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Using House of Quality (HOQ) to Integrate Energy Efficiency Decision Making Among Stakeholders of Mass Housing Projects

by

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MASTER OF PHILOSOPHY

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DECLARATION

I hereby declare that this submission is my own work towards the MPhil Building Technology and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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ABSTRACT

Design for the built environment is essentially collaborative and demands effective communication between the various stakeholders who in most cases have varying and opposing perspectives on how, when and why a building should be energy efficient. Studies indicate conflicting stakeholder requirements is a major barrier in implementing sustainability in buildings with decisions often made based on short-term economic grounds. However, the important role that different building stakeholders play in determining the type and extent of impact of building stakeholders on Building Energy Efficiency (BEE) requirement and the alignment among these stakeholders have not been accounted for in most studies. This research presents a unique investigation into evaluating the impact of different groups of stakeholder requirements on sustainable and technical aspects of building energy efficiency decisions in the mass housing sector. In this research, a House of Quality (HOQ) model was developed to synthesize the differences among the stakeholders and integrate their competing objectives to establish BEE ranking that meets stakeholder requirements in the mass housing sector. The HOQ analysis revealed that the stakeholder type in the study did not affect the ranking of their requirements, and in general, all the groups of stakeholders involved in this study did not affect the ranking of their requirements. All the stakeholders involved in this study, agreed that the primary reasons for implementing energy efficiency decision-making is based on economic grounds. The study also established that a top-down owner commitment to sustainability is needed to align the many competing stakeholder requirements and eliminate barriers that could potentially prevent efficient project decisions and results.

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HOQ	House of Quality
BEE	Building Energy Efficiency
EC	Energy Commission
MWRWH	Ministry of Water Resources Works and Housing

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DEDICATION

I dedicate this work, with much admiration, to the memory of my late Grand mum, Madam Rebecca Mills, in appreciation of her love, care and kindness during our upbringing.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Buildings are focal points of human activity and constitute greatly to energy use and emission of green gas (OECD, 2003; EPA GB, 2004; Chan and Lau, 2005). Threat of climate change and future energy price uncertainty has led to national debate on energy efficiency, particularly the energy efficiency of housing projects (Morrissey and Horne, 2010). This serious global problem calls for improvement in energy efficiency of all sectors, especially the building sector, considered a major energy consumer (Zheng et al., 2011). Energy efficiency is greatly acknowledged as a major factor in decoupling economic growth from the threat imposed by energy consumption increase and greenhouse gas emission by reducing the amount of energy services provided. Further, efficiency in energy supply meets the goal of providing security of supply and efficiency of economic productivity. Despite the promising benefits of energy efficiency, significant challenges exist in both developed and developing countries due to variety of barriers.

Housing, seen as a critical component of a country's economic and social fabric. According to Nubi (2008), housing seen as a basic need of a man; is a key indicator of the standard of living of a person in a society. With the rapid growth in the economy and living standards of people improving, housing needs and supply discrepancy coupled by rapid urbanization has been a major challenge to various governments.

Increasing growth in both energy use and housing demand due to rapid urbanization, adoption of energy efficiency design practice in the building sector will contribute greatly to the sustainability process. Various researchers have indicated that urbanization trends will further increase the importance of Building Energy Efficiency (BEE) in the coming years ahead (Costa and Kahn, 2009; Davis, 2009; Zheng et al., 2009, 2011) with Ghana's housing sector not an exception.

The building industry has been characterized as been conservative in culture, due to the evidence of embedded practices that impedes increase in energy efficiency of new buildings (Levine et. al., 2007; Karlstrøm et al., 2012). Thus, a little increase in the building of sustainable housing, and additionally in the adaptation of energy efficiency practices in their construction, will have major impact in the current energy use and the life-cycle consumption of energy (Levine et. al., 2007). Various research into building energy efficiency in housing indicate that the energy use throughout the lifetime of a building can be categorised into two distinct stages namely; the operational energy and embodied energy (Verbeeck and Hens, 2010; Iddon and Firth, 2013).

Fragmented nature of the design and construction process of building with many building stakeholders influencing from different background the building process; a consideration into energy efficiency level of the different stakeholders is justified. Making decisions for building energy efficiency is a social and highly dependent process, mainly affected by the building stakeholders' perception and uniqueness of a project's characteristics (Menassaa and Baer, 2014) emphasize the need for the various stakeholders to agree in the decision-making process. Achieving the energy efficiency at the design phase and construction phase of buildings at the project-level is a major challenge upon the acceptance of BEE needs.

With Building Energy Efficiency (BEE) housing projects unfamiliar to most stakeholders due to the compounded nature of such process, a comprehensive decision making framework that aligns the requirement of the various stakeholders to determine a sustainable and engineering acceptable solution (Lapinski et al., 2007; Klotz and Horman, 2010; Menassaa and Baer, 2014). Design for the built environment is essentially collaborative and demands effective communication between the different stakeholders, all of which have their own specialist terminology and knowledge. The resolution of this problem often falls in the hands of stakeholders in the built environments, who have the professional skills and knowledge to address this issue best.

Thus, stakeholders' alignment for energy efficiency improvement is a fundamental challenge that needs to be addressed if the goal of energy use reduction in buildings is to be achieved. A more complete approach to a truly energy efficient building should include stakeholder requirements to achieve social, economic and environmental equity (Savitz and Weber, 2006). Thus, it is imperative to appreciate the requirements of the various stakeholders, their effect and the extent to which its affects the sustainable and technical aspects of a building.

1.2 PROBLEM STATEMENT

With Mass housing projects constituting the single largest in the construction sector in terms of enhancement of the economy of most countries (Wells, 1999; Zawdie and Langford, 2000). Together with the rapid rate of urbanization experienced by most countries and the acceleration of infrastructure development there is a real need for urgency in introducing energy efficiency practices in the housing sector.

This hints at the fact that man's basic need is housing (shelter) and consumes the highest amount of energy among the various sectors (Energy Commission, 2012). It is now well recognized that efficiency improvements in energy used by the building industry would make a major contribution to meeting national goals such as increasing investment in energy efficiency, energy supply improvement security, productivity enhancement, competiveness and greenhouse gas emission reduction.

With growth in demand for housing units together with the increase in energy use, residential buildings could contribute greatly to energy use reduction with the adoption of sustainable energy efficiency design approach (Costa and Kahn, 2009; Zheng et al., 2011). With energy supply in Ghana below the demand level (Brew-Hammond and Kemausuor, 2007; Essah, 2011). Whiles design for the built environment is essentially collaborative and demands effective communication between disciplines, all of which have their own specialist terminology and knowledge; sustainable solution can be achieved by engaging the various stakeholders in the design process early to confront conviction and presupposition of all stakeholders and provide solutions that meet the sustainability features of buildings (Boecker et al., 2009).

Thus, a design phase based on four E's (everybody, engaging, everything, early) to explicitly address each team stakeholders values, aspirations and objectives (e.g., reduced energy consumption and increased thermal comfort) very early on in the design process to achieve a consensus (alignment) is the way to go. The need for an iterative process that allows communication at every level to incorporate each stakeholder's values so each stakeholder can understand how their values relate to the others would lead to identifying creative solutions that placate all stakeholder concerns since the various building stakeholders enters the building process at different stages.

Thus, the primary objective of this study is to present a concise decision framework that evaluates the impact of different groups of stakeholder requirements on sustainable and technical aspects of building energy efficiency decisions in the mass housing sector.

1.3 AIM

The principal aim of the study is to use the House of Quality model to integrate energy efficiency decision making among stakeholders of mass housing projects.

1.4 OBJECTIVES

To achieve the aim, the following specific objectives were accomplished:

1. To identify the important building energy efficiency requirements among stakeholders of mass housing projects.
2. To assess the impact of technical characteristics of mass housing project on each stakeholders' requirements.
3. To assess the impact of sustainability pillars on each stakeholders' requirements.
4. To adopt the HOQ model in integrating energy efficiency decision making for mass housing projects.

1.5 RESEARCH QUESTIONS

In achieving the objectives, the following questions were articulated to guide the research;

- What is the level of awareness of stakeholders on Building Energy Efficiency and how does it affect decision making?
- What are the perceptions of stakeholders on the concept of energy efficiency?
- What are the requirements of the various building stakeholders' and how do these requirements correlate with the technical component of the building?
- How is the technical aspect of the building affected by the ranking of the type of stakeholder requirement?
- What are the impacts of sustainability pillars on each stakeholder's requirement?
- Is there a gap in the current decision making practice among stakeholders on energy efficiency in the mass housing sector?

1.6 RESEARCH METHOD

An approach involving a mix-method thus a combination of both qualitative and quantitative research methods was adopted for this study. Elaborate literature grounded on the objectives of the study to ascertain the development and global status of building energy efficiency in mass housing. This was done to discover the major challenges facing the industry and the contributions that could be made thereof by this study, in order to characterise the study context and help identify the relevant participants for the study.

This is followed by a field study involving the designing, sampling, collection of data and data analysis for the study. The sample population consists of building stakeholders in the housing sector. Questionnaire was designed taking into cognizance the objective of the research and the information gathered from literature. With House of Quality (HOQ), a primary tool of Quality function deployment (QFD) (Delgado-Hernandez et al., 2007), was adapted for the study. The HOQ matrix was used to present the building stakeholders requirement (the WHAT side) to how those requirement would be achieved (the HOW side). In achieve the best design product development, the voice of the customer is a major tool employed by HOQ. Statistical tools considered for the analysis include: Relative Importance Index, Relative Weight. A more detail discussion of the research methodology was done at the Chapter three of this thesis.

1.7 SIGNIFICANCE OF STUDY

The importance of the application of energy efficiency decision making in mass housing project during the design phase cannot be underestimated. It is well recognized that engaging everybody early to explicitly address each stakeholders values, aspirations and very early on in the design process to achieve a consensus (alignment) is the way to go. The research major contribution to knowledge is that, it identified the main various requirements in the integration process that will aid building stakeholders to implement energy efficiency practice in their decision making, in the context of mass housing project especially.

Secondly, empirically-based evidence is provided from the findings of the study for the various stakeholders in the housing industry on the current nature of Building Energy Efficiency (BEE) practices currently practiced in Ghana. The work will further strengthen and improve stakeholders and key players' contribution in the formulation of effective energy efficient framework to aid energy efficiency practice in decision making for mass housing delivery in Ghana. Lastly, the study of building energy efficiency in mass housing project is a relatively new area in energy management in Ghana and its successful determination does not only make mass housing projects energy friendly but will also inevitably show the way forward for further research to strengthen and improve the housing sector.

1.8 SCOPE OF STUDY

The research focused on embodied energy aspect of building energy efficiency. With building stakeholders and their influence in the decision making process were engaged since 'success' in the implementation of energy efficiency can be viewed from several interpretations, by wide range of persons and measured by many factors that affect projects outcomes. The study adopted HOQ model of participants in the application of HOQ analysis. Against this background, potential respondents for the study were depicted from Ghana Real Estate and Developers Association (GREDA) membership recognized by government with the primary business of construction of mass housing project. The fact that GREDA members specializes in mass housing projects construction process and are involved in the decision making process is important, viz. the criteria associated with HOQ.

With a typical organization structure comprising of building stakeholders; architects, quantity surveyors, facilities managers, service engineers (Ahadzie, 2007) and housing client who beneficial to housing projects. Geographically the study was focused on GREDA members in the Greater Accra region, with over 95% of the composition of GREDA members based in that region since the Ghanaian construction industry is significantly skewed towards the capital city.

1.9 OUTLINE OF THESIS

Outline of the study, divided into five main chapters is discussed below;

The first chapter (Chapter 1) provides a brief of the study introduction, which includes the background/introduction of the study; together with the problem statement thus the reason for conducting such research. The main aim with the specific objectives of the study and the questions asked in achieving the aim of the study. Also this chapter gives an outline of a brief of research approach, scope of study and the significance of the study. The second chapter (Chapter 2) looks at the global focus on energy efficiency, mass housing industry, building energy efficiency, building energy efficiency decision making, House of Quality and BEE approach using HOQ through a comprehensive literature review. The third chapter (Chapter 3) discusses the methods, strategy and approach chosen for this study. Also, procedure for the sampling technique and population for the study are discussed in this chapter. Finally, data collection method, data analysis and presentation of data are elaborated. The chapter four (Chapter 4) provides the analysis, finding and discussion of the data collected from the survey. Both tabular and graphical presentation of data was presented for discussion and finally, the fifth (5) Chapter provides a summary for the conclusion and recommendation of the study. A brief of the study objective outline, contribution to knowledge, limitation of the study and direction for future study is presented in this chapter.

1.10 CHAPTER ONE SUMMARY

The background and problem statement of the study, with the aim of integrating energy efficiency decision making among stakeholders of mass housing project have been presented together with the objectives. A primary tool of Quality function deployment (QFD), known as The House of Quality (HOQ) that aligns features of design and construction process though an integrated decision-making methodology was adopted for the study. The significance of the study in relationship to building stakeholders integration in making energy efficiency decisions in the context of the housing sector was be enlighten. In the next chapter, an elaborated review of building energy efficiency in the housing sector, especially those relating to energy efficiency decision-making among building stakeholders.

CHAPTER TWO

LITERATURE REVIEW

2.1 BUILDING ENERGY EFFICIENCY

Efficiency generally is expressed as a relationship between resources (e.g. materials and energy) required to undertake a task or to render a service and the output of the task (IEA, 1991). Globally, both empirical and anecdotal evidence shows low levels in efficiency, particularly in energy. There is therefore an attempt by the various building stakeholders to improve energy efficiency. The International Energy Agency (IEA) (1991) defined energy efficiency improvement as the conscious efforts made by a producer or consumer of energy products towards reducing energy use per unit of output, without compromising the level of service provided. The Agency further established three ways of achieving energy efficiency: requiring less energy to achieve the same result, requiring the same amount of energy to produce a better result and requiring less energy to produce a better result. Aside the environmental benefits, energy efficiency also has significant economic advantages and helps to reduce the external energy dependence leading to competitive advantages. Additionally, energy efficiency measures have short payback periods and ultimately add to bottom line profits as continued increases in the price of the energy (Anbumozhi, 2009).

With energy consumption of buildings accounting for more than forty percent (40%) of energy demand and one-third of global greenhouse gas emissions (Wulfinghoff, 1999; Perez-Lobard et al., 2008; Saidur, 2009), buildings have become one of the focal points of energy efficiency efforts. Introduction of sustainable energy technologies and reducing energy demands have been in the heart of the endeavour in the environmental performance of building improvement.

