures and lamp types such as compact florescent lighting (CFL) and other highly efficient types, should be selected for their energy efficiency in addition to their suitability in color rendition, functional use, cost, longevity, and so on.

Occupancy sensors turn off the space lights when no movement is detected (therefore the space is assumed unoccupied) for a period of time, the occupancy sensors are assumed to reduce the space lighting load by 15 percent, which can translate into an overall energy cost reduction of 2 – 3%.

2.1.4.2 High Efficiency Systems

To a great extent, high efficiency systems have a higher first cost; on the other deliver improved long-term operating costs. More efficient systems can also lead to downsizing of equipment or systems, which will provide some offsetting initial cost savings.

1. **High Efficiency Chiller Systems**

Using chiller with efficiency of 0.50 kw/metric ton for the central plant saves energy by using less electricity to produce the same quantity of chilled water. In areas where cooling loads are a significant contributor to the energy usage, high efficiency chillers can provide significant energy savings, and are very cost effective.

2. **Increased Chilled Water Delta-T**

Increasing the temperature rise (delta T) on the chilled water system to 16°F can produce modest energy savings, particularly in areas where cooling loads are significant contributors to the energy cost. The delta T increase has a very slight effect on the construction costs as it requires slightly larger cooling coils on the Air Handling equipment. The cost increase would typically be less than 1 percent of the overall cost of the heating, ventilation and air conditioning (HVAC) system.

3. Cogeneration – Combined Heat and Power (CHP)

Incorporating cogeneration with combined heat and power for some or the entire electrical load of the facility provides several energy efficiencies, some of which extend beyond the simple reduction in energy demand at the facility.

Cogeneration systems normally have a very high first cost, and their cost effectiveness depends greatly on the electricity rate structure and the local utility's policies related to zero net metering or electricity resale. The cost effectiveness can be greatly enhanced where the cogeneration can be fueled in whole or in part through the use of reject or non-commercial fuels, such as medical waste, biomass, methane, etc.

4. **Energy recovery**

The most effective energy recovery approach is a Total Energy Recovery Wheel, although heat pipes and run around coils can also be utilized. Total Energy Recovery Wheels are particularly effective in humid climates since both sensible (heat) and latent (humidity) energy are exchanged, which in effect pre-heats the outside air during the heating season and pre-cools the outside air during the cooling season.

5. **Condensing boilers**

Condensing boilers are widely available and widely used, and are very economical. They can provide very good energy cost efficiency. The most significant limitation is that they are typically limited in size range, and not available at the size required by very large facilities, particularly those with high heating loads.

6. **Ground source heat pumps**

Ground source heat pumps use the ground or ground water as a sink for heat rejection. Ground temperatures are usually very favorable for heat rejection, being generally consistently cooler than the design temperature of spaces. Ground source can also be used for heating, but with less energy efficiency. Another advantage is that ground temperatures are usually very stable, and so heat pumps can be designed more efficiently.

2.1.4.3 Design Considerations Initiatives for Achieving Energy Efficiency in Buildings

Whole building design guide (2010) outlined the typical features for achieving energy efficiency in buildings towards offsetting cost which include the list of applicable design objectives elements as outlined below.

1. **Cost-Effective**

High-performance buildings (such as offices) should be weighed-up by the use of life. Sometimes, owners need to be glad about the fact that optimizing building performance will involve the readiness to invest more initially to save on long-term operations and maintenance.

During design phase building development, appropriately applied value engineering considers alternative design solutions to enhance the expected cost/worth ratio of projects at completion. During the construction phase, contractors are encouraged by means of shared savings to draw on their special 'know-how' to suggest changes that cut costs while maintaining or improving quality, value, and functional performance.

2. Functional/Operational

a. Tenant Requirements

The design of the building must take into account the combined requirements of the proposed tenants. This consist of their desired image, degree of public access, operating hours, growth demands, security issues and vulnerability assessment results, organization and group sizes, growth potential, long-term consistency of need, group assembly requirements, electronic equipment and technology requirements, acoustical requirements, special floor loading and filing/storage requirements, special utility services, any material handling or operational process flows, special health hazards, use of vehicles and types of vehicles used, and economic objectives.

b. Flexibility

The high-performance office must effortlessly and efficiently accommodate regular renovation and modifications. The modifications may be as a result of management restructuring, personnel shifts, changes in business models, or the advent of technological innovation, on the other hand, the building infrastructure in a case of office building, interior systems, and furnishings must be up to the task.

- Raised floors for easy access to cabling and power distribution should be taken into consideration, as well as developed air distribution capabilities to tackle individual occupant comfort.
- Features such as plug-and-play floor boxes for power, data, voice and fiber, modular and harnessed wiring and buses, and conferencing hubs should be

integrated in order to allow for daily flexibility at work as well as future restructuring of office workstations.

3. **Urban Planning**

The large concentration of workers within one building can have a substantial influence on the environs. Office organization can energize neighborhoods with the retail, food service, and interrelated business links. Transportation should be considered when developing office structures. Office buildings are often wedged by urban planning and municipal zoning, which try to promote compatible land use and exciting neighborhoods.

- When selecting office locations, Consideration should be given to the distance in which the majority of occupants will have to travel to reach the office. The developments of new office locations will habitually require relocation of employees, especially if the office is moved or opened in a new geographical area. When considering the resources of the community, it should include housing costs and availability, traffic congestion, school system quality, cultural resources such as museums, sports teams and institutions of higher education, natural attractions such as coastal areas, mountains and public parks, availability of educated labor, crime rate and law enforcement, and civic infrastructure capacity such as water, waste water and waste processing.
- As soon as a building has been built and occupied, it is precarious that long-term performance be confirmed through an aggressive process of metering,

monitoring and reporting. The outcome of this feedback should notify maintenance and be available as input to new design efforts.

4. Productive

Worker Satisfaction, Health, and Comfort: In office environments specifically, the specific greatest cost to employers is the salaries of the employees occupying the space. It mostly exceeds the tenancyand energy costs of a facility by a factor of ten on a square foot basis. Hence, the health, safety, and comfort of employees in a high-performance office are of utmost concern.

- Strategies such as increased fresh air ventilation rates, the specification of non-toxic and low-polluting materials and systems, and indoor air quality monitoring should be employed.
- Individualized climate control that permits users to set their own, localized temperature, ventilation rate, and air movement preferences should be provided.
- Although there is difficult to quantify, it is generally acknowledged that worker satisfaction and performance is enhanced when office workers are provided with stimulating, dynamic working environments. Access to windows and view, the opportunity to interaction and control of one's immediate environment are some of the issues that contribute to enhance the satisfaction of a workplace.
- The use of natural light is important to the health and psychological well-being of office workers. While designing the office environments emphasis

should be given to the provision of each occupant with access to natural light and views to the outside. A minimum of 30 foot candles per square foot of diffused indirect natural light is needed.

- The design of the acoustical environment of the office must integrate the other architectural systems and furnishings of the office. Exceptional importance must be given to noise control in open office settings, with absorptive finish materials, masking white noise, and enough separation of individual occupants.

5. **Technical Connectivity**

Technology has turn out to be an essential tool for business, industry, and education. As long as technology is driving a variety of changes in the organizational and architectural forms of officebuildings, consider the following issues when integrating it, especially information technology (IT), into an office:

- Plan new office buildings to have an allocated, robust, and flexible IT infrastructure, which ought to permit technological access in virtually all the spaces.
- throughout the planning stage, it is required to identify all necessary technological systems (for example, voice/cable/data systems such as audio/visual systems, speaker systems, Internet access, and Local Area Networks [LAN] / Wide-Area Networks [WAN] / Wireless Fidelity [WI-FI]), and provide adequate equipment rooms and conduit runs for them.
- Consider and accommodate for wireless technologies, as appropriate.

- For existing office buildings, consider improving access to the IT infrastructure as renovations are undertaken.

6. Secure / Safe

There exist terrorist attacks and design has focused on protection of occupants and assets against violent attack. During comprehensive threat assessment, vulnerability assessment, and risk analysis, security requirements for individual buildings and appropriate reasonable design responses are identified for integration into the office buildings design.

- Entrances that do not face uncontrolled vantage points with direct lines of sight to the entrance should be considered. Make use of site barriers and setbacks, perimeter barriers and blast resistances, access control and intrusion detection, entrance screening, package screening and control, open areas that allow for easy visual detection by occupants, and minimized glazing.
- Visitors that are unfamiliar with their surroundings may encounter difficulty in navigating to the safest exit route from the building. Consider using increased signage and/or providing safety information and a building directory in welcome brochures.

7. Sustainable

Energy Efficiency: Answerable to the office's size, local climate, use profile, and utility rates, strategies for minimizing energy consumption involve:

i. Reduction of load (by integrating the building with the site, optimizing the building envelope [decreasing infiltration, increasing insulation], and so on.)
ii. Sizing the heating, ventilating, and air-conditioning systems correctly.
iii. High-efficiency equipment, lighting, and appliances should be installed.

The application of renewable energy systems should be given due consideration, this include building that generate building electricity, solar thermal systems that produce hot water for domestic hot water (DHW) or space conditioning, or geothermal heat pump systems that draw on the thermal capacitance of the earth to improve HVAC system performance.

2.1.5 The Factors Militating Against Energy Efficiency in Building

There are a number of factors and challenges inherent in improving EE in buildings. And while many of these at first can seem daunting, experience from different countries and cities over the past three decades demonstrates a number of ways they can be surmounted. Table 2.1 outlines and provides examples of some of the most common challenges and barriers.

Some barriers to greater EE are specific to certain stakeholder groups. For example, high transaction costs relative to returns and the perceived unreliability of repayment often deter commercial banks from financing building EE projects. Other barriers are sector-wide, such as energy subsidies and/or a widespread lack of data and in formationon EE opportunities, costs, and benefits. Addressing systemic problems such as these typically requires policy interventions and support at the national and regional level, although municipal governments can be influential in policy design and implementation.

Table 2.1: Common Barriers to Improving Energy Efficiency in Buildings

Barrier Categories	Common Barriers
Lack of knowledge and knowhow	Lack of reliable and credible information about energy performance and the costs and benefits of efficiency improvements Lack of implementation capacity: shortage of relevant technical skills in local markets to ensure compliance of building EE codes Risk aversion to unfamiliar materials, methods and equipment, or uncertain outcomes
Institutional and regulatory deficiencies	Lack of national and/or local commitment to EE in general, and to EE in buildings in particular Government internal procedures and lines of responsibility that discourage EE in public buildings (e.g., budgetary and procurement policies not conducive to contracting EE services) Poorly designed social protection policies that undermine price signals for efficient use of energy (e.g., generally subsidized energy prices)
Financing challenges	Local government budget constraints Lack of long-term financing at a moderate cost High transaction costs due to small individual investments Unattractive financial returns Unreliable repayments
Market failures and inefficiencies	Split incentives: EE investment decisions are made by actors that do not receive direct financial benefit Suboptimal decisions or choices due to insufficient information Fragmented building trades: multiple professions involved in different stages or decision processes

2.1.6 Level of Sustainable Approach that can be adopted towards Developing Energy Efficiency Buildings in Offsetting Greenhouse Gases

Nigeria is a developing country that aims at developing in sustainable manner. Sustainability allows developing by meeting the needs of present and yet taking into consideration and allowance of the needs of the future generations (Kates *et al.*, 2001; Lafferty, 2004). Therefore the utilization of energy is meant to be efficient, sensible and wise so that the purpose of sustainable development will become manifest.

The most appropriate approach is embraced by means of the application and understanding of thermal comfort, human behavior and energy utilization behavior of buildings. Recently, the level of energy consumption has increased owing to the substantial growth of the building industries; hence, it is important for Nigeria building industries to organize its development in a sustainable way.

Energy efficiency in building is a straightforward concept which can conceivably be summed up with the saying, "doing more with less," the term is normally associated with how energy is consumed at the point of end use, but the concept of energy efficiency in building can also be applied to how energy is produced and distributed.

Mohsen (2011) mentioned that buildings are accountable for 40% of energy consumption and 36% of CO_2 emissions. Enhancing the energy performance of buildings is a cost effective way of fighting against climate change and improving energy security while at the same time creating job opportunities especially in the building industry.

The Community Research and Development Centre (CREDC) is a non-governmental, non-profit organization registered in Nigeria to provide services that ensure the sustainable management of the environment and environmental resource. CREDC further assert that the energy been produced in Nigeria are from the combustion of fossil fuel such as oil and gas. For every kilowatt-hour (kWh) of electricity we consume; there is an equivalent emission of greenhouse gases (GHGs). Energy efficiency in building initiatives can help reduce the dependency on petroleum and also emission of greenhouse gases and the negative environmental impacts associated with the generation of energy will also be reduced if we use energy efficiently.

Many persons can be hired during intervention programs to change the behavior of people to use energy efficiently but then there are other methods ranging from retrofitting or employing energy efficient appliances to designing an energy efficient building to relate to the environment. In so doing there will be little or no use of energy. Companies involved in the manufacturing of electrical appliances will experience competition among themselves; those who manufacture the most efficient appliances capture the patronage of consumers.

According to Energy Commission of Nigeria (2013)on sustainable design and energy efficiency measures the following initiative/strategies are postulated for offsetting greenhouse gases towards energy efficiency building.

2.1.6.1 Renewable Systems

The use of renewable energy either off site or on site, will contribute in the reduction of greenhouse gas emissions by reducing non-renewable energy demand. There are several advantages to generating energy on site, such as increasing electrical reliability and providing an emergency backup system. In addition, every kilowatt hour(kWh) provides a renewable energy credit (REC) which may be exchanged with the local utility for credits, or used as a part of an Energy Savings Performance Contract (ESPC) arrangement.

1. **Offsite**

Purchasing green power (power derived from solar, wind, geothermal, biomass or low-impact hydro sources), by selecting a Green-e certified power provider for a portion of electric purchases, purchasing a portion of electric power through a Green-e accredited utility program, or by purchasing Green-e accredited Tradable Renewable Certificates (RECs).

2. **On Site**

Photovoltaic (PV): PVs are placed on building's exterior so as to generate electricity through collection of solar energy. Light shining on a PV cell, which is a solid-state semiconductor device, liberates electrons that are collected by a wire grid to produce direct current electricity which is then converted to alternating current for use by the facility.

Photovoltaic window or glazing modules can be integrated into a building as non-view windows, skylights, greenhouse windows, curtain walls, facades, and so on.

Wind Energy: Wind energy are mostly harnessed by wind turbines, it is usually located either on the building or at an adjacent site. The Wind rotation of the turbine converts the mechanical movement into electric power.

Biomass: The use of Biomass systems can be fed from a variety of sources, and can directly use gasses emitted from the decomposition of biomass, or can use the biomass in high temperature reformers to generate hydrogen, which is then fed into fuel cells. Some biomass can also be converted to biodiesel for use in diesel generators.

2.1.6.2 Energy Conservation verses Energy Efficiency

These two concepts may be taken to be alike but differ in strategies, the common idea is that both are important ways to reducing overall energy use. A write-up by AK energy smart on energy conservation and energy efficiency differentiates the terms as follows (www.akenergysmart.org/).

1. **Energy conservation**

Energy conservation simply means reducing energy use by means of a behavioral adjustment that result in not using energy at a time when one might normally make use of it. For example, unplugging computers and other electronics at night or when not in use, or turning off the lights when you leave a room.

2. **Energy efficiency**

Energy efficiency means reducing energy use by installing appliances, equipment or lighting that use less energy, i.e. allows us to do more with less. Examples of energy efficiency include replacing incandescent light bulbs with compact fluorescents (CFLs) or LEDs, adding extra insulation to a house, or using Energy Star appliances that have power-saving measures installed.

Energy consumption is not just about electricity used in the building, it also has to do with the material used for its construction. Building an environmentally friendly and energy conscious architecture helps to lessen energy consumption and also reduces environmental degradation. Adopting the concept of embodied energy is a way to compare the performance of building materials. The embodied energy of a building material is the energy that has been required to extract, process, and manufacture it and then to transport it to the building site. The embodied energy in the structure of a new building is considerable, exceeding the total energy required to heat that building for the next twenty years (Umar, 2010).

During the manufacture of materials, the highest embodied energy is found in metals (steel requires 57,000kWh/m3 or 251200MJ/m3), and highly processed industrial products (hardboard and MDF require 2,000 kWh/m3). The middle ranges of materials are simpler to make but require lot of energy in their manufacture (bricks needs 5170 and concrete blocks need 2350kWh/m3). The lowest embodied energy is in materials that require only simple processing (building timber needs 180kWh/m3) or those made from salvaged materials or local natural materials (for example, straw bale, aggregates) which require little or no energy (Umar, 2010).Table 2 shows different building materials and their embodied energy in MJ/kg and MJ/m3.The lower the embodied energy the higher its insulation properties and vice-versa, the lower embodied energy materials have high insulation but lacks strength and durability.

Table 2.2: Embodied energy of materials - source: www.boralna.com.

MATERIAL	EMBODIED ENERGY	
	MJ/KG	MJ/M^3
Aggregate	0.10	150
Straw bale	0.24	31
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete precast	2.0	2780
Lumber	2.5	1380
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.0	93620
Paint	93.3	117500
Linoleum	116	150930
Polyslyrene insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700

Note: Embodied energy values based on several international sources-local values may vary

Table 2.3: Approaches for Improving Energy Efficiency in Buildings as illustrated by Liu and Hammer (2014)

Focal Area	Technical Approach
Reducing heating, cooling, ventilating, and lighting loads for new buildings or when renovating existing buildings	Apply local climate-sensitive passive design techniques, such as building form, orientation, surface color, sun shading, building envelope insulation, air tightness, ventilation, etc.
Increasing the efficiency of energy-using devices and equipment	Optimize system design and operation to match actual heating, cooling, and lighting loads through commissioning and retro-commissioning Upgrade or replace heating, ventilation, and air conditioning (HVAC) systems, indoor lighting, water heating, home appliances, and other electric and mechanical devices
Manage energy use in public and commercial buildings	Monitor, analyze, and control energy use through energy performance benchmarking Establish new maintenance standards, label building energy performance, and communicate energy performance indicators to building owners/tenants Organize information and awareness raising campaigns

According to Liu and Hammer (2014) before committing significant private and public financial resources, it is important for city leaders to develop a clear view of the main opportunities, issues, and options available in improving the energy efficiency of new and existing buildings.

A key first step is to carry out a sector energy efficiency assessment that can cover either the entire building sector or a specific segment of it. The basic approach for conducting energy efficiency assessments for buildings is described in a separate guidance note for city energy efficiency assessments.

City governments should also lead by example by initiating cost-effective measures that boost energy efficiency in municipal buildings and/or testing new EE policy initiatives.

It is critical for city governments to work with national and state/provincial governments, as well as other stakeholders such as energy utilities, banks, building owners, and energy service trades to address the major barriers to scaling up EE in buildings.

The most common policy and regulation instruments and tools to increase energy efficiency in buildings are listed below. These measures tend to be accompanied by specific support programs, as a portfolio of actions is generally more effective than a single, stand-alone energy efficiency intervention (Liu and Hammer (2014).

Energy regulatory policies. Usually formulated at the national or regional level, energy regulatory policies address general inefficiencies in energy markets. Examples include policies to replace general pricing subsidies with targeted social assistance schemes, that require users of network-based energies be charged based on metered consumption, and which introduce incentives encouraging energy utilities to carry out demand-side management activities.

Mandatory standards and codes: Generally developed at the national and regional level and updated periodically, mandatory standards and codes address key market failures or inefficiencies, in this case, defined as situations in which rational decisions taken by market participants have led to negative or suboptimal economic outcomes for society as a whole. The case of split incentives (Table 2.3) is a main reason for introducing mandatory building energy efficiency codes (BEECs). Minimum energy performance standards (MEPS) for majorenergy-consuming equipment are targeted at manufacturers, but supportedby demand-side promotions (e.g., rebate programs for appliance replacement)implemented by energy utilities or city authorities.

Labels and certificates. These are means of recognizing and encouraging EE efforts that go above and beyond the mandatory requirements outlined above. Examples include the voluntary Energy Star program for buildings, components, and equipment in the United States and the Green Mark scheme for buildings in Singapore.

Financial facilitation schemes. These include fiscal and monetary incentives to encourage investments in energy efficiency. Examples include tax credits, cash rebates, and capital subsidies, as well as special funding vehicles and risk-sharing schemes to increase funding and lending for investments in EE.

Requirements for energy management. Several cities in the US and the European Union have introduced mandatory energy performance benchmarking and disclosure programs that require large public and commercial buildings to monitor and a city's ability to develop and deploy these tools and instruments varies, depending on the particulars of the local governance structure. Table 3 provides a general map of the key policy tools, the barriers they intend to address, and the potential role of municipal authorities.

2.1.6.3The Benefits of Energy Efficiency

Wafula, (2012), study on the energy efficiency strategy, point out the benefits of energy efficiency as follows:

i. Economic growth: Energy efficiency measures when fixed often require local work force, and the venture has the possibility of enhancing employment and economic growth. There are long-term growth benefits, for example, it lowers domestic energy bills, this can lead to higher disposable incomes that can be spent elsewhere in the economy, while businesses can see a reduction in running costs and so an increase in productivity.

ii. Innovation of energy efficient technology: this offers a longer term investment in energy efficiency technology which can lead to a virtuous circle as innovation leads to cost reductions which can make it cheaper and easier to invest in energy efficiency in the future. Developing our innovative capacity in technology, materials or business models for energy efficiency opens up the potential for increasingly significant export opportunities for Nigeria as the global effort to combat climate change ramps up.

iii. Increase in productivity: Economic studies show that improved energy efficiency can encourage productivity, increases growth and reduces inflation. This provides additional jobs due to the cumulative impact of higher growth.

iv. Savings for domestic and business consumers: this is central to delivering a fair deal for the consumer. Most buildings are already benefitting from improvements in energy efficiency such as heating efficiency and insulation, if there had not been energy efficiency measures, energy use would be almost double the current level. Energy efficiency will continue to have a role in driving long term reductions in a building's energy bills.

v. Increase in general well-being: good health can be improved through increased energy efficiency, e.g. a higher disposable income; due to lower energy bills can permit increased expenses on other needs. The health benefits from properly installed energy efficiency measures can be significant.

vi. Emission reductions: In order to fight against greenhouse gas emission which has been the targets over the coming decades in the most cost effective way, we need energy efficiency to improve significantly across all sectors because energy efficiency tends to be a cost-effective option.

vii. A sustainable and secure energy system: when energy consumption is reduced there is improvement in energy security. There can also be specific benefits to the energy system of decreasing demand as it reduces the long-term need for investment in additional infrastructure that would have otherwise been required. This has the potential to reduce the overall cost of energy generation framework in the future.

2.1.7 Environmental Impact of Electricity Generation

Energy consumption is the cause of several environmental problems (Blom, 2010). Type and intensity of the problems demand on how the energy is produced.

Fossil fuels (crude oil, coal and natural gas) account for greater percentage of Nigerian total energy consumption. The combustion of fossils emits CO_2, the most important greenhouse gas and sulphur dioxide (SO_2) and nitrogen oxides (NO_x), which cause acidification. Nitrogen oxides, entering the nitrogen cycle contribute to nutrient enrichment in waters.

Natural gas, however, has a significant lower carbon and sulphur content than crude oil and coal. Per energy unit it emits 40% less CO_2 than coal. Substituting oil and coal with natural gas therefore, reduces the emission of CO_2 and SO_2.

Several combustion products of fossil fuel are also precursors for the photochemical formulation of ground level ozone. High concentration of ozone at ground level can occur especially in hot months of the year in cities with heavy traffic and can have adverse health effects after a few days of exposure, in particular inflammatory responses and reduction in lung function. Blom, (2010).

Blom, (2010) also state that apart from the impact of climate change and acidification and consumption of fossil fuel resources by the industrialized world in the current quantities is also in conflict with the principle that limited resources should be shared among present and future generation in a just way – a key thought of the sustainability principle.

Donna and DiBona (1996) reviewed the relationship between the building sector, energy efficiency and global warming. Their work qualitatively analysed the connection on how both energy efficiency as a key policy measure, and the building construction sector, as recipient of such policies, can act together to significantly mitigate the effects of global warming and resulting climate change.

Major Energy – Environmental Issues by Scale

To date, the focus in the field of sustainable building has been on new building design. However, existing buildings inflict great environmental burden through three causes: continuous energy consumption, regular building maintenance and replacement. Reducing energy consumption for climate control and electrical appliances are much more effective means of making buildings sustainable. The sustainability of electricity supply is essential to decrease the total environmental impact of the existing building stock, Blom, (2010).

The contribution to an environmental impact category represents a potential effect on the environment. Each particle of substance flows may contribute to several of the considered environmental problems, but generally not at the same time. For example, some ozone depleting substances are also greenhouse gases. However, ozone layer depletion is a chemical process in which the ozone layer depleting substance is transformed, after which it is no longer a greenhouse gas. The entire substance is counted in both environmental impact categories. These causal links are seldom unambiguous causal chains but usually “causal network” because single causes usually have multiple effects.

Impact Categories

Abiotic Depletion

The impact category abiotic depletion is a measure for the global depletion of natural, non-living resources. Abiotic resources can be divided into three categories: deposits, which are not regenerated within the human life span and thus can only be depleted (fossil fuels, minerals); funds which can be regenerated within the human life span and thus can be used or depleted if use is faster than regeneration (groundwater, soil); and flows, of which a more or less constant supply is available and thus can only be used (wind, water, solar energy). Depletion is defined as decreasing the amount of available resources without replacement (deposits), or decreasing the amount of available resources faster than they can be replaced by nature (funds). The consequences of Abiotic resource depletion are that the resources are no longer available and extraction may cause severe disruption to ecosystem.

Global Warming

Global warming is an emerging issue that poses great threats to environmental sustainability. The main cause of global warming is greenhouse gas (GHG), product which mainly originate from burning of fossil fuel (Du. et al.,2013)

The global warming impact category is a measure for the emission of substances that absorb heat radiation in the global atmosphere. The emission of these substances may have an adverse effect on the health of ecosystems and humans, as well as the earth's temperature. The impact score is expressed in kg carbon dioxide (CO_2) equivalents.