A similar view is expressed by UNEP (2007) with buildings consuming about 80 percent of the energy consumption of a building lifecycle when the building is occupied and in use. A significant reduction in the lifecycle consumption of buildings can be attained by instituting energy efficiency design practice in the Architecture, Engineering and Construction (AEC) industry. Consequently, a major role is played by energy efficiency in satisfying the energy demands of buildings especially because building industry offers significant and cost-effective reduction in green-house gas emission in comparison to other sectors (Sustainable Building and Climate Initiative, 2009). Hence major attention is being placed on low energy building design and construction and in ambitious cases buildings that are net producers of energy (World Business Council for Sustainable Development, 2007).

Furthermore, recently focus of client has been on an economic life-cycle cost of buildings in preference to cheaper possible constructional design (Mbelede, 2010). This has led to the introduction of energy efficient building technologies into buildings to reduce the future energy cost and the environmental, social issues related to energy use.

2.2 GLOBAL SITUATION OF BUILDING ENERGY EFFICIENCY (BEE)

Sustainable Development agenda and urbanisation demand the need to resort to the use of different energy. Also, future projections further underscore the need for alternative energy sources. The IEA pegs energy consumption at 40% by 2030, based on its value in 2007. According to the United Nations (UN), buildings form part of the highest consumers of energy, accounting for 30–40% of the world's energy consumption (UNEP, 2007) with developed countries contribution in the region of 40-45% of CO_2 emissions (Shorrock and Henderson, 1990; Shorrock et al., 2001; Shorrock et al., 2005). As aforementioned, buildings contribute remarkably to the total energy consumption in many countries. Studies (e.g. Vine, 2003; Butler, 2008; Pe´rez-Lombard et al., 2008; Saidur, 2009) argue that buildings consume almost half of the primary energy resources. The various authors emphasize energy efficiency has become the foremost targets for energy policy at all levels of government organization system. Saidur (2009) further reiterates that energy efficiency improvement is the most cost-effective measure to carbon dioxide (CO_2) emissions reduction, a major cause of global warming.

Consequently, policy directives have been steered towards improved energy efficiency in buildings for at least 35 years. Albeit these policies and the success stories so far (see for instance Deason and Hobbs, 2011) buildings energy use continues to grow. The probable explanation is that these policies have been ad-hoc rather than focusing on the long term development agenda. The current trend is particularly worrying especially when cost-effective opportunities abound. For instance, in 2010, about a third of global final energy demand (IEA, 2011) and carbon dioxide (CO_2) emissions were from energy services in residential and commercial buildings. As suggested by Levine et al, (2007) about 29% of global baseline buildings CO_2 emissions could be eliminated with investments that pay for themselves through reduced energy cost. The largest part of this CO2 emission reduction is associated with installation of energy efficiency

technologies. The pervasiveness of such opportunities is a testament to the difficulties of achieving apparently cost-effective energy improvements.

It will not be farfetched to say that energy efficiency improvement is imperative to achieving energy security and in consequence environmental and economic challenges. Indeed, IEA (2011) argued energy efficiency improvement as both the fastest and costeffective strategy. New buildings are considered to be an easy target for implementing cost-effective energy efficiency improvements using existing technologies (Levine et al., 2007). This view has gained considerable support at a policy level in Europe. Enhancing the thermal performance of the building envelope should therefore be a priority in the delivery of new, energy efficient housing.

However, the experience of developed countries suggests that implementing these improvements may not be so straight forward in practice. Recent studies of new housing being constructed in the UK suggest a significant discrepancy (Taylor et al., 2013). Notwithstanding, attempts are made towards improving energy efficiency. A remarkable approach is the pragmatic shift in the direction of the exploit of building energy regulations, standards and codes to reduce building energy consumption (Vine, 2003; Hitchin, 2008; Fayaz and Kari, 2009; Radhi, 2009; Iwaro and Mwasha, 2010).

2.3 BUILDING ENERGY EFFICIENCY SITUATION IN DEVELOPING

COUNTRIES

Urbanisations amongst other factors, have led to the increase in energy consumption in most developing countries. This has fuelled environmental problems such as unusual increase in energy demand, global warming, acid rain and air pollution (Building Energy Standards, BES, HKU, 2009; Janda and Busch, 1994). According to Abbasi and Abbasi (2010), the energy sectors in developing countries are faced with two major challenges on the road to a sustainable future, which are securing energy supply and curbing contribution of energy use to climate change.

Existing research shows buildings as the biggest energy consumer which accounts for 45% of the primary resources of energy (Chow, 2001; Omar and Mohammed, 2004; Yamtraipat et al., 2006;Yang et al., 2008; Radhi, 2008; Lombard et al.,2008). Globally energy consumption has increased steadily from 20% and 40% in developing countries in both residential and commercial building (EC, 2007; Hassan, 2008; Lombard et al., 2008). With the rising swing in energy demands in buildings expected to grow given the increasing population growth, with increasing demand for building services and comfort, and the rise in time spent inside buildings (Perez-Lobard et al., 2008) energy consumption in developing countries will be increased. A significant component of sustainability is energy efficiency. Commitment of developing countries to the Climate Change Act (2008), for 80% reduction in each country's anthropogenic CO2 emissions, or rather its net carbon account below the 1990 levels by the year 2050 looks difficult to be achieved. Demand in energy will continue to increase in the future with economic development and increasing population in most developing countries. For this reason, energy efficiency in building is seen today as a principal objective for energy policies at various levels of government (Lombard et al., 2008; Saidur, 2009). A major hindrance in attaining the UN Millennium Development Goals (MDGs) of economic and social development in developing countries; is the lack of accessibility to energy services (IEA, 2006, 2008, 2009, 2010; WEC, 2010; REN21, 2010). Developing countries regardless of energy or fuel prices; need to undertake energy efficiency policies more diligently in the long-term.

In most developing countries, with the increase in the number of new buildings, existing market often stifles the application of efficient energy technologies (Hui, 2000). These have led to adoption of the energy building standards and codes to control and manage energy consumption in developing countries. Surprisingly, fundamental legislations to regulate energy consumptions are non-existing in most developing countries. Even where they exist, they are still in the preliminary stages (Deringer et al., 2004; UNEP, 2009a, 2009b). However, its effectiveness varies significantly from country to country, mainly due to difficulties and resulting differences in compliance and enforcement, corruption, etc. (Deringer et al., 2004). This partially explains the reluctance of International Donor Agencies in promoting energy building standards in developing countries.

Improvements have been made at the operation phase of building energy efficiency (Kaygusuz, 2012) with electrical appliances and new technologies such as “smart” metering, solar photovoltaic and more efficient lighting in most developing countries. Seventy percent (70%) of new buildings could be made more efficient than existing buildings through more efficient designs and use of insulated windows (Kaygusuz, 2012). However, advances in energy efficiency could be achieved through governments development and implementation of policies such as regulations and standards, fiscal incentives, public information campaigns, labels, and public-sector leadership on building energy efficiency (OECD, 2007; IEA, 2008, 2010a, 2010b).

2.4 GHANA'S SITUATION ON BUILDING ENERGY EFFICIENCY

Throughout the progressive era and in the decades since, an eagerness to define important public issues as questions of efficiency has been a common strategy. Thus it is not surprising to see efficiency reappear at the centre of today's energy debate. Ghana, as a member of the United Nations Framework Convention on Climate Change, is obliged to reduce emission of greenhouse gases to protect the globe environment and to promote sustainable development of the world. Energy efficiency in buildings has become a key factor that has a great impact of energy security, optimization of energy structure, energy efficiency improvement and Green House Gas (GHG) emission reduction. Other countries may have similar situations, but the extent of new building construction makes Ghana's case unique. It provides not only a major opportunity to 'grow out' of much of the problem, but also a danger, if not addressed, of locking in enormous energy waste and inefficiencies for future generation (World Bank, 2001). In July 2006, the Ghana government released its Strategic National Energy Plan on Energy

Conservation in the Mid- to Long-term, with its focus on reducing Ghana's GDP energy intensity by 20%, as well as a reduction in the total emissions of pollutants by 20% below the current level.

In Ghana, energy efficiency initiatives started since the mid-1980s. Ghana with the aim to integrate Renewable Energy (RE) and Energy Efficiency (EE) development into the energy sector reforms, established two regulatory agencies in 1997, namely, the Energy Commission (EC) and the Public Utilities Regulatory Commission (PURC). The Energy Commission was established by an Act of Parliament (Act 541) to recommend the development and utilization of Ghana's indigenous energy resources, through the reparation of a strategic national energy plan. The second regulatory agency, the PURC, was also established by an Act of Parliament (Act 538) to be responsible for price and quality of service regulation. A third institution is the Energy Foundation (EF), which was, created in 1997 as a Public-Private Partnership institution. The primary aim of this institution is to focus on the promotion of energy efficiency development. The Foundation also specializes in providing energy solutions, particularly for industrial and residential consumers (Energy Commission, 1997; Gboney, 2008; Energy Commission, 2006a). Recognizing the very important role energy efficiency and conservation plays in ensuring security of energy supply, Ghana has pioneered standards for household appliances in Africa. The country developed Energy Efficiency Standards and Labels for Refrigerating Appliances similar to that for Room Air Conditioners and Energy Saving Lamps. The measurement of energy efficiency initiatives is growing and accumulating some positive results. There are, however, several features in the Ghana energy market which inhibit its effectiveness, due to a series of obstacles and imperfections (Gboney, 2008).

Whilst need for energy efficiency building standard and codes inserted in the National Building Regulation are the most common policy measures in most countries, Ghana's building efficiency policies are more focused on the operational phase of the building with little focus on the embodied energy phase of energy efficiency building. Thus, the need to develop the capacities of construction professionals and other self-builders through training, education and information dissemination. Also, Ghana's energy efficiency regulations and policies must be administered at levels ranging from the highest level of state government down to municipal and district level, with sole purpose to integrated and build a consensus approach in sectors of development.

2.5 MASS HOUSING

Housing is one sector that interrelates with other sectors of the society and the overall national economy. Keija (2008) affirmed that the housing development is closely related to economy development of the country. At the apex of this importance is the contribution of housing construction towards the overall construction output. Various research estimates that contribution of Mass Housing Project accounting for about 60% of the construction GDP in relation to all other building projects (such as schools, factories, offices and commercials) (Zawdie and Langford, 2000: Wells, 2007). Mass housing projects contribute to the largest share of the Gross Fixed Capital Formation

(GFCF).

For the purpose of this research Mass Housing Project adopts the definition of Ahadzie et al, (2006a) as "the design and construction of speculative standardised multiple house-units usually in the same location and executed within the same project scheme". This definition acknowledges the key concept of repetitive techniques in the production methods and also recognises the peculiar characteristics of the construction industry (Ahadzie et al, 2006c).

Mass Housing projects (MHPs) are said to differ significantly from 'one-off' traditional projects and thus require unique managerial skills and efforts to deliver them successfully (Thorpe et al., 1999; Turner, and Müller, 2003; Ahadzie et al., 2007; Adinyira et al., 2013). Choice of meeting large housing deficit and speculative needs of the population have led to the choice of mass housing projects for mass-scale delivery of house-units within the shortest attainable time (Youngha Cho, 2003, Roy et al, 2003) which led to the choice of such housing project for this study.

With the rapid population growth in most developing countries Mass Housing Projects makes the single most important contribution to the Gross Fixed Capital Formation (GFCF). Unlike other government controlled works like civil engineering works, mass housing projects is now controlled by private sector developers and employs the largest human resources (UK Trade and Investment, 2004; Ahadzie et al, 2006; Wells, 2007). References to indicators such as the population growth rate, household income and economic growth show the significance of mass housing project to the economy of most countries (Windapo et al., 2004).

2.5.1 Mass Housing and Stakeholders in Ghana

Fragmented and unsustained efforts in the provision of housing in Ghana from the various stakeholders have contributed to the huge housing deficit in the country (Ahadzie et al., 2007; Kwofie et al., 2012). With delivery and access to decent accommodation throughout the country at it crisis peak (Kwofie et al., 2012). One of the most critical socio-economic challenges in Ghana is the housing shortage (Ghana National Development Plan, 2008, Kwofie et al., 2012). With statistics showing the country's housing deficit is projected around 1.2 million house-unit as against an annual delivery of 37,000 housing unit which is dominated by individual self-house projects (Amoa-Mensah, 2008). This situation presents a gloomy picture with current data and literature suggesting that the situation will get worse in the wake of rising urban population. Indeed in Ghana, formal housing provision is largely of two forms:

The first is large scale houses built by commercial speculative residential building companies such as those belonging to the Ghana Real Estate Developers Association (GREDA). The second are houses built and financed by individual owner-occupiers often constructed by contracting small and/or labour only contractors (Ahadzie and Badu, 2011).

As in many developing countries, housing provision remains one of the critical socioeconomic challenges facing Ghana (Tipple et al, 1999; Konadu-Agyemang, 2001). The global paradigm in housing delivery have shifted government from been a main stakeholder to the role of a facilitator (Konadu-Agyemang, 2001; Bank of Ghana, 2007; Benjamin 2007;) represented by two government agencies; the Ministry of Water

Resources, Works and Housing (MRWH) and the State Housing Corporation (SHC). Government plays the role of a facilitator in housing provision by creating the enabling environment for the private sector to thrive, including assistance with finance where necessary.

In addition, to been facilitator's, government is in charge of regulating housing sector through policymaking and regulations for the other stakeholders (Ahadzie, 2007; Ahadzie et al, 2010; Kwofie et al., 2012). The private sector through self-finance houses, Ghana Real Estate Development Association (GREDA), and cooperative schemes have been identified as key players and stakeholders in housing delivery in the country in recent times (SSNIT, 2006; Gyabaah, 2009; Ahadzie et al, 2010). In Ghana, the housing industry is characterized by private developers belonging to the Ghana Real Estate Developers Association (GREDA) established together by the Ministry of Works and Housing (MOWH) of Ghana and the private estate developers in 1988 (Ashley, 2003).

The construction industry in Ghana derives its practice from the British industry, with a work environment made up of a separation between design and construction.
Furthermore, there is independence in the operation of the professions and commitment to their corresponding professional bodies namely, Ghana Institution of Architects (GIA), Ghana Institution of Engineers (GhIE), Ghana Institute of Construction (GIOC) and Ghana Institution of Surveyors (GIS). GREDA makes significant contribution towards the housing supply in Ghana. Organization chart showing the relation of professional of property developers (GREDA members) has shown in Figure 2.1 below. Depending on

the size of the company, the architect, quantity surveyor, service engineer and facilities may be in-house or out-house (Ahadzie, 2007).