Ozone Layer Depletion

Maller, .J. Horne, R.E. (2011) stated that the impact category ozone layer depletion is a measure for the emission of substances that can deplete ozone in the stratosphere. This causes the ozone layer to thin, which will lead to higher fractions of solar UV-B radiation reaching the earth surface. UV-B radiation is harmful to human health and ecosystems. The reference substance is trichlorofluoromethane (CFC-11). Knowledge should be gained on the relationship between ozone depletion potential and global warming potential, since many ozone depleting substance are also greenhouse gases. Therefore, part of the substance emission may contribute to depletion of the ozone layer, while another part may contribute to global warming.

Acid Rains

Acid rains are caused by the release of sulphur dioxide (SO_2) and oxide of nitrogen (NO_x) when fossil fuel burns. The oxides combined with water vapour in the air to form acids, which return to the ground as acid rains. The problems posed by the acid rains include corrosion of the built environment, soil degradation, water pollution and depletion of forest. Acid rains corrode the built environment including buildings, statues and metal bridges. Acid rains remove useful nutrients that support plant life. This will adversely affect agriculture. Acid rains could cause lakes, ponds and rivers to loose aquatic life and destroys forest. One of the problems caused by acid rain is political. The sulphur dioxide and nitrogen oxides that cause acid rain originate far away, in other states or in other countries. It is only natural for people to be very upset by losses caused by others, and they might be demanding action.

Air Pollution

Acid rains and greenhouse effect arising from fossil fuels receive great attention but they cause economic disruption such as destruction of buildings while acid rain kills trees and fishes. Air pollution on the other hand results to loss of lives of human beings together with human suffering from illnesses. The possible health effects of these pollutants when summarized include: firstly, sulphur dioxide is highly associated with many types of respiratory diseases including bronchitis, asthma, colds, and cough (Shoaib & Bhran, 2013). Clinical studies have shown increase death rate from exposure to high level of sulphur dioxide among individuals with lung and heart diseases. Nitrogen oxides, another pollutant in this case, cause pneumonia, bronchitis as well as irritating the lungs. It also lowers resistance to diseases of upper respiratory system such as influenza (Shahir et al., 2014). Carbon monoxide, killer combines with haemoglobin hence reducing the amount of oxygen found in blood which is transported through the body. This gas also weakens the rate of contraction of the heart hence furthering the reduction of amount of oxygen supplied within the body tissues. The gas is so lethal that even at its low concentration; it can cause damage to the respiratory system resulting to chronic or acute illnesses in upper respiratory system. Toxic metals are also released from fossil fuels too and they pose with themselves a variety of harmful effects.

Human Toxicity

The impact category human toxicity covers the effects of toxic substances present in the environment on human health. Human toxicity includes smog, carbon monoxide and sulphur compounds at ground level. The effect of toxins depends on contration of substance exposure to them, the risk of exposure

Photochemical Oxidation

In contrast with ozone layer depletion in the stratosphere, photochemical oxidation deals with the formation of ozone and other reactive chemicals in the troposphere, near the earth's surface. Photo-oxidation may be formed through photochemical oxidation of Volatile Organic Compound (VOCs) and carbon monoxide (CO), in the presence of ultraviolet light and nitrogen oxides (NO_x). Photo-oxidation formation is also known as summer smog.

2.2Theoretical Framework

Three theories were adopted and used for this study and they include Behavioural Model Theory (BMT) develop by Skinner (1974), Retrofitting Existing Building Theory(REBT) and Building Information Model Technology Theory(MIMTT) invented by International Energy Agency (1985), developed by Arno and Frank (2009).

Behavioural Model Theory

This study used the Three-Term Contingency Theory (A-B-Cmodel) by Skinner (1974) in explaining the behavioural model theory. The Three-term contingency theory was invented by the famous behavioural scientist, B. F. Skinner. In order to experimentally analyze human behaviour, he divided the behaviour into three key parts which constitute - stimulus, operant response and reinforcer/ punishment. The term 'Contingency' defined as relationship between the events, three term contingency refer to the sequential relation between the stimulus, response and reinforcement/punishment that prompt and maintain behaviour. Three-term contingency theory is also known as A-B-C (Antecedents-Behaviour-Consequences).

A ⟶	B ⟶	C
Antecedents	behaviour	Consequences
People	Appropriate	Reinforcement
Events	Inappropriate	Punisshmenr

Figure 2.2: Three Term Contingency or A-B-C (Antecedents-Behaviour-Consequences) model Sources: Maag (2004)

The A-B-C model can be used to explain how people achieve awareness and manage their behaviour. Table 2.4 outlines and summarizes the characteristics of each key part.

Table 2.4: Characteristics of the key parts of the A-B-C model

(A) Antecedent	(B) Behaviour	(C) Consequence
• Stimulus or setting event. External environment that set the occasion for behaviour to occur.	• Cognitive (thinking) – voluntary behaviour that we choose to do or not to do • Respondents (physical)- changes occurring within our body . • Operant (acting)- Voluntary behaviour that we choose to do or not to do	• Event (external) that occur during and /or after a particular covert and/or operant behaviour.

Sources: Kahn, (1999)

Maag (2004) defines antecedents as the circumstances that exist in the environment before behaviour is exhibited. This means that, antecedents are the reason, cue or prompt for someone to behave in a certain way. For example, people tends to waste energy (did not switch off electric equipment when not using it, air conditioning system operated to the overcooling) in commercial/public building because they do not pay energy bills directly. In this case, ‘free from paying any electricity fee' act as the antecedent for the reason of why people do not appreciate energy.

The behaviour section in the three-term contingency theory is divided into three parts - cognitive, respondent and operant. The cognitive behaviour represents how people think, imagine and self talk, all of these will affect people's decision in the later stage. Respondent behaviour refers to involuntary physiological/biochemical changes in our body when we are ready to take certain action. Operant behaviour is behaviour that is voluntary and operates on the environment to produce desirable consequences (Kahn, 1999). More accurately, operant behaviour refers to the action that we take.

Consequences are immediate or long-term events or changes in the environment following target behaviour (Kahn, 1999). Generally, consequence can be defined as effect or cause of previous action or condition. Consequences can be reinforcing (positive) or punishing (negative). As mentioned by Maag (2004), "consequences affect future behaviour by serving to either increase, decrease or maintain it." If the consequences are reinforcing, then probably the respondent will repeat it to obtain the desirable results/events/changes. On the other hand, respondent will not repeat it for the purpose of avoiding the undesirable results/events/changes. For instance, if someone receives high bill for leaving electrical appliances on the person would probably be more aware in future.

According to Wedge (2003), the outcome of behavioural approach is very effective and helpful in energy conservation as in the case of the commercial building when they embrace on management initiatives, encourage staff participate in switch-initiatives during break and when areas were vacated. Experiments have shown that 5 to 10% of the domestic energy use can be saved by correct domestic behaviour (Loozen & Moosdijk, 2008).

Related research reveals that behavioural approach is vital in any energy conservation program and regarded as one of the key of success in energy management (Loozen & Moosdijk, 2008). Facility managers should realize that the behavioural approach is useful to manage energy. Nowadays, the responsibility of a facility manager is not only limited to managing buildings, but it also includes management of energy and people. Sheila Sheridan, chairman of the International Facility Management Association (IFMA) during an interview with Druckman (2004) had given her opinion that facility management professional have growing shared responsibilities with human resources. So, besides focusing on technology fixed to conserve energy, human behaviour should also be considered. It is important to take account of human behaviour factors in energy conservation. As stated by Energy Efficiency Office (2003), being successful in saving energy is thus a question of motivating people to behave differently.

According to Wong (2007) awareness is the seed for tomorrow changes and this suggests that, the first step in behavioural approach in energy saving is to raise energy awareness. In promoting behavioural changes energy awareness will be defined and discussed.

The Microsoft Encarta Dictionary (2005) defines awareness as knowing something; having knowledge of something because you have observed it or somebody has told you about it, noticing or realizing something, mindful that something exists because you notice it or realize that it is happening, knowledgeable, well-informed about what is going on in the world or about the latest developments in a particular sphere of activities. In this study, awareness refers to having knowledge or realizing a current development or initiative.

Energy awareness is significant in energy conservation program (Vesma, 2002; Wong, 2007). Williams (2003) states that one of the most successful means of motivating employees to conserve energy is through awareness. Besides that, according to Camp (2005), staff awareness plays a crucial role in reducing utility bill and can make a big impact and therefore, raising awareness is large part of the solution.

In the past, raising awareness has been utilized as the method to conserve energy, for instance, the Imperial College of Science, Technology and Medicine in London, has defined objectives to focus on raising staff and student awareness of energy conservation issue as one of the strategy to help protect the environment through more efficient energy use and to save money on fuel bills (Pancucci, 2003).

As from the above discussion, raising awareness is so significant. However, most managers still do not pay much attention to the benefits of raising energy awareness. This is because facility managers and plant operators tend to be skeptical of behavioural approach and have little understanding of them and their potential (Geller, Richard and Peter, 1992). Because of that, 'lack of awareness' becomes one of the reasons of energy inefficiency. According to Yik and Lee (2002), one of the key barriers to improving energy efficiency of buildings is lack of knowledge and motivation of the operation and maintenance (O&M) staff. In their other research, Yik, Lee and Ng (2006) pointed out that the key barrier to energy efficiency improvement in existing buildings is the knowledge. Awareness is defined as knowledge; lack of knowledge also means lack of awareness.

2.2.2 Building Information Model Technology Theory

Arno and Frank (2009) successively conducted a preliminary study on integrated design process and the related technologies and provided an original framework which they named Building Information Model Technology Theory.

Arno and Frank (2009) affirmed that building information modeling technology is a digitalized expression for building facilities' physical and functional features. As shared building information resource, BIMT is not only used in building design, but also in structure design, equipment management, statistics of project quantity, cost calculation, property management, etc. BIMT can also play its role in the whole construction industry and provides solid foundation for all decisions of building life cycle.

Since its appearance in mid-80s, BIM technology has existed for over forty years in which period the international academia has been doing active exploration on architectural design information modeling and gets a consensus and this technology has got fast development at abroad in recent years. According to statistics,48% of Architectural Design Firms in America use BIM technology (Arno & Frank, 2009).The studies on energy saving design includes: using BIM modeling to do energy consumption analysis at early-stage building design (Stumpf, Kim & Jenicek, 2009); the application of BIM technology in passive design and the assessment of energy consumption (Charalambides, 2009), energy saving design method based on building information modeling (Yoon, Park& Choi, 2009). The study shows that using BIM technology could effectively and apparently balance project cost and energy efficiency

The problems faced by traditional building energy-saving work are as follows (Arno & Frank, 2009)

- On the concept of energy saving design there exists the trend that puts more emphasis on technology than design. For many of the existing energy conservation demonstration projects, energy saving is always identified as visible and tangible high technology but buildings' design itself is put behind, such as building's shape and the envelop structure.
- There exists the problem of incomprehensive building energy consumption（BEC） assessment on energy saving evaluation which puts more attention on the equipment' operating energy consumption, while ignoring the indirect energy consumption of the material energy consumption

(MEC） in the construction process and energy spent on the production and transportation of all the equipment. Some foreign scholars' research on energy consumption in the buildings' life cycle shows that for some energy-saving buildings, the percentage of the energy consumption of building materials among buildings whole life cycle energy consumption can reach up to 40%.

- There exists the detachment between energy-saving technology and building design on energy-saving design method. For traditional design method, building energy efficiency is categorized as one of the technological subjects, and the design concept that lacks of synergy effect among different jobs makes the energy saving technology distant from architecture design.
- There exists the problem of "solitary information island" on the application of design technology. Building is a complicated system in which all factors interacted with each other and it is hard to define which building design is better.

In order to implement the integrated design on building energy saving that is based on BIM technology firstly we need to understand the concept of integrated design and the workflow of BIM. Integrated design considers the building as a whole system and optimizes the whole process from the point of building's lifecycle. It has following features:

- Its design process considers the traditional building and technological integration as its study focus;

- It is based on actual situation rather than formality which means BIM technology uses flexible or suitable technologies to acquire the dynamic interactive information between building and environment;
- It is based on multi subjects and can meet the needs of designers with various academic backgrounds that require synchronous communication under different conditions;
- It is because of the above features that integrated design gets that the energy saving design based on this concept can make the best out of the whole design.

On the other hand, BIM's advantages on data management provide an excellent operation platform for integrated design. The object-oriented method used by BIM technology includes the buildings' comprehensive information such as the three-dimensional geometric information, all of which information can be reused and calculated and could significantly contribute to the consistency of project information in different phases. BIM technology can provide quantitative assessment in every phase of building design. All these features make the BIM technology stand out in building energy design especially under complicated environment.

2.2.3. Retrofitting Existing Building Theory

Retrofitting existing buildings for energy efficiency has been identified as an effective measure to reduce global energy consumption and greenhouse gas (GHG) emissions. Currently the majority of the existing building blocks in Abuja were built in a haste in order to develop the new Nigerian capital. They were built before the introduction of sustainability benchmarks in construction industry and are energy inefficient. To achieve an energy use reduction in the building sector, the issue of energy inefficiency of existing buildings must be addressed. Chidiac (2011) states that the implementation of energy retrofit measures (ERM) for increasing the energy efficiency of existing buildings have been shown to have significant effect on reducing the total energy demand. The International Energy Agency (IEA) has launched a set of Annex projects to promote energy efficiency of existing buildings, such as:

- Annex 4E – Holistic assessment toolkit on energy efficient retrofit measures for government buildings;
- Annex 55 – Reliability of energy efficient building retrofitting; and
- Annex 56 – Energy & greenhouse gas optimised building renovation.

These efforts provide policy guideline, financial assistance and technical support for the implementation of energy efficiency measures in existing buildings.

In the USA, the Energy Policy Act of 2005, expanded under the Energy Independence and Security Act of 2007, requires that the existing buildings must reduce energy consumption 30% by 2015, compared with 2003 level, through building upgrade and efficient appliances.

While these are global number of policies with the requirement of reducing emission and energy consumption through retrofitting, Nigeria has not keyed into them in order to achieve effective retrofitting measures for energy efficient buildings.

Defining energy efficiency retrofit

Understanding what energy efficiency retrofitting means and entails is seen as an important first step to progress, especially since various authors have underlined the confusion in terms and fluidity of the language that surround this term (Douglas, 2006; Fawcett, 2014). As Douglas (2006) observes ‘in the world of building the terms “rehabilitation”, “conversion”, “remodelling”, “reinstatement” and so forth are unhappily confused’ which denotes that the topic is still in its early stages of development and still evolving.

The Oxford English Dictionary defines retrofit as: “to provide (something) with a component or feature not fitted during manufacture; and add (a component or feature) to something that did not have it when first constructed”. Thus, extending this definition to interventions that are targeting the reduction of energy efficiency retrofit would refer to improvements done to a building or to buildings in order to achieve a better energy performance. There is a clear distinction between “renovation” and “retrofit” taking into account the extent of the work involved. Thus, renovation have been defined as an extensive interventions which require longer time, larger costs and professional technical expertise (Maller & Horne, 2011), in contrast with “retrofit” which refer to smaller, sometimes Do It Yourself (DIY) works undertaken by the homeowner, normally though during a home renovation process (Wilson et al., 2014). Dixon et al., (2014) pointed out that “retrofitting” mainly referred to “lighter”, non-intrusive interventions which could be performed while occupants were still using the property, whilst “refurbishment” meant a “deeper” alteration or improvement of the building exterior and interior characteristics of the building.

Barriers to Implementing Building Retrofitting

Retrofitting existing buildings for energy efficiency is a big challenge because it involves funding and decision making from a wide range of stakeholders such as landlord, tenants, property managers, developers and local councils. Potential barriers against uptake of energy efficiency retrofitting may arise from any stakeholder or group of stakeholders. Therefore, it is essential to understand the potential factors that may prohibit the uptake of energy efficient measures in buildings. From these listed literatures (Buildings Performance Institute Europe, 2011, Ernst & Young, 2015, and Initiative, 2013), Four categories of barriers were identified which either prohibits or slow down the uptake of energy efficient retrofitting. These are Economic, Regulatory, Knowledge and Social barriers. They are described in details below:

Table 2.5 Barriers to uptake of Building energy retrofitting

1.	**Economic Barrier**
Lack of Finance	Building owners or consumers do not have access to sufficient fund for retrofitting
High upfront costs and payback expectation	Retrofitting existing buildings requires high upfront costs and the benefits accrue gradually over time which sometimes result in longer payback period.
Priorities in investment	Interested to invest the capital in other higher earning investments.
Price signals	Have a higher propensity to undertake energy retrofit investments. If the financial incentive associated with it is sufficiently large
Split-Incentives	Not interested to retrofit when the person who would pay the cost of retrofitting would not receive the full benefit of them.
Minimize cost	Cutting the funds for energy efficiency generally comes first if cost minimization is required
Uncertainties over financial gain.	The difference between actual and predicted energy savings from retrofit influence cost savings and hence payback period
Lack of attention and materiality	Incremental savings from retrofitting are quite small compared to the benefits from other investments and hence less attention is given
2.	**Regulatory Barrier**
Fragmented market	In most cases, none of the involved professionals (during design, construction and operation stage) are expert in building energy efficiency, but the responsibility for achieving it is defused among them which present a coordination challenge.
Institutional	There is a bias among institutional investors more familiar and comfortable with supply-side investments and large-scale financing, rather than

	generally smaller (and "more risky") projects on the demand side.
Structural	Average age of the building stock is increasing because of low demolition rate. Because of the age of buildings, the landlord-tenant dilemma makes it difficult to ameliorate the existing building stock.
Multi-stakeholder issues	It can be very difficult to agree on energy saving investments in multi-owner buildings if the owners have to either approve a decision or make a financial contribution.
Government not a strong driver.	If the government demonstrate a strong commitment, to policies that encourage sustainability, as well as lead by example, this can create a long-term positive impact on industry.
3.	**Knowledge Barrier**
Lack of information and awareness	Sustainability is not usually understood well by owners or consumers. In some cases, they are not aware of current best practise or do not fully comprehend the effectiveness of energy efficient technologies.
Awareness of saving potentials	While there is a general appreciation that energy saving is a "good thing", there remains lack of understanding of the energy cost and carbon savings from different measures.
Lack of motivation	Some building owners are not interested in improving their buildings unless the equipment is about to break or there is a concerning high level of vacancy that is affecting his rental income.
Skills & knowledge related to building professionals	Skill shortages exist in both the contractor market responsible for the effective installation of energy saving measures, as well as in professional services, with few architects, designers and constructors familiar with energy efficient renovation.

Confusion in choosing the best option	If two or more professionals give supposedly conflicting advice as to the best way to renovate, this may lead to scepticism amongst the consumer over the installation of energy efficient measures.
Perception regarding energy efficiency	Some building owners have the perception that energy efficiency investment would not yield a return and see it as compliance and cost burden.
4 Social Barrier	
Interruption to building operation	The usual operation of a building is interrupted when a renovation is being undertaken. In the case of deep renovation, the entire building may need to be vacated which will involve practical and financial barriers associated with re-locating the occupant for the period of the retrofit.

The study adopted the Retrofitting Existing Building Theory by using the European Foundation for Quality Management (EFQM) Excellence Model for the study, it is a theoretical framework for delivering sustainable building energy efficiency retrofit by Bassioni, Price and Hassan, (2005) and Westerveld (2007)

The EFQM Excellence Model is one of the most widely used organizational frameworks in Europe. It is the basis for the majority of national and regional Quality Awards. The EFQM Excellence Model is a non-prescriptive framework based on nine criteria. Five of these are "Enablers" and four are "Results." The "Enabler" criteria cover what an organization does and how it does it. The "Results" criteria cover what an organization achieves. "Results" are caused by "Enablers," and "Enablers" are improved using feedback from "Results."

Fig. 2 shows the theoretical framework of sustainable BEER under the EPC mechanism. Sustainable BEER contains the three dimensions. The sustainability of each dimension can be measured by BEER projects' Key Performance Indicators.

Identified at the bottom level are the EPC critical success factors affecting the Key Performance Indicators. The EFQM Model is presented in diagrammatic form as shown in Fig. 3. The arrows emphasize the dynamic nature of the model. They show innovation and learning helping to improve enablers that in turn lead to improved results. The EFQM Model is based on the premise that excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, which is in turn delivered through People Partnerships and Resources, and Processes. The EFQM model is used to measure and improve the overall quality of the organization.

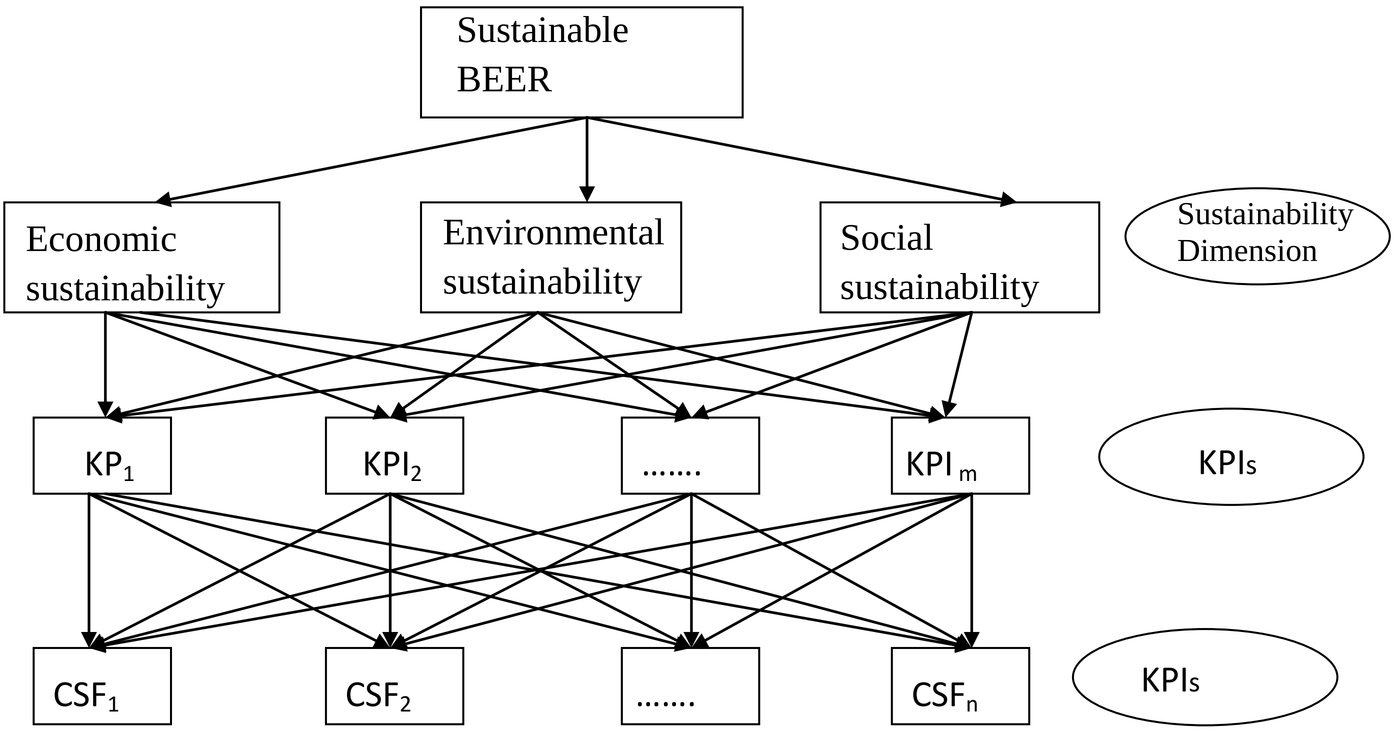


Fig. 2.3: A Theoretical Hierarchy of Sustainable BEER .
(KPI- Key Performances Indicators- and CSF- Critical Success Factor
Source: Westerveld (2007)

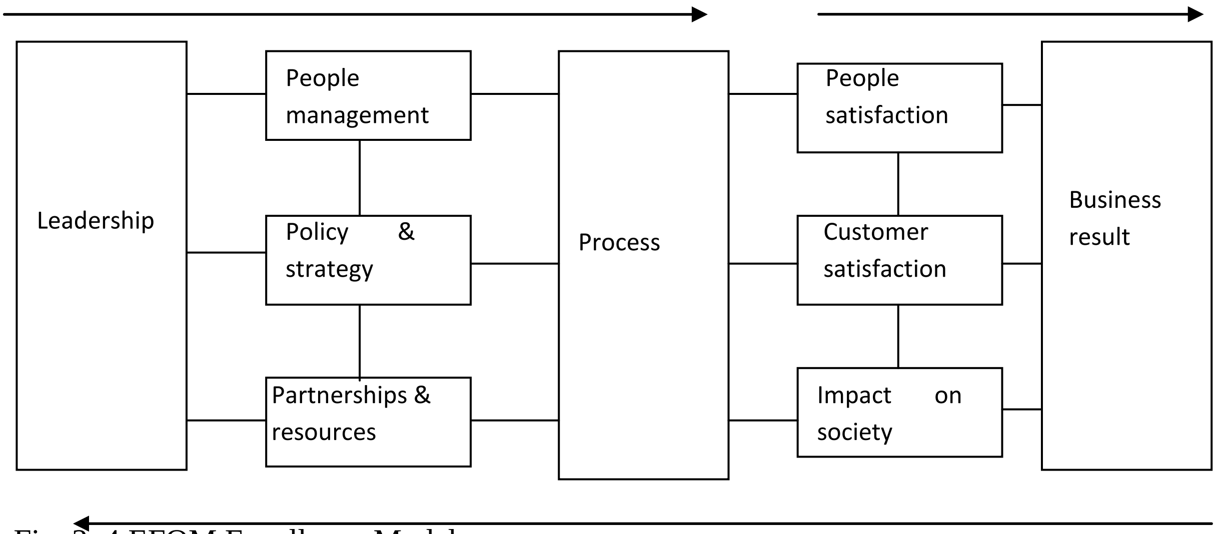


Fig. 2. 4 EFQM Excellence Model
Source: Westerveld (2007)

The EFQM Excellence Model can be used for improving sustainability performance. However, it is suitable for business organization in enterprises, rather than at project level. For this study, in order to introduce the EFQM as a framework for measuring the sustainability performance of a BEER project, it is necessary to modify and improve it. Some researchers have tried to use EFQM for construction projects. Bassioni, Price and Hassan, (2005) built a conceptual framework for measuring business performance in construction based on the EFQM Excellence Model and Balanced Scorecard. Westerveld (2007) modified it for projects and established the Project Excellence Model. One of the essential characteristics of the EFQM Model is that it distinguishes result areas (the results the organization has achieved (the "what") and organization areas (Management of the organization (the "how") (Westerveld, 2003). In order to implement the EFQM Excellence Model at the project level, the performance criteria of sustainable

BEER projects could be regarded as result areas, and the critical success factors (CSF) under EPC, as organizational areas:

- Result areas – Performance criteria of sustainable BEER projects
- Organizational areas – Critical success driving factors under an EPC mechanism.

2.2.4. Key result areas of sustainable BEER

"Key Result Areas" refer to general areas of outcomes or outputs for which a role is responsible. Before developing a set of Key Performance Indicators for sustainable BEER, it is necessary to analyze their Key Result Areas (KRAs). Previous performance measurement frameworks and systems in building retrofits and sustainable construction could be studied for finding KRAs.

There are a wide variety of sustainability performance measurement tools for existing buildings and retrofits. Most of them are decision-making tools for selecting retrofit scenarios and retrofit actions. Reddy *et al*. (1993) offered a frame-based decision support model for building refurbishment. Rosenfiels and Shohet (1999) developed a decision-support model for semi-automated selection of renovation alternatives. Alanne (2004) proposed a multi-criteria "knapsack" model to help designers select the most feasible refurbishment actions in the conceptual phase of a refurbishment project.

Flourentzou *et al*. (2002) and Caccavelli and Gugerli (2002) presented a retrofit decision-making model for existing buildings. This model brings energy, indoor environment quality (IEQ) scenarios and cost analysis into the decision-making process.

Dascalaki and Balaras (2004) introduced a new XENIOS methodology for assessing refurbishment scenarios and the potential of applying renewable energy sources and rational use of energy in the hotel sector. Matinaitis *et al*. (2004), Matinaitis *et al*. (2007), and Zavadskas *et al*. (2008) proposed methods for appraising building renovation and energy efficiency improvement projects in an economic perspective. Juan *et al*. (2010) developed a hybrid decision-support system for sustainable office building renovation and energy performance improvement. All the above models are decision-making tools for use before implementing a retrofit. Another tool named IPMVP (International Performance Measurement & Verification Protocol) is the most commonly used in retrofit projects for verification and measurement of the energy saving result of a retrofit project.

Many global organizations have developed comprehensive sustainability assessment systems to promote sustainability in building environments. Current well-known comprehensive assessment systems for green or sustainable building are the Leadership in Energy and Environmental Design (LEED), developed by the U.S. Green Building Council; the Building Research Establishment Environmental Assessment Methodology (BREEAM), developed by Building Research Establishment (BRE) Globalin the UK; the GitHub (GB) Tool/Sustainability Building (SB) Tool, developed by the Green Building Challenge (a collaboration of more than 20 countries), and the Hong Kong (HK) -BEAM developed in Hong Kong.

Several versions of these sustainable systems have been formulated, all of them having special versions for existing buildings. However, the existing building sustainable evaluation tools assess mainly the actual performance of a building and simply give guidance on its potential best performance. With specific reference to retrofit projects, BRE Global is developing a new standard to enable the sustainable refurbishment of existing housing, entitled BREEAM Domestic Refurbishment.

In summary these previous sustainable models for building retrofits can be classified mainly into two categories: decision tools for decision making at the primary stage of retrofit projects, and labeling tools for existing buildings. Previous research on performance measurements for construction projects is mostly concerned with the performance from project management objectives, such as the three iron triangles: time, cost, quality, and people satisfaction. Following the review above, this study intends to examine the KPIs from three areas:

- KRA 1: Project results – energy saving, project profitability, etc.
- KRA 2: Project life cycle sustainability – environmental quality, health & safety etc.
- KRA 3: Project management objectives – cost, quality, time, satisfaction, etc.

2.3 Empirical Studies

Oligbinde, Odunfa, Ohunakin and Odunfa (2014) conducted a study on Energy Efficiency in Residential Buildings: A Case Study of 1004 Federal Housing Authority Estate in Victoria Island, Lagos. This study investigated the energy consumption in residential buildings (1004 Federal Housing Authority Estate), in Lagos state. Survey analysis approach was adopted in this work. Field trips to the study area were conducted; measurements were taken and questionnaires were administered to occupants. The design features of the buildings were analyzed. The household equipment and the occupants were also taken into consideration. The work also analyzed the electric energy use for cooling and lighting typical residential buildings of upper income households in the area and the possible energy savings by adopting certain energy efficient features(in wall) in the case study building. The enveloped thermal transfer value (ETTV) equation was utilized to account for the quantity of heat taking into the building through the buildings envelop. Building wall of 200mm concrete thickness plastered with 13mm cement thickness in and out was used in the study. Result obtained indicated that doubling the thickness of external walls, reduces the cooling load of the building and hence reduces its total energy consumption. The total envelop energy of the building obtained was found to be 64.98W/m2, while 57.60 W/m2 was obtained when perlite was used in wall plastering in place of the cement with same thickness. Improvement of energy efficiency in residential buildings was also achieved through series of demonstration works carried out in the analysis using ETTV equation. The study established that the perlite plaster has a lower thermal transmittance value (U-value) when compare to that of cement hence a better energy reducing material option in building construction. The impact of ETTV on the energy consumption of residential buildings leading to a reduction in building heat load was also established in the study.

This study by Oligbinde *et al*.(2014) has identified that apart from other energy efficient building features that doubling the thickness of external walls or using a different plaster will improve the energy efficiency of residential buildings in Lagos, Nigeria. In this work, it was established that using perlite plaster in place of the cement plaster, improved the cooling of the inside the building, but the work was highly limited to the provision of detailed solution and procedure towards proactive initiatives that can enhance the reduction of cost and sustainable energy reduction by household devices which the present study intends to cover.

Wafula (2012) conducted a study on Evaluating Energy Efficiency in Building Control Regulations in Local Authorities in South Africa. This research evaluated energy efficiency measures implemented through the building control regulations in the key metropolises of Johannesburg. Significantly, it investigated the formulation and implementation of energy efficiency building standards/codes through the building control regulations to achieve energy efficiency in building developments under municipal jurisdictions. The study was based on a mixed methods research approach consisting of documentary review, structured questionnaire and semi-structured field interviews. The analysis was based on the key themes of investigation; the importance and awareness of energy efficiency measures in buildings, implementable energy efficiency measures through the building control regulations and the integration of energy efficiency building standards/codes in the National Building Regulations. The key finding was that the lack of a definitive legal requirement of energy efficiency measures in the national building regulations impedes the formulation and implementation of an effective energy efficiency programme through the building control mechanisms in local authorities. The main recommendation is that the proposed energy efficiency building standards/codes should be operationalized as soon as possible to provide a legal framework for the energy efficiency programmes in buildings through the building control processes, provide a foundation for the development of market transformation measures which complement the regulations and set the stage for the implementation of next generation energy efficiency measures like Zero energy buildings.

Wafula (2012) comprehensively explained and discussed on energy efficiency building standards/codes. The study explained the findings of the research from the field survey and document reviews in detail and related them to findings of other similar researches. The chapter had discussed the various means and ways the topic of energy efficiency in buildings was being addressed in South Africa through the building control regulations. It explained how it was clear that the building sector in South Africa is alive to the challenges of energy efficiency, fundamentally because of the escalating prices of electric energy, security of supply and environmental concerns. But did not outlay the solutions towards proper initiative in reducing energy use and cost in residential and commercial building.

Iraklis (2014) conducted a study on urban sustainable energy development: A case study of the city of Philadelphia. The study explored the role of cities in sustainable energy development through a governance-informed analysis. Despite the leading position of municipalities in energy sustainability, cities have been mostly conceptualized as sites where energy development is shaped by external policy scales, i.e. the national level. A growing body of research, however, critiques this analytical perspective, and seeks to better understand the type of factors and dynamics that influence energy sustainability within a multi-level policy context for urban energy. The study identifies four areas of policy recommendation that could enhance Philadelphia's prospects for energy sustainability: integrated municipal energy planning; stable financing for market development; enhanced actor interactions; and multi-level policymaking that facilitates local action. These policy directions could be of interest to a broader body of metropolitan cities regarding their efforts in sustainable energy development, but it fail to determine a reliable energy development initiative that will reduce energy consumption, usage and cost in commercial and public buildings.

Kahu (2014) conducted a study on evaluating energy efficiency in the design of large scale office building in hot-dry climate of Nigeria. This research sought to improve the level of energy consumption in large office buildings through improved technological installation of efficient appliances and passive design in order to reduce the negative impact of buildings to their physical environments. The employed computer simulation case studies were carried out (in which one was simulated), and relevant information sourced from pertinent literature and internet. In the course of the research, the building was designed to maximize the use of passive elements such as daylight, air flow, sun light, and so on. Based on computer simulation, the proposed design was able to achieve about 76% energy reduction as compared with the simulated case study.

The study gave a detailed analysis of the elements that comprise energy efficiency which should be applied in a building design to minimize energy consumption. But it failed to identify the general energy efficiency that can be used to reduce energy such as appliances, equipment or lighting that use less energy, i.e. allows us to do more with less energy, which this study intends to identify.

Smedby (2016) conducted a study on local environmental governance: assessing proactive initiatives in building energy efficiency. This study explored and analyzed the outcomes of proactive initiatives in the field of building energy efficiency, and the governance approaches taken. It also addressed outcomes both in the socio-technical system that constitutes the building, and in the institutional sphere. The overarching objective is to contribute to knowledge on the role of local initiatives in addressing current environmental challenges. The study focused on a number of governance initiatives in the form of policies or strategic approaches in urban development projects in Sweden, and one in Denmark. The primary focus was on proactive initiatives for enhancing the energy efficiency of new buildings. The study combined a number of methods for data collection, including document studies, interviews and participant observation to analyze the governance approaches in local governance initiatives and the different types of outcomes. A key finding was that the local governance initiatives investigated have played a role in environmental governance through outcomes across socio-technical systems and institutional spheres.

That Smedby (2016) study addressed the proactive initiatives in the field of building energy efficiency, but did not consider the economic viability, environmental quality, and social equity at the project level which ensure optimal long-term energy performance and reduction in cost.

2.4 Gaps in Literature

Sustainable building energy efficiency retrofit (BEER) is the integration of sustainable development into existing buildings and retrofit projects (Xu & Chan, 2010). In recent decades more attention has been paid to the issue of sustainable retrofit. Keeping and Shiers (1996) proposed “green” refurbishment and analyzed its potential benefits. Sobotka and Wyatt (1998) applied the principles of “sustainable development” to the renovation of apartment buildings. Sitar *et al.* (2006) developed a model of sustainable renovation for a multi-apartment building. The sustainable renovation of a building was presented in two scenarios that examined the connection between the possibilities of using architectural design, renovation technology, and energy efficiency for the heating of the building.

Mickaityte, Zavadskas, Kaklauskas and Tupenaite, (2008) arrived at a conceptual model of sustainable building refurbishment.

Xu and Chan (2010) proposed an assessment framework from the result of the project, the technical process, and the organizational process perspectives, based on a balance scorecard. According to the concept of sustainable development, a truly sustainable BEER should consider economic viability, environmental quality, and social equity at the project level. The economic sustainability of BEER includes the cost efficiency of the retrofit project. Economic sustainability is achieved by reducing the retrofitting capital costs and the running costs of the retrofitted building. As this research is about residential and commercial buildings, it also aims to increase the operating profit of the hotel by improving its competitiveness and attractiveness after the retrofit.

However, BEER environmental sustainability is the main objective of these projects. Saving energy and, therefore money, is inherent in a successful project result. Besides, environmentally friendly activities should be embraced in the project process. The social sustainability of BEER at the project level includes improving public awareness and energy efficiency education, improving health and safety, and taking account of the local cultural heritage, etc. Sustainable development is not only an end goal, but also a continuous process. As part of the sustainable development strategy, analysis and understanding of sustainable projects should address both the project result and the project process.

Previous researches paid more attention to the result of the retrofit, the design, the choice of materials, and the technical process rather than the organizational project process. The Energy Performance Contracting (EPC) mechanism as a delivery method has great advantages for building owners implementing sustainable building energy efficiency retrofits. An Energy Performance Contracting mechanism offers a streamlined approach to improving facilities. Energy Service Company's or Energy Savings Company's (ESCOs) can provide a full range of services and work continuously with owners to ensure that they get optimal long-term energy performance. According to the analysis above, in order to achieve sustainable BEER, it is necessary to integrate sustainable development strategy into both the sustainability performance of the BEER and the EPC mechanism.

The BEER process can be simplified into four phases: energy audit, design, execution, and operation. This study takes an EPC mechanism as the retrofit business model and focuses on residential and commercial buildings in FCT Abuja. The study will cover the stated gap above by paying more attention to the result of the retrofit, the design, the choice of materials, the technical process and the organizational project process in order to clearly help to define the sustainable development of initiatives for energy efficiency in building at FCT Abuja in particular and Nigeria as a whole.

2.4.1. Summary of Gap in Literature

1. Previous researches paid more attention to the retrofit, the design, the choice of materials and the technical process of energy efficiency rather than operational use of electricity for sustainability of the built environment in Abuja.
2. No previous work on Abuja has analysed the use of Energy Performance Contracting mechanism as a delivery method for sustainable building energy efficiency.
3. None of the previous works on energy efficiency in buildings developed any usable template and model for achieving energy efficiency in Abuja.
4. From the literature review there is no strategies engaged by the Nigeria government in solving the problem of providing adequate, affordable and sustainable energy efficiency in building in the study area.
5. From the literature review none of the work review the environmental impact of use of fossil fuel for electricity generation and its effect on energy inefficient building in FCT.

CHAPTER THREE

THE STUDY AREA

This chapter deals with the description of the study area. This study covers FCT Abuja with particular reference to Gwarimpa District. The study area is discussed under the following subheadings: Location, Physical characteristics, human characteristics and propose area of study.

3.1 Location

The study area is Federal Capital Territory (FCT) Abuja in Nigeria (Fig. 3.1). Nigeria is located along the Western coast of Africa. The country is a Federation consisting of 36 States with 768 Local Government Areas and a Federal Capital Territory (FCT) (FGN, 1999).

Abuja is the capital city of Nigeria (fig. 3.1). It is located in the centre of Nigeria, within the Federal Capital Territory (FCT).The FCT is made up of six area councils and the Federal Capital City, with a population of about 1,406,239 (NPC, 2010)making it one of the ten most populous cities in Nigeria. The FCT Act of 1976 established the FCT. The establishment of the FCT is an implementation of the report of the Capital Relocation Committee set up by the Federal Government of Nigeria (Jatau, 1991). The committee reported that Lagos, the former capital city of Nigeria can no longer perform effectively the dual role of Federal and State Capital, due to several reasons, among which is inadequate land space for development. The physical development of the Federal Capital City, Abuja began in the early 1980s after the approval of the Abuja Master Plan by the Federal Government and the capital was finally moved from Lagos to Abuja in 1991 (Jibril, 2006).

FCT Abuja lies between latitude 8°86`N to8°95`N and longitude 7°18`E to 7°29`E (fig. 3.2). The capital city covers about 250 km^2, the whole FCT has a land area of approximately 8,000 km^2. The FCT is made up of six area councils and the Federal Capital City (Fig. 3.3), with a population of about 1,406,239 (NPC, 2010). The area councils are Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali. The map in figure 3.2 shows the six area councils and the four phases of the Federal Capital City while the map in figure 3.3 show the federal capital territory with its districts.

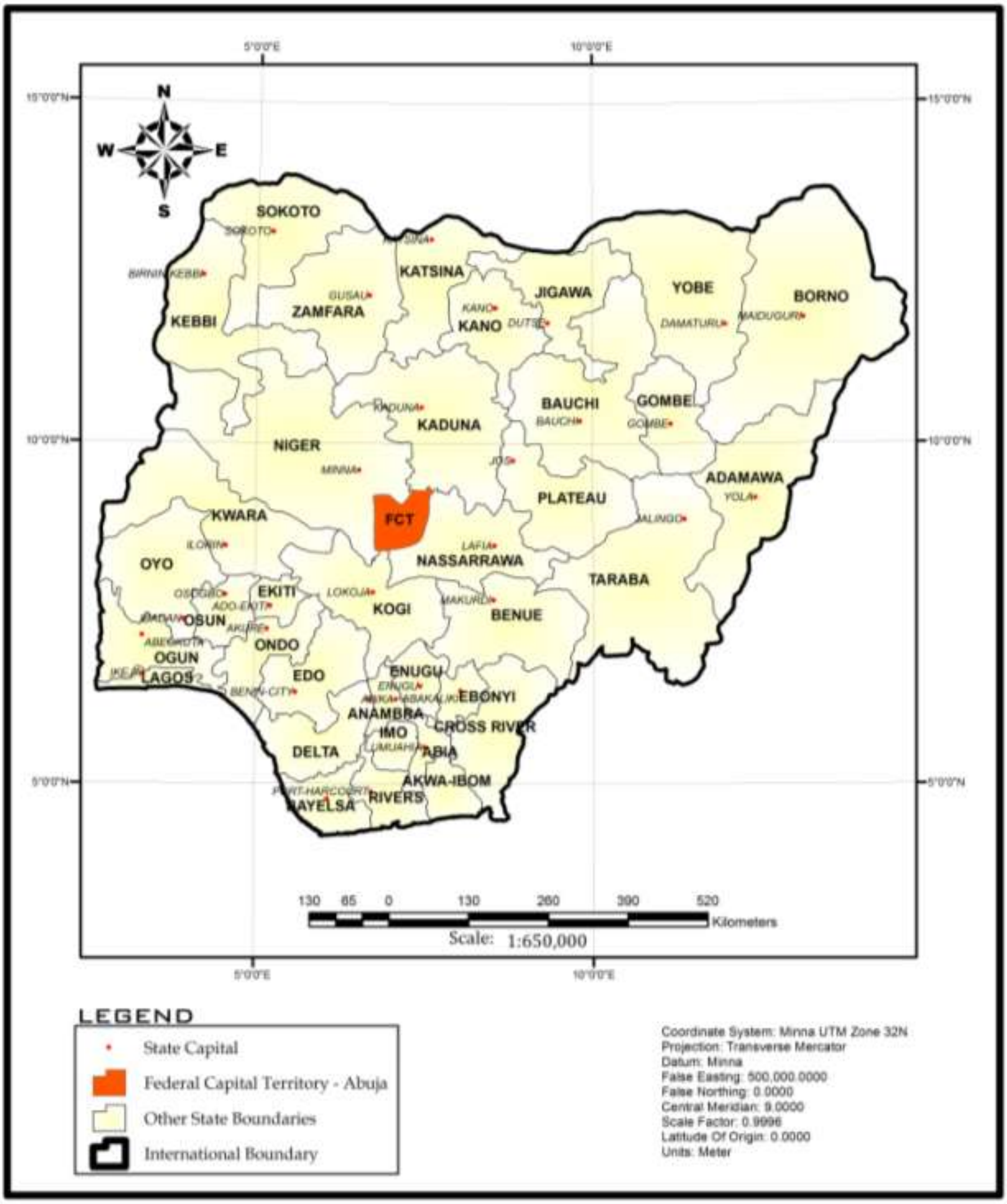


Fig. 3.1: Map of Nigeria showing Federal Capital Territory (FCT) Abuja in Nigeria

(Source: Department of Environmental Management GIS Lab 2016)

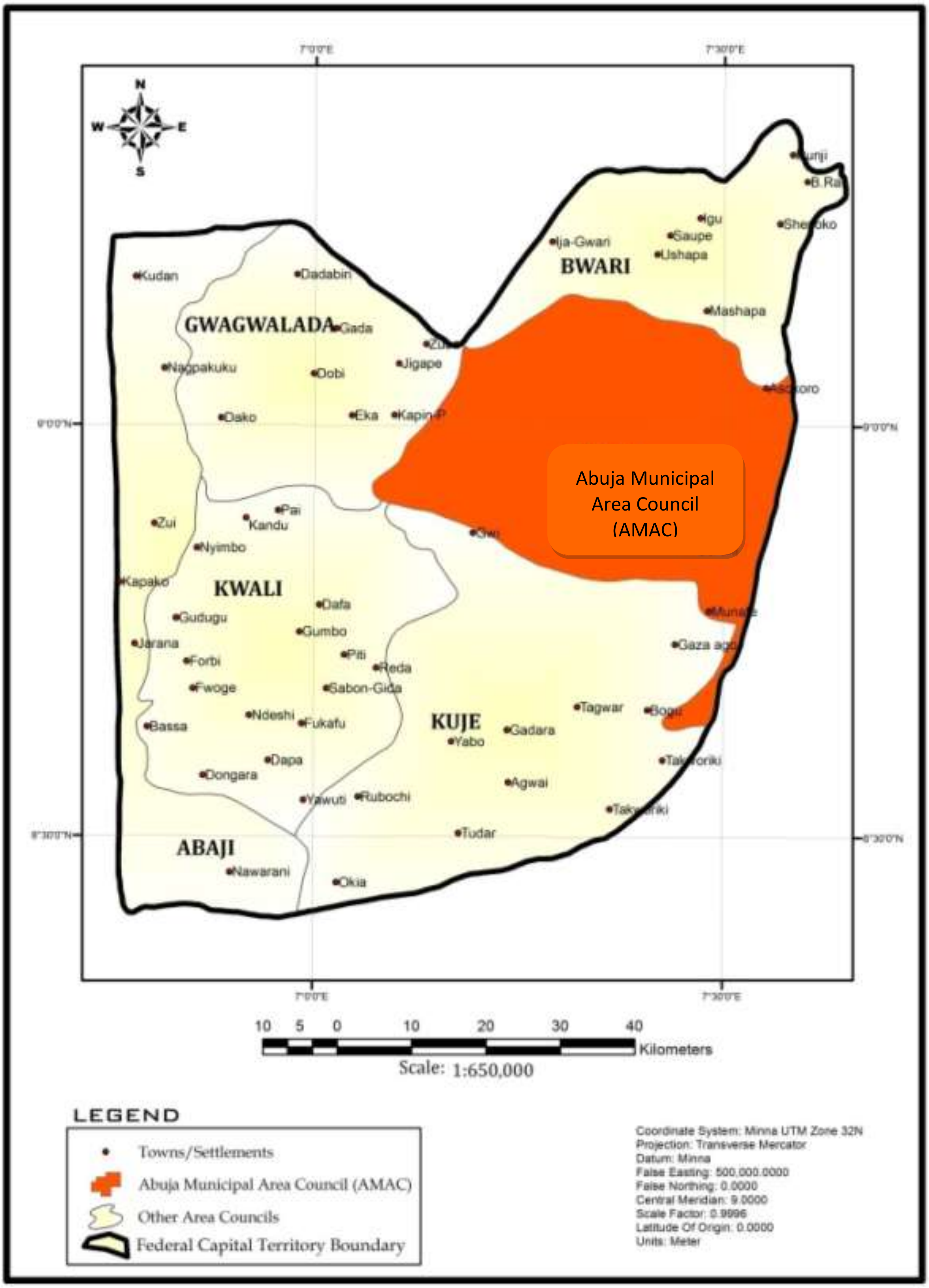


Figure 3.2:Map of Abuja showing the Area Councils of the FCT

(Source: Department of Environmental Management GIS Lab 2016)

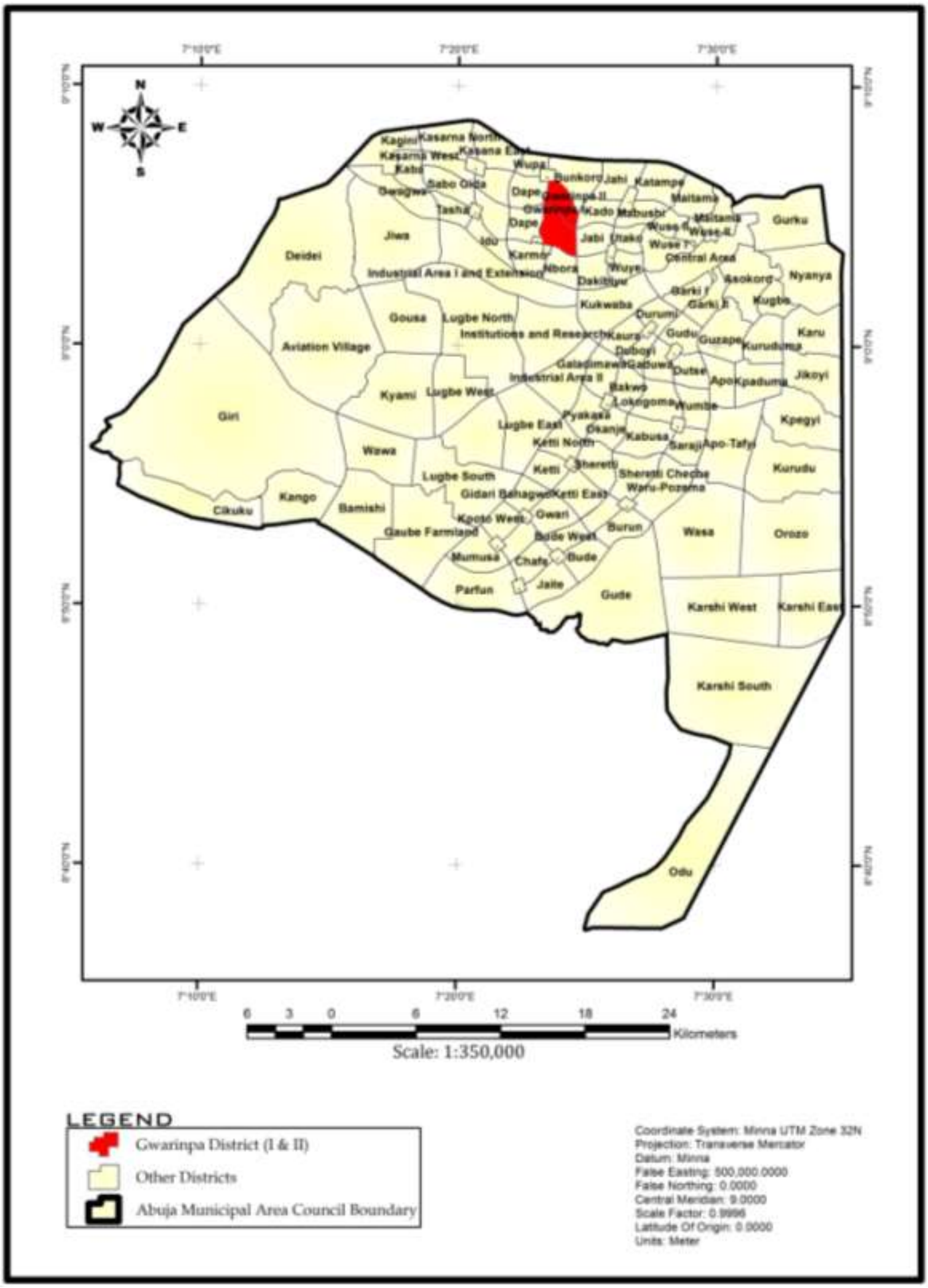


Figure 3.3:Map of FCT showing the Area Councils of the FCT

(Source: Department of Environmental Management GIS Lab 2016)

3.2Physical Characteristics

3.2.1 Physiography and Topography

The area is characterized by hills and valleys that are fairly covered by vegetation and soil, though there are several areas where the bed rock outcrops. The topography is rugged and undulating with the basement rocks outcropping as hills and inselbergs. The Gwagwa plains occurring at the west of the FCT are underlain by migmatites and gneisses, and stand about 305m in the south-west and 516m in the east above mean sea level. These plains form part of River Usumanu that originates in the Bwari-Aso hills.