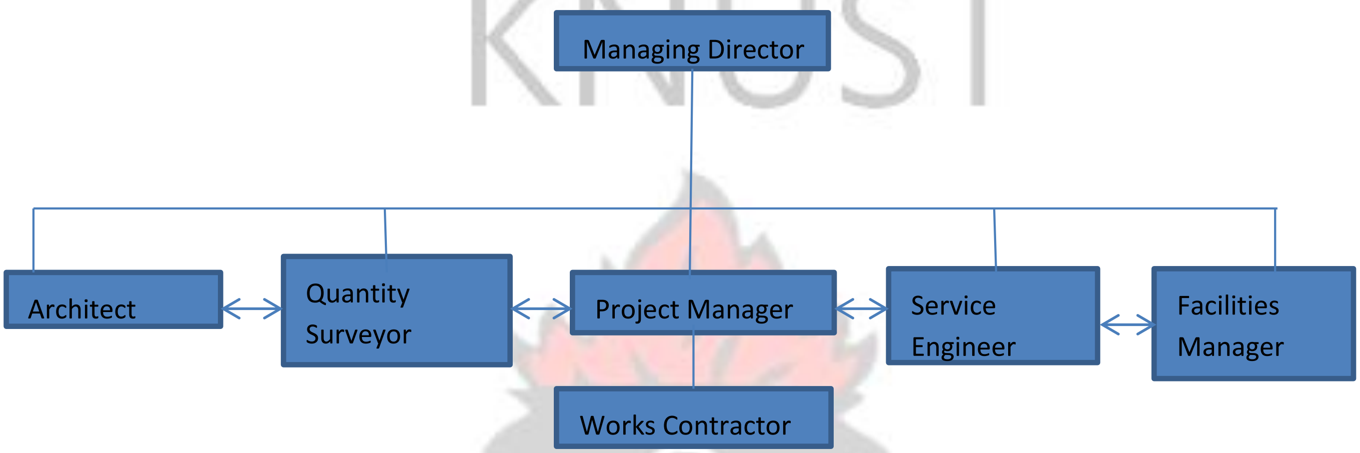

Figure 2.1: Typical organizational structure for GREDA adapted from Ahadzie (2007)

For the study a client definition by Masterman (2002) was as: "an individual, organization with the desire to satisfy his/its needs commissions the activities necessary to implement and complete a project by entering into a contract by commissioning the parties". Whiles the commissioned party takes decisions with the goal of achieving the client's objective of aesthetic satisfaction, functional satisfaction, value for money, completion on time and of quality (Walker, 2007). The individual/group client financing project is the initiator of the construction process. In the housing industry, clients are heterogeneous and vary in size, interests and motivation (Ofori, 1990).

In Ghana, Gyadu-Asiedu (2009) classified clients according to their reason for investing in a project. Four (4) main clients were established: owner occupiers (individuals who decide to build their houses to live in), the government, real estate developers, and investors (usually financial companies that decide to invest their excess capital into building construction). The study adopted the owner occupier as the housing clients.

2.6 CONCEPTUAL FRAMEWORK FOR BUILDING STAKEHOLDERS INTEGRATION

Building energy efficiency involves processes that are complex and typically unfamiliar to many building stakeholders. Just like any other implementation, energy efficiency in buildings requires a lot of planning and the involvement of major stakeholders is imperative to achieving a lasting solution to energy efficiency (Lapinski et al. 2006). Studies conducted by Yudelson (2010); and (Bernstein and Russo, (2009) revealed that among the different stakeholders, determining how, why, and when sustainable measures are to be implemented; however, these stakeholders have opposing perspectives on building energy efficiency.

Lapinski et al. (2006) in their study of Lean processes for sustainable building delivery noted that facilities owners and project teams are faced with the herculean tasks of implementing sustainable energy requirements. The study also noted that high level of multidisciplinary cooperation amongst each of the stakeholder groups starting at the early design stage of the capital planning process in a sustainable building project is needed. The reasons for these challenges or difficulties are numerous and varied. However, Lapinski et al. (2006) ascribed the difficulties primarily to the limited importance of all-inclusiveness and close collaboration in decision making processes.

A multi criteria assessment methodology which takes into account environmental, social, and economic criteria to support the decision making process was proposed (Rey, 2004). The author concluded that the varying views of stakeholders have major influence in the choice of the element related to the building use, beyond the economics of building performance. Rey (2004), further proposed the integration of opposing requirement of stakeholders like energy consumption reduction, occupant comfort improvement and diminishing environmental impact. Addressing the problem of conflicting and opposing stakeholder requirement has been identified as a sustainable strategy to ensuring sustainable building energy efficiency. This is seen in the plethora of studies that highlight the issue as a major barrier to the evolving concept of sustainable buildings.

Stakeholders such as the owner, tenant, architects, engineer, policy makers and developers are all responsible for an energy efficient building. However, each stakeholder as different and contrasting views on why buildings should be energy efficient. Example, owners and developers will be more concerned in accomplishing high returns on investment capital with low costs of operating; whiles low rent and occupant comfort will be the interest of the tenant; facility managers will have easy access, standardization, with easy and efficient repairs as the major perspective. Furthermore, between the owner and the tenant, the owner often feels they are paying for the efficient upgrades in the building while the tenant is the most beneficial from reduced energy cost, and the tenant feel they are being over charge for energy efficient upgrades. That is why a framework that integrates the various stakeholders and their requirements is needed to overcome these barriers and

tackles the interactions between the social, environmental, economic, and technical aspects of building energy efficiency. The House of Quality (HOQ), the main tool from Quality Function Deployment (QFD), was selected as a tool to address the problem of integrating the varying requirements of various building stakeholders in the housing industry, while selecting sustainable measures, during the decision making at the design stage. The HOQ provides a framework to coordinate and maintain priorities amongst all stakeholders involved, and translate those priorities into technical focus areas using a series of two-dimensional matrices and mathematical calculations. House of Quality (HOQ), encourages the preferences of those technical considerations for a decision making comparison by identifying technical considerations that have the positive effect on the various stakeholders requirements (Mallon and Mulligan 1993; Kamara and Anumba 2000;
Yang et al. 2003).

For this research the sustainability consideration decisions was divided into two main technical considerations of the building: electrical and building envelope (that is "exterior skin" - windows, shading, roof, insulation, doors, etc.). Data will be collected and analyzed using the HOQ model to establish the relation between the building stakeholder requirements (independent variables) and each of the two technical considerations (dependent variables). This interrelationship will help identify the main building stakeholder requirements and how the stakeholder type (tenant, owner, or operator) affects the ranking of their requirements for each of the sustainability consideration**.**

2.7 QUALITY FUNCTION DEPLOYMENT (QFD)

The concept of Quality Function Deployment (QFD) is a quality improvement approach and also product of Total Quality Control methodology for new product development in Japan in the late 1960s for shipbuilding and automobile industries (Delgado-Hernandez et al, 2007). QFD is also referred as designed-in quality rather than traditional inspectedin quality since it shifts from product quality inspection at the finished level to quality product design through analysis of customer needs (Guinta and Praizler, 1993).

Quality function deployment (QFD) aligns the element of design and construction processes with the customer's needs and requirement through its integrated decisionmaking methodology (Yang et al., 2003). A similar view is expressed by Gonalez (2001) who describes QFD as a methodology that stresses on cross-functional integration in product development process. QFD satisfies client's needs and requirements by coordinating skills within an organization to design and construct facilities through a set of planning and communication routine requirements (Bicknell and Bicknell, 1995; Ahmed and Kangari 1996).

Various fields have already applied QFD, such as non-traditional machining process (Chakraborty and Dey, 2007), rapid proto typing (Ghahramani and Houshrar, 1996), product design (Chen and Ko, 2009), construction industry (Dikmen et al., 2005), software industry (Erikkson and McFadden, 1999), semi-conductor industry (Chen, 2010), food processing industry (Viaene and Januszewska,1999), hospitality industry (Jeong and Oh, 1998) and even in the game of soccer (Partovi and Corredoria, 2002).

Extensive review of application of QFD in diverse fields is given by Chan and Wu (2002). Application of QFD into other fields must be treated with caution since QFD as a tool originated from the manufacturing industry hence the different in the mechanism and practices of application caution (Stehn and Bergstro¨m, 2002).

2.7.1 House of Quality (HOQ)

The principal tool of QFD is the House of Quality (HOQ) also known as a product planning matrix or diagram matrix. The HOQ is an iterative process that utilizes a mathematical analysis using a weighted relationship scale and often a symbolic correlation scale (Delgado-Hernandez et al. 2007). HOQ employs matrices to establish relationships between organization functions and customer satisfaction providing the systematic method to support the process of design decision making (Yang et al., 2003). HOQ serves as an important tool by displaying the relationship, significance and measures of each issue (McElroy 1987, 1989; Hauser and Clausing 1988; Griffin 1992). HOQ contains up to six basic matrices integrated into a system with many steps that shapes into a roof of a house put together. Primarily HOQ matrix consist of customer (stakeholders) requirements ("what's"), technical solutions ("how's"), a correlation matrix weighted numerically in the center, and at the top of the house is the visualized correlation between technical solutions in the form of triangular matrix at the top in the shape of a roof which is not applied to this study. A division of rows and column makes a systematic comparison using the planning matrix gives a competitive analysis of design performance. A computed ranking of the technical consideration responses are represented at the foundation or bottom of the matrix. Two dimensional matrices will be applied at the planning stage of this study. Figure 2.2; illustrate the basic HOQ structure (Delgado-Hernandez et al. 2007).

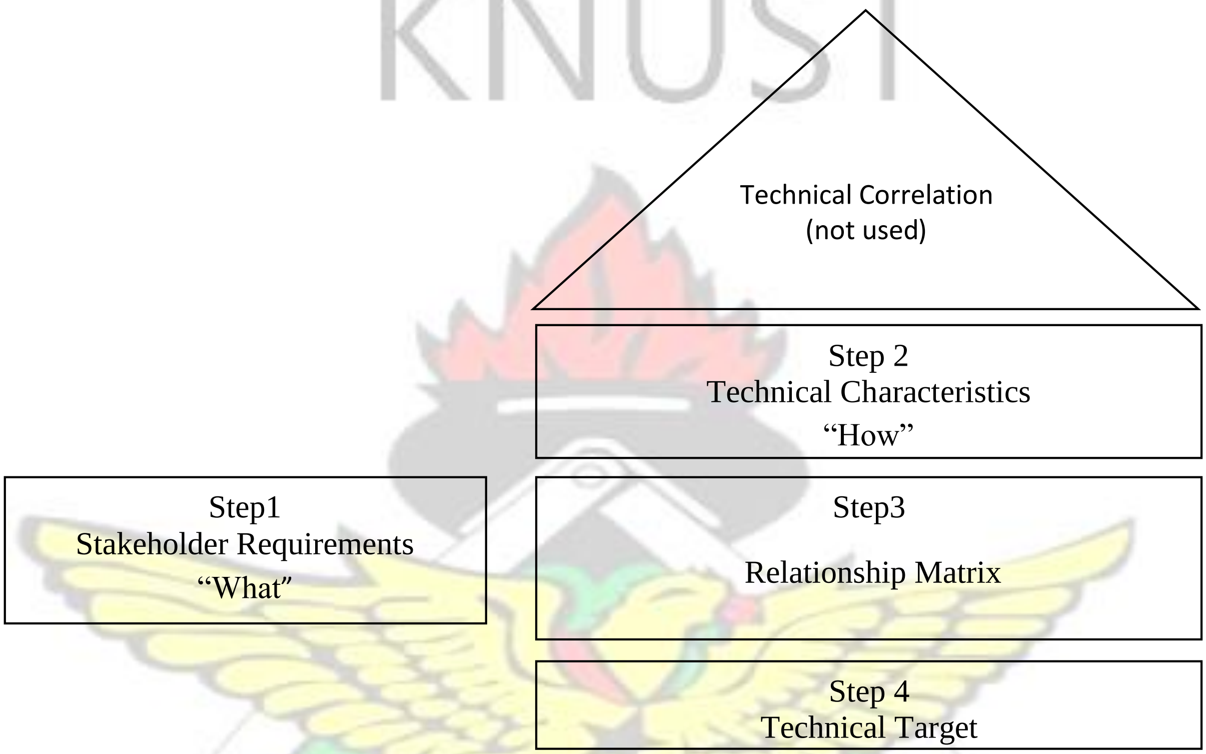

Figure 2.2 House of Quality template adapted from Delgado-Hernandez et al. (2007).

i. A structure list of the customers' requirements present the Customer requirements (Whats).

ii. A structured set of important and measureable product or service characteristics or design specifications is represented by Technical requirements (Hows).

iii. The ‘Whats’ and ‘Hows’ interrelationship between each stakeholder’s requirement and the technical consideration.

iv. Technical correlation matrix exhibit relationship between technical requirements which supports or impedes the product design is also known roof matrix.

v. Requirement of the various stakeholders are quantified and rated in order of importance is represented by the Planning matrix.

vi. Requirement of the technical considerations are quantified and rated in order of importance is represented by the Prioritized technical consideration.

HOQ framework is used to transcribe customer requirements into product specifications and also employ the voice of the customer (VOC) in providing a solution to best product development (Hauser and Clausing 1988; Hjort et al., 1992; Cohen, 1995; Crow, 2003).

2.7.2 Quality Function Deployment Methodology (House of Quality) in the Construction Industry

Literature on the use of HOQ in the construction industry is limited in number and with publications on the method growing steadily in recent years. The ratiocinate for adopting QFD/HOQ in the construction industry has been the concentration of several publications. Various literatures that scrutinize the suitability and application of HOQ for various situations in the construction industry were viewed. Understanding and implementation of HOQ methodology in the industry was supported from the various literatures. Use of QFD/ HOQ in the construction industry is structured into five categories that include:

i. Awareness of QFD/HOQ among construction professionals in the industry (Pheng and Yeap 2001; Delgado-Hernandez and Aspinwall 2007).

ii. Proposing HOQ models for application in the construction industry (Kamara and Anumba 2000; Yang et al. 200; Huovila and Porkka 2005; Delgado-Hernandez et al. 2006; Dahl 2009).

iii. Assessment of HOQ suitability in the construction industry through case studies (Mallon and Mulligan 1993; Gargione 1998; Yang et al. 2003; Eldin and Hikle 2003; Ahmed et al. 2003; Dikmen et al. 2005; Delgado-Hernandez et al. 2006).

iv. Proposing HOQ methodology for application in the construction industry (Mallon and Mulligan 1993; Gargione 1998; Alarcon and Mardones 1998; Nieminen and Huovila 2000; Kamara et al. 2001; Eldin and Hikle 2003; Ahmed et al. 2003; Huovila and Porkka 2005; Dikmen et al. 2005; Delgado-Hernandez et al. 2006).

v. HOQ methodology application in achieving construction objectives (Nieminen and Huovila 2000; Dahl 2009).