3.2.2 Relief

The lowest elevation in the Federal Capital Territory (Abuja) is found in the extreme southwest where the flood plain of the river Guraja is at an elevation of about 10mabove sea level from there, the land rises irregularly eastward, northwards and north westwards. The highest part of the territory is in the northeast where there are many peaks over 760m above sea level. Hills occurs either as clusters or form long ranges.

The most prominent of these include the Gawa range in the northeast, the Guarfata range southwest of Suleja; the Bwari-Aso range in the northeast, the Idon-Kasa range north-west of Kuje and the Wuna range north of Gwagwalada. Elsewhere in the territory, there are many rather roundish isolated hills usually called ISELBERGS in between the major hills are extensive plains, the most important of which are the Gwagwa plains and the Rubochi plains. Indeed about 50% of the

Federal Capital Territory (Abuja) consists of plains. Out of these plains, the Gwagwa plain was selected for the building of the Federal Capital Territory City (F.C.T).

3.2.3 Geology

The study area is located within the Central Nigeria Precambrian Basement Complex. The geology of the area has been studied and discussed by previous workers like Oyawoye (1972), McCurry (1976) etc. They described the rocks as comprising mostly granite, gneisses, mica schists, hornblende and feldspathic schists and migmatites. The rocks are highly fractured and jointed showing essentially two fracture patterns, NE – SW and NW – SE. These fractures control the drainage and flow patterns of rivers in the area.

However, minor Cretaceous deposits of Nupe sandstones occur in the southern part of FCT between Kwali and Abaji, extending to Rubochi and the border with Nassarawa State. Similarly, metasediments have also been mapped along a general NNE-SSW direction through the west of Kusaki (in the south) and east of Takushara (in the north) (USGS 1977). Mica schists and amphibolite schists occur around Kusaki and Buze villages outside the study area.

The rocks comprise migmatites, migmatitic-gneisses, fine to medium grained gneisses, mica schist, calc-silicate rock, and amphibolite, coarse grained older granites occasionally overlain by superficial deposits that include laterites, soils and alluvium deposits. The gneisses and migmatitic gneisses formed the bedrock at the low-lying areas while the migmatites occur as very large massive and well-formed hills with the gneisses occurring as cluster of elongated hills.

The migmatite constitutes about 35% of the study area outcropping in the SW part while the migmatitic gneiss occur in the central and eastern part constituting 40% of the area. The gneisses outcropping as fine to medium grained granite gneisses in the NE part cover about13% of the surface area, while the coarse grained Older Granites are exposed in the extreme NE corner where they constitute about 6% of the area forming small-sized residual hills with rounded tops.

3.2.4. Climate

The F.C.T (Abuja) has 2 main seasons, rainy (April – October) and dry (November – March) seasons. The high altitude and undulating terrain of the territory act to provide a regulating influence on its weather. During the dry season, the typical month being March, the temperature varies between 300 ^{0}C in the north east to about 370 ^{0}C in the southwest. This period is characterized by high diurnal ranges when drops as low as 170 ^{0}C may be recorded between the highest and lowest temperature in the dry season. During the rainy season, temperature drop considerably due to dense cloud cover. The annual range also drops to around 70 ^{0}C, especially between July and August. The F.C.T records a relative humidity in the dry seasons of some 20% in the afternoon at higher elevations and at more northern locations but also 30% in the extreme south. Hence, with the kind of temperature in FCT, buildings are supposed to be plan with provision of ventilation or cooling system that will reduce the use of energy consumption, thus the need for development of initiatives for energy efficiency in building in FCT Abuja is mandatory.

Rainfall in the FCT reflects the territory‘s location on the windward side of the Jos Plateau and the zone of rising air masses. The annual total rainfall is in the range of 1100mm to 1600mm.

3.2.5. Soils and Vegetation

The soils of the Territory (Abuja) are generally shallow and sandy in November, especially on the major plains such as iku-Gurara, Roboes and Roubochi. The high sand content makes the soils to be highly erodible. The shallow depth is a reflection of the presence of strong lower horizons. Those on the famous Gwagwa plains are however deep and clayey, perhaps reflecting the influence of parent materials gabbro and fine to medium textured biotite granite.

Thus, the soils rich of the Gwagwa plains are the most fertile and productive. In addition, their being more or less from all exposed interfluves summits, makes them ideal for urban development. The F.C.T (Abuja falls within the guinea savanna vegetation zone of Nigeria.

Patches of rain forest, constituting about 7.4% of the total mass of the vegetation, however, occurs in the Gwagwa plains, especially in the gullied terrains to the south and rugged southeastern parts of the territory. Patches of the rainforest certain trees such as Antirisem Africana, Anthocleista noblis, ceiba, pentandra, cola the gigantean, celtis spp, chotorophora excels, khaya grandifondlia , terminnala superb, piptadenianum africanum, Triplochiton sceroxylon and

Dracaena arborea. The dominant vegetation of the territory is classified into 3 namely.

- Park or grassy savanna – about 53%
- Savannah woodland - about 12.85%
- Shrub savannah – occurs extensively in rough terrains close to hills and ridges in all parts of the territory and covers about 12.9% of the total area.

3.2.6. Hydrogeology and Surface Drainage

The water resources of the area comprise both the surface and groundwater sources including thestreams and rivers that occur in the sloppy terrains in the south. Lower Usumanu and Jabi dams which supply water to the Federal Capital Territory, Abuja are located in the area.

Drainage

The drainage pattern generally varies from trellis to dendritic. The area is drained by many rivers in and around Abuja including Rivers Gwagwalada and Usmanu while Rivers Wupa, Wosika and other smaller seasonal southerly-flowing streams form the tributaries and drain the study area. These rivers depend on rainfall for their recharge. As such, their stages are high in rainy season and decrease appreciably in the dry season.

The groundwater component of the water resources of the area are contained in the aquifers and basement rocks. Hydro geologically, two types of aquifers are recognized namely, the regolith or weathered basement aquifers and the fractured zone aquifers. Therefore geology and climate are the limiting factors of groundwater occurrence in hard rocks. Fortunately there exists in the area a thick loose and discontinuous blanket of decayed and decaying rock debris (regolith). A combination of thick regolith and high rainfall and favourable temperature pattern in the FCT offers a conducive condition for occurrence of groundwater. The decayed/decaying and fresh rock fragments lie on top of, below and adjacent one another in an irregular manner creating intergranular spaces between rock fragments lying together. Precipitation introduces water into the regolith through the usually numerous pore spaces. The regolith therefore acts as a storage medium for water from rainfall and can also transmit water vertically and horizontally to underlying rocks. If the underlying bed rock has high fracture density, regolith can serve to transmit water to underlying bedrock storage sites.

The occurrence of the groundwater is a function of the overburden thickness, the type, composition and texture of rock fragments that constitute the overburden and the degree density and interconnections of the fractures. The overburden aquifers occur extensively and receive recharge directly from rainfall. Some measure of artificial recharge come from the Lower Usumanu and Jabi dams. Villagers extract the groundwater from the overburden through hand-dug wells. Most of the boreholes are located on the overburden aquifer and have shown the depths to bedrock to vary from 0m (where the bedrock outcrops) to about 73m with an average of 30m. The direction of groundwater flow is generally downhill converging in the valleys and river channels.

Depths to water table vary from place to place with the water level rising during the rainy season and falling during the dry season resulting in seasonal fluctuation in the actual volume of water in storage

3.3 Human Characteristics

3.3.1 Population

The FCT is made up of six area councils and the Federal Capital City, with a population of about 1,406,239 (NPC, 2010).

3.3.2 Settlement Patterns and Economic Activities

3.3.2.1 Central District

Abuja's Central District is located between the foot of Aso Rock and into the Three Arms Zone to the southern base of the ring road. It is like the city's spinal cord, dividing it into the northern sector with Maitama and Wuse, and the southern sector with Garki and Asokoro. While each district has its own clearly demarcated commercial and residential sectors, the Central District is the city's principal Business Zone, where practically all parastatals and multinational corporations have their offices located. An attractive area in the Central District is the region known as the Three Arms Zone, so called because it houses the administrative offices of the executive, legislative and judicial arms of the Federal Government. A few of the other sites worth seeing in the area are the Federal Secretariats alongside Shehu Shagari Way, Aso Hill, the Abuja Plant Nursery, Eagle Square (which has important historic significance, as it was in this grounds that the present democratic dispensation had its origin in May 29, 1999) and the Tomb of the Unknown Soldier across the road facing it. The National Mosque and National Church of Nigeria are located opposite each other on either side of Independence Avenue. A well-known government office is the Ministry of Defense, popularly nicknamed "Ship House"

3.3.2.2 Wuse District

Wuse District is the northwestern part of the city, with the Maitama District to its north and the Central District to its south. The District is numbered Zones 1-8. The Wuse Market is Abuja's principal market (Zone 5). The second most important Post Office in the city is located here. This district also houses the Sheraton Hotel and Towers (Zone 4), Ibro International hotel, the Foreign Affairs Ministry Headquarters (Zone 1) and Nigerian Customs Services Headquarters, Corporate Affairs Commission (Zone 5), Federal Road Safety Commission (FRSC), National Agency for Food and Drugs Administration (NAFDAC) (Zone 7), Wuse General Hospital, and the Nigerian Tourism Development Corporation. Just as Garki District has Garki II, Wuse has Wuse II. This is distinct from Wuse Zone 2

3.3.2.3 Maitama District

Maitama District is to the north of the city, with the Wuse and Central Districts lying to its southwest and southeast respectively. This area is home to the top bracket sections of society and business, and has the reputation of being very exclusive and very expensive. Interesting buildings include the Transcorp Hilton Hotel, National Communications Commission Headquarters (NCC), National Universities Commission (NUC), Soil Conservation Complex, and Independent National Electoral Commission (INEC). The British High Commission is located along Aguiyi Ironsi Way, in Maitama. Also, the Maitama District Hospital is another notable building in Maitama. Maitama District is home to many of the European embassies in Nigeria.

3.3.3.4 Asokoro District

Asokoro District, the doyen of all the districts, houses all of the state's lodges/guest houses. The ECOWAS secretariat is a focal point of interest. Asokoro is located to the east of Garki district and south of Central district. It is one of the most exclusive districts of Abuja and houses virtually all of the federal cabinet ministers; in addition, the Presidential Palace (Aso Rock) is located in Asokoro district. By virtue of this fact, Asokoro is the most secured area of the city.

3.3.3.5 Gwarimpa District

Gwarimpa is the last district located in the Abuja Municipal Area Council. It is a 20 kilometer drive from the central district area of the city and contains the largest single housing estate in Nigeria, called the Gwarimpa Housing Estate. The Estate was built by the Administration of General Sani Abacha and is the largest of its kind in Africa. It provides residence for the majority of the civil servants in Federal Ministries and government parastatals. The ECOWAS Court has an official quarter for the President and Members of the Court in Gwarimpa.

Gwarinpa is mainly a residential area though recently some businesses especially service oriented businesses like banks and eateries are springing up very rapidly. Most of these businesses are located on the three major roads in Gwarinpa. The roads are 1st avenue, 2nd avenue and 3rd Avenue.

Within Gwarinpa Estate there are also some small estates. These include Federal ministry of works and housing Estate, War College Estate, FHA Estate, Citec villas, Abuja Model City etc.

3.4 Area of Study

This research focuses on hotel and public buildings, which is one type of large-scale public/commercial building. Gwarimpa District was selected among the five districts in FCT in order to accomplish the framework of this study. This area is home to the top bracket sections of society and business, and has the reputation of being very exclusive and very expensive, while Gwarimpa district contains the largest single housing estate in Nigeria. This area was selected due to high population of hotels and residential building in the area which contain a lot of electrical devices that consumes energy.

Plate3.1: Sample of Residential Building in Gwarinpa Housing Estate
Source: Researchers Field Work (2016)

Plate 3.2: Sample of Residential Buildings with Heavy Energy Appliances in Gwarinpa Housing Estate
Source: Researchers Field Work (2016)

Plate 3.3: Sample of Modern Hotels with Heavy Energy Usage in Gwarinpa Housing Estate
Source: Researchers Field Work (2016)

Plate 3.4: Sample of Hotels in Gwarinpa Housing Estate
Source: Researchers Field Work (2016)

CHAPTER FOUR

RESEARCH METHODOLOGY

This chapter described the techniques that were adopted in data acquisition, presentation and analysis in this research. The chapter consists of research design, data need, source of data, the study area, sampling size and techniques, research instruments, validity/reliability of research instrument, method of data collection, method of data analysis and presentation.

4.1 Research Design

The type of research design applied for this study is descriptive survey design. According to Ezejelue, Ogwo, and Nkamele (2008), descriptive survey research design describes a method of gathering data from usually a large number of respondents, who themselves constitutes the sample.

This research has combined aspects of both 'exploratory' and 'descriptive' approach. It was exploratory in that it sought to establish the existing practices of energy efficiency in building control regulations. It was descriptive by describing and categorizing the various energy efficiency measures being initiated by the local authorities through their building control regulations as Financial/Economical, Behavioural, or Legal among others.

4.2 Data Need

The data needs for this research are informed by the research objectives and hypotheses. They include information on the following:

1) Data on sustainable energy efficiency strategies for retrofitting buildings in FCT Abuja
2) Data on the basic principles/strategies in achieving energy efficiency in buildings and offsetting cost?
3) Data on the factors militating on energy efficiency in building in FCT Abuja
4) Data on sustainable approach that can be adopted towards developing energy efficiency in buildings and offsetting greenhouse gases in FCT?

4.3 Source of Data

The data used in this study was sourced from two types, namely

i primary source and

ii secondary data

4.3.1. Primary Source

The primary data include all the data that were collected by the researcher through field observation, oral interview and the administering of well-structured questionnaires. The questionnaire was structured in two sections, A and B. Section A is the bio data of the respondents while section B is structured on open ended questions (yes and no) and five point scale with the following response options; Strongly Agreed (SA), Agreed (A), Undecided (UD), Strongly Disagreed (SD) and Disagreed (D). Other information obtained from primary source for this study include; interview, simulation of some of the office building to be studies and Visual survey. In this research, interviews were conducted with urban and regional planners, local government departments, practicing professionals and residents of Gwarimpa Housing Estate Abuja.

4.3.2. Secondary Source

Secondary data was obtained through the review of published and unpublished literature, journal materials, seminars, textbooks, magazine, published statistics and synopsis as well as internet exploration.

4.4 The Study Population

The populations of the study comprise of the residents of the five (5) districts in FCT, Abuja. Abuja had a population of 776,298. The five districts are Central District, Wuse District, Maitama District, Asokoro District and Gwarimpa District. Also included in the study are the practicing professionals from the following groups of respondents: Ten (10) Building Controls and Approvals Officials (BCAOs) from Federal Housing Authority (FHA) located at Gwarinpa in FCT, ten (10) Key Professional Practitioners (KPPs) of National Planning Commission (NPC) and sixteen (16) participants from Energy Savings Company's (ESCOs) involved with policy issues for energy efficiency in the built environment (Construction specialist on hotel buildings).

4.5 Sampling Size and Techniques

Sampling is defined as the selection of a part of a whole population for a study; unlike a census, which is the study of the whole population (O'Leary 2004). In this particular research, the population being studied includes the residents of the housing estate in Gwarinpa, the building control regulations departments of the metropolis of FCT.

The key stakeholders were the professionals submitting their plans on their clients' behalf, the metropolis officials involved in the evaluation and approval process and participants from Energy Savings Company's (ESCOs) involved with policy issues for energy efficiency in the built environment.

This research employed both random sampling techniques and non-random sampling techniques (purposive). Non-random/non probability sampling is identified as including handpicked, snowball, voluntary and convenience sampling. In the selection of the district for the research, convenience sampling was the main method considering the time and financial implications involved. Convenience sampling was employed in selecting residents of Gwarinpa housing estate due to the fact that it is the largest housing estate in West Africa and all types of buildings are found here hotels inclusive (Akingbade, Navarra, Zevenbergen & Georgiadou, 2012). Whereas sometimes non probability sampling is dismissed, this research was also based on a case selection with representativeness in mind and therefore the non-random samples credibly represented the population (O'Leary 2004).

Two hotels in Gwarinpa housing estate was purposively selected for the study. The selection of ten Building Controls and Approvals Officials (BCAOs) from Federal Housing Authority (FHA) and ten Key Professional Practitioners (KPPs) from National Planning Commission (NPC)for participation in the research was based on the snowball sampling method. Sixteen participants from Energy Savings in Building Constructing Company's (ESBCOs) were handpicked to participate in the research because of their known and valued contribution to the implementation of energy efficiency measures in the built environment in FCT, Abuja, making a total of thirty six (36) officials.

It must be emphasized that representativeness was maintained in this research despite the use of non-random sampling methods. This was achieved by giving the results of the interrogations from the district an equal weighting; this ensured uniformity, consistency and eliminated the possibility of sampling bias. The inclusion of KPPs and ESCOs ensured diversity and enabled the capture of additional information outside the local authorities.

The random sampling techniques was used to determine the household to be sampled. The housing estate in Gwarinpa is estimated to be over 5000 buildings obtained from Federal Housing Authority (FHA) (2016).

The entire population of the housing estate in Gwarinpa was considered for sampling. Since the population of the study is finite (total number of population is known = 5000) the researcher made use of Taro Yameni's formula to arrive at sample size of three hundred and seventy (370) respondents.

The formula is stated as:

$$S = \frac{N}{1 + Ne^2}$$

Where:

S = Sample size

N = Number of population

e = error terms (5%)

Therefore $S = \frac{5000}{1 + 5000(0.5)^2}$

$$S = \frac{2000}{1 + 5000(0.0025)}$$

$$S = \frac{5000}{1 + 12.5}$$

$$S = \frac{5000}{13.5}$$

$$S = 370.4$$

S = 370 approximately

4.6 Research Instruments

The tools or instrument of data collection to be used are;

i. Questionnaire

ii. Interview

4.6.1 Questionnaire

Questionnaire is described as an information gathering tool which to a large extent is self-administered and which have the advantage of being less susceptible to bias as interviewer effects and deviations from the instructions are eliminated. Questionnaires were used because they have several advantages. These included; their relatively low cost of administration as they required less supervision of the participants, they reduced the chances of bias and they provided greater confidentiality and anonymity (Pedhazur & Schmelkin, 2007).

Since this research was limited in resources (time), in addition to the need to protect the confidentiality of information sources, it was appropriate to use questionnaires for gathering data. The questionnaires were used to investigate the four key areas which were developed to answer the four research questions.

4.6.2 Interview

Interviewing is defined as the act of collection or gathering information for research purposes via verbal interaction or conversation (Punch, 2005). Types of interviews are; individual-face to face, group-face to face, or telephone interviews on one hand and structured, semi-structured or unstructured interviews on the other. The main type of interview option that was used in this research is presented below.

The researcher adopted Kitzinger (2004) approach, he combined the advantages of structured and unstructured interviews to allow for a deeper and lengthy probe into organizational and institutional procedures as was required in this research. This was appropriate because the interview respondents were chosen on the basis of their good experience and expert knowledge in implementing building control regulations and/or being leading participants in energy efficiency building practices. Their information was used to gain deeper insight into the subject matter from an expert's perspective and to triangulate and compliment the information from field questionnaire. Additionally, this enabled the research to capture spontaneous information not restricted to a specific set of answers as would be with structured interviews.

The interview guideline outlined four (4) broad areas derived from the four sub-questions of the research for discussion which the interviewer relied on to get information from the respondents. Only one interview guideline was used for all the different categories of the respondents. Multiple respondents were interviewed for the research. This had the effect of increasing information and broadening the point of view of the entire research (Newcomb, 2009). The interviews were conducted with section heads/chief officers of the groups named in this chapter.

The interviews were conducted with ten (10) section heads of building control departments in Gwarinpa, FCT. Ten (10) key members of the KPPs group and sixteen (16) chief officers from the ESBCOs group were also interviewed.

4.7 Validity/Reliability of Research Instrument

The administration of a standardized questionnaire and interview guideline by the researcher limited potential observer bias. Additionally, the researcher was readily available to explain the required level of evidence for each criterion. This is because the researcher administered the questionnaire and conducted the interviews personally.

The use of multiple sources of evidence specifically document review, interviews, and questionnaire entrenched the construct validity and reliability in the research and ensured triangulation of findings and complementary of information. This eventually led to a high level of accuracy. This is referred to as convergence of lines of inquiry. The use of multiple sources of evidence of similar phenomenon under study in equal measure adequately addressed the ‘construct validity’ issues. The development of case distinctive databases using case study notes (which were prepared during the field study), narratives (which were taken from interviews) and case study documents ensured that reliability concerns were addressed.

4.8 Method of Data Collection

The researcher and three research assistants guided the respondents through the questionnaires. The participants were allowed up to one week to complete the questionnaires. Three hundred and seventy (370) copies of questionnaires were distributed to residents of Gwarinpa Housing Estate and 300 was dully filled and returned. The covering letter for the questionnaires clearly indicated the time frame for completing them and the procedure for returning.

Furthermore, thirty six (36) copies of questionnaires was distributed to key representatives of the building control function in the local authorities and key participants in energy efficiency programmes for buildings in FCT, Abuja, and thirty six (36)of the questionnaires were dully filled and collected.

Data on hotels was collected mostly from the Sixteen (16) participants from Energy Savings in Building Constructing Company’s (ESBCOs) who are specialist in hotels construction in order to assist in the delivery of a sustainable energy efficiency office and with high rating of energy performance. The research approach was conducted in order to check the effectiveness of energy efficient measures or strategies that had been applied to achieve energy efficiency in existing office buildings especially in hotels due to the fact that they run a 24 hour business with steady electrical appliances. Two hotels were purposively selected for the study.

4.9 Method of Data Analysis and Presentation

The data collected for the study was analyzed using frequency tables, mean, standard deviation, bar chart, factor and principal component analysis, correlation and student's t-test. Frequency tables were used to analyze the demography of the respondents, while mean and standard deviation were used to answer the four research questions. Any item with the mean value of 3.0 and above was considered as Agree, while any item with the mean value that is less than 3.0 was considered as Disagree. The four null hypotheses were tested using statistical tools such as factor and principal component analysis, correlation and student's t-test at 0.05 level of significance (the computation was done with SPSS 22 package).

Any item where the calculated significance value is greater than 0.05, the hypotheses of no significance different was up-held at probability of 0.05 level of significance, but where the calculated significance value is less or equal to 0.05, the hypotheses of no significance difference was rejected at 0.05 level of significance.

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS

5.1 Data Presentation

This chapter involves the presentation of data collected through the various instruments of data collection as well as analysis of the data collected.

5.1.1Socio-demographic Characteristics of the Respondents from Gwarinpa Housing Estate

Table 5.1 Sex

Items	Frequency (n=300)	Percentage (%)
Male	177	59
Female	123	41

Source: Field questionnaire survey (2016)

Table 5.1 clearly shows that 177(59%) of the respondents are males while 123(41%) are females. The table shows that occupants of Gwarinpa Housing Estate who participated in the study were mostly males (59%).

Table 5.2: Age

Age	Frequency (n=300)	Percentage (%) (100)
30-40	70	23
41-50	105	35
51-and above	125	42

Source: Field questionnaire survey (2016)

Table 5.2 shows that 23% of the respondents are between ages 30-40, 35% are between the ages of 41-50, while 42% are 51 years and above. The above implied that between 51 years and above constitute the major age of occupants living in the study area.

Table 5.3: Marital Status

Marital status	Frequency (n=300)	Frequency (%)
Single	107	36
Married	178	59
Divorced	5	2
Widowed	10	3

Field questionnaire survey(2016)

Table 5.3 shows that, 36% of the respondents are singles, 59% are married, 2% are divorced, while 3% are widowed. Here majority of the occupants are married.

Table 5.4: Educational Attainment

Educational Attainment	Frequency (n=300)	Frequency (%)
O-Level	83	28
NCE/OND	76	25
No formal education	18	6
HND/ BSc and above	123	41

Field questionnaire survey (2016)

Table 5.4 shows that 28% of the respondents holds either WASC/NECO/GCE, 25% were NCE/OND holders, 6% have no formal education while 41% had HND/B.Sc. and above. These imply that majority of the respondents have formal education, they are literate and are conversant with the study.

5.1.2 Socio-Demographic Characteristics of the Officials

Out of the 36 respondents, 50 percent of the respondents had experience of between 5 to 10 years of working with building regulations, 25 percent of respondents indicated an experience of between 10 to 15 years, while the remaining 25 percent had over 15 years’ experience in dealing with building regulations in the building development processes (figure 5.1).

5.1.2 Socio-Demographic Characteristics of the Officials

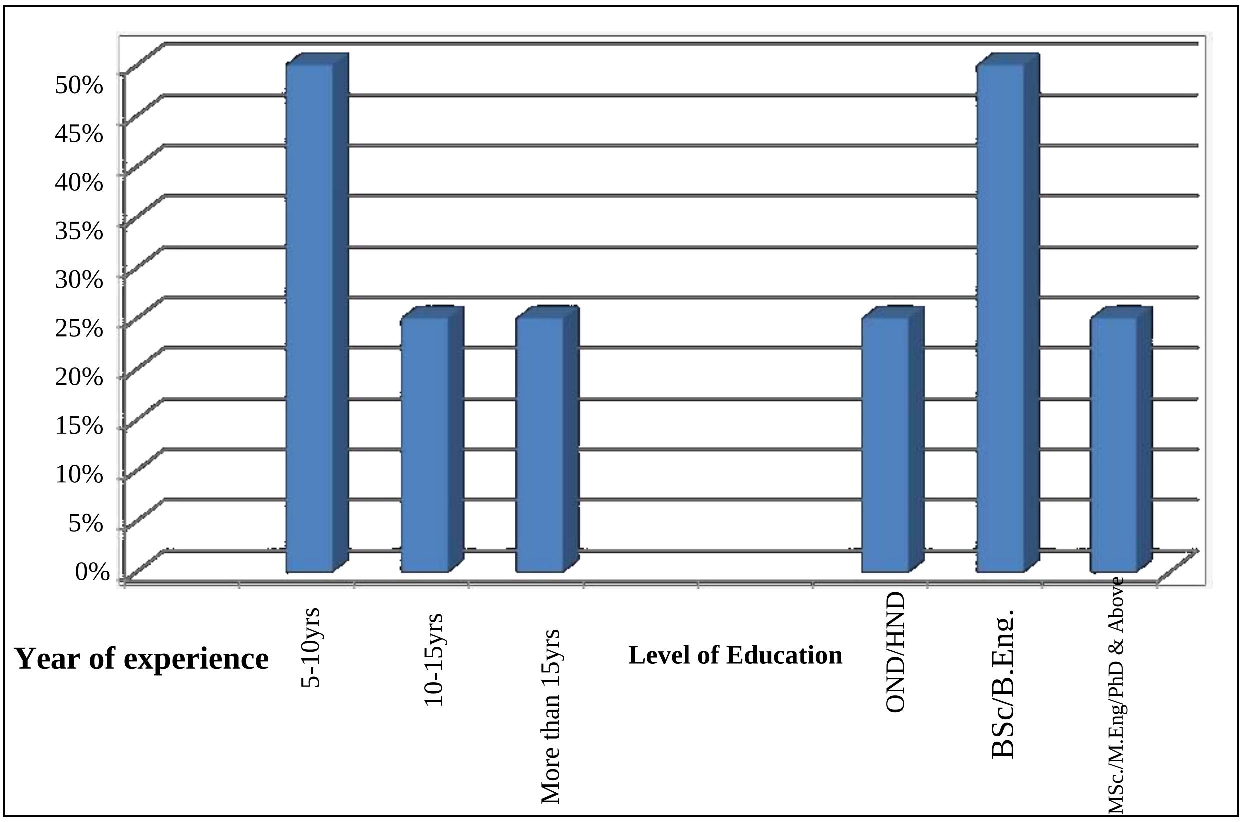


Figure 5.1 Experience and Educational Level of officials
Source: Author's work (2016)

In terms of educational background, among the 36 respondents, 50 percent of the respondents had B.Sc./B.Eng. as their higher qualification, 25 percent of respondents had OND/HND while 25% of the respondents had MSc/Men/PhD as their higher qualification (figure 5.1).

5.1.3 Presentation and Analysis of the Substantive Data

5.2 Basic Principles in Achieving Energy Efficiency for Sustainable Built Environment in FCT

Table 5.5: Officials' Responses on basic principles in developing energy efficiency approaches towards sustainable built environment in FCT

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Remark
1	Reduce heating, cooling and lighting loads.	9	21	3	3	0	4.0	0.828	Accept
2	Utilize active solar energy and other environmental heat sources and sinks.	13	16	5	2	0	4.1	0.854	Accept
3	Increase the efficiency of appliances, heating and cooling equipment and ventilation.	15	11	0	8	2	3.8	1.348	Accept
4	Consider building form, orientation and other related attributes.	16	12	1	4	3	3.9	1.308	Accept
5	Utilize system approaches to building design strategy	9	9	2	5	11	3.0	1.639	Accept
6	Sitting and organizing the building configuration and massing to reduce loads	11	15	0	8	2	3.7	1.283	Accept
7	Reducing cooling loads by eliminating undesirable solar heat gain.	10	18	0	6	2	3.8	1.198	Accept
8	Reducing heating loads by using desirable solar heat gain.	14	15	2	1	4	3.9	1.264	Accept
9	Using more efficient and cooling equipment to reduce loads.	19	9	2	3	3	4.1	1.308	Accept
	Cluster mean & Std.						**3.8**	**1.226**	**Accept**

***Source**: Field Survey, 2016*

The descriptive results above showed that the nine (9) suggested items with mean values ranging from 3.0 – 4.1 were all accepted as basic principles for developing energy efficiency for a sustainable built environment in FCT Abuja. This is also confirmed by the cluster mean of 3.8 > 3.0 (baseline) and associated standard deviation of 1.226 < 1.581 (baseline) respectively. Particularly, the results showed that the major principles in achieving energy efficiency and sustainable buildings in the area are utilization of active solar energy towards other environmental heat sources and sinks, and use of more efficient and cooling equipment to reduce energy loads. Based on descriptive evaluation, the researcher could not take a relevant statistical decision; a higher inferential statistics (Principal Component Analysis) was performed to confirm the major principle among the listed principles in achieving energy efficiency for a sustainable built environment in FCT, Abuja. The results are presented in Appendix IV.

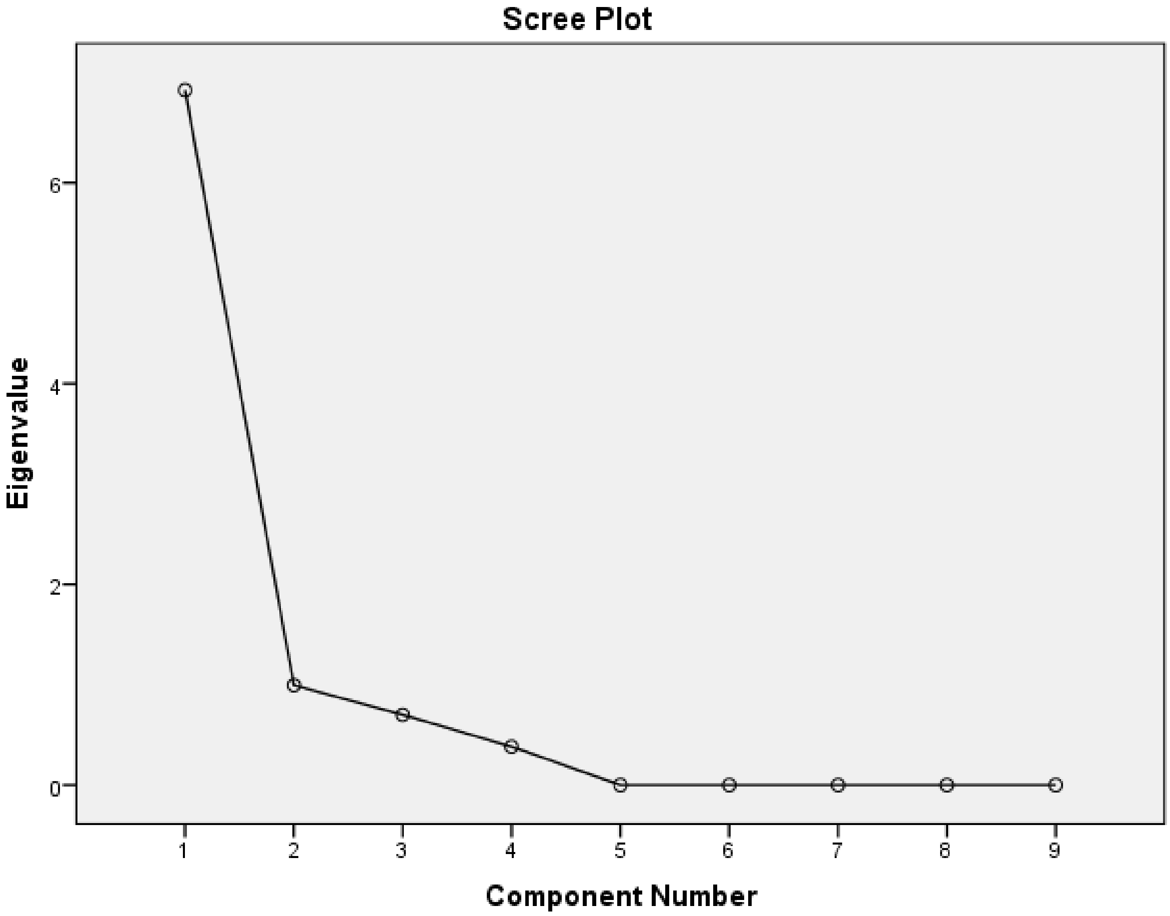


Fig. 5.2: Scree Plot of the outlined Basic Principles in Achieving Energy Efficiency and Sustainable Buildings in FCT, Abuja.

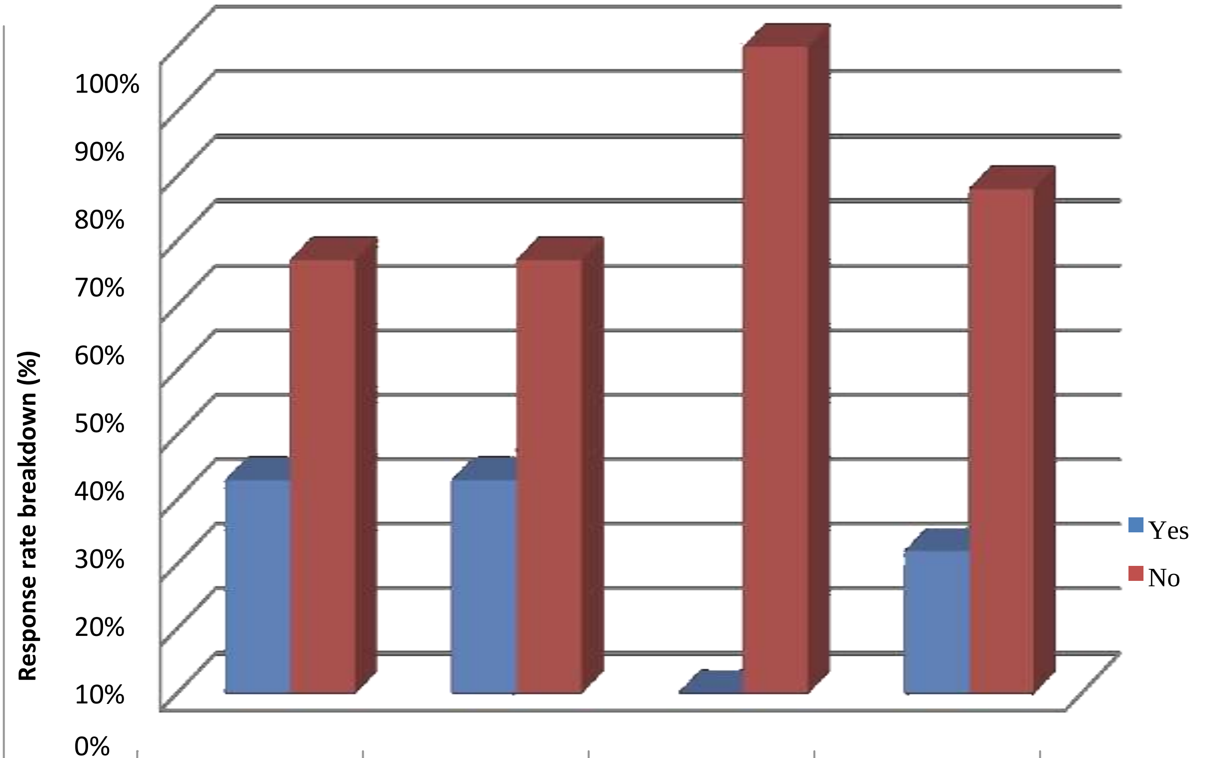
Source: Author's Computation Using SPSS 22

The scree plot result shows a level-off after extracting the first component. This implies that only one principle is important in achieving energy efficiency towards sustainable built environment in FCT, Abuja.

5.2.1 Requirement for Energy Efficiency Principles/Initiatives in Building Control Regulations

According to figure 5.3, 78% of the officials stated that energy efficiency initiatives are not legally required in the current building regulations. In terms of breakdown: of this, 100% of BCAOs and 75% each of KPPs and ESCOs indicated the lack of energy efficiency principles in the current building regulations.

However, nearly 61% of the participants were aware of the energy efficiency building guidelines issued by the key local authorities in the study area. The building designers and developers in the respective jurisdictions are actively encouraged to incorporate the above energy efficiency guidelines in designs and building plans for building control approvals-though voluntarily.



	KPPS	ESCOs	BCAOs	Overall (%)
Yes	33%	33%	0%	22%
No	67%	67%	100%	78%

Figure 5.3 Requirement of Energy Efficiency Principles in Building Control Regulations
Source: Author‘s Administered Questionnaire (2016)

The awareness of the energy efficiency issues was exhibited by their knowledge of the contents of the energy efficiency design and construction guidelines issued by the Federal Capital Territory and the application of the star rating tool for buildings being implemented by the participants from Energy Savings Company’s (ESCOs) among other ongoing energy efficiency activities in buildings. They also added that this awareness had been gained through industry arranged forums like workshops and conferences/exhibitions. Many of these forums had been arranged by ESCOs and occasionally in collaboration with government departments. The 22% who believed that there was a legal requirement, mostly from either KPPs or ESCOs cited sections of the National Building Code (2006) requirements and the energy efficiency building guidelines issued by the various local authorities as giving a legal basis for energy efficient building principles. Furthermore, 100% ESCOs and nearly 60% KPPs claimed collaborative efforts within themselves which had created voluntary energy efficiency building standards which their respective members were required to follow when executing building developments. They mentioned the Green Star building rating system being implemented by the ESCOs members as one such effort.

5.2.2 Implementable Energy Efficiency Initiatives through Building Control Regulations

In Fig 5.4, all the officials stated that there were many possibilities to implement a number of energy efficiency initiatives in new and existing stock of buildings through the building control & approvals mechanism. They listed such aspects as orientation of the building, lighting, HVAC and other mechanical systems, Insulation and landscaping among others as being clear areas which hold a large potential for energy savings.

For example, 74% of the participants stated that nearly 98% energy savings could be achieved via a change in buildings lighting system regulations (Figure 5.4). Other responses were that up to 67% savings in energy consumption could be achieved through the change of water heating building regulations in residential buildings by the introduction of solar (and other alternative/renewable) energy appliances. 65% of the participants saw an opportunity for significant energy saving in change of specifications for installed equipment in buildings, both domestic and commercial, from the current ones to an energy rating standard. Nearly 76% of the participants saw a huge potential for energy savings in retrofits and refurbishments if energy efficiency principles were to be introduced in building control & approvals regulations.

In so far as the point of introduction of the energy efficiency measures is concerned; the common statement among the respondents was that many of the above stated measures be introduced at the design approval stage and be checked alongside the other requirements in the building control standards until the completion and occupation of the development. A few officials respondents from the KPPs and ESCOs groups stated that the energy efficiency measures be introduced at the design approval stage and then be confirmed during the operation of the building.

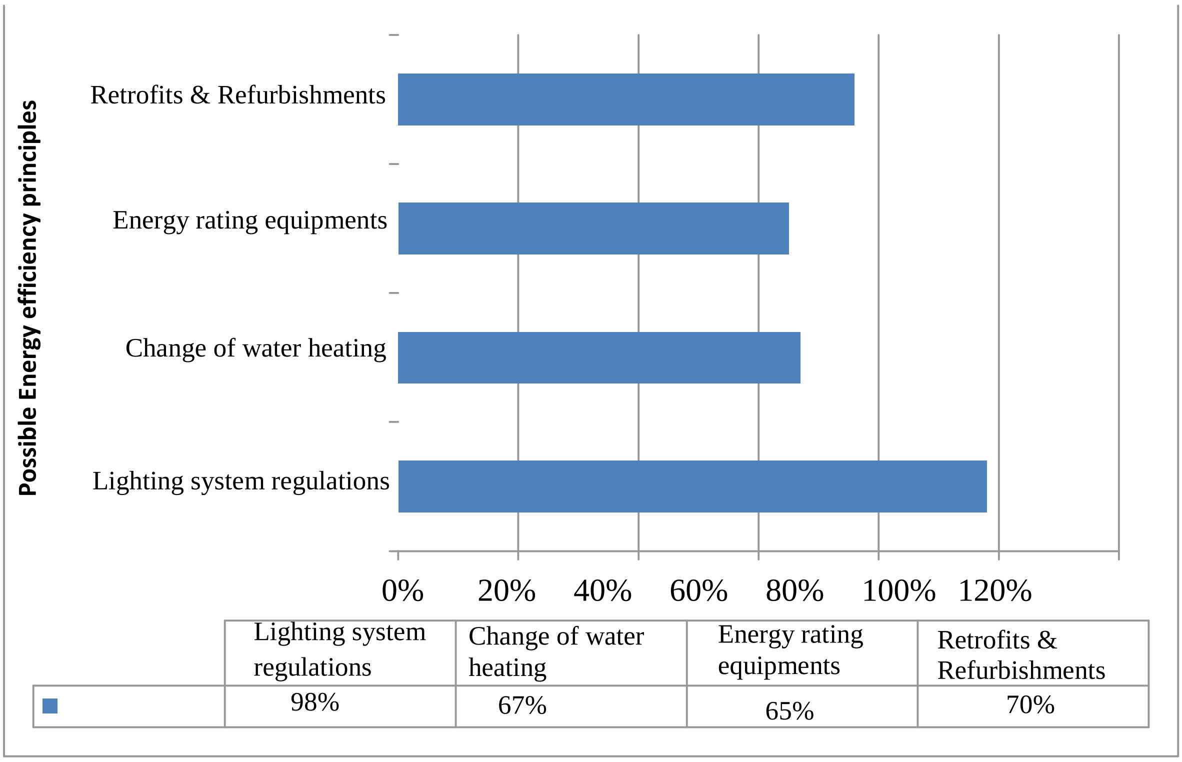


Figure 5.4 Possible implementable EE initiatives through building control regulations

Source: Author's administered questionnaire (2016)

5.3: Sustainable Practices and Energy Efficiency Strategies in Buildings in the Study Area

Table 5.6: Officials' responses on sustainable practices and energy efficiency strategies in building in FCT, Abuja

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Decision
1	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices	9	18	6	3	0	3.9	0.874	Accept
2	Replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, facades and windows	15	12	7	1	1	4.0	0.996	Accept
3	Assess occupancy patterns, and then apply daylight heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable.	13	8	10	5	0	3.8	1.091	Accept
4	Re-commission all energy and water systems to verify if they are functioning at optimum performance; then renovate energy and water systems to minimize consumption	16	8	5	3	4	3.8	1.390	Accept
5	Insulating a home such as installing or replacing high voltage bulbs with compact fluorescent lights	17	11	3	5	0	4.1	1.063	Accept
6	Installation of a cool or green roof surface that shade against solar radiation	12	13	5	5	1	3.8	1.134	Accept
7	Installation of solar energy devices to supplement other power sources	11	17	3	5	0	3.9	0.984	Accept
8	More VAC-VCR system instead of split units and planting of trees around the building to assist in cooling of the environment and sun shedding	9	19	3	3	2	3.8	1.082	Accept
	Cluster Mean						**3.9**	**1.077**	**Accept**
t-stat. = 22.29; p = 0.0000									

Source: *Field Survey, (2016)*

From the results above, it is ascertained that the outlined are sustainable practice and energy efficiency strategies in building in FCT Abuja. Considering their mean scores and standard deviations which ranges from 3.8 – 4.1 and 0.874 – 1.390 respectively, insulating a home such as installing or replacing high voltage bulbs with compact fluorescent lights is the major sustainable practice with a mean score of 4.1 and associated standard deviation of 1.063. This is followed by replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, facades and windows. Other relevant sustainable practices are installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices, installation of solar energy devices to supplement other power sources, among others.

Table 5.7: Opinions of residents of Gwarimpa on the sustainable practices and energy efficiency strategies in buildings in FCT, Abuja

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Decision
1	Putting off electrical appliances when not in use to reduce cost.	107	136	31	15	11	4.0	0.996	Accept
2	More VAC-VCR system instead of split units and planting of trees around the building to assist in cooling of the environment and sun shedding.	111	102	68	17	2	4.0	0.941	Accept
3	Mounting of solar energy devices.	138	142	18	2	0	4.4	0.631	Accept
4	Insulating a home such as installing or replacing high voltage bulbs with compact fluorescent lights.	67	104	98	12	19	3.6	1.070	Accept
5	Replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, facades and windows.	57	76	68	71	28	3.2	1.259	Accept
6	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices	49	83	75	65	28	3.2	1.219	Accept
	Cluster Mean						**3.7**	**1.019**	**Accept**
t-stat. = 3.71; p = 0.014									

***Source**: Field Survey, (2016)*

From the results above, the researcher accepts the six items outlined as the sustainable practices and energy efficiency strategies in buildings in FCT, Abuja. The weight of this result was ascertained using one-sample student's t-test indicating that the outlisted with t-statistic value of 3.71 and associated probability value of 0.014 < 0.05 contribute significantly in achieving overall development of initiatives for energy efficiency buildings in FCT, Abuja. Particularly, from the residents' opinions, the researcher discovered that the key strategy for retrofitting buildings in FCT, Abuja is by mounting the solar energy devices, launching of VAC-VCR system instead of split units air conditioners and planting of trees around the buildings to assist in cooling of the environment and sun shedding, and putting off electrical appliances when not in use to reduce energy consumption and cost.

5.3.1 The Importance of Sustainable Energy Efficiency Strategies for Retrofitting of Buildings in FCT Abuja

In terms of the importance of energy efficiency initiatives in the building development process, the majority (100%) of the participants agreed that retrofitting of building is important (see figure 5.5). All participants from ESCOs and KPPs supported this finding while only 50% of the BCAOs were in agreement.

The following reasons were cited as to why sustainable energy efficiency strategies in the building development process were deemed important and are listed below (authors' interview of urban and regional planners, local government departments, practicing professionals):

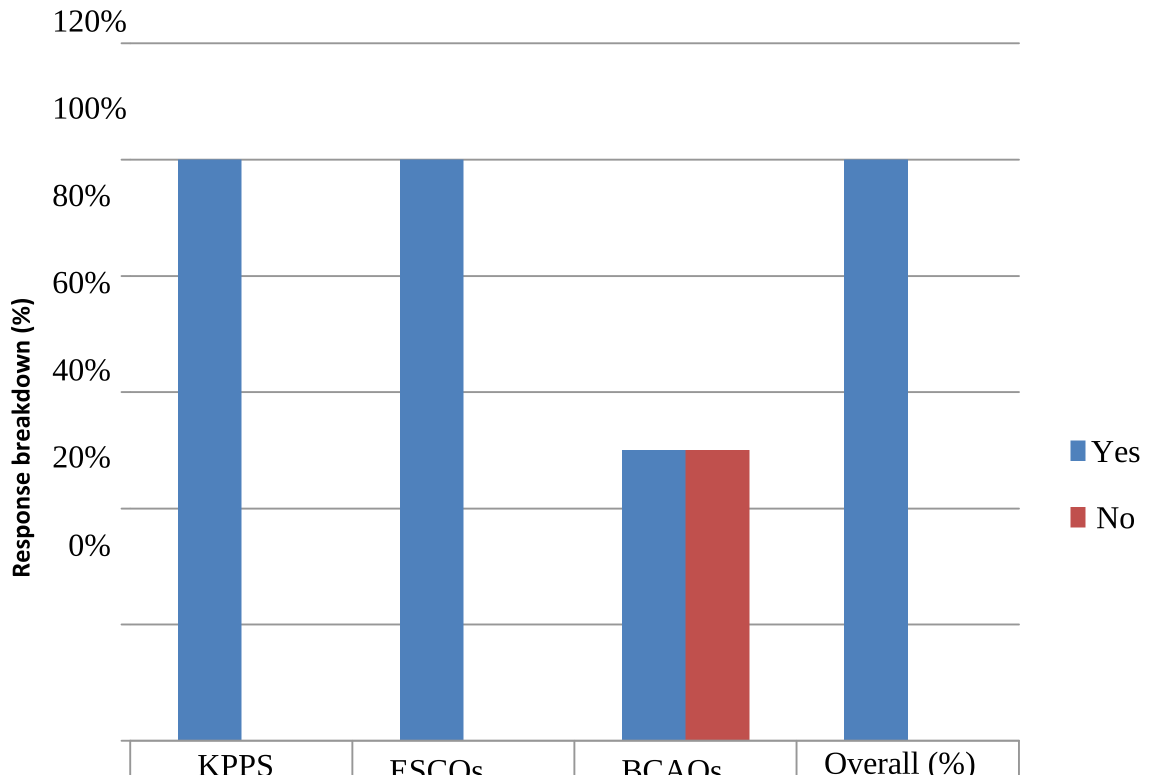
1. Escalating costs of electrical energy (70%),

2. Irregular energy supply crisis (68%),

3. Conservation/Environment (58%), and

4. As a preparation for anticipated regulatory requirement (55%) among others.

The other 50% of the BCAOs in disagreement about the importance of energy efficiency principles in the building development process cited lack of legal requirement as the reason for not considering energy efficiency initiatives important in the building process.



	KPPS	ESCOs	BCAOs	Overall (%)
yes	100%	100 %	50 %	100 %
No			50 %	0 %

Figure 5.5 Importance of EE principles in building development process
Source: Author‘s administered questionnaire (2016)

5.4 Major Barriers Militating Against Development of Energy Efficiency and Sustainable Built Environment in FCT

Table 5.8: Opinions of the residents on major barriers militating against the development of energy efficiency approaches towards sustainable built environment in FCT

S/N	ITEM	SA	A	UD	SD	D	Statistics		Rank
							Mean	Std.	
1	Lack of business and technical infrastructure	19	2	2	5	1	4.1	1.329	3
2	Financial and Economic barriers	12	16	5	0	3	3.9	1.120	4
3	Policy and Institutional barriers	22	12	3	0	2	4.3	1.009	2
4	Lack of consultation, co-ordination and co-operation	9	23	0	0	4	3.9	1.131	4
5	Vested interest and inertia	7	15	2	5	7	3.3	1.446	5
6	Human resource limitation	19	9	0	3	5	3.9	1.472	4
7	Lack of information exchange and awareness	17	8	5	0	6	3.8	1.464	
8	Knowledge gap on energy efficiency i.e. information barriers	23	10	0	2	1	4.4	0.969	1
9	Political and structural barriers	13	5	3	7	8	3.2	1.641	6
10	Behavioral and organizational barriers	11	19	2	0	4	3.9	1.180	4
Cluster mean							**3.9**	**1.276**	

Source: *Field Survey, (2016)*

From the descriptive results above, the major barrier militating against development of energy efficiency approaches for a sustainable built environment is knowledge gap; followed by policy and institutional barriers. The least is political and structural barriers. The extent of effect of these factors was ascertained using one-sample t-test.