Further, Pheng and Yeap (2001) and Delgado-Hernandez and Aspinwall (2007) investigated the awareness of QFD/HOQ methodology and application in the construction industry which is limited due to scarcity of literature. Conversely, Mallon and Mulligan (1993) promoted awareness by explaining the use and benefits of HOQ as a management tool in the renovation of a computer workroom facility. The HOQ has been used in a wide array of application as a product development tool. Within the interface of design and construction, Alarcon and Mardones (1998) suggested that the utilization of HOQ identifying and prioritizing the effective and quality control design tools that help to reduce design challenges at the construction phase.

In the real estate on value adding from both the buyer and business perspectives, Gargione (1999) HOQ proved an important method for practically identifying and prioritizing improvements by transcribing customers' views and opinions into manageable design information which increases collaboration amongst designers. Mallon and Mulligan (1993) studied relationship of QFD with other quality tools, such as total quality management in the layout of apartments. Abdul-Rahman et al., (1999) applied HOQ analysis for design of low-cost housing project with respect to reliability, cost and delivery. Also, Cariaga et al., (2007) evaluate design alternatives in the construction industry using QFD analysis.

Application of QFD for civil engineering capital project planning for sewage facility improvement (Syed, 2003). While, Armacost et al. (1994) proposed HOQ for customer requirement integration for an industrialized form of housing project using exterior structured wall panel. Dikmen et al. (2005) proposed to adapt the methodology to marketing strategy of a construction company for a large housing complex project, and evaluated the results for long-term strategic decisions (Huovila and Seren, 1998) applied QFD as a part of a concurrent engineering practice for rapid construction projects.

On communication and integrated information management among stakeholders in the construction industry, Kamara et al (2000) established that more of systematic grouping of customers' requirement with solution which are neutral design parameters to the process of collating and represent customer requirement early on in the design stage when using HOQ. Examples and case studies of HOQ in the construction industry as well as proposals for improved HOQ models for the construction industry use have also been explored by various researchers (Eldin and Hikle 2003; Ahmed et al. 2003; Huovila and Porkka 2005; Dikmen et al. 2005; Delgado-Hernandez et al. 2006; Delgado-Hernandez et al. 2007).

2.8 BUILDING ENERGY EFFICIENCY (BEE) USING HOQ CONCEPT

Although a lot has been done in the applicability of QFD in the construction industry, prioritizing energy conservation or building energy efficiency for housing project has not been the primary objective. However, we can draw relationship from limited literature in similar contexts demonstrating HOQ methodology as an important tool for such purpose. Building Energy Efficiency using HOQ analysis has been conducted for various projects such as housing project, refurbishment of offices, school classroom project, etc. (Mallon and Mulligan, 1993; Armacost et al., 1994; Dikmen et al., 2005). Lower investment and cost of service, lower environmental effects in usage, and better indoor climate were amidst the prioritize dominant clients requirement in most studies.

Recent studies on sustainable retrofits in existing buildings of a US navy barracks (Menassa and Baer, 2014), reveals the extent of different stakeholders type, requirement and perception on retrofit measures. The authors developed a House of Quality (HOQ) model that collaborated differences amongst the various stakeholders by integrating their opposing objectives, to achieve social, environmental and economical energy efficient building. In post construction marketing decisions strategies; Dikmen et al (2004) looked at QFD application for a high rise housing project with overall stakeholders rating operation provision and maintenance among the important contributors to lower cost of energy, efficient central heating and high thermal comfort also among customers' requirements linked to the technical measures.

A methodology was introduced using House of Quality (HOQ) to establish nonperforming building systems as designed by retrieving performance data from all stakeholder groups' in the renovation projects of two institutional organizations (Dahl, 2008). The study revealed that building sustainability does not certainly function better than their non-sustainable counterparts, whiles conflict between facility end-users and the project team was revealed. In a learning environment for a new children's nursery, Delgado-Hernandez et al (2007) revealed that control of temperature, day lighting and ventilation were among the most important customer requirement with QFD analysis. On the application of HOQ to support the decision making process in energy efficient building designs as a design trade-off tool. Nieminen and Houvila (2000) investigated design innovation concept for eco-efficient buildings using energy analysis from similar buildings through energy management of heating system to assess energy performance and environment impact of design concept. A framework for solar heating and cooling program task was published by the International Energy Agency (IEA) in 1998 using

HOQ.

Building energy efficiency in the housing industry involves whole lot stakeholders with conflicting views, opinions and perspective. HOQ application have shown to provide a platform to implement BEE by planning and communicating the views of the numerous stakeholders earlier on in the design process to achieve a commitment to shared objective for all involved. Also the social factor of acknowledging the interest and opinions of all the parties is achieved through HOQ application.

2.9 BUILDING ENERGY EFFICIENCY REQUIREMENT AMONG STAKEHOLDERS

Decision on the sustainability of a building depends on the stakeholders in the construction process: designers, owners, managers, firms, etc. The pace of decision making on sustainable application is dependent on the knowledge, awareness and understanding of the actions taken by the various stakeholders (Braganca et al., 2007; Adidin, 2010). Stakeholders are concerned with the social, environmental, economic and technical perspectives in increasing the energy efficiency of building. Commitment to the various stakeholders' goals and beneficial solution to the implementation of energy efficient housing involves significant communication and planning among the various stakeholders (Lapinski et al., 2007).

With most stakeholders typically unfamiliar with the energy efficiency of housing projects with its complex processes; there is the need to determine an economic and environmentally acceptable engineering solution by aligning the various stakeholders requirement to each a concise decision-making framework (Lapinski et al., 2007; Klotz and Horman, 2010).

However, over 50 percent of energy saving methods are overlooked with the major focus on maximizing economic benefits to engaging building stakeholders in the process (Schneider and Rode, 2010; Azar and Menassa, 2012). For example, if building stakeholders know about the building's energy performance and are involved in the decision process to reduce energy consumption, they will have bigger incentive to reduce energy use through behavioral changes that do not require any additional expenditure.

Several studies, such as Menassa and Baer (2014) reveal conflicting energy efficiency requirement among building stakeholders as a major barrier in implementing energy efficiency, with decisions often based on short-term economic grounds. Different Stakeholders role is important in establishing the type and magnitude of any energy efficiency measure, or proposal or methodology that integrate social, environmental, economic, and technical concerns have not been taken into account in most research into building energy efficiency. This has led to varying, and in most cases conflicting perspectives among the numerous stakeholders' on when, why and how a building should be energy efficient (Bernstein and Russo, 2009; Yudelson, 2010). Example, interest of the owner in building energy efficiency will be a return to his/her investment by reducing the life cycle cost. Whiles for the tenant, lower rent or increase in productivity of employee will be the main incentive (Bosch et al., 2003; Beheiry, et al., 2006; Poel et al., 2007; Fuerst and McAllister, 2011). Interest globally on energyefficient dwellings pose as a major challenge to the various building stakeholders in the housing industry to develop sustainable management scheme towards enhancing the quality of our environment through environmental and energy-conscious planning, design and construction (Kaygusuz, 2012).

Thus, an extensive review of literature was conducted and 16 potential stakeholder requirements were identified to be important for building energy efficiency as shown in Table 2.1 below. These requirements can be mostly viewed as quantifiable economic benefits; however, many of them are difficulty to quantify such as long-term benefits (social and environmental). These requirements were included in a survey that was conducted during early stages of design. All requirements were clearly defined in the survey to reduce ambiguity and ensure that the different building stakeholders have the same information and perspective while filling out the survey as discussed in chapter three.

Table 2.1 Perceived benefits for pursuing energy efficiency in building

Stakeholder Requirement	Source
Increased return on investment (ROI)	Papadopoulos et al. (2002); Rey (2004); Gaterell and McEvoy (2005); Beheiry et al. (2006); Yudelson, (2010); Entrop et al. (2010); Juan et al. (2010); Chidiac et al. (2011)
Achieve lower total ownership costs	Bosch et al. (2003); Scofield (2009); Entrop et al. (2010); Juan et al. (2010); Yudelson (2010); Chidiac et al. (2011); Fuerst and McAllister (2011)
Lower project capital costs	Bosch et al. (2003); Fuerst and McAllister (2011); Scofield (2009); Yudelson (2010)
Reduce energy costs	Papadopoulos et al. (2002); Rey (2004); Scofield (2009); Juan et al. (2010)
Increased property value	Bernstein and Russo (2009); Entrop et al. (2010); Yudelson (2010)
Improve occupant comfort	Bosch et al. (2003); Rey (2004); Lapinski et al. (2007); Klotz and Horman (2010),

Improve occupant health	Bosch et al. (2003); Rey (2004); Lapinski et al. (2007); Klotz and Horman (2010),
Increase energy efficiency	Papadopoulos et al. (2002), Rey (2004); Poel et al. (2007), Juan et al. (2010); Chidiac et al. (2011)
Reduce energy consumption	Papadopoulos et al. (2002); Bosch et al. (2003); Scofield (2009); Juan et al. (2010); Nemry et al. (2010); Chidiac et al. (2011)
Provide a secure energy supply	Papadopoulos et al. (2002); Singer et al. (2007); Yudelson (2010)
Facilitate renewable energy	Papadopoulos et al. (2002); Singer et al. (2007); Yudelson (2010)
Minimize environmental impact	Papadopoulos et al. (2002); Bosch et al. (2003); Rey (2004); Gaterell and McEvoy (2005); Beheiry et al. (2006); Lapinski et al. (2007); Scofield (2009); Juan et al. (2010),
Meet regulatory requirements	Papadopoulos et al. (2002); Poel et al. (2007); Fuerst and McAllister (2011),
Comply with policy or legislation	Papadopoulos et al. (2002); Poel et al. (2007)
Diversify investment portfolios	Beheiry et al. (2006); Yudelson (2010); Fuerst and McAllister (2011),

Thus, in achieving truly sustainable solutions, engaging all stakeholders in the design process at an early stage of the project will help achieve solutions that are economically, esthetically, functional and environmentally viable by challenging deeply held assumptions of the stakeholders (Boecker et al., 2009).

2.10 BUILDING ENERGY EFFICIENCY DECISION-MAKING AMONG STAKEHOLDERS

From a sustainability perspective where balancing economic, environmental and social aspects are important, there is the need for the numerous building stakeholders to agree on the decision of whether a building should be energy efficient. In this context the definition for stakeholders was adopted from (Menassa and Baer, 2014), who defined them as the people who directly or indirectly have a vested interest in the building, its operation, and the outcome of a mass housing project. Building stakeholders here include the designer, facility manger, owner, tenants, investors and policy makers.

Thus, a process discovery design phase based on four E's (that is everybody, engaging, everything, early) is proposed to explicitly address each team member values, aspirations and objectives (e.g., reduced energy consumption and increased thermal com-fort) very early on in the design process to achieve a consensus (alignment) before getting into a more detailed exploration of technological solutions. Achieving team alignment and commitment around explicitly identified values and aspirations would lead to identifying creative solutions that placate all stakeholder concerns.

In addition, they emphasize that this should be an iterative process that allows communication at every level to incorporate each member's values so each member can understand how their values relate to the others (Menassa and Baer, 2014). For example, if building stakeholders know about the building's energy performance and are involved in the decision process to reduce energy consumption, they will have bigger incentive to reduce energy use through behavioral changes that do not require any additional expenditure (Menassa and Baer, 2014).

Moreover, in most cases the chosen BEE measures do not contribute to achieving stakeholder requirements of improved comfort, health and productivity (Heerwagen, 2000). Thus, energy saving, improve work environments and profit maximization which among others is a fundamental challenge in BEE can be achieve with the alignment of the various stakeholders requirement. A similar view is expressed by Savitz and Weber (2006) a complete approach to truly building energy efficiency (BEE) should include stakeholder requirements to achieve social, economic and environmental equity. Thus, it is imperative to appreciate the requirements of the various building stakeholders in energy efficiency building.

2.11 CHAPTER TWO SUMMARY

In this chapter important issues regarding BEE, especially, within the aspect of mass housing industry was discussed. Whiles BEE, increase the sustainability of building having large effect on present energy use and life-cycle energy consumption of building. Subsequently, aligning stakeholders' requirement among others is fundamental challenges that need to be addressed if targeted reduction in energy use in building is to be achieved. Consequently, a critical review of building stakeholder decision-making on BEE was undertaken to identify the main requirement among stakeholders' in pursing energy efficient building. Based on literature, House of Quality (HOQ) approach is the appropriate methodology in integrating energy efficiency among building stakeholders.

Subsequently, BEE integration among building stakeholders was undertaken in order to establish the potential building stakeholder requirement and the extent of impact on both the technical and sustainability aspects of the building. It is contended that integration of energy efficiency among stakeholders of mass housing project, which considers the use of House of Quality (HOQ) is prudent for this research. Next chapter discuss the research method chosen for the research.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The cogitate backing the selected research methodology is outline in this chapter since the effect of any chosen approach on the end result of any research cannot be exaggerated. In conducting a research the choice of the appropriate method in ensuring the research objectives are met and findings endorse (Steele 2000; Fellows and Liu, 2003).

The objective of the research in integrating energy efficiency decision making among the various building stakeholders is explored in this chapter. Also, the chapter describes available research designs and selects the appropriate one that would address the research problem and the key questions in section 1.5. Also included in this chapter, is the selection and justification of the methods and techniques used in research approach, sampling, data collection and analysis of data.

3.2 RESEARCH PHILOSOPHY / RESEARCH PROCESS

Choice of a research methodology is a dilemma in that there are a series of compromises and no ideal solution, principally the selection of the right strategies and method for answering the research questions arising. According to Dainty (2007), principally concerned with research philosophy is the assumptions that a researcher brings to an investigation. With the type of philosophy adopted influence by the research situation under consideration and the questions asked (Pollack 2007, cited by Yankah 2013).

The study adopted the ‘research process onion’ for the research terminologies by Saunders *et al*. (2007). The two utmost paradigms principal of social science explained by the authors; were positivism or radical structuralism or phenomenology. With positivism leaning towards deductive approach whiles phenomenology, leans to inductive approach. Within the utmost research paradigms lie eight research philosophies, seven research strategies, three research choices, two research time horizons, and a range of research methods for data collection and analysis (Saunders *et al*., 2007). The research philosophies that lie between the two extreme paradigms of positivism and phenomenology are interpretivism, pragmatism, realism, subjectivism, objectivism functionalist, radical humanism, and interpretive. The sequence in terms of which they are chronicle reveal the magnitude to which they tilt towards either deduction or induction.

Drawing up from a solely positivistic standpoint to a solely radical structuralism viewpoint are seven (7) main strategies of research: surveys, action research, experiments, case studies, grounded theory, ethnography, and archival research. In a similar order, are three research choices namely: mono methods, mixed methods, and multi-methods. All pitch into either cross-sectional or longitudinal time horizons. With varied strategies and procedures convenient for data collection and data analysis, for example questionnaire, interview, content analysis, focuses groups, and observation (Wilkinson and Birmingham, 2003). Finally, the methodology of a research also determines the philosophical paradigm adopted.