Table 5.9: Officials' Responses on factors militating against development of energy efficiency approaches for a sustainable built environment

S/N	Item	SA	A	UD	SD	D	Statistics		Rank
							Mean	Std.	
1	Lack of a legal requirement	22	11	1	2	0	4.5	0.810	1
2	Lack of appropriate information to guide decision making	19	12	3	1	1	4.3	0.951	2
3	Economic/financial barriers	11	3	5	10	7	3.0	1.558	4
4	Lack of technical skills and products to match	6	11	4	10	5	3.1	1.360	3
5	Behavioural/organizational barriers	6	11	0	11	8	2.9	1.489	5
6	Cheapness of electricity	8	9	2	5	12	2.9	1.635	5
7	Other types of barriers	7	8	6	9	6	3.0	1.404	4
Cluster Mean							**3.4**	**1.315**	

Source: ***Author's Computation from Field Survey, (2016)***

From the descriptive results above, the researcher discovered that the outlined are the major factors militating against the development of energy efficiency approaches for a sustainable built environment in FCT, Abuja. By ranking, the result shows that the major factor militating against the development of energy efficiency for a sustainable built environment in FCT, Abuja, is the lack of legal requirement followed by lack of appropriate information to guide decision making. Behavioural/organizational barriers and cheapness of electricity are not relevant factors.

Table 5.10: Opinions of Gwarinpa residents on factors militating against development of energy efficiency approaches for a sustainable built environment.

S/N	Item	SA	A	UD	SD	D	Statistics		Rank
							Mean	Std.	
1	Financial challenges	67	83	28	53	69	3.1	1.506	3
2	Lack of a legal requirement	176	79	37	5	3	4.4	0.842	1
3	Lack of technical skills and products to match	61	83	28	59	69	3.0	1.488	4
4	Lack of appropriate information to guide decision making	133	106	49	8	4	4.2	0.895	2
Cluster Mean							**3.7**	**1.183**	

Source: ***Author's Computation from Field Survey, (2016)***

The results above with strata mean values ranging from 3.0 – 4.4 and associated standard deviations ranging from 0.842 – 1.506 indicates that all the factors outlined are accepted as militating against the development of energy efficiency approaches for a sustainable built environment in FCT. A cluster evaluation shows a mean value of 3.7 > 3.0 and a standard deviation of 1.183 < 1.581. This confirms that the factors work against development of energy efficiency and sustainable buildings in FCT, Abuja. A combination of the two results indicate that the major factors militating against energy efficiency in buildings in FCT is lack of legal requirement; followed by lack of appropriate information to guide decision making and finance. Others are financial challenges and lack of technical skills and products to match. These factors were ascertained to contribute significantly in achieving overall development of energy efficiency approaches for a sustainable built environment in FCT Abuja (t = 13.24; p-value = 0.000).

5.5. Major Environmental Implications of Energy Inefficient Buildings in the Study Area

Table 5.11: Respondents' opinions on the major environmental implications of energy inefficient buildings in FCT Abuja**.**

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Rank
1	Global warming causing changes in weather and causing flooding	175	58	17	42	8	4.2	1.207	2
2	Ozone layer depletion thereby increasing the heat within the environment	108	125	42	0	25	4.0	1.134	3
3	Increasing outdoor and indoor air pollution	158	100	25	0	17	4.3	1.031	1
4	Abiotic depletion affecting non-living things	75	108	67	33	17	3.6	1.150	5
5	Influence of acid rain and smog in the environment	100	92	50	50	8	3.8	1.162	4
	Cluster Mean						**4.0**	**1.140**	

Source: ***Author's Computation from Field Survey, (2016)***

From the table 5.11, the major environmental implications of energy inefficient buildings in the study area is the increase in both outdoor and indoor air pollution. Others include global warming that has altered or changed the weather pattern with much rain that have resulted to flooding in the city. Also the presence of acid rain and excessive heat due to ozone layer depletion. Poor indoor air quality affects the health of the occupants, whereas, abiotic depletion affects agricultural products within the nation.

Table 5.12: Officials' responses on the major environmental implications of energy inefficient buildings in FCT Abuja**.**

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Rank
1	Global warming causing changes in weather and causing flooding	12	6	2	10	6	3.2	1.570	
2	Ozone layer depletion thereby increasing the heat within the environment	11	21	0	2	2	4.0	1.028	
3	Increasing outdoor and indoor air pollution	15	9	1	8	3	3.7	1.431	
4	Abiotic depletion affecting non-living things	6	11	0	11	8	3.0	1.481	
5	Influence of acid rain and smog in the environment	11	3	5	10	7	3.0	1.558	
	Cluster Mean						**3.38**	**1.414**	

Source: ***Author's Computation from Field Survey, (2016)***

The officials' opinion on the major environmental implications of energy inefficient buildings also indicated that the greenhouse gases due to fossil fuel use in electricity generation has resulted to pattern changes in weather causing global warming via the release of pollutants, ozone layer depletion, acid rain and effects on both human health due to pollutants and thermal discomfort. The opinions of these two groups of samples were tested for level of association using the Spearman's rank correlation analysis. It was found that the opinions of the respondents/officials on the environmental implications of energy inefficiency building in FCT are statistically significant. There is no significant difference between the opinion of the residents of the FCT and the building officials in FCT on the environmental implications of energy inefficient buildings. Hence, the major environmental implications are miserable life due to thermal discomfort for the people, energy injustice and insecurity.

5.6 Test of Hypotheses

5.6.1.Hypothesis one

The Principal Component Analysis (PCA) method was used in testing hypothesis 1 in order to identify and evaluate the basic principles in developing energy efficiency approaches towards sustainable built environment in FCT, Abuja, the hypothesis state that:

H_0: There are no significant relationship between the basic principles in achieving energy efficiency and sustainable built environment in FCT.

H_1: There are significant relationship between the basic principles in achieving energy efficiency and sustainable built environment in FCT

The result obtained in table 5.5 was used in testing hypothesis one.

Level of Significance (α) = 0.05

Correlation Analysis

Correlation Matrix[a]

Principles		1	2	3	4	5	6	7	8	9
Correlation	1	1.000								
	2	**.918**	1.000							
	3	**.627**	**.736**	1.000						
	4	**.701**	**.853**	**.938**	1.000					
	5	.261	.215	.407	**.509**	1.000				
	6	**.858**	**.805**	**.897**	**.839**	.407	1.000			
	7	**.946**	**.855**	**.791**	**.794**	.431	**.970**	1.000		
	8	**.842**	**.926**	**.784**	**.932**	**.558**	**.807**	**.852**	1.000	
	9	.483	**.740**	**.869**	**.951**	.431	**.645**	**.570**	**.831**	1.000

a. This matrix is not positive definite

The correlation results above indicate that the outlined principles have significant linear association among themselves. This property confirms the data relevant for principal component analysis. Particularly, the highest degree of association was recorded between principle 1 and principle 7. This is followed by 1 and 2; the least is between 1 and 5.

Decision Rule:

Hence H_0 was rejected while H_1 was accepted which state that there are significant relationship between the basic principles in achieving energy efficiency and sustainable built environment in FCT.

5.6.2 Hypothesis two

One sample t-test method was used in testing hypothesis two in order to ascertain whether the identified sustainable practices and energy efficiency strategies in buildings have contributed significantly in achieving the overall development of energy efficiency building towards sustainable built environment in FCT Abuja, the hypothesis states that:

H_0: Sustainable practices and energy efficiency strategies in buildings are not statistically significant.

H_1: Sustainable practices and energy efficiency strategies in buildings are statistically significant

The result obtained in table 5.6 was used in testing hypothesis two

Level of Significance (α) = 0.05

Decision Rule:

The student's t-test result with t-statistic value of 22.29 and associated probability value ($p < 0.001$) revealed that adoption of these practices contribute significantly to achieving overall development of sustainable practices for energy efficiency in buildings in FCT, Abuja. Hence H_1 was accepted which states that sustainable practices and energy efficiency strategies in buildings are statistically significant.

5.6.3 Hypothesis three

One sample t-test was used in order to evaluate the major barriers militating against the development of energy efficiency in building and sustainable built environment in FCT, the hypothesis state that:

H_0: There are no significant major barriers militating against the development of energy efficiency in building and sustainable built environment in FCT

H_1: There are significant major barriers militating against the development of energy efficiency in building and sustainable built environment in FCT

In testing this hypothesis, table 5.8 was used.

Level of Significance (α) = 0.05

Variable	N	Mean	St. Dev.	SE Mean	T	P
Mean test	10	3.870	0.380	0.120	7.24	0.0000

Decision Rule:

A summary result with t-stat = 7.24 and p-value = 0.000 < 0.05 indicates that the barriers contribute significantly to the development of energy efficiency approaches towards sustainable built environment in FCT Abuja. Hence H_1 was accepted which states that there are significant major barriers militating against the development of energy efficiency in building and sustainable built environment in FCT.

5.6.4 Hypothesis four

Spearman's rank correlation analysis was used in order to conform if there are major environmental implications of energy inefficient buildings towards sustainable built environment. The hypothesis state that:

H_0: There are no major environmental impacts of energy inefficient buildings towards sustainable built environment

H_1: There are major environmental impacts of energy inefficient buildings towards sustainable built environment

The result obtained in table 5.12 was used in testing hypothesis four

Level of Significance (α) = 0.05

Correlations

			Officials' opinion ranks	Residents' opinion ranks
Spearman's rho	Officials' opinion ranks	Correlation Coefficient	1.000	.500
		Sig. (2-tailed)	.	.667
		N	3	3
	Residents' opinion ranks	Correlation Coefficient	.500	1.000
		Sig. (2-tailed)	.667	.
		N	3	3

Decision Rule:

The result shows that r = 0.50; with p-value of 0.667 > 0.05 indicating that the

opinions of the respondents/officials on the environmental implications of energy inefficient buildings in FCT are statistically significant. There is no significant difference between the opinions of the residents of FCT and the building officials in FCT in the environmental implications of energy inefficient buildings.

Hence H_1 was accepted which states that there are major environmental impacts of energy inefficient buildings for a sustainable built environment.

5 .7 Discussion of Findings

This study was carried out to determine laudable ways of developing energy efficiency approaches for sustainable built environment in building in FCT Abuja. The study made use of structural questionnaire distribution to residents and commercial houses (commercial buildings with particular reference to hotels) in Gwarinpa Housing Estate. This area was purposively chosen due to the fact that it is the largest housing estate in Nigeria and all types of modern buildings can be found here. There are high population of hotels and residential buildings in the area, the hotels operate a 24 hour services with electrical devices that consume energy.

Also included in the study are the practicing professionals from the following groups of respondents: Ten (10) Building Controls and Approvals Officials (BCAOs) from Federal Housing Authority (FHA) located at Gwarinpa in FCT, ten (10) Key Professional Practitioners (KPPs) of National Planning Commission (NPC) and sixteen (16) participants from Energy Savings Company's (ESCOs) involved with policy issues for energy efficiency in the built environment (Construction specialist on hotel buildings).

The respondents indicated in table 5.7 that putting off electrical appliances when not in use to reduce cost, installation of more VAC-VCR system instead of split units, mounting of solar energy devices, installing or replacing high voltage bulbs with fluorescent lights, replacement the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, façades and windows and installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices are among the strategies they adopted towards sustainable energy efficiency for retrofitting of buildings in FCT.

The basic principles in achieving energy efficiency in buildings and offsetting cost were outlisted in table 5.5 such as reduce heating, cooling and lighting loads. As energy efficiency is an emerging issue in the developing countries generally and Nigeria in particular, the respondents were of the view that it's important but it was going to take a while longer before it gets the attention it deserves in the built environment. And there being no legal demand to enforce it, developers had no obligation to follow on it. The importance of energy efficiency in the built environment was ascertained in the second hypothesis tested. The results revealed that adoption of these practices will contribute significantly to achieving overall development of sustainable practices for energy efficiency in buildings.

But, they said certain barriers are militating against the development of energy efficiency in building and sustainable built environment

Specifically, the respondents emphasized that the measures were driven by the need to reduce energy bills and subsequently also contribute to a clean environment. On the other hand, the respondents said that developers still viewed energy efficient buildings as costing more to construct. However, the respondents were aware that the cost difference between energy efficient buildings and the ordinary business-as-usual ones is continuously decreasing.

The clear answer from the Officials' was that at the moment, there is no legal requirement in the existing building control regulations which oblige the developers or local authorities to implement energy efficiency principles in buildings. From the descriptive results, the major barriers militating against development of energy efficiency and sustainable built environment in FCT were outlist in table 5.8, 5.9 and 5.10 respectively. The responses were mixed and varied, but the main common response was that the lack of a legal framework for EE measures in the national building regulations was the number one barrier which consequently hindered market transformation to mainstream energy efficient buildings in the entire economy. Other common responses included informational barriers, behavioural/organizational barriers, economic/financial barriers and the presumed cheapness of electricity in Nigeria.

However, FCT has energy practice guidelines which is being issued by Building Controls and Approvals Officials (BCAOs) from Federal Housing Authority (FHA) located at Gwarinpa Housing Estate, which the developers intending to build in areas under their jurisdiction can voluntarily follow. Second, Energy Savings Company's (ESCOs) involve in hotels and residential contracting and construction indicated that many of their members follow voluntary guidelines issued by their respective bodies mostly to cut their clients energy bills and as environmental initiative.

Respondents from the BCAOs and ESCOs talked of the so called 'low hanging' good practice energy efficiency measures such as passive solar designs, solar home systems such as solar PVs (photovoltaic) and solar water heaters and residential load control focused on the installation of ripple control systems for geysers. They said this can be easily written into building control regulations and be implemented at no extra cost either to the local authorities or the developers. The respondents from KPPs mentioned installed equipment as another requirement which can be easily added to building control regulations. They pointed out that FCT guidelines for energy efficient buildings were especially meant to change the design paradigm using simple design parameters and low technologies voluntarily.

All respondents suggested retrofit requirements to address energy efficiency requirements in the large stock of existing buildings (see fig. 5.2). Generally, all respondents were in agreement that there exists many opportunities to reduce energy consumption in buildings if the requisite building regulations can be put in place. They were in agreement that these regulations should be inspection based mandatory measures applied from the design phase to completion and operation of the building.

The major environmental implications of energy inefficient buildings in the study area were outlisted in table 5.11 and table 5.12 respectively. All the respondents were unanimous, from the descriptive result, the major environmental implications of energy inefficient buildings in the study area is the increase in both outdoor and indoor air pollution. The officials' stated that the greenhouse gases due to fossil fuel use in electricity generation has resulted to pattern changes in weather causing global warming via the release of pollutants, ozone layer depletion, acid rain and effects on both human health due to pollutants and thermal discomfort.

In this light, all respondents welcomed the proposed new building regulations and hoped they will inspire the building industry to achieve more than the minimum requirement. They said that this will have a market transformational impact as well and create opportunities for the development and use of market based EE business models like ESCO's in the existing buildings. The respondents also added that energy efficiency regulations should be periodically revised to include principles they will not have covered at inception, like retrofits and building equipment standards which are captured but not effectively implemented and monitored in the legislation, and also to take care of developments in technology and higher energy efficiency requirements in newer developments.

They said that behavioural barriers presented a difficult challenge to address as most EE regulations, hardly target the consumers. Additionally, the respondents said the energy efficiency regulations should be accompanied with a robust informational/educational campaign to sensitize the citizenry on the benefits of energy efficiency in buildings and get them to buy into it from the beginning.

During the field investigations, documents used for building/construction development approvals were also evaluated (Appendix V). They contained requirements to be fulfilled by the developers before approval for construction and occupation could be granted. These requirements included: approved drawings by a qualified professional, structural soundness certifications, health and safety certifications for the construction and the general public, electrical and plumbing installations soundness certification and construction completion soundness certification.

The electrical installation and connection requirements dwelt much on safety of the installation, the various tariffs for the various building uses and the payment modes for the connection among others. In all this requirements, there was no direct reference to any section requiring the developers or BCAOs to check for EE measures in the developments. Appendix V shows a typical checklist of documents used by BCAOs when approving building developments in areas under their respective jurisdictions.

The interview guidelines followed the same pattern of questions grouped like the ones for questionnaires, which are listed in Appendix II& III. However, the interviewees' discussions allowed more latitude in the way they answered the questions because of their higher specialized experience and expert knowledge on energy efficiency matters and building control regulations. This was used to gain deeper insight into the subject matter and to triangulate and compliment the other findings from the questionnaires and documents review.

Majority of the questionnaire participants and interview respondents were in agreement that energy efficiency had become an important principle in the way we build and manage buildings in Nigeria as a whole and FCT in particular. The awareness of the need for energy efficiency in the building/construction process was very high among the respondents. As stated above, this had been significantly brought to the fore by the electricity supply woes. All key sectors of government at all levels and other government agencies involved in energy issues were working on one or other program to try and address the issue.

The respondents were significantly aware of and were in most cases already encouraging the application of "low hanging" opportunities in the various building processes voluntarily. These opportunities were common in the buildings lighting systems, water heating systems and generally low rise natural ventilation designed buildings as opposed to high rise high density mechanical equipment intensive buildings.

Problems impeding the implementation of energy efficiency principles in the building control processes in local authorities could be broadly summarized as: Legal, Informational/awareness, Behavioural/Lifestyle, Economic/Financial and to some extend the presumed cheapness of electricity in Nigeria.

CHAPTER SIX

SUMMARY, RECOMMENDATIONS AND CONCLUSION

6.1 Summary of Finding

The problems and challenges facing the development of energy efficiency approaches towards sustainable built environment in FCT Abuja were examined in this study.

The usage of energy mostly depends on what region or climate it is being used and the appliances that use it. If the region is hot and dry, effort to achieve thermal comfort is a paramount issue. Designers often make sure that reasonable amount of indoor air quality are been attained to maintain user’s comfort. But then some building sectors consume energy more than others. Energy performance of buildings is an important issue to building owners because it transmutes to cost. Energy efficiency does not mean that the use of energy is eliminated, it simply implies that the quantity of energy needed for the provision of services will be utilized in a way that minimizes its usage.

The supply of energy in Nigeria has not been able to meet up with the demand, hence the cost of providing alternative energy supply is an utmost concern; most organizations provide stand-by generators, uninterrupted power supply (UPS) and inverters because a lot of energy is needed to achieve a conducive environment for users in order to be productive.

The inadequate energy supply led to the need for alternative energy supply, its generation also led to the emission of greenhouse gases to the environment. Thus, the need to incorporate energy efficiency is a necessity since it reduces the need for fossil fuels (oil and gas) and would thereby improve not only environmental quality but also national security.

Hence these problems have made this study very necessary as it ex-rays the problems and factors militating against the development of energy efficiency approaches towards sustainable built environment in FCT Abuja with a view of proffering solutions. To this effect, the study identified the challenges facing the development of initiatives for energy efficiency in building at FCT Abuja

To achieve these study objectives, three hundred and thirty six (336) respondents were sampled comprising of 300 randomly selected residents from Gwarinpa housing estate, ten 10 Building Controls and Approvals Officials (BCAOs) from Federal Housing Authority (FHA) located at Gwarinpa ten,10 Key Professional Practitioners (KPPs) of National Planning Commission (NPC) and sixteen (16) participants from Energy Savings Companies (ESCOs) involved with energy efficiency in the built environment were purposively selected.

A total of three hundred and seventy (370) copies of coded questionnaire were distributed to generate data for the study while 300 were returned and used for the study. The data collected were analyzed using descriptive statistics which comprise measures of mean, standard deviation, frequency table and bar chart.

The four null hypotheses were tested using statistical tools such as factor and principal component analysis correlation and student's t-test at 0.05 level of significance (the computation was done with SPSS 22 package).

The research revealed that there was no significant sustainable energy efficiency strategy for buildings in FCT, Abuja. It also showed that there were no basic principles that have been adopted in achieving energy efficiency in buildings in the study area. Inadequate knowledge, lack of awareness, absence of energy efficiency standards and policies were the factors militating against energy efficiency in the built environment, resulting in poor thermal comfort, poor indoor air quality, local air pollution and CO_2 emission into the environment within the study area and beyond. The area lacks clear legal requirement and regulations that will mandate citizens to key into. Likewise it was found that there is significant level of sustainable approach that can be adopted towards developing energy efficiency in buildings in order to offset greenhouse gas emissions in FCT.

6.2 Contribution to Knowledge

The current energy outlook in Federal Capital Territory, Abuja is challenging.

It is clear that a continuation of current energy trend will have many undesirable consequences, grave risk and global threats, to the well-being of the human race.

The findings of this research had made available to both local and national authorities that are involved in drafting and drawing up policy recommendations some necessary tools to effect positive measures to avert the ugly trend.

The research has contributed to raising residents' awareness relating to mainstreaming energy efficiency through renewable energy sources and retrofitting for energy efficiency of existing buildings.

A template and model were developed on the approaches for a sustainable built environment in FCT. The research identified the energy efficient retrofit activities as an opportunity to tackle the complex environmental issues within the study area.

The research contributed in filling the research gaps identified in the literature. The research investigated the mind set and requirements of the end users regarding the energy efficiency geared towards sustainability performance of their buildings and providing solutions that foster improvement of those sustainability performances.

The research contributed to knowledge about energy efficiency approaches for sustainable built environment in FCT, Abuja, which is relatively new subject in scientific literature. This is scientifically relevant due to this geographical area studied, that has not been attracting enough academic attention like other developed countries on issues relating to energy efficiency in buildings.

The study framework outlined below in table 6.1 emanates from the conceptual as well as the key gaps in the literature concerning effective energy efficiency approaches for a sustainable built environment in Federal Capital Territory (FCT), Abuja. The new model developed for achieving energy efficiency in building in FCT includes:

- Utilize integrated building design approach
- Utilize active solar energy and other environmental heat source and sinks
- Sitting and organizing the building configuration and minimizing
- Consider building form, orientation and other related attributes.
- Reduce heating loads by using undesirable solar heat gain.
- Design using the provisions of Building Energy Efficiency code.
- Improvement through the design of building envelope, new system application and green roof system.
- Optimize system design and operation to match actual cooling and lighting load through commissioning
- Apply local climate sensitive passive design technique such as building form, orientation, sun shading, building envelope, insulation , air tightness, ventilation

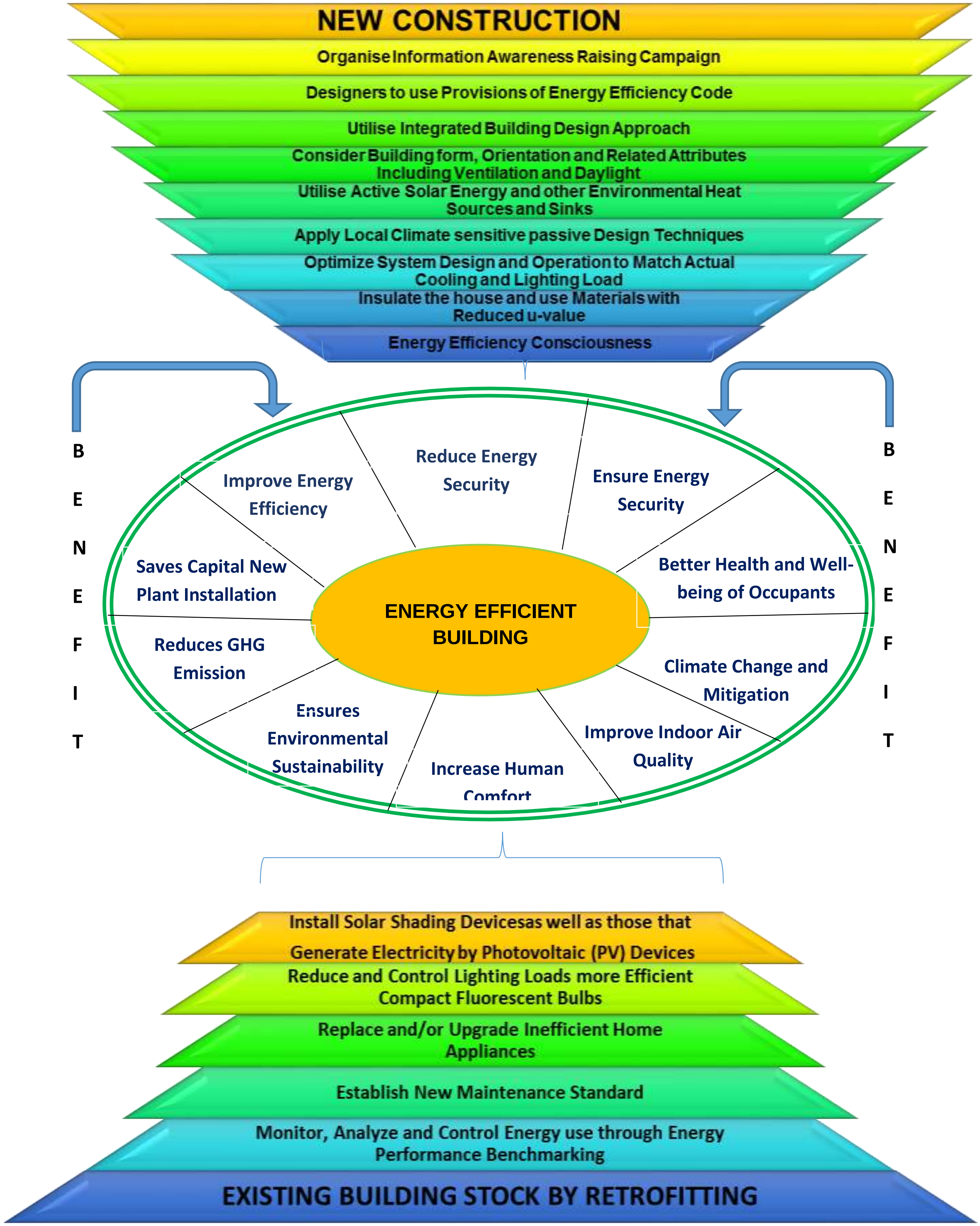
The framework forms the approach for complementing the existing building stock by retrofitting.