3.2.1 Philosophical Position of the Study

Analyzing the above philosophical traditions and consideration (epistemology, ontology and axiology) in connection to the objective of the study, a description of the philosophical position is as follows; Epistemologically, this study adopted positivist tradition, since positivist makes it possible to determine the link of the study in connection to literature and theory, makes replication of the study with an existing case possible. This research was of the belief that the complexity and difficulty in integrating the views and perspective of the various building stakeholders might be scrutinize along a structured but clarified balanced approach (Saunders et al., 2000).

Ontological level of the adopted research is a realist stand. This is because factors that reveal the perspective of different stakeholders on energy efficiency building largely do exist in literature. However, such factors have not been effectively used in the context of mass housing industry among the various stakeholders. Also, this research viewed the investigation to be conducted as practical rather than abstract. Moreover, understanding of extent of influence of the different stakeholders is beyond the researchers influence as it exists as an external factor (Saunders et al., 2000).

Axiologically, the choice of the approach to what and how to study determine by criteria of the study objective makes the research value free. Moreover, this study involved a real life context and involves people and their decisions, converging on measurements and attributed to these measurements. Also, while taking a realist view in ontological assumption, it holds positivist stance in epistemological tradition with value free axiological position (Saunders et al., 2000).

3.2.2 Method of Scientific Inquiry and Reason

Both deductive and inductive reasoning are different but equally valid routes to drawing conclusions in a scientific research (Babbie, 2008). These two approaches involve logic (theory) and observation (data) and how these two pillars of science are related in a piece of research. Deductive reasoning draws conclusions based on facts from a general to specific perspectives in its operation (Burney, 2008), this position is supported by Robinson (2007) outline that's deductive logic in research enables the determination of the correlation linking distinct and and variables; hypothesis testing; outcome of justification or verification; and of the theory verification from the findings.

Having adopted the positivism, and in attempt to integration BEE in the decision making of building stakeholders. Reasoning along the area of deductive logic is important in pursuit of this study due to the social and quantitative nature of the study objective.

3.3 RESEARCH APPROACH AND STRATEGY

Research strategy for every research is divided into several parts. These parts can be; theoretical (analytical) and empirical (collection of qualitative and quantitative data). Decision making about the strategy, design and approach of the research is important to the underpinning philosophy and contribution the study will make (Thurairajah et al., 2006, Harty & Leiringer, 2007). Whiles, Creswell (2003) emphasises that the research topic nature, the general aim and objectives, and the available resources are the criteria that mainly largely determine the method of research for the study.

Deductive reasoning together with elaborated reviews of literature, and expert focus group approach help in the research phase. The theoretical part will focus on analysing the literature review of Building Energy Efficiency in general and reviewing relevant existing House of Quality (HOQ) models which in turn led to the conceptualisation model for the study at hand, whereas the empirical part will focus on experimental data collection. A foundation is provided for the research aim and issues relating to building energy efficiency decision making was achieve through the elaborative literature.

Wide range of issues pertaining to energy efficiency in the mass housing industry whiles the emphasize on a coherent proposition and appreciation of the different building stakeholders decisions on energy efficiency was developed through review of literature. In achieving societal sustainability as a whole and focus on the housing industry in particular, smart decision-making among building stakeholders with knowledge and understanding on BEE is needed at the design stage of each project. Information from literature provided the base for further study and posed research questions.

It is clear from the nature of research question, data collection source that data will be both qualitative and quantitative in methodology. The mixture of qualitative and quantitative approaches as a methodology involves philosophical assumption that guides the direction of collecting and analysing data is a main phases of the research problem.

3.4 RESEARCH DESIGN

The structure which directs the collection and further analysis of data or technique for conducting such issues is described as the research design (Yin, 2003). Whiles, Frazer and Lawley (2000) view research design as a plan for required information needed to answer research question or problem, concept and paradigm together with information for the research. According to Yin (2003) and Bryman (2004) the research design enables the researcher is able to connect the actual data and the inception questions from the research to draw conclusion in rational manner. Research design is categorized into five main options namely case study, cross-sectional, experimental, longitudinal, and comparative research designs (Bryman, 2004). Realizing the relationship and difference between the various options of research design is very important. Yin (2009) also classifying the various options of research design into experiment, survey, archival analysis, history and case study. Relevant situations in the assemblage of appropriate research design alternative are categorized by Yin (2009) as shown in Table 3.1 below.

Table 3.1: Appropriate Situations for Different Research Design

Strategy	**Structure of Research Question**	**Entail Authority of Behavioural Events?**	**Centered on Contemporary Events**
Experiment	Why? How?	Yes	Yes
Survey	What? Who? Where? How? How much? How many?	No	Yes
Archival Analysis	Who? What? Where? How many? How much?	No	Yes / No
History	Why? How?	No	No
Case Study	Why? How?	No	Yes

Source: (Yin, 2009)

It must be noted as already emphasized that the positivist approach/paradigm was the predominant stance adopted for this research. In this regard the epistemological, ontological and axiological assumptions gave strong credence for the use of archival analysis and surveys as gathered from Table 3.1 above, this is mainly due to the nature of research question these strategies answer. Going by Yin's (2009) first condition, some of the questions that the empirical portion of the research focused on were "what" questions that centered on the frequencies, incidence or prevalence of the phenomenon rather than the need for operational links that needed to be traced over time hence surveys and archival analysis were possible choices. Survey was however selected as a more appropriate choice given that the issue of inquiry is a contemporary one and because relevant accumulated documents or archives on integration of decision making on energy efficiency building were not available.

In the conduct of this research, the choice of the survey and case study methods were appropriate in the light of the aim of the study which was to integrate energy efficiency decision making among building stakeholders and to propose a framework for the mass. The research design option chosen was a cross-sectional survey employed through structured questionnaire with the collection of data done at one point in time preferably to been done over time to prospective respondents identified through the 'house of quality' method adopted for the study.

3.5 DATA COLLECTION METHODS

Gathering data is pivotal in every research, as it accords a clear understanding of a conceptual background of the research (Bernard, 2002). Manner of data collection and source from which data will be need selected requires sound judgment since wrong data collected can lead to makeup of analysis (Tongoco, 2007). Also, plain explanation of the principal elements of the research design and procedures are analytical in disclosing what was done in tackling the research concerns. A comprehensive explanation to all the methods adopted in tackling the aims, objectives, and research questions is describe in this section.

3.5.1 Sources of Data

Earlier section reveals multiple source of information was used to address the research goals. However, the time consuming and relatively expensiveness of this approach in comparison to a single source of data. Data collection method for the study was categorized into two main parts. A desk study and a field study approach were adopted for the study. An essential aspect of the research is formed by the desk study since it sets the stride for field survey instrument development though the use of questionnaires and interview (Fadhley, 1991). Whiles, the field survey involves actual collection of data though questionnaire. The study adopted a single approach for data gathering which involves questionnaire.

3.5.2 Development of Questionnaires

Questionnaires are designed to address the aim, objective and research question of this study. An effectual questionnaire survey design hinges on four (4) important standards

namely; wording of the questionnaire, categorization, coding of variables and general acceptance (Sarantakos, 2005). Survey instrument design must be preceded by firstly establishing distinctly the focal point of the study; and secondly, interpreting the study objectives of the research into quantifiable factors that contribute to the focus of the research (Salant & Dillman, 1994). With, a good questionnaire been the one that produces answers that are reliable and gives valid measures to what been described
(Fowler & Floyd, 1995).

According to Creswell (2005) various advantages of survey questionnaire exist such as ability to approach a vast number and geographically disseminated population; assembling of data by mechanism of discretionary involvement without compulsion or force; reduction of researcher bias; and minimization of time requirement for the respondent and the researcher. According to Gall et al., (2003) to avoid double-barreled and ensure easy manner of questionnaire, it must be organized and kept short in their presentation. With questionnaire success dependent on proper structuring of the content and format for the respondent; a questionnaire will serve as the one of the cheapest method of accessing a large group of people in achieving a data for a good result
(McQueen and Knussen, 2002).

Self-administrated questionnaire comprising of closed-ended and scaled response questions was adopted for the study. To measures the strength or intensity of respondent's opinion, Likert response scale employed. The questionnaires were personally administered by the researcher. Whiles, Sarantakos (2005) and Creswell (2005)

acknowledge that Likert scale is exceptionally appropriate for attitudes study; with Cohen et al. (2005) viewing Likert scale favourable to build distinctionness, compute attitudes, and generate hard data on the respondents; and it also offers information such as frequency, flexible responses and linkage between opinion and quantity. A five point Likert response scale was adopted by the study to measure responses to statements in the questionnaire; and allow degrees of difference measurement but not specific to the amount of difference (Kapadia-Kundu &
Dyalchand, 2007).

3.5.2.1 Questionnaire Format

Literature on questionnaire development points that the appropriate length of a good questionnaire should range from one to eight (8) pages of A4 paper (Oppenheim 2000; Saunders et. al., 2000; Fellows & Liu, 2003). A questionnaire covering four (4) pages was designed for the study as detailed in Appendix A.

3.5.2.2 Content of Questionnaires

According to Wahab (1996) there is the need for the research questionnaire to be structured for the understanding of the respondent since the quality of the responses is affected by the structuring of the research questions. Next is the design of the actual questions that solicited the requisite information for the study after identifying the respondents for the questionnaire and their characteristics.

The questionnaire consisted of five (5) questions scaled-response closed-ended type questions with front cover page introducing the researcher and the study topic. The questions were further divided into three (3) sections, mainly, section A, B and C. While section A solicits information regarding the background of the respondent, Section B looks at the importance the various stakeholders place on pursing energy efficiency building. The last section was on evaluating the extent of influence (impact) that each sustainability pillar and technical solutions has on building energy efficiency. The detail of the questionnaire of questionnaire structure is shown below;

Demography:

Apart from the introduction, the first section of the questionnaire survey instrument comprises the demographical information associated to the classification of the respondent; the nature of involvement in the housing industry; and the level of awareness on building energy efficiency. Information from the background helped in establishing the credibility of the collected data. Descriptive statistic was used in the analysis of the data collected in this section due to the descriptive nature of the survey instrument.

Stakeholders Requirement on Building Energy Efficiency:

In eliciting for information on the stakeholders' requirement (the independent variables) what is views as important by participants in pursing energy efficient housing. The 16 potential stakeholders requirement for building energy efficiency housing identified in chapter two were used for this purpose (Table 2.1). The importance of stakeholder requirements are thus measured on a scale of 1-5, where 5 stood for "Extremely Important" requirement, 4 for "Very Important" requirement, with 3 equals to

"Somewhat Important" requirement, 2 equal to "Not Very Important" requirement and 1 representing "Not Important" requirement. The scale was adopted since all the literature reviewed on House of Quality (HOQ) application adopted the 1-5 scaled ranking.

Relationship of Stakeholders Requirement with Technical Characteristics and Sustainability Pillars:

The third part of the survey was on the relationship matrix (technical and sustainability consideration) on the decision alternatives (dependent variables) being appraised in connection to its effect on the individual stakeholder requirement (independent variables). These two technical decision alternatives are being studied to appreciate how the various building stakeholders requirement might impact the energy efficient decision or ranking of these requirements and assess perceptions of stakeholders in relationship to the influences of each of the different stakeholders' requirements for building energy efficiency on social, environmental, and economic considerations. The magnitude of the relationship for the two consideration (i.e., technical and sustainability) were weighed on a five-point Likert scale: 9 (extremely strong), 5 (very strong), 3 (fairly strong), 1 (weak), and 0 (no relationship).

3.5.3 Pilot survey

A pilot survey was undertaken prior to the major survey, with the aim of testing the questionnaire in order to identify any ambiguity in the questions. The pilot survey tests the purposive approach of collection of data to evaluate the effectives of the responses. Critical and extensive review of related literature suggested that stakeholders' engagement in the design process early to confront conviction and presupposition of all stakeholders and provide a solution that meets the sustainability features of buildings (Boecker et al., 2009). Pilot study was also used to examine the appropriateness of listed stakeholders requirement and participant solicited to add new requirement if the need be. Several researchers argue that pilot surveys are important to determine the rigor nature of the survey methodology (Moore and Abadi, 2005).

Using purposive sampling techniques, 10 stakeholders who play key roles in mass housing projects and energy efficiency across the country from the Ministry of Water Resources Works and Housing, Energy Commission, GREDA, research institutions-e.g. (Energy Centre, KNUST), built environment professionals, policy makers and housing clients. The collated results initiated the motivation of the main questionnaire to examine the relationship of the various stakeholders in integrating energy efficiency decision in mass housing project. The pilot questionnaires were delivered and retrieved in person by the researcher. A covering letter accompanied the questionnaire explaining the reason for the study. Critically appraisal of the questions was undertaken by the respondent which provided a feedback as to the importance and responsiveness of the questions, length and time for completing and proposition for refinement. All ten (10) questionnaires for the pilot survey were retrieved within two weeks by the researcher.

Due to the outcome of the analysis of the pilot survey, the questionnaire was carried out through a process of modification to make it more appropriate for the main questionnaire survey. The main research questionnaire was modelled on the sixteen (16) structured and established stakeholder's requirement. Generally, feedback from the survey shows that the survey instrument was appropriate for the work intended. In the light of this the respondents were people with grounded knowledge in mass housing project and energy efficiency policies with considerable years of experience. They are people involved through research, construction, education, policy making or implementation.

3.6 SAMPLE SIZE DETERMINATION

As previously mentioned, building stakeholders for energy efficient mass housing projects (e.g. architects, engineers, owners, occupants, policy makers, researchers) are the target source of data and hence constitute the population. The total population of building stakeholders is however unknown since the total number of housing clients, architects, quantity surveyors, facility managers, electrical and mechanical engineers within the Ghanaian housing sector is not adequately documented.

Owing to the fact that accessing and collecting data on all the elements defined within the population described above was not feasible and access to all subjects, cost and time requirements placed limitations on carrying out a survey of the entire study population; a sample was used as an alternative. Time and cost constraints make sampling the best method to data collection (Babbie, 1990). It is important to emphasize that although stakeholders were sampled, the professionals in the housing industry roles in the decision making within the firms were the ultimate target source of the data required. The use HOQ for analysis of decisions pertaining to energy efficiency of housing requires little variation from the traditional approach. Traditionally the customers are narrowed to the final-user

or client in the House of Quality (HOQ) methodology. The customers are not limited to the tenants (end users) but include any stakeholders' intent in the outcome of an energy efficient housing project and need to be engaged in the decision process. Lessons learned from House of Quality (HOQ) literature guided the data collection and model development in this research. Most notably: (1) Participants in a HOQ application must have authority in the decision-making process, experience and intuition so as to secure effective outcome in the decision-making service (Gargione, 1999; Yang et al., 2003; Dikmen et al., 2005; Delgado-Hernandez & Aspinwall, 2007); (2) degree of importance and relationship allocated is mainly based on the professional judgment of the respondent (Ahmed et al., 2003); and (3) with HOQ participants mainly consisting of three research team members (Dikmen et al., 2005), four design team members (Dahl, 2008), and up to 10 professional with various backgrounds such as architectural, engineering, business etc. (Nieminen and Huovila, 2000; Eldin and Hikle,
2003).