Table 6.1: Developed Template for Achieving Energy Efficiency in Building in the FCT, Abuja.

	FOCAL AREA	TECHNICAL APPROACHES	BENEFITS
New Construction	• Utilize integrated building design approach • Utilize active solar energy and other environmental heat source and sinks • Sitting and organizing the building configuration . • Consider building form, orientation and other related attributes. • Reduce heating loads by using undesirable solar heat gain. • Design using the provisions of Building Energy Efficiency code.	• Improvement through the design of building envelope, new system application and green roof system. • Optimize system design and operation to match actual cooling and lighting load. • Apply local climate sensitive passive design technique such as building form, orientation, sun shading, building envelope, insulation , air tightness, ventilation	• Reduces energy cost • Ensure energy security • Reduced GHG emission • Less energy consumption • Encourage climate responsive building planning and design . • Provide ways to improve energy efficiency in building and to take the advantages by limiting the design. • Reduce energy and temperature control.
Existing Building Stock by Retrofitting	• Utilize appliance labelling • Purchase energy efficient appliances (energy star appliances) • Reduce lighting loads • Utilize active solar energy and other environmental heat sources. • Establish and maintain energy management system. • Change all incandescent light bulbs to compact fluorescent bulbs or LED light.	• Monitor, analyze and control energy use through energy performance benchmarking. • Establish new maintenance standards • Upgrade or replace heating, ventilation and air-conditioning (HVAC) systems, indoor lighting, water heating, home appliance and other electric and mechanical devices. • Organise information and awareness raising campaign	• Improve indoor air quality • Increase human comfort • Direct towards sustainable actions • Reduce urban heat island effect . • Provides mitigation to climate change. • Ensures environmental sustainability in the built environment.

Source: Author Development, (2016)

ENERGY EFFICIENCY APPROACH MODEL



Source: Researcher Field Model Development, 2016

6.3. Suggestion for further research

The research described in this dissertation points to various approaches of further research. First, it could be extended by including broader environmental and socio-economic issues relating to life cycle assessment of buildings especially embodied energy associated with building material sourcing, extraction, manufacturing, transport and deconstruction of buildings in FCT.

Second, the level of details should increase by evaluating the energy efficiency of appliances, their labelling and impact of residents' choice of purchasing and use of second hand appliances (Tokumbo appliances) on the environmental sustainability of built environment in FCT.

6.4 Recommendations

The following are the recommendations of this research:

1) Sustainable and energy efficiency strategy for retrofitting of buildings has become a future development trend in the building sector. Building Energy Efficiency Retrofit provides excellent opportunities to reduce energy consumption in existing buildings, and to promote environmental protection, the rational use of resources, occupants' health, all of which helps to improve the sustainability of existing buildings. Energy Performance Contracting (EPC) provided by Energy Service Companies is a market mechanism to provide financial and technological support for energy efficiency projects. On this, it is recommended that Nigeria should patronize these companies and also study

regulations which have set a specific floor area threshold which when reached in refurbishment must effect energy efficiency measures in buildings. This should be localised to the Nigerian conditions through an early revision of the standards and be implemented through the building control regulations.

2) The process of operationalising the proposed energy efficiency building standards through the local authorities should be expedited to meet the EE milestones set by the Federal Government guidelines for the building sector. Additionally, the current environment of electric energy supply instability has raised interest and awareness on the need for implementation of energy efficiency measures in the entire Nigeria economy. The local authorities and other stakeholders should seize the opportunity and intervene with the requisite EE in building as a matter of urgency

3) It was found that some of the factors militating on efficient energy buildings include inadequate awareness and finance. It has been shown that the development and deployment of effective communication and information programmes are critical to the successful implementation of energy efficiency building regulations. This is more important in jurisdictions developing their first regulations and where staff needs training as well. It is recommended that the various national and local government agencies, as well as other interest groups, which will be involved in the implementation of the proposed building regulations develop a robust public awareness

programme which will be ready to be deployed once the regulations are promulgated. This will inform and sensitize the building sector actors and the whole citizenry on the benefits of energy efficient buildings. Additionally, energy efficiency programmes cost a lot of money to set up and implement especially in the developing world where energy markets are not well developed to spur the required level of growth on their own. These costs are high for both new and existing buildings. This therefore requires specific financial/economic tools by the national or local governments to set up and implement a successful energy efficiency programme in buildings.

4) It is recommended that the national and local governments put in place specific agencies to coordinate and direct the energy efficiency programmes in their areas of jurisdictions to make them successful.

5) The National Energy Efficiency Code should be developed and included in the existing National Building Code to foster planning, construction of energy efficient and sustainable buildings in the country.

6) In addition, energy efficiency retrofitting of existing building stock, utilization of energy efficient tested technologies and renewable energy sources should be used to minimize the environmental impact of buildings in the environment, which will result in enormous reduction of green house gas emission

6.5 Conclusion

Energy efficiency building regulations have been in use in many developed countries for decades. In Nigeria, the end of an era of presumed cheap electric energy as evidenced by the escalating new tariffs, the security of electricity supply problems and the high carbon intensity nature of electricity production have reinforced the importance of the energy efficiency agenda in the economy. In the past, this had been frustrated by perceived low energy prices and lack of clear national strategy among others. It is important that the government introduce or develop an initiative for new energy efficiency strategy which will commits the country to achieve demand reduction in the buildings sector and emphasize mandatory application of regulatory instruments. Flowing from this, the government should prepare new legislation to aid in the implementation of energy efficiency regulations in building.

REFERENCES

Adeyeye, K., Osmani, M. & Brown, C. (2007). Energy conservation and building design: the environmental legislation push and pull factors. *Structural Survey* 5(1), 55-57.

African Ministerial Council in Urban Development, AMCHUD (2008). Report of the Second Biennial Ministerial Conference for the African Ministerial Conference on Housing and Urban Development (AMCHUD II) Abuja - Nigeria. Retrieved on 14th July 2016. From www.housing.gov.za.

Akindoyeni, A. (2012). Sustainable Development and Environmental Protection. *Journal of Sustainable Development*, 2(1): 56-58.

Arno, S. & Frank, T. (2009). Building information model based energy/energy performance assessment in early design stages. *Automation in Construction* 18(2), 153-163

Bassioni, H. A., Price, A. D. F. & Hassan, T. M. (2005). Building a conceptual framework for measuring business performance in construction: An empirical evaluation. *Construction Management and Economics* 23, 495-507.

Blom, (2010). Environmental Impacts During Operational Phase of Residential Building. IOS Press BV Amsterdam, Netherland.

Breedt, T.F. (2007). Friendly Accommodation for Physically Challenged and Elderly Travelers and Tourists in South Africa. Mini-dissertation submitted in partial fulfillment of the requirements for the Degree Master of Business Administration at the Potchefstroom Campus of the North-West University, Potchefstroom.

Brundhand Report of the World Commission on Environment and Development Over Common Future. World Commission on Environment and Development, 1987. Published as Annex to General assembly document A/42/427.

BPIE (Building Performance Institute Europe), Europe's Buildings Under the Microscope – A country-by Country Review of the Energy Performance of Building – 2011.

Bryman, A. & Burgess, R. (2004). *Analyzing Qualitative Data*. London: Routledge

Camp, A. (2005). Counting every drop. *Facilities Management*, 12(4), 16-17.

Chappell's, H. & Shove, E. (2005). Debating the Future of Comfort: Environmental Sustainability, Energy Consumption and the Indoor Environment. *Building Research and Information* 33(1), 66-68.

Charalambides, J. (2009). Improving Energy Efficiency in Building Through Automated Computer Design Process. Building a Sustainable Future - Proceedings of the 2009 Construction Research Congress, 628-635,

Cheung, C. K., Fuller, R.J. & Luther, M.B. (2005). Energy-Efficient Envelope Design for High-Rise Apartments. *Energy and Buildings* 37 (1): 37-48.

Chididiac, S.E, at el A Screening Methodology for Implementing Cost Effective Energy Retrofit Measure in Canadian Office Buildings. Energy and Buildings 2011 43 (2-3): p 614-620.

Department of Minerals and Energy (DME) (2008). The White Paper on energy policy of The Republic of South Africa, Pretoria.

Deringer, J., Iyer, M., Yu J. & Huang, Y.J. (2004). Transferred just on paper? Why doesn't the reality of transferring / adapting energy efficiency codes and standards come close to the potential? In: Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, August 2004.

Deringer, J.J. and Gilling J. (1998). The Design and Implementation of Energy Efficiency Building Codes in Developing Countries: Case of Jamaica.

Dixon, T. Britnell, J. Watson , G.B. 92014) . 'City-wide' or City Blind'. An Analysis of Emergent Retrofit Practices in the UK Commercial Property Sector. Retrofit 2050 Working Paper wp/2014/1.

Douglas J. (2006). Building Adaptation. Armsterdam Boston, London, Betterworth Heineman, 2006.

Druckman, A. (2004). *Facility Management for the Future*. *Journal of Property Management,* 69(1), 52-53.

Du, L, He, Y., & J., 92013). The Effects of Electricity Reforms on Productivity and Efficiency of China's Fossil Fired Power Plants: An

Durrheim, K. (2006). Research in Practice: Applied Methods for the Social Sciences, 3rd Edition. South Africa: University of Cape Town Press, 34-60.

Dubois, U. (2012). From Targeting to Implementation: The Role of Identification of Fuel Poor Households. *Energy Policy 49*, 107-115.

Emerole, C.G. (2002). Restructuring Housing Development and Financing in Nigeria: The Role of Partnership and Collaboration Strategies. *Housing Today- The Journal of the Association of Housing Corporations of Nigeria (AHCN)* 1(5): 26-29

Energy Commission of Nigeria (2013). Assessment of Energy Options and Strategies for Nigeria: Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development (2000-2030). Report No. ECN/EPA/2013/01.

Energy Efficiency Office (2003). General information report: Energy management guide. Garston: BRECSU.

Ernst and Young. (2015) Mid-tier Commercial Office Buildings in Australia, 2015.

European Union (2000). Towards a European strategy for the security of energy supply. *Green Paper* 2(1), 45-47.

Ezejelue, A, C., Ogwo, E.O. & Nkamnele, A. D. (2008). *Basic Principles in Managing Research Projects*. Aba, Nigeria; Afritowers Ltd.

Emerole, C.G. (2002). Restructuring Housing Development and Financing in Nigeria: The Role of Partnership and Collaboration Strategies. *Housing Today- The Journal of the Association of Housing Corporations of Nigeria (AHCN)* 1(5): 26-29

Energy conservation vs. energy efficiency. Retrieved from www.akenergysmart.org/. Accessed 23/07/2016.s

European Construction Technology Platform (2013). Energy-Efficient Buildings Multi-annual roadmap for the contractual PPP under Horizon 2020.

EIA (2014). Annual Energy Review - Commercial sector energy consumption Estimates. Retrieved on 27th August, 2016. From www.eia.gov.

Fasakin, O. (2009). Affordable Housing in Nigeria –Perspectives and Prospect, Paper delivered at Hybrid workshop on Housing and Urban development Issues in FCT State , Akure, 28-29 October, 2009.

FGN (1999). 1999 Constitution of the Federal Republic of Nigeria, Federal Government of Nigeria (FGN).

Fawcett, T. Killip, G., (2014). Anatomy of Low Carbon Retrofits: Evidence form Owner Occupied Superhome. Building and Information , 42 (4) pp. 434-445.

Geller, E. S., Richard, W. & Peter, E. (1992). *Preserving the Environment*. New York: Pergammon Press.

Holden, R. M. (2004). Towards Energy Efficient Building Regulations: The City of Johannesburg's. *Building Bylaws Review Process* 3(1), 45-47.

Initiative , C.C.P., (2013) Building Energy Efficiency in China, Germany and United States , 2013.

International Energy Agency (IEA) (2004). *Energy Balances for OECD Countries and Energy Balances for non-OECD Countries; Energy Statistics for OECD Countries and Energy Statistics for non-OECD Countries*. Paris:

Intergovernmental Panel on Climate Change (IPCC) (2007). Mitigation: Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Iraklis, A. (2014). Urban sustainable energy development: A case study of the city of Philadelphia. A dissertation submitted to the University of Delaware.

Jatau, B. (1991). Designing a spatial database to improve plot application processing in Abuja, Nigeria. *ITC, Enschede* 1(1), 92-93.

Jiboye, A.D. (2010). Correlates of Public Housing in Lagos, Nigeria. *Journal of Geography and Regional Planning* 3(2): 017-028

Jibril, I.U. (2006). Resettlement Issues, Squatter Settlements and the Problems of Land Administration in Abuja, Nigeria's Federal Capital, 5th International Federation of Surveyors (FIG) Regional Conference. International Federation of Surveyors, Accra, Ghana, 15-16.

Kahn, W.J. (1999). *The A-B-C's of Human Experience (An Integrative Model)*. Belmont, Calif. Brooks/Cole Wadsworth.

Keeping, M., & Shiers, D. (1996). The "green" refurbishment of commercial property. *Facilities*, 14(4), 15-19.

Koeppel, S. & Ürge-Vorsatz, U. (2007). Assessment of policy instruments for reducing greenhouse gas emissions from buildings, UNEP–Sustainable Buildings and Construction Initiative, September, Budapest.

Kornelis, B., Luis, G., Danny, H., Siwei, L., Geoffery, L., Anthony, M.M., Sevastian, M., Aleksandra, N., Jacques, R. & Hiroshi, Y. (2007). Residential and commercial buildings. Chapter 6, 394-395.

Kahu, R. (2014). Evaluating energy efficiency in the design of large scale office building in hot-dry climate of Nigeria. An Unpublished thesis submitted to Ahmadu Bello University, Zaria Nigeria

Kitzinger, J. (2004). *Audience and Readership Research' in the Sage Handbook of Media Studies*. London: Sage

Liu, F. & Hammer, S. (2014). *City Energy Efficiency Assessment: Mayoral Guidance Note #5*. Washington DC: Energy Sector Management Assistance Program.

Loozen, A. & Moosdijk, C.V.D. (2008). A Consumer Advise on Energy Efficient Use and Purchase of Household Appliances and Lighting. In: Bertoldi, P., Ricci, A. & Almeida, A.D. *Energy Efficiency in Household Appliances and Lighting*. Berlin: Springer, 468-474.

Laustsen, J. (2008). Energy efficiency requirements in building codes: energy efficiency policies for new buildings. IEA Information paper. OECD/ IEA, Paris.

Maag, J. W. (2004). *Behavior Management: From Theoretical Implication to Practical Applications*. Belmont, CA: Thomson/Wadsworth.

Maller, C.J. Horne, R.E. (2011) Living Lightly: How Does Climate Change Feature in Residential Home Improvement and What are the Implications for Policy? Urban Policy and Research 29(1) pp. 59-72.

McCurry, P. (1976). The geology of the precambrian to lower paleozoic rocks of Northern Nigeria. In C.A. Kogbe (Ed). *Geology of Nigeria*. Elizabethab Press. Lagos,15-39

Mickaityte, A., Zavadskas, E. K., Kaklauskas, A. & Tupenaite, L. (2008). The Concept Model of Sustainable Buildings Refurbishment. *International Journal of Strategic Property Management* 12, 53-68.

Microsoft Encarta Dictionary (2005). Definition of awareness. Retrieve on 23/06/2016. From www.microsoftcorporation.com.

Mukhija,V. (2004) The Contradictions in Enabling Private Developer of Affordable Housing: a Cautionary Case from India. *Urban Studies* 4(11), 2231-2244.

Newcomb, H. (2009). The Creation of Television Drama' In a Handbook of Qualitative Methodologies for Mass Communication Research (7th edi.). London and New York: Routledge.

Nigerian's Newspaper: The Daily Star (2009). Power disruption and load shedding in Nigeria, may 13, 2009.

NPC (2010). National Population Commission (NPC) (2006). Final Census Results. National Population Commission (NPC) Abuja.

Nwofe, P.A. (2014). Need for Energy Efficient buildings in Nigeria. *International Journal of Energy and Environmental Research* 2(3): 1-9.

O'Leary, Z. (2004). *The Essential Guide to Doing Research*. London: Sage Publications, 45-46.

Oladapo, M. A (2002). Procurement Systems and Project Organization Model for Low Cost Housing. *Housing Today* 1(6): 32-36.

Olatubara, C.O. & Fatoye, E.O. (2007). Evaluation of the Satisfaction of Occupants of the Abesan Public Low-Cost Housing Estate in Lagos State, Nigeria. *The Nigerian journal of Economic and Social Studies* 49 (1).

Oligbinde, O.S., Odunfa, K.M. Ohunakin, O.S. & Odunfa, V.O. (2014). Energy Efficiency in Residential Buildings: A Case Study of 1004 Federal Housing Authority Estate, Victoria Island, Lagos. *International Conference of Mechanical Engineering, Energy Technology and Management* 4(2), 45-46.

Organisation for Economic Co-operation and Development (OECD) (2003). Environmentally Sustainable Buildings Challenges and Policies. OECD, Paris.

Pollock, M., Roderick, Y., McEwan, D. & Wheatley, C. (2007). *Building Simulation as an Assisting Tool in Designing an Energy Efficient Building: A CaseSstudy*. U.K.: Glascow, Integrated Environmental Solutions Limited.

Oyawoye, M.O. (1972). The Basement Complex of Nigeria. In T.F.J. Dessauvagie & A. J. Whiteman, Eds *African Geology*. Ibadan: University Press, 67-99.

Pancucci, D. (2003). Imperial college and energy savings. *Facilities Management* 6(2), 23-24..

Pedhazur, E.J. & Schmelkin L.P. (2007). *Measurement, Design, and Analysis: An Integrated Approach*. New Jersey: Lawrence Erlbaum Associates.

Power-switch. Energy efficiency challenge. Retrieved 25th July, 2016. From www.panda.org,powerswitch.

Praznik, M., Butala, V. & Zbašnik-Senegačnik, M. (2013). Simplified evaluation method for energy efficiency in single-family houses using key quality parameters. *Energy Build*. 67(10), 489-499.

Punch, K.F. (2005). *Introduction to Social Research: Quantitative and Qualitative Approaches*. London: Sage Publications.

Shahir, S.A. Masjuki, H.H. , Kalam, M.A., Imran, A., Fattah I., , and Rizwanul, S.A., (2014). Feasibility of Diesel-Biodiesel –Ethanol/Bioethnal Blend as Existing C.I. Enginee Fuel. An Assessment of Properties, Materials Compatibility, Safety and Combustion Renewable and Sustainable Energy Review 32, 379-395.

Shanghai Construction and Transportation Commission (2008). Evaluation Standard of Energy Efficiency for Existing Building, China.

Shen, L. H. (2007). *Promoting EPC mechanism and strengthening energy conservation cooperation in Northeast Asia*. China: National Development and Reform Commission Energy Research Institute.

Shoaib, A.M. and Bhran , A. A., (2013). A New Hierarchical Approach for Maximizing Biodiesel Mixing ratios Based on the Final Product. Specifications. Petroleum and Coal SS (4), 351-360.

Skinner, B. F. (1974). *About behaviorism*. New York: Alfred A. Knopf.

Smedby, N. (2016). *Local Environmental Governance: Assessing Proactive Initiatives In Building Energy Efficiency*. Sweden: Lund University

Stumpf, A., Kim, H. & Jenicek, E. (2009). Early design energy analysis using BIM's building a sustainable future - proceedings of the 2009 construction research congress, 426-436

Umar. H. A. (2010). Environmental Protection Board Headquarters: Maximization of Passive Elements of Ecological Design.

United States Green Building Council. (2006a). *LEED for New Construction Version 2.2 Reference Guide.* Washington, D.C.: United States Green Building Council.

USGS (1977). Preliminary Engineering Geologic Report on selection of Urban sites in the Federal Capital Territory, Nigeria. Project Report Nigerian Investigations.

Vesma, V. (2002). Power to the People Facilities Management. *Facilities Management* 9(5), 54-56.

Voss, K. (2008). What is really new about zero-energy homes? Proceedings of 12th international conference on passive houses 2008, Nuremberg, Germany, 187-19

Wedge, R. (2003). Energy efficiency: Key to managing costs. *Journal of Forest Industries*, 3(1), 45-47.

Westerveld, E. (2007). The Project Excellence Model: Linking success criteria and critical success factors. *International Journal of Project Management* 21, 411–418.

Wilkinson, P., Kirk, R.S., Sean, B., Cathryn, T. & Tadj, O. (2007). Energy Efficiency and the Built Environment. *The lancet* 370(100) London, UK

Williams, M. A. (2003). Initiating, Organizing, and Managing Energy Management Programs in.: Wayne, C. T. *Energy Management Handbook*. Liburn: The Fairmont Press, Inc.

Wafula, (2012). Evaluating Energy Efficiency in Building Control Regulations in Local Authorities in South Africa. A dissertation submitted to the University of the Witwatersrand, Johannesburg.

Wilson, C., Crane, L., Chrysssochiodis G., (2014) Why do People Decide to Renovate their Home to Improve Energy Efficiency? Working Paper 160, Nonoich, UK: Tyndall Centre fr Climate Change Research.

Wong, N.H. & Li., S. (2007). A Study of the Effectiveness of Passive Climate Control in Naturally Ventilated Residential Buildings in Singapore. *Building and Environment*, 42(3), 1395-1405.

Xu, P. P., Chan, H. W. E. & Xu, Y. (2010). An assessment framework for sustainable building energy efficiency retrofit (BEER) project under energy performance contracting (EPC) mechanism based on Balanced Scorecard, Proceedings of the CRIOCM 2010 International Symposium on Advancement of Construction Management and Real Estate, 24-33.

Yik, F.W.H., Lee, W.L. (2006). Building energy efficiency and the remuneration of operation and maintenance personnel. *Journal of Facilities* 20(14), 406-413.

Yik, F.W.H., Lee, W.L. & Ng, C.L. (2006). Building energy efficiency and the remuneration of operation and maintenance personnel. *Journal of Facilities*. 20(14), 406-413.

Yoon, S., Park, N. & Choi, J. (2009). BIMT-based design method for energy-efficient building. NCM 2009 -5th international joint conference on INC, IMS, and IDC, 376-381.

APPENDIX I

Department of Environmental Management,
Faculty of Environmental Sciences,
Nnamdi Azikiwe University,
P.M.B. 5025, Awka.
17/10/2016

Dear Respondents,

QUESTIONNAIRE ON DEVELOPMENT ENERGY EFFICIENCY APPROACHES TOWARDS SUSTAINABLE BUILT ENVIRONMENT IN THE FEDERAL CAPITAL TERRITORY (FCT) ABUJA

I am a Ph.D. student at the Nnamdi Azikiwe University Awka, Anambra state. I am carrying out a research on the above topic. The objective of this research is to discover laudable ways of achieving overall development of initiatives for energy efficiency in building in FCT Abuja. This research at the end would proffer recommendations that could help in the sustainable planning and development of the region, which is the capital territory of Nigeria.

I therefore kindly solicit your cooperation in filling out the attached questionnaire, while assuring you that all furnished information would be treated with utmost confidentiality and strictly for academic purpose.

Thanks

Yours Sincerely

Obiegbu, Micah
1995070047P
Department of Environmental Management
Faculty of Environmental Sciences

QUESTIONNAIRE FOR RESIDENTS OF GWARINPA HOUSING ESTATE

SECTION A BIO-DATA

Please fill in the blank spaces provided and tick the box(es) whose information applies to you

1. **Sex**: (a). Male [ ] (b). Female [ ]

2. What is your age bracket (year)?

a)30-40 [ ] , (b) 41-50 [ ], (c) 51 and above [ ]

3. Marital Status

a) Single [ ], b) Married [ ], c) Divource [ ], d) Widowed [ ]

4. Educational Attainment

(a) NCE/OND [ ], (b) HND/B.Sc/B.Eng [ ], (c) M.Sc/M.Eng/P.hD and above [ ]

SECTION B

Please tick [√] in the appropriate space representing your opinion on statements specified in the following question.

SA - strongly agree

A - Agree

UN - Undecided

DA - Disagree

SD - Strongly disagree

1. **What is the sustainable energy efficiency strategies for retrofitting of buildings in FCT Abuja**

S/No	Item	SA	A	UN	SD	D
5	Putting off electrical appliances when not in use to reduce cost					
6	Planting of trees around the building to assist in cooling of the environment and sun shedding					
7	Mounting of solar energy devices					
8	Insulating a home such as installing or replacing high voltage bulbs with fluorescent lights					
9	Replacement the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, façades and windows					
10	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices					

2. **Factors Militating on Energy Efficiency in Building**

S/No	Item	SA	A	UN	SD	D
20	Financing challenges					
21	Lack of a legal requirement					
22	Lack of Technical skills and products to match					
23	Appropriate information to guide decision making					

3. Level of Sustainable Approach that can be adopted towards Developing Energy Efficiency in Buildings in Offsetting Greenhouse Gases in FCT

S/No	Item	SA	A	UN	SD	D
24	Reducing heating, cooling, ventilating, and lighting loads for new buildings or when renovating existing buildings					
25	Increasing the efficiency of energy-using devices and equipment					
26	Manage energy use in public and commercial buildings					

APPENDIX II

Department of Environmental Management,
Faculty of Environmental Sciences,
Nnamdi Azikiwe University,
P.M.B. 5025, Awka.
17/10/2016

Dear Respondents,

QUESTIONNAIRE ON DEVELOPMENT ENERGY EFFICIENCY APPROACHES TOWARDS SUSTAINABLE BUILT ENVIRONMENT IN THE FEDERAL CAPITAL TERRITORY (FCT) ABUJA

I am (name of researcher), a PhD student at the Nnamdi Azikiwe University Awka, Anambra state. I am carrying out a research on the above topic. The objective of this research is to discover laudable ways of achieving overall development of initiatives for energy efficiency in building in FCT Abuja.

You are invited to consider participating in this research study. Your participation in this study is entirely voluntary. Before you participate it is important that you read and understand the explanation of the purpose of the study and the study procedures. If you have any questions, do not hesitate to ask me.

This research at the end would proffer recommendations that could help in the sustainable planning and development of the region, which is the capital territory of Nigeria.

I therefore kindly solicit your cooperation in filling out the attached questionnaire, while assuring you that all furnished information would be treated with utmost confidentiality and strictly for academic purpose.

Thanks

Yours Sincerely

Obiegbu, Micah
1995070047P
Department of Environmental Management
Faculty of Environmental Sciences

QUESTIONNAIRE FOR OFFICIALS

Please fill in the blank spaces provided and tick the box(es) whose information applies to you

Section A Bio-Data

1. **Sex**: (a). Male [ ] (b). Female [ ]

2. What is your age bracket (year)?

(a) 20-29 [ ], (b) 30-40 [ ], (c) 41-50 [ ], (d) 51 and above [ ]

3. Educational Attainment

(a) NCE/OND [ ], (b) HND/B.Ed/BSc/ [ ], (c) M.Sc/Ph.D. and above [ ]

4. Length of time at this organization/department (Years)

a) Between 5 Years to 10 years [ ]

b) Between 10 Years to 15 years [ ]

c) More than 15 years [ ]

Please tick [√] in the appropriate space representing your opinion on statements specified in the following question.

SA - strongly agree

A - Agree

UN - Undecided

DA - Disagree

SD - Strongly disagree

5. What is the sustainable energy efficiency strategies for retrofitting of buildings in FCT Abuja

S/No	Item	SA	A	UN	SD	D
5	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices					
6	Replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, façades and windows					
7	Assess occupancy patterns, and then apply daylight heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable.					
8	Re-commission all energy and water systems to verify if they are functioning at optimum performance; then renovate energy and water systems to minimize consumption					
9	Insulating a home such as installing or replacing high voltage bulbs with fluorescent lights					
10	Installation of a cool or green roof surface that shade against solar radiation					
11	Installation of solar energy devices to supplement other power sources					
12	More VAC-VCR system instead of split units and planting of trees around the building to assist in cooling of the environment and sun shedding					

6. Basic Principles/Strategies in Achieving Energy Efficiency in Buildings and Offsetting Cost

	Items	SA	A	UN	SD	D
13	Reduce heating, cooling and lighting loads.					
14	Utilize active solar energy and other environmental heat sources and sinks					
15	Increase the efficiency of appliances, heating and cooling equipment and ventilation					
16	Consider building form, orientation and other related attributes					
17	Utilize system approaches to building design. Strategy					
18	Sitting and organizing the building configuration and massing to reduce loads.					
19	Reducing cooling loads by eliminating undesirable solar heat gain					
20	Reducing heating loads by using desirable solar heat gain					
21	Using more efficient heating and cooling equipment to reduced loads					

7. Factors Militating on Energy Efficiency in Building

S/No	Item	Yes	No
22	Lack of a legal requirement		
23	lack of appropriate information to guide decision making		
24	Economic/financial		
25	Lack of Technical skills and products to match		
26	Behavioral/organizational barriers		
27	cheapness of electricity		
28	Other types of barriers		

8. Major environmental implications of energy inefficient buildings due to the fossil fuels used for electricity generation.

S/No	Item	SA	A	UN	SD	D
29	Global warming that is causing seasonal changes and flooding					
30	Ozone layer depletion that is increasing heat within the environment					
31	Air pollutants that are increasing both outdoor and indoor air quality affecting human health					
32	Abiotic depletion that has been affecting non-living things including agriculture					
33	Acid rain that is creating smog and corrosion of buildings and bridges, affecting water and soil					

APPENDIX III

INTERVIEW GUIDELINES FOR CHIEF BCAOS, KEY KPPS AND CHIEF OFFICERS OF ESCOs

1. The reasons why sustainable energy efficiency strategies in the building development process were deemed important

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2. Requirement for Energy Efficiency Principles/Initiatives in Building Control Regulations

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3. Implementable Energy Efficiency Initiatives through Building Control Regulations

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4. Opinion of Officials on Factors Militating on Energy Efficiency in Building

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5. List and explain key principles considered important during the building development approvals process and the procedures followed to ensure their implementation

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6. Explain the importance and your awareness of energy efficiency/energy conservation principles in the building development approval process

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7. Explain any energy efficiency measures required for buildings development approvals

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THANK YOU FOR YOUR GENEROUS CONTRIBUTION TO THIS STUDY

APPENDIX IV

Result of Mean, Std. Deviation and Hypothesis Computation for Residents of Gwarinpa Housing

Hypothesis one
Level of Significance (α) = 0.05
Officials' Responses on basic principles in developing energy efficiency approaches towards sustainable built environment in FCT

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Remark
1	Reduce heating, cooling and lighting loads.	9	21	3	3	0	4.0	0.828	Accept
2	Utilize active solar energy and other environmental heat sources and sinks.	13	16	5	2	0	4.1	0.854	Accept
3	Increase the efficiency of appliances, heating and cooling equipment and ventilation.	15	11	0	8	2	3.8	1.348	Accept
4	Consider building form, orientation and other related attributes.	16	12	1	4	3	3.9	1.308	Accept
5	Utilize system approaches to building design strategy	9	9	2	5	11	3.0	1.639	Accept
6	Sitting and organizing the building configuration and massing to reduce loads	11	15	0	8	2	3.7	1.283	Accept
7	Reducing cooling loads by eliminating undesirable solar heat gain.	10	18	0	6	2	3.8	1.198	Accept
8	Reducing heating loads by using desirable solar heat gain.	14	15	2	1	4	3.9	1.264	Accept
9	Using more efficient and cooling equipment to reduce loads.	19	9	2	3	3	4.1	1.308	Accept
	Cluster mean & Std.						**3.8**	**1.226**	**Accept**

***Source**: Field Survey, 2016*

Standardization of the Principal Component variables

Variable name	Variable label	Standardized Label
Reduce heating, cooling and lighting loads.	X_1	Z_1
Utilize active solar energy and other environmental heat sources and sinks.	X_2	Z_2
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	X_3	Z_3
Consider building form, orientation and other related attributes.	X_4	Z_4
Utilize system approaches to building design strategy	X_5	Z_5
Sitting and organizing the building configuration and massing to reduce loads	X_6	Z_6
Reducing cooling loads by eliminating undesirable solar heat gain.	X_7	Z_7
Reducing heating loads by using desirable solar heat gain.	X_8	Z_8
Using more efficient and cooling equipment to reduced loads.	X_9	Z_9

The standardization or transformation was performed at zero mean and a unit standard deviation.

Correlation Analysis
Correlation Matrix[a]

Principles		1	2	3	4	5	6	7	8	9
Correlation	1	1.000								
	2	**.918**	1.000							
	3	**.627**	**.736**	1.000						
	4	**.701**	**.853**	**.938**	1.000					
	5	.261	.215	.407	**.509**	1.000				
	6	**.858**	**.805**	**.897**	**.839**	.407	1.000			
	7	**.946**	**.855**	**.791**	**.794**	.431	**.970**	1.000		
	8	**.842**	**.926**	**.784**	**.932**	**.558**	**.807**	**.852**	1.000	
	9	.483	**.740**	**.869**	**.951**	.431	**.645**	**.570**	**.831**	1.000

a. This matrix is not positive definite

The correlation results above indicate that the outlined principles have significant linear association among themselves. This property confirms the data relevant for principal component analysis. Particularly, the highest degree of association was recorded between principle 1 and principle 7. This is followed by 1 and 2; the least is between 1 and 5.

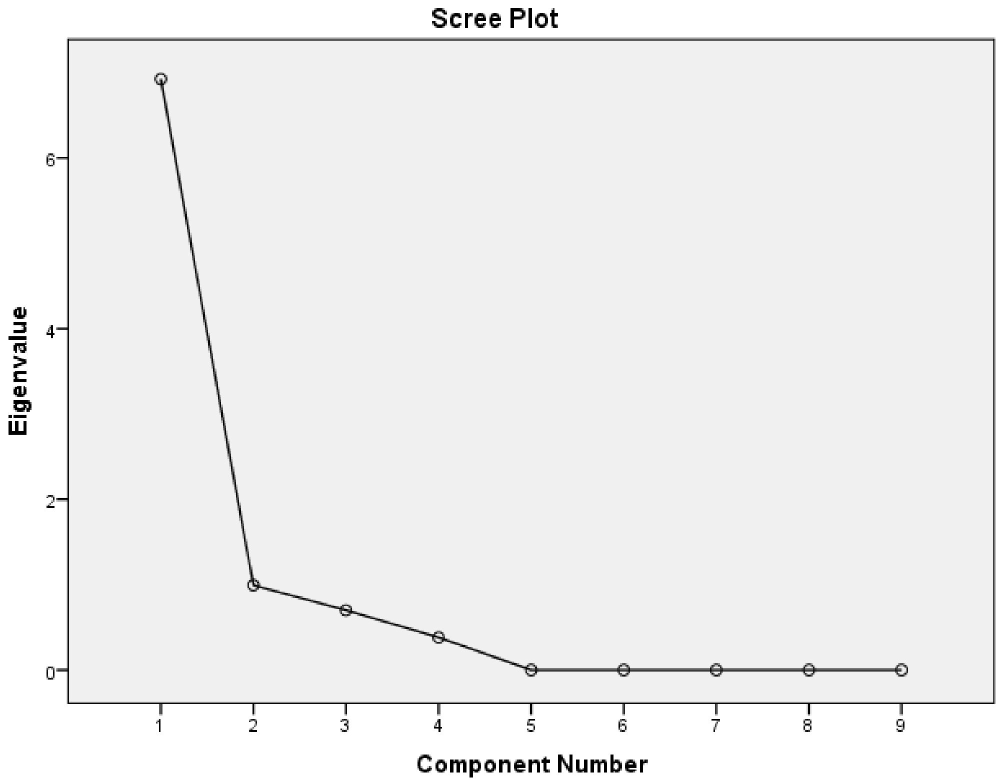

Fig. 1: Scree plot of the outlined basic principles in achieving energy efficiency and sustainable buildings in FCT, Abuja.

Source: Author's Computation using SPSS 22

The scree plot result shows a level-off after extracting the first component. This implies that only one principle is important in achieving energy efficiency towards sustainable built environment in FCT, Abuja.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.924	76.932	76.932	6.924	76.932	76.932
2	.995	11.052	87.984			
3	.700	7.776	95.760			
4	.382	4.240	100.000			
5	5.114E-16	5.682E-15	100.000			
6	1.031E-16	1.145E-15	100.000			
7	1.005E-16	1.116E-15	100.000			
8	-1.689E-16	-1.877E-15	100.000			
9	-3.263E-16	-3.626E-15	100.000			

Extraction Method: Principal Component Analysis.
Source: Author's Result using SPSS 22

Component Matrix[a]

	Component
	1
Reduce heating, cooling and lighting loads.	.861
Utilize active solar energy and other environmental heat sources and sinks.	.918
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	.906
Consider building form, orientation and other related attributes.	**.962**
Utilize system approaches to building design strategy	.499
Sitting and organizing the building configuration and massing to reduce loads	.931
Reducing cooling loads by eliminating undesirable solar heat gain.	.927
Reducing heating loads by using desirable solar heat gain.	**.961**
Using more efficient and cooling equipment to reduce loads.	.834

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

Communalities

Principles	Initial	Extraction
Reduce heating, cooling and lighting loads.	1.000	.742
Utilize active solar energy and other environmental heat sources and sinks.	1.000	.842
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	1.000	.821
Consider building form, orientation and other related attributes.	1.000	**.925**
Utilize system approaches to building design strategy	1.000	.249
Sitting and organizing the building configuration and massing to reduce loads	1.000	.866
Reducing cooling loads by eliminating undesirable solar heat gain.	1.000	.860
Reducing heating loads by using desirable solar heat gain.	1.000	**.924**
Using more efficient and cooling equipment to reduce loads.	1.000	.695

Extraction Method: Principal Component Analysis.

Test statistic: One-sample t = $\frac{\bar{x}-\mu_0}{\frac{s}{\sqrt{n}}}$

Officials' responses on sustainable practices and energy efficiency strategies in building in FCT, Abuja

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Decision
1	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices	9	18	6	3	0	3.9	0.874	Accept
2	Replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, facades and windows	15	12	7	1	1	4.0	0.996	Accept
3	Assess occupancy patterns, and then apply daylight heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable.	13	8	10	5	0	3.8	1.091	Accept
4	Re-commission all energy and water systems to verify if they are functioning at optimum performance; then renovate energy and water systems to minimize consumption	16	8	5	3	4	3.8	1.390	Accept
5	Insulating a home such as installing or replacing high voltage bulbs with fluorescent lights	17	11	3	5	0	4.1	1.063	Accept
6	Installation of a cool or green roof surface that shade against solar radiation	12	13	5	5	1	3.8	1.134	Accept
7	Installation of solar energy devices to supplement other power sources	11	17	3	5	0	3.9	0.984	Accept
8	More VAC-VCR system instead of split units and planting of trees around the building to assist in cooling of the environment and sun shedding	9	19	3	3	2	3.8	1.082	Accept
	Cluster Mean						**3.9**	**1.077**	**Accept**

t-stat. = 22.29; p = 0.0000

Opinions of residents of Gwarimpa on the sustainable practices and energy efficiency strategies in buildings in FCT, Abuja

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Decision
1	Putting off electrical appliances when not in use to reduce cost.	107	136	31	15	11	4.0	0.996	Accept
2	More VAC-VCR system instead of split units and planting of trees around the building to assist in cooling of the environment and sun shedding.	111	102	68	17	2	4.0	0.941	Accept
3	Mounting of solar energy devices.	138	142	18	2	0	4.4	0.631	Accept
4	Insulating a home such as installing or replacing high voltage bulbs with fluorescent lights.	67	104	98	12	19	3.6	1.070	Accept
5	Replacing the existing mechanical ventilation system with a natural ventilation system and reducing heat losses through reduced U-values in roof, facades and windows.	57	76	68	71	28	3.2	1.259	Accept
6	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices	49	83	75	65	28	3.2	1.219	Accept
	Cluster Mean						**3.7**	**1.019**	**Accept**

t-stat. = 3.71; p = 0.014

Hypothesis Three

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Major barriers militating against the development of energy efficiency approaches towards sustainable built environment in FCT

S/N	ITEM	SA	A	UD	SD	D	Statistics Mean	Std.	Rank
1	Lack of business and technical infrastructure	19	2	2	5	1	4.1	1.329	3
2	Financial and Economic barriers	12	16	5	0	3	3.9	1.120	4
3	Policy and Institutional barriers	22	12	3	0	2	4.3	1.009	2
4	Lack of consultation, co-ordination and co-operation	9	23	0	0	4	3.9	1.131	4
5	Vested interest and inertia	7	15	2	5	7	3.3	1.446	5
6	Human resource limitation	19	9	0	3	5	3.9	1.472	4
7	Lack of information exchange and awareness	17	8	5	0	6	3.8	1.464	
8	Knowledge gap on energy efficiency i.e. information barriers	23	10	0	2	1	4.4	0.969	1
9	Political and structural barriers	13	5	3	7	8	3.2	1.641	6
10	Behavioral and organizational barriers	11	19	2	0	4	3.9	1.180	4
	Cluster mean						**3.9**	**1.276**	

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Officials' Responses on factors militating against development of energy efficiency approaches towards sustainable built environment

S/N	Item	SA	A	UD	SD	D	Statistics Mean	Std.	Rank
1	Lack of a legal requirement	22	11	1	2	0	4.5	0.810	1
2	Lack of appropriate information to guide decision making	19	12	3	1	1	4.3	0.951	2
3	Economic/financial barriers	11	3	5	10	7	3.0	1.558	4
4	Lack of technical skills and products to match	6	11	4	10	5	3.1	1.360	3
5	Behavioural/organizational barriers	6	11	0	11	8	2.9	1.489	5
6	Cheapness of electricity	8	9	2	5	12	2.9	1.635	5
7	Other types of barriers	7	8	6	9	6	3.0	1.404	4
	Cluster Mean						**3.4**	**1.315**	

Source: ***Author's Computation from Field Survey, 2016***

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Opinions of Gwarimpa residents on factors militating against development of energy efficiency approaches towards sustainable built environment.

S/N	Item	SA	A	UD	SD	D	Statistics Mean	Std.	Rank
1	Financial challenges	67	83	28	53	69	3.1	1.506	3
2	Lack of a legal requirement	176	79	37	5	3	4.4	0.842	1
3	Lack of technical skills and products to match	61	83	28	59	69	3.0	1.488	4
4	Lack of appropriate information to guide decision making	133	106	49	8	4	4.2	0.895	2
	Cluster Mean						**3.7**	**1.183**	

Source: ***Author's Computation from Field Survey, 2016***

Hypothesis Four

Respondents' opinions on the major environmental implications of energy inefficient buildings in FCT Abuja.

S/N	ITEM	SA	A	UN	SD	D	Mean	Std.	Rank
1	Global warming causing changes in weather and causing flooding	175	58	17	42	8	4.2	1.207	2
2	Ozone layer depletion thereby increasing the heat within the environment	108	125	42	0	25	4.0	1.134	3
3	Increasing outdoor and indoor air pollution	158	100	25	0	17	4.3	1.031	1
4	Abiotic depletion affecting non-living things	75	108	67	33	17	3.6	1.150	5
5	Influence of acid rain and smog in the environment	100	92	50	50	8	3.8	1.162	4
	Cluster Mean						**4.0**	**1.140**	

Source: ***Author's Computation from Field Survey, 2016***

Officials' responses on the major environmental implications of energy inefficient buildings in FCT Abuja.

S/N	**ITEM**	**SA**	**A**	**UN**	**SD**	**D**	**Mean**	**Std.**	**Rank**
1	Global warming causing changes in weather and causing flooding	12	6	2	10	6	3.2	1.570	
2	Ozone layer depletion thereby increasing the heat within the environment	11	21	0	2	2	4.0	1.028	
3	Increasing outdoor and indoor air pollution	15	9	1	8	3	3.7	1.431	
4	Abiotic depletion affecting non-living things	6	11	0	11	8	3.0	1.481	
5	Influence of acid rain and smog in the environment	11	3	5	10	7	3.0	1.558	
	Cluster Mean						**3.38**	**1.414**	

Source: ***Author's Computation from Field Survey, (2016)***

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principle6 principle7 principle8 principle9

  /MISSING LISTWISE

  /ANALYSIS principle1 principle2 principle3 principle4 principle5 principle6
principle7 principle8 principle9

  /PRINT INITIAL CORRELATION SIG KMO EXTRACTION ROTATION FSCORE

  /PLOT EIGEN ROTATION

  /CRITERIA MINEIGEN(1) ITERATE(25)

  /EXTRACTION PC

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Factor Analysis

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Correlation Matrix[a]

Principles		1	2	3	4	5	6	7	8	9
Correlation	1	1.000								
	2	.918	1.000							
	3	.627	.736	1.000						
	4	.701	.853	.938	1.000					
	5	.261	.215	.407	.509	1.000				
	6	.858	.805	.897	.839	.407	1.000			
	7	.946	.855	.791	.794	.431	.970	1.000		
	8	.842	.926	.784	.932	.558	.807	.852	1.000	
	9	.483	.740	.869	.951	.431	.645	.570	.831	1.000

a. This matrix is not positive definite.

Communalities

	Initial	Extraction
Reduce heating, cooling and lighting loads.	1.000	.742
Utilize active solar energy and other environmental heat sources and sinks.	1.000	.842
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	1.000	.821
Consider building form, orientation and other related attributes.	1.000	**.925**
Utilize system approaches to building design strategy	1.000	.249
Sitting and organizing the building configuration and massing to reduce loads	1.000	.866
Reducing cooling loads by eliminating undesirable solar heat gain.	1.000	.860
Reducing heating loads by using desirable solar heat gain.	1.000	.924
Using more efficient and cooling equipment to reduce loads.	1.000	.695

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.924	76.932	76.932	6.924	76.932	76.932
2	.995	11.052	87.984			
3	.700	7.776	95.760			
4	.382	4.240	100.000			
5	5.114E-16	5.682E-15	100.000			
6	1.031E-16	1.145E-15	100.000			
7	1.005E-16	1.116E-15	100.000			
8	-1.689E-16	-1.877E-15	100.000			
9	-3.263E-16	-3.626E-15	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
Reduce heating, cooling and lighting loads.	.861
Utilize active solar energy and other environmental heat sources and sinks.	.918
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	.906
Consider building form, orientation and other related attributes.	.962
Utilize system approaches to building design strategy	.499
Sitting and organizing the building configuration and massing to reduce loads	.931
Reducing cooling loads by eliminating undesirable solar heat gain.	.927
Reducing heating loads by using desirable solar heat gain.	.961
Using more efficient and cooling equipment to reduce loads.	.834

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Component Score Coefficient Matrix

	Component
	1
Reduce heating, cooling and lighting loads.	.124
Utilize active solar energy and other environmental heat sources and sinks.	.133
Increase the efficiency of appliances, heating and cooling equipment and ventilation.	.131
Consider building form, orientation and other related attributes.	.139
Utilize system approaches to building design strategy	.072
Sitting and organizing the building configuration and massing to reduce loads	.134
Reducing cooling loads by eliminating undesirable solar heat gain.	.134
Reducing heating loads by using desirable solar heat gain.	.139
Using more efficient and cooling equipment to reduce loads.	.120

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

T-Test for Hypothesis three

```
Test of mu = 3.000 vs mu not = 3.000


Variable     N      Mean     StDev   SE Mean         T          P

Mean tes    10     3.870     0.380     0.120      7.24     0.0000
```

T-Test

```
Test of mu = 0.000 vs mu not = 0.000

Variable     N      Mean     StDev   SE Mean         T          P

average      7     3.371     0.674     0.255     13.24     0.0000
```

For hypothesis four

```
NONPAR CORR

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  /MISSING=PAIRWISE.
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Nonparametric Correlations

Notes

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a. Based on availability of workspace memory

Correlations

			Officials' opinion ranks	Residents' opinion ranks
Spearman's rho	Officials' opinion ranks	Correlation Coefficient	1.000	.500
		Sig. (2-tailed)	.	.667
		N	3	3
	Residents' opinion ranks	Correlation Coefficient	.500	1.000
		Sig. (2-tailed)	.667	.
		N	3	3

APPENDIX V
Building Control and Approval Documents

CLERK OF WORKS SECTION
BUILDING DEVELOPMENT - MUNICIPAL INFRASTRUCTURE

REQUIREMENTS

1. Documents to be submitted by contractor to C.O.W. prior to commencement of work on building site

- 1.1 Valid Good Standing Ceritificate for the duration of the contract ☐
- 1.2 Section 37 (2) signed Health & Safety contract ☐
- 1.3 Safety File ☐
- 1.4 Public Liability Insurance Cover ☐
- 1.5 Clearance Certificate from Health & Safety Officer ☐

2. Documents required for Construction (Where applicable)

- 2.1 Full set of approved Building Plans from architecht ☐
- 2.3 Geo Tech Report ☐
- 2.4 Soil Test Report ☐
- 2.5 Land Surveyor's Certificate ☐
- 2.6 Engineer's Certificate (A19 Appointment) ☐
- 2.7 Engineer's Inspection Reports ☐
- 2.8 Concrete Super Structure Report & Inspections (Concrete Columns/Beams/Slabs/Steelwork) ☐
- 2.9 Completion Report ☐

3. Roof Structures

- 3.1 Roof Design & Drawings (Gangnail / Steel / Concrete) ☐
- 3.2 Roof Guarantee ☐
- 3.3 Loading Certificate ☐

4. Electrical

- 4.1 Electrical Layout plan ☐
- 4.2 Local (EMM) Inspection Report (Before C.O.C. will be accepted) ☐
- 4.3 Certificate of Compliance (C.O.C.) ☐

5. Plumbing

- 5.1 Plumber's Certificate (Only Olifantsfontein Plumbing Trade Certificate accepted) ☐

6. Certificates Required for Occupation of building or structure

- 6.1 A19 Appointment of Engineer ☐
- 6.2 Completion Certificate / Report - Engineer ☐
- 6.3 Roof Guarantee ☐
- 6.4 Loading Certificate ☐
- 6.5 C.O.C. ☐
- 6.6 Fire Department Inspection Report ☐
- 6.7 Project Manager's Completion Certificate ☐

.... Name of C.O.W.   .... Signature   .... Date

CLERK OF WORKS SECTION
BUILDING DEVELOPMENT - MUNICIPAL INFRASTRUCTURE

INSPECTION CHECK LIST

1. **Commencement of Project**
   - 1.1 Boundary Pegs ☐
   - 1.2 Position and Setting out of Buildings ☐
   - 1.3 Water Connection ☐
   - 1.4 Sewer Connection ☐
   - 1.5 Electrical Connection ☐
   - 1.6 Ablution Facilities and Site Offices ☐

2. **Foundations**
   - 2.1 Excavations ☐
   - 2.2 Foundation Re-inforcing ☐
   - 2.3 Engineer's Inspection ☐
   - 2.4 C.O.W. Inspection ☐
   - 2.5 Correct mix of Concrecte casted ☐

3. **Floor Slabs**
   - 3.1 Compaction and Filling ☐
   - 3.2 Engineer's Inspection ☐
   - 3.3 C.O.W. Inspection ☐
   - 3.4 Correct mix of Concrecte casted ☐

4. **SuperStructure**
   - 4.1 Correctness & Quality of Workmanship ☐
   - 4.2 Correctness & Quality of material ☐
   - 4.3 Execution of Correct Building Practice ☐
   - 4.4 Execution of Correct Health & Safety Specifications ☐

5. **Plumbing & Drainage**
   - 5.1 Engineer's Inspection - Open test ☐
   - 5.2 C.O.W. Inspection - Open test ☐
   - 5.3 C.O.W. Inspection - Close test ☐
   - 5.4 Rodding ie's and Manholes ☐
   - 5.5 Vent Valves at correct positions ☐
   - 5.6 Bollerstops at all wc's, sinks and WHB's ☐
   - 5.7 Correct size water & sewer pipes used ☐
   - 5.8 Geyser correctly installed ☐
   - 5.9 Plumbing done correctly ☐

6. **Roof Inspection**
   - 6.1 C.O.W. Inspection ☐
   - 6.2 Engineer's Inspection Report ☐
   - 6.3 Ceiling Joist / Brandering / Purlins & Bracing Inspection ☐

7. **Electrical**
   - 7.1 C.O.W. Inspection ☐
   - 7.2 Electrical Inspector's Inspection & Report ☐
   - 7.3 Correct Material used ☐

8. **Completion**
   - 8.1 Snag List ☐
   - 8.2 Snag List executed ☐
   - 8.3 Check all required documents necessary for occupation ☐

....	....	....
Name of C.O.W.	Signature	Date