With the research focus on building energy efficient mass housing projects in Ghana, the intended target respondents are vast and the size of the population is unlikely to be known or infinite as no formal records of register of industry professionals practitioners in mass housing exist in the country unlike other relevant built environment professionals and associations such Ghana Institute of Architects (GIA), Ghana Institute of Surveyors (GhIS), Ghana Institute of Engineers, Ghana Institute of Construction (GIOC) where well developed register of their members and easy means of contacting them were available, it was not easy in respect of this to come by a register of respondents who are involved in mass housing projects in various forms or capacities.

Moreover it is very difficult to identify their location and meaningful size or numbers available in a particular region across the country.

Against this background the targeted respondents for the study consist of Ghana Real Estate Developers Association (GREDA) members with the essential line of work of constructing Mass Housing projects. Evidence of members of GREDA specialty in the construction of Mass Housing Projects and are involved in the decision-making process is important viz. the criteria associated with the HOQ. According to Borman (1978) the assumption that person with knowledge on the aim, objectives and are frequently observers of a job; are equip about the content and behavior pertaining to the job.

A convenient sample size of thirty (30) GREDA members with an organizational structure that includes all the professionals has listed by Ahadzie (2007) was adopted and respondents were identified by the 'purposive sample' method. The sample size of thirty (30) was chosen to represent GREDA members with an in house of professionals. A study by Ahadzie (2007) reveals that most GREDA members do not have a full house of professional. Also in the same study Ahadzie noted that GREDA membership composition is skewed toward the Greater Accra Region with over ninety-five (95%) membership based in the capital city due to business concentration limited there. Hence, the study limits itself to the Greater Accra region.

As indicated by Dikmen et al., (2005) participants in HOQ model primarily consist of research team. Hence ten (10) respondents who were researchers on energy efficiency and mass housing such as the Energy Commission; Energy Centre, KNUST; Ministry of Water Resources Works and Housing, Building and Road Research Institute was adopted for the study.

On the housing clients (customers) for mass housing project, since there is no data base of housing client a convenience sample of fifty public servants in government institution was adopted for the study. In sticking to the core of HOQ methodology which is the voice of the customer. The choice of 50 sample size was supported by studies by Armacost et al. (1994), Abdul-Rahman et al. (1999), Chan et al. (1999), Dikmen et al., 2005), Menassa and Baer (2014).

3.7 DATA ANALYSIS

In ensuring completeness, consistency and readability of the questionnaire completed for analysis and discussion. The edited data was checked and arranged in a format for easy analysis and coded into a software for analysis. User-friendliness of Microsoft Office (Excel 2012) makes it appropriate for this study. The sub-sections are statistical techniques employed for the analysis of the collected data for the study;

3.7.1 Relationship of Stakeholders Requirement

Assessment of the relationship of the different stakeholders' requirements with technical considerations in the relationship matrix of the House of Quality (HOQ) is done.

Importance rating from the various stakeholders' requirements matrix together with the rating of the relationship from the relationship matrix was equalized into a technical importance factor given by Eq. (1):

Technical Importance (i, j) = Importance (i) x Relationship (j)

Where i represent the stakeholders requirement (1-16) and j represents the correlating relation with the technical or sustainability pillars.

3.7.2 Decision making Framework

Finally, the technical importance sum for each of the stakeholder requirement, technical characteristics and sustainable consideration in the relationship matrix is collated and entered into the technical targets matrix on the bottom of the HOQ in Figure 2.2. The value is equated into a single value of 1-5 to represent the prioritized relative weight for a decision-making comparison using Eq. (2):

$$\text{Relative Weight (j)} = 5 \times \frac{\text{Technical Importance}}{\text{Maximum Technical Importance}}$$

where Technical Importance (j) = $\sum$Technical Importance (i, j), i = 1, 2,..........,16 borrowed from Delgado-Hernandez et al. (2007).

The technical characteristics that receives a relative weight of 5 is the most important consideration for the focus of design efforts and further economic and environmental analysis. The consideration with the lowest relative weight is the least important area of focus from the integrated perspective of all stakeholders.

3.8 CHAPTER THREE SUMMARY

This chapter highlighted the approach taken in the selection of the various techniques and methods in arriving at the aim and objectives of the research. The research design and methodology, including the philosophical positions of the research, research strategy, and research design adopted for this study as described in this chapter.

A deductive approach was adopted for the research which involves a survey through the application of a structured questionnaire. HOQ participants for study consist of research team, design team and professionals with decision-making authority. Purposive sampling involving building stakeholders in mass housing project were chosen for the study. Analysis of data collected was undertaken using the HOQ application tools such as relative weight and inter-quartile ranges.

CHAPTER FOUR

ANALYSIS, FINDINGS AND DISCUSSION

4.1 CHAPTER INTRODUCTION

Details of analysis of data and discussion of results obtained from the analysis are presented in this chapter. The analysis of data and discussion in this chapter is grouped into two headings. The demography of the respondent is first tackled in this chapter. The second sections captured detailed analysis of the questionnaire survey. Information on the importance rating, technical importance of stakeholders' requirement on technical and sustainable consideration was analyzed. Also, the extent of impact of the different stakeholders combined on both technical and sustainable consideration is presented. The analyses were pivoted around the objectives of this study captioned in Chapter one (section 1.4).

4.2 CHARACTERISTICS OF DATA COLLECTION AND RESPONSE

In fortifying the justifiability and authenticity of the findings for drawing valid conclusions and generalization, there is the need for background assessment of respondent in any data collection survey (Cresswell, 2009). As indicated in Chapter 3, the respondents are building stakeholders actively engaged in mass housing projects. In all a population target of 200 was selected through 'purposive sampling', with data collected through the administering of questionnaires from September, 2014 and ended in November, 2014. A total of 175 questionnaires were received out of the 200 respondents constituting a response rate of 87.5% to the various building stakeholders constituting architects, engineers, housing clients, policy makers, researchers, facility managers etc.

4.3 DATA ANALYSIS

Analysis of the data was undertaken in four main areas. The first area was wholly directed on information pertaining to the background of the respondents stated in section A, the focus of the second area was on the importance of building energy efficiency by building stakeholders whiles the third and fourth looks at the extent of influence (impact) that each sustainability pillar and technical solutions has on building energy efficiency. Full details can be seen at section 3.5.2.2 of chapter three.

4.3.1 Analysis of the Biographic Data

Descriptive statistics involving the use of frequency and percentage was used in analyzing the data in section A of the questionnaire. With, questions in this sections involving the nature of involvement and years of involvement in the housing industry. The purpose of this response from respondents was to assess and increase the precision and reliability of data collected. The result is summarized in Table 4.1

4.3.1.1 Involvement in Housing Industry

The intent of this part of the background information was to categorize the various stakeholders into their respective groups to ascertain their involvement in mass housing industry. From Table 4.1; out of the 175 respondents received 50 (29%) were involved from both Housing Client and architects side of stakeholders. Twenty (11%) were involve in the housing sector as Engineers (service and electrical) and another 11% as Facilities Managers, whiles 17% of the respondents were quantity surveyors. Also, 5

(3%) where involved as Researchers and Policy Makers.

This information gives relevance to the kind and quality of information that will be given out since its gives a fairly balanced ratio in the attempt to establish any agreement or otherwise in respect of their responses. This spread of respondent from the various building stakeholder's years provide a balanced view on building energy efficiency in the Ghanaian housing sector.

Table 4.1 Involvement in Housing Industry

	Frequency	Percent
Researchers/Policy Makers	5	3%
Occupant (housing client)	50	29%
Engineer	20	11%
Architects	50	29%
Facilities managers	20	11%
Quantity Surveyor	30	17%
Total	175	100%

Source: Field Data (2015)

4.3.1.2 Years of Involvement

Respondent's years of involvement is necessary as the knowledge gain by the respondent will be of importance to the subject matter. Moreover, years of involvement gives an idea about the knowledge and awareness of the various stakeholders on Building Energy Efficiency (BEE) from Table 4.2, 43 percent of the respondent involved with the survey have less than 5 years of involvement. Meanwhile, high majority represented by 46 percent of the respondents have years of involvement between the periods of 6-10 years.

Whiles, respondents represented by 11 percent have working experience between the periods of 11-15 years. The results give indications that respondent in this survey have reasonable experience and possible conclusion can be drawn since the respondents are vexed in BEE and confirm that the respondents have adequate experience on the subject matter and are more likely to give accurate answers to the variables.

Table 4.2 Years of Involvement in Housing Development

	Frequency	Percent
0-5 years	75	43%
6-10 years	80	46%
11-15 years	20	11%
Total	175	100%

Source: Field Data (2015)

4.3.2 Building Energy Efficiency Decision Using House of Quality (HOQ)

4.3.2.1 HOQ Results

In reference to importance rating together with extent of relationship (Importance and Relationship of Stakeholders Requirement Matrix) stated in section 3.7, data for HOQ analysis was gathered. Data received was analyzed using Microsoft Excel per the HOQ model and in conformity with the approach presented in section 2.7.1 and 3.7 (House of Quality Methodology and Development for Building Energy Efficiency).

A combined data of the entire participants involved in the decision making was accumulated in order to ascertain which technical aspect on a building need to be tackled in meeting BEE requirement of the various stakeholder groups was performed to achieve the final HOQ analysis.

Also the HOQ analysis provides indication of the impact of each sustainability consideration (Economic, Environmental and Social) perceived by the various stakeholders requirement. Analysis on each stakeholder group stated in section 2.4.2 (architects, housing clients, engineers, facility managers and policy makers) to determine how the different group of stakeholders view BEE requirement was presented using the HOQ matrices. In addition, HOQ data analysis was performed on the stakeholders' requirement to determine the major influential requirement in implementing sustainable building decisions. Also, on the technical and sustainable aspect of BEE perception of the different stakeholders were also analyzed.

Firstly, data for HOQ was analyzed to ascertain the important rating on the BEE requirement of stakeholders without focusing on the technical aspect of the building (i.e. electrical system and building envelope). Followed by, analysis of the stakeholder requirements on the two technical features to ascertain the most important requirements. Thus, the column for the importance rating for the sixteen (16) BEE requirements of the different stakeholders was analyzed together with each of the two (2) technical features as shown in the HOQ column for the technical features. A combined analysis for both the importance rating and technical importance rating was done for the entire different stakeholder groups.

Finally, literature reviewed observed the conflicting perspective of building stakeholders on when, why and how a building should be energy efficient, which acts as a major barrier in implementing and achieving sustainability in buildings (Beheiry et al., 2006; Scofield, 2009; Yudelson, 2010). In determining how the type of stakeholder affect BEE requirement ranking, HOQ result was used to compare the perception of conflicting stakeholder groups during the analysis.

4.3.2.2 Importance Rating of Stakeholder Requirements

In achieving the objectives (see section 1.4.1), analysis was done using descriptive statistics to rank the importance of the stakeholders requirements. The procedure, findings and relevant discussions are as follows; it was deemed necessary to establish from building stakeholders (architects, housing clients, engineers, facility managers and policy makers) their rating of the various BEE requirements. Respondents rated the BEE requirements on a 1-5 scale, where 5 stood for "Extremely Important", 4 for "Very Important", with 3equall to "Somewhat Important", 2 equal to "Not Very Important" and 1 representing "Not Important".

In this section, analyses of the 16 BEE requirements of the stakeholders presented in the House of Quality (HOQ) Stakeholders Matrix, as seen in Figure 2.2 were assigned their rating of importance. Overall, each of the different stakeholder requirements importance rating was independent of both the electrical and building envelope (technical features of the building) importance rating. Relationship rating was built for the importance rating and the technical importance rating. Table 4.3 and Table 4.4 of this chapter displays summary of the importance assigned to the various requirement of the stakeholders.

Table 4.3 Average Results of Importance Rating of the Combined Group of All Stakeholders

Prospective Stakeholders Requirement	Importance (1-5 scale)	Considera						chnical Cons			
		Social Impact	Technical Importance social	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance Econs	Electrical Impact	Technical Importance (Elect)	Building Envelop	Technical Importance (Build)
Facilitates renewable energy	4.0	4.0	16.1	4.5	18.0	4.2	16.8	3.6	14.4	3.2	12.9
Minimize environmental impact	3.7	4.0	15.1	4.3	15.9	3.4	12.7	3.4	12.6	3.8	14.1
Increased Property rate	3.1	2.9	8.9	3.2	9.8	4.3	13.2	2.2	6.7	3.2	9.8
Improve occupants comfort	4.2	3.9	16.4	3.8	15.9	3.4	14.2	3.9	16.2	4.3	18.2
Reduce energy consumption	4.5	4.5	20.3	4.2	18.8	4.2	18.8	4.2	19.2	4.0	17.9
Lower project capital costs	3.4	3.4	11.6	3.3	11.3	3.7	12.5	2.9	9.9	3.9	13.1
Reduce energy costs	4.9	3.6	17.6	3.5	16.9	4.3	21.1	4.3	21.1	3.7	18.1
Meet regulatory requirement	3.5	3.3	11.4	4.0	13.9	3.0	10.4	3.1	10.8	3.4	11.8
Diversify investment portfolios	3.7	2.7	9.8	3.2	11.8	3.6	13.4	2.7	10.0	3.1	11.4
Increase occupant health	3.3	3.5	11.7	3.4	11.4	2.9	9.6	3.6	12.0	3.9	13.0
Increase energy efficiency	4.6	4.2	19.3	3.7	16.8	4.3	19.8	4.5	20.8	4.2	19.2
Comply with policy or legislation	3.2	3.4	10.8	3.8	12.1	3.0	9.7	3.1	9.9	3.0	9.6
Increase return on investment (ROI)	4.0	2.9	11.6	3.2	12.8	3.9	15.5	3.3	13.0	3.5	14.0

Provide a secure energy supply	4.5	3.9	17.5	3.5	15.9	4.1	18.4	4.4	20.0	3.7	16.7
Achieve lower total ownership costs	3.3	2.8	9.1	2.6	8.5	3.6	11.7	3.2	10.5	3.1	10.3
Decrease outages/interruption	3.9	3.5	13.6	3.5	13.6	3.2	12.7	4.1	15.9	3.4	13.3
∑ Technical Importance			**221**		**223**		**230**		**223**		**223**
Relative Weight (1-5, 5 most important)			**4.8**		**4.9**		**5.0**		**4.8**		**4.9**

Source: Field Data (2015).

Table 4.4 Technical Target: Technical Consideration

Summary		Technical Importance (Elect)	Technical Importance (Build)	Total
Average	∑ Technical Importance	223	223	446
	% Total Technical Importance	50%	50%	100%
	Relative Weight (1-5, 5 most important)	4.8	4.9	
Housing Clients	∑ Technical Importance	249	252	501
	% Total Technical Importance	50%	50%	100%
	Relative Weight (1-5, 5 most important)	4.9	5.0	
Engineer	∑ Technical Importance	211	191	402
	% Technical Importance	52%	48%	100%
	Relative Weight	5.0	4.5	
Quantity Surveyors	∑ Technical Importance	188	196	385
	% Technical Importance	49%	51%	100%
	Relative Weight	4.8	5.0	
Facility Managers	∑ Technical Importance	216	206	422
	% Technical Importance	51%	49%	100%
	Relative Weight	5.0	4.8	
Architect	∑ Technical Importance	266	292	558
	% Technical Importance	48%	52%	100%
	Relative Weight	4.6	5.0	
Researchers/Policy Makers	∑ Technical Importance	208	203	411
	% Technical Importance	51%	49%	100%
	Relative Weight	5.0	4.9	

Source: Field Data (2015)

Table 4.5 Importance Rating of Each Stakeholder

Importance Ratings Summary and Analysis																					
	Housing Client			Engineer			Facilities Managers			Quantity Surveyors			Researchers			Architects			Weighted Average		
Prospective Stakeholders Requirement	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.	Average	Std. Dev.	Var.
Facilitates renewable energy	4.1	0.7	0.5	3.0	0.0	0.0	4.3	0.9	0.7	3.7	0.5	0.2	4.0	0.0	0.0	5.0	0.0	0.0	4.0	1.6	2.7
Minimize environmental impact	3.8	0.4	0.2	3.0	0.0	0.0	3.3	0.4	0.2	3.3	0.5	0.2	4.0	0.0	0.0	5.0	0.0	0.0	3.7	1.6	2.4
Increased Property rate	2.8	0.4	0.2	3.0	0.0	0.0	3.0	1.3	1.6	2.3	0.5	0.2	3.0	0.0	0.0	4.4	0.9	0.9	3.1	1.3	1.8
Improve occupants comfort	5.0	0.0	0.0	4.0	0.0	0.0	4.5	0.5	0.3	3.7	1.0	0.9	3.0	0.0	0.0	5.0	0.0	0.0	4.2	1.7	3.0
Reduce energy consumption	5.0	0.0	0.0	5.0	0.0	0.0	4.5	0.5	0.3	4.0	0.0	0.0	5.0	0.0	0.0	3.6	0.9	0.9	4.5	1.8	3.2
Lower project capital costs	3.5	0.5	0.3	4.0	0.0	0.0	3.5	0.9	0.8	2.3	0.5	0.2	3.0	0.0	0.0	4.0	0.0	0.0	3.4	1.4	2.0
Reduce energy costs	5.0	0.0	0.0	5.0	0.0	0.0	4.5	0.5	0.3	4.7	0.5	0.2	5.0	0.0	0.0	5.0	0.0	0.0	4.9	1.8	3.4
Meet regulatory requirement	3.0	0.0	0.0	3.0	0.0	0.0	2.3	0.4	0.2	4.7	0.5	0.2	3.0	0.0	0.0	5.0	0.0	0.0	3.5	1.7	2.7
Diversify investment portfolios	3.6	0.8	0.7	4.0	0.0	0.0	3.3	0.4	0.2	3.7	1.0	0.9	3.0	0.0	0.0	4.4	0.9	0.9	3.7	1.5	2.1
Increase occupant health	3.5	0.5	0.3	3.0	0.0	0.0	3.5	0.5	0.3	3.7	0.5	0.2	2.0	0.0	0.0	4.3	0.5	0.2	3.3	1.4	2.1
Increase energy efficiency	5.0	0.0	0.0	4.0	0.0	0.0	4.5	0.5	0.3	4.0	0.0	0.0	5.0	0.0	0.0	5.0	0.0	0.0	4.6	1.8	3.2
Comply with policy or legislation	4.1	0.7	0.5	3.0	0.0	0.0	2.3	0.4	0.2	3.3	0.5	0.2	3.0	0.0	0.0	3.3	0.5	0.2	3.2	1.3	1.7
Increase return on investment (ROI)	3.8	0.4	0.2	5.0	0.0	0.0	3.8	0.4	0.2	4.3	0.5	0.2	4.0	0.0	0.0	3.0	0.0	0.0	4.0	1.6	2.6
Provide a secure energy supply	4.8	0.4	0.2	4.0	0.0	0.0	4.3	0.4	0.2	4.0	0.0	0.0	5.0	0.0	0.0	5.0	0.0	0.0	4.5	1.8	3.1
Achieve lower total ownership costs	3.5	0.5	0.3	3.0	0.0	0.0	3.5	0.5	0.3	2.7	0.5	0.2	3.0	0.0	0.0	4.0	0.0	0.0	3.3	1.3	1.7
Decrease outages/interruption	4.5	0.5	0.3	3.0	0.0	0.0	3.3	1.3	1.8	4.7	0.5	0.2	3.6	0.5	0.3	4.3	0.5	0.2	3.9	1.6	2.6
Minimum	**2.8**			**3.0**			**2.3**			**2.3**			**2.0**			**3.0**			**3.1**		
1st Quartile (Lower 25%)	**3.5**			**3.0**			**3.3**			**3.3**			**3.0**			**4.0**			**3.4**		
2nd Quartile (Median)	**3.8**			**4.0**			**3.5**			**3.7**			**3.0**			**4.4**			**3.7**		
3rd Quartile (Lower 75%)	**5.0**			**4.0**			**4.5**			**4.2**			**4.8**			**5.0**			**4.4**		

Maximum	**5.0**		**5.0**		**4.5**		**4.7**		**5.0**		**5.0**		**4.9**	

4.3.2.2.1 Importance Rating of Stakeholders Requirement

An investigative analysis using ordinal data analysis and descriptive statistics as outline in Section 3.7 of chapter three was carried out in this section. Table 4.5, indicate three categories in ranking data from the HOQ survey; 75% (third quartile) for items allocated the maximum importance rating, 50% (second quartile) for item with median allocation of importance and 25% (first quartile) items with minimum rating of importance.

From Table 4.3, the result revealed that the items in the first quartile received the lowest importance rating. To begin with, the requirement for BEE included in the least ranked importance were increased property rate, improve occupants comfort, achieve lower total ownership costs, and increase occupant health. However, speculations can be drawn at point of the analysis that the major interest of the various stakeholders was on the upgrade of the building envelope in order to increase the indoor and environmental quality as confirmed in the studies of (Savitz and Weber 2006; Singer et al. 2007).

According to the combined stakeholders, most ranked stakeholders requirement can be grouped as energy and money saving items. The requirements for, energy consumption reduction, energy costs reduction, increasing energy efficiency, increased return on investment (ROI) and providing a secure energy supply were the top 5 most ranked objective of stakeholders for pursing BEE in the third quartile; which assert the conception that decisions on building sustainability is often formulate entirely or solely on economic grounds (Mckinsey and Company 2008;

Entrop et al. 2010; Yudelson 2010). Among the various stakeholders that participated in the study there was alignment in assigning importance to the stakeholder requirement with economic benefits.

In addition, requirements to meet regulatory requirement, minimize environmental impact, facilitate renewable energy, decrease outages/interruption, and diversify investment portfolios were in the second quartile. From the Tables (4.3; 4.5), none of the stakeholders' requirement such as increase property rate, improve occupants comfort, achieve lower total ownership costs, and increase occupant health associated with improving the environment of the occupants was rated higher in the requirement. Also, in the rating of the social and economic long term benefits stakeholders rated the prospective stakeholders' requirements second to economic benefits.

4.3.2.2.2 Technical Importance Rating of Stakeholders Requirement

4.3.2.2.2.1 Building Envelope Technical Importance

This section deals with the importance rating of the building envelope in meeting the various stakeholder requirements. Table 4.3 and 4.4 displays a summary of average importance rating of building envelope (technical feature). Again, stakeholder requirement for energy consumption reduction, energy cost saving and improving occupants' comforts were rated among the highest technical features on the various stakeholders requirement list. On the technical importance of the technical considerations; the building envelope technical importance was valued moderately lower when collate to that of the electrical system; however, the stakeholders' requirement for the building envelope was the same as the top ranked requirement for the electrical system except for the improvement of occupant comfort. The result reveal that perception of all stakeholders combined on both electrical and building envelope are closely related in achieving sustainable building. Stakeholders perceive that both of the two technical features are related in their choice of energy consumption reduction and energy cost saving.

Lower rating for stakeholders' requirements mostly related to strengthening the indoor of the built environment; whiles increasing comfort for housing clients was rated in the third quartile immediately after the higher requirement of energy consumption reduction and energy cost saving.

4.3.2.2.2.2 Electrical System Technical Importance

Comparably to the Building Envelope, energy consumption reduction and energy cost saving were the stakeholder requirements that received the higher importance rating through the electrical system. Table 4.4, reveal the similarity between the electrical and building envelope for the technical importance rating. Electrical system as an aspect of the technical features was rated higher technical importance among the entire stakeholder requirement. Overall, the most important requirement among the various stakeholders was based on economic benefits.

4.3.3 Technical Targets Matrix: Stakeholder Comparison

House of Quality (HOQ) Technical targets matrix is a tool used in project planning and design to express the different stakeholders and their opposing requirement into technical focus areas. Information on the perception of the different stakeholders in relation to technical consideration most important to address sustainable requirements are well contain in the technical targets matrix.

In establishing areas where competing views may exist among the different stakeholder, on what each individual stakeholder perceive as important, compared to each other and the entire stakeholders combined using HOQ analysis. In the sections below; Table 4.4 to 4.5 reveals HOQ results of all stakeholder group and a correlation summary of the final HOQ results on the technical target matrix was presented. Summary of ranking of the importance and technical importance each stakeholder group placed on the sixteen (16) stakeholder requirement can be seen at appendix B from Table 4.7 to 4.12.

4.3.3.2 Opposing Stakeholder Groups

In Section 4.3.2, perception of stakeholders on technical consideration was evaluated to identify the top ranked technical importance. The analysis revealed agreement among all the stakeholders on electrical system been the top priority for Building Energy Efficiency (BEE). Further, all stakeholders combined rated the building envelope has the second prioritize technical consideration.

Decision regarding importance rating and technical importance of each stakeholder requirement and sustainable consideration for meeting each requirement was explored. Energy consumption reduction, reduce energy costs and increase energy efficiency were the primary reasons for sustainability implementation for each stakeholder group, and that improving the comfort of the environment was the secondary benefit for Building Energy Efficiency (BEE) as demonstrated by the results in table 4.3; 4.4; 4.5 and 4.6.

From the tables presented in Section 4.3.2 the importance ranking was aligned with the technical ranking for each stakeholder requirement. The importance ratings and technical importance rating for each stakeholder and consideration were greater than or equal to each other. Therefore, the driving force in HOQ energy efficiency decisions-making is thee importance rating of each stakeholder requirement.

4.3.4 Social, Environmental, and Economic Sustainability Considerations

Technical target mix focus on two sections, the HOQ for the two main technical considerations (electrical and building envelope) displayed in section 4.3.2.2 whiles that of the three sustainability considerations (economic, environmental and social) and their impact will analyzed in this section.

Throughout literature review, sustainable decisions on the long term environmental and social benefits of sustainable building features have been quantify into economic returns (Rey 2004; Juan et al. 2010). Further, with short- term economic decision taking on building sustainability without the impact of that decision on the long-term social and environmental been quantify (Oreszcyn and Lowe, 2010; Yudelson 2010). With, Klotz and Hormon (2010) affirming the understating of the impact of building sustainability on the three sustainable consideration (i.e. economic, social and environmental). Often decisions on sustainability are made on financial grounds with energy saving paybacks as priority which still has significant footprint on long-term sustainable consideration (i.e. economic, social and environmental) (Gaterell and McEvoy, 2005).

Therefore, HOQ analysis was conducted ascertain the extent of impact of the requirement of the different building stakeholders on the three sustainability considerations (Economic, Social and Environmental); also requirements for each sustainability consideration and the effect of sustainable decision by the different stakeholders will be determined. Furthermore, the balance between the economic environmental and social sustainable practice perceive by the various stakeholders will be assessed.

4.3.4.1 Sustainable Considerations House of Quality.

Comparably to the Technical Considerations House of Quality (HOQ) that was set forth in Section 4.3.2.2. Table 4.4 shows the averages for the importance rating, technical importance and relationship matrices, seen in the HOQ model in Figure 2.1. Appendices B show the summary of the calculations;

Drawing from Table 4.4 above, the results indicate the biggest impact of stakeholders' sustainable consideration was on economic benefits, with a relative weight of 5.0. In summation the study reveal that, Building Energy Efficiency (BEE) objectives were primarily motivated by economic concerns. Impact on social considerations of sustainability was perceived to be secondary among the different stakeholders combined, with environmental sustainable consideration with the least impact with relative weights of 4.9 and 4.8 respectively. Agreement and disagreement amongst the stakeholder groups on sustainable consideration is presented in Table 4.3, with individual HOQ's also summarized at Table 4.5

Furthermore, social and environmental considerations were allocated with average relative weight ranging from 4.9 to 4.8; lower than that of economic considerations.

However, the three sustainability weren't far from balance with both the environmental and social consideration having fairly" to "very" impact in reference to the HOQ survey. In terms of percentage wise of the technical importance in Table 4.5, economic, environmental impacts each have 42, 29, and 3.7 percent respectively. Sustainability principles equate the impact of the sustainable consideration thus economic, environmental and social to be 33.33% with possible maximum overlap. Thus, equal strength of impact of the three main sustainable considerations must be shared among each consideration.

Furthermore, Savitz and Weber (2006) emphasize that economic returns should be provide by both environmental and social impact benefits in the long term. Example, housing client implementing sustainable building may not have immediate benefit but still benefit from future economic returns such as provide a secure energy supply, avoidance of future carbon taxes (Gluch and Baumann, 2003; Savitz and Weber, 2006; Singer et al., 2007).

In summary, the study demonstrates that stakeholder requirements are more focused on economic issues in terms of the sustainability consideration; with economic concerns been primary motivation for sustainable decisions. Progress has been made towards the principles of sustainability with overlapping consideration among the three main sustainability features. Thus, common ground for sustainability among the objectives of the various stakeholders groups.

4.3.4.2 Sustainability Consideration and Stakeholder Requirements

A comparison of individual stakeholder's requirement on the sustainability consideration was provided to assess the benefits on the economic, environmental and social concerns. The results indicated an overlap between stakeholders' most important requirement in each of the three sustainable considerations (economic, environmental and social). In Table 4.5, the important sustainability considerations were identified for each stakeholder's requirements in the upper quartile (above 75%) of the HOQ results. A summary of requirement found in the third quartile is shown at Appendix B.

The ranking results summarized in Table 4.3 demonstrate that energy consumption reduction, energy costs reduction and increase in energy efficiency requirements were amid the top rated requirement in sustainable building delivery. Section 4.3.2 confirmed the perception of the various stakeholders were on economic benefits of the stakeholder requirement in their BEE decisions.

Furthermore, requirements of stakeholders' have primary impacts on the lower rated sustainable consideration (social and environmental) with secondary impact on the economic sustainable consideration. For example conserving natural resources for future generations and reduce green gases emission on the environment can be achieve through facilitation of renewable energy. With both effect of global warming and future carbon taxes, being perceived as having small economic effect (Papadopoulos et al. 2002; Gaterell and McEvoy 2005). According to Scofield (2009) and Prowler (2012) stakeholders' perception on initial cost of investment and available level of renewable technology are not equated to economic benefits.

In summary, perceptions of stakeholder decision-making were based on economic benefits even though there was balance in the sustainability considerations. Furthermore, there was balance among the sustainable consideration of the most rated requirements thus energy consumption reduction, reduce energy costs and increase in energy efficiency.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

The study sought to develop a framework that integrates energy efficiency decision making among building stakeholders of mass housing project. The research objectives presented in section 1.4 were developed to assist in achieving the aim. House of Quality (HOQ) methodology was used to develop a framework that integrates the entire building stakeholder in making energy efficiency decisions. Conclusions, recommendations, implications of the study as well as contribution of the study to existing knowledge are all highlighted in this chapter.

5.2 OBJECTIVES REVIEW

The study's aim was to use the HOQ model to integrate energy efficiency decision making among stakeholders of mass housing project. The following specific objectives were set to achieve this novel aim:

5.2.1 Objective 1: To identify the important building energy efficiency requirements among stakeholders of mass housing projects;

The results from the study showed that among the stakeholders requirements, reducing energy consumption, reducing energy costs, increasing energy efficiency, increases return on investment (ROI) and providing a secure energy supply were the top 5 most ranked objective of stakeholders for pursing energy efficiency building. Also the study revealed alignment among the different stakeholders groups in the ranking of the different stakeholders' requirements.

5.2.2 Objective 2: To assess the impact of technical characteristics of mass housing projects on each stakeholders' requirements;

In case of the second objective, electrical system was rated higher than the building envelope with decisions of the different stakeholder groups primarily based on economic grounds. On the perception of stakeholders on the technical consideration (that is electrical system and building envelope) there was close relationship of stakeholder requirement such as reduce energy consumption, reduce energy cost, increase energy efficiency and improving comfort of occupants. Whiles, stakeholder requirement relating to the indoor comfort of occupant was the second rated requirement.

5.2.3 Objective 3: To assess the impact of sustainability pillars on each stakeholders' requirements;

The study revealed that sustainable decisions on the benefits of long term environmental and social impacts of stakeholders' requirements were quantified into economic returns. Thus, short- term economic decision were taking on building sustainability without impact of such decision on the long-term social and environmental benefits been quantified. Although, decisions are often made on economic grounds such decisions still had consequential footprint on both environmental and social concern in the long-term. Furthermore, there was balance among the various stakeholders on the main sustainability features (economic, environmental and social).

5.2.4 Objective 4: To adopt the HOQ model in integrating energy efficiency decision making for mass housing projects;

In achieving the main aim of the study, statistical tools such as the relative weight, ordinal data analysis, importance and technical importance were used to establish the relationship between the dependent variables (technical and sustainability considerations) and individualistic variables (stakeholders' requirement) and measure the impact of the stakeholder type on the requirement. Also the extent of influence of the stakeholder type on both the technical characteristics and the sustainability pillars were analyzed. Inter-quartile range was applied to establish competing requirement among each stakeholder. All this was achieved with the aid of the House of Quality (HOQ) model developed using the technical target matrix (see figure 2.2).

5.3 CONCLUSIONS

The challenge of the study to address four independent but interlinked objectives in an attempt to fill identified research gaps (see section 1.3.). This led to the overall aim of using the HOQ model to integrate energy efficiency decision making among stakeholders of mass housing projects thereby acknowledging the major role of the housing industry in the development agenda of every country.

The HOQ model adopted in the study allows decision makers to understand and appreciate the changes in the ranking between the different building stakeholders. Indications of disagreement among the various stakeholders groups, the stakeholder type and their effect on the sustainable decision will be detected; to develop strategies in reducing stakeholders' requirement gaps. This framework can be used by decision makers during the conceptual and pre-planning design stages of mass housing project to identifying technical areas (i.e., electrical or building envelope) importantly ranked by the building stakeholders; allowing decision-makers to be more focused at their product planning stage.

Decision-making comparisons are made since the HOQ model provides a methodology which identifies technical measures with potentials to achieve stakeholder requirements, through prioritization of those technical measures. The HOQ provides opportunity for decision makers to engage all stakeholder groups earlier in the design process to ensure that the various needs, interest, opinions and views of all parties are met.

The HOQ analysis revealed no major disagreements in ranking or magnitude since the stakeholder type did not affect the ranking of their requirements. In general, all stakeholders groups in this study, where in agreement that reduce energy and saving energy cost for the two main technical systems where the primary focus for sustainability implementation.

In summary, the various stakeholders agreed that sustainability progression can be achieved through energy efficiency increase; by integrating the views, values, opinions and expectation of the various stakeholders earlier at the design stage in the decision making.

5.4 RECOMMENDATIONS

The section proposed recommendations arising from this research;

- Integration of the various building stakeholders earlier in the design stage of project planning will help align the various perspective and views of the stakeholders in making energy efficient decision.

- Effective communication and collaboration among the different building stakeholders is needed to integrate energy efficiency building in the mass housing industry.
- The National Building Regulation needs to be revised with energy building standards and codes to enforce energy efficiency practice among the building stakeholders.
- Need for continuous professional development of the various stakeholders with current energy efficiency practice to help develop their capacity and knowledge.

5.5 CONTRIBUTION TO KNOWLEDGE

- Knowledge on the role of different stakeholders' in decision-making integration of the sustainable aspect (economic, environmental and social) and technical features of BEE decision has been produced by this research to assist policy makers, researcher and housing clients.
- Furthermore, stakeholders in the housing industry have information on the perception of different stakeholders' requirement and conflicting requirement that exist in their sustainable decision in overcoming barriers to energy efficient building.

5.6 LIMITATIONS OF THE STUDY

The following are limitations which provides basis for further research;

- The uniqueness of HOQ model to each project makes it difficult to use HOQ matrices template for future projects (Mallon and Mulligan 1993; Ahmed et al. 2003).

Therefore, HOQ design matrices are important as the obtained data, which needs great deal of care at the design stage.

- In addition, the HOQ method relies solely on the decision making authority of the participants involved thus their experience, professional judgment and intuition are important in the application, making the data subjective in nature.
- Analysis of data collected from the survey was reached through the average weight of each stakeholder's response rather than the total number. This was done in order to prevent final HOQ decision from been dominated by stakeholders with more participant.

5.7 DIRECTION FOR FUTURE RESEARCH

The following directions for future studies are therefore suggested to enhance research into BEE in Ghana and other developing countries:

- Further research study to refine and validate a model into the perception of various stakeholders requirement such as a private real estate firm and a public sector housing agency.
- Similarly, future studies should provide the springboard for research to investigate the perception of housing clients in self-build houses.
- Moreover, research into available technologies and methods for each of the technical and sustainability consideration in meeting the stakeholders' requirements identified in this study will be welcoming.

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APPENDIX A – HOQ Survey Questionnaire

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY DEPARTMENT OF BUILDING TECHNOLOGY

To Whom It May Concern:

Dear Sir or Madam

RESEARCH INTO ENERGY EFFICIENCY DECISION MAKING AMONG STAKEHOLDERS OF MASS HOUSING PROJECTS IN GHANA

The Department of Building Technology of Kwame Nkrumah University of Science and Technology is conducting a research aimed at investigating energy efficiency decision making in Ghana with the focus on stakeholders in mass housing projects.

Relying on your broad industrial experience, please answer all questions to the best of your ability. There are no "correct" or "incorrect" answers. Only your valued expert response is requested. The questionnaire will take 10minutes to complete. All answers will be treated in absolute confidence and used for academic purposes only. Extra space is provided to enable you expand your answers to the questions where necessary.

If you have any questions or should you require any explanation please contact Mr. Felix Quarcoo using the contact information below. Thank you very much for your time.

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SECTION A: GENERAL INFORMATION

Q1. How are you involved in the housing industry?

a) Researcher b) Real Estate Developer c) Policy Maker d) Occupant (Housing Clients) e) Engineers f) Architects g) Facilities Managers

Q2. How long have you been involved / participated in Housing Development Issues?

a) 0-5 years b) 6-10 years c) 11-15 years d) 16 and above

SECTION B: IMPORTANCE RATING

Q3. The following are the importance of pursing Building Energy Efficiency in mass housing? (Rate on a scale of 1-5)

Please tick (√) where applicable for the following questions: 1=Not Important, 2=Not Very Important, 3=Somewhat Important, 4=Very Important and 5=Extremely Important

Stakeholders Requirements	**1**	**2**	**3**	**4**	**5**
Facilitates renewable energy					
Minimize environmental impact					
Increased Property rate					
Improve occupants comfort					
Reduce energy consumption					
Lower project capital costs					
Reduce energy costs					
Meet regulatory requirement					
Diversify investment portfolios					
Increase occupant health					
Increase energy efficiency					
Comply with policy or legislation					
Increase return on investment (ROI)					

Provide a secure energy supply					
Achieve lower total ownership costs					
Decrease outages/interruption					

SECTION C: Relationship of Stakeholders Requirement with Technical solutions and Sustainability Pillars

Q4. What is the extent of influence (impact) each technical characteristics has on Building Energy Efficiency? (Rate on a scale of 1-5)

Electrical System components include items such as lighting fixtures, lighting controls, electrical meters, or electrical circuiting and control.

Building Envelope or Exterior skin components include items such as windows, doors, insulation, roof, day lighting features or runoff control measures.

Please tick (√) where applicable for the following questions: 1=No relationship, 2=Weak, 3= Fairly Strong, 4=Very Strong and 5=Extremely Strong

Stakeholders Requirements	**Electrical System**					**Building Envelope**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Facilitates renewable energy										
Minimize environmental impact										
Increased Property rate										
Improve occupants comfort										
Reduce energy consumption										
Lower project capital costs										
Reduce energy costs										
Meet regulatory requirement										
Diversify investment portfolios										
Increase occupant health										
Increase energy efficiency										
Comply with policy or legislation										
Increase return on investment (ROI)										
Provide a secure energy supply										
Achieve lower total ownership costs										
Decrease outages/interruption										

Q.5 What is the extent of influence (impact) that each sustainability pillar has on Building Energy Efficiency? (Rate on a scale 1-5)

Economic constraints: Items that effect financial performance and financial resources such as sales, profits, taxes paid, debt operating costs, return on investment, cash flow, labor costs, shareholder value, or capital.

Environmental factors: Concern for the effect of your actions on the quality and supply of natural resources such as air, water, soil, ozone, energy sources. Minimizing the environmental impact by preserving natural resources to support native species, maintain natural ecological processes, sustain air and water resources and contribute to health and quality of life.

Social factors: Acknowledging the needs and interests of other parties such as community groups, the workforce, public and future generations in order to reinforce the network of relationships that ties them together. Social concerns include community impacts, human values including family life, intellectual growth, and artistic expression.

Please tick (√) where applicable for the following questions: 1=No relationship, 2=Weak, 3= Fairly Strong, 4=Very Strong and 5=Extremely Strong

Stakeholders Requirements	**Social**					**Environmental**					**Economic**				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Facilitates renewable energy															
Minimize environmental impact															
Increased Property rate															
Improve occupants comfort															
Reduce energy consumption															
Lower project capital costs															
Reduce energy costs															
Meet regulatory requirement															
Diversify investment portfolios															
Increase occupant health															
Increase energy efficiency															
Comply with policy or legislation															
Increase return on investment (ROI)															
Provide a secure energy supply															

Achieve lower total ownership costs															
Decrease outages/interruption															

APPENDIX B – HOQ Data and Calculations

Table 4.7 Sustainability and Technical Consideration of Housing Clients

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	EnviImpact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	3.6	14.4	4.5	17.9	3.6	14.4	3.9	15.8	3.1	12.3
Minimize environmental impact	3.7	4.4	16.4	4.4	16.4	3.1	11.4	3.6	13.4	4.6	17.2
Increase Property rate	3.1	2.7	8.4	2.2	6.9	3.9	12.1	1.9	5.9	3.0	9.3
Improve occupants comfort	4.2	4.8	20.0	4.5	19.0	4.2	17.5	4.9	20.5	5.0	21
Reduce energy consumption	4.5	5.1	23.0	4.8	21.5	3.7	16.5	4.4	20.0	5.2	23.5
Lower project capital costs	3.4	3.5	11.9	2.3	7.9	3.3	11.1	3.5	11.9	3.1	10.5
Reduce energy costs	4.9	4.1	20.0	3.9	19.0	3.9	19.0	4.6	22.5	4.6	22.5
Meet regulatory requirement	3.5	2.7	9.6	3.8	13.2	2.8	9.9	2.7	9.6	3.1	10.8
Diversify investment portfolios	3.7	2.9	10.8	2.8	10.4	4.9	18.0	3.1	11.2	3.5	12.8
Increase occupant health	3.3	4.1	13.7	4.4	14.8	3.8	12.8	4.1	13.7	4.6	15.2
Increase energy efficiency	4.6	4.4	20.0	4.0	18.5	3.5	16.0	5.2	24.0	5.2	24
Comply with policy or legislation	3.2	4.5	14.3	6.5	20.5	5.6	17.8	5.3	16.7	5.0	15.8
Increase return on investment (ROI)	4.0	2.9	11.4	2.9	11.4	4.0	16.0	3.5	13.8	3.4	13.4
Provide a secure energy supply	4.5	4.8	21.7	4.3	19.2	3.7	16.9	4.5	20.2	4.0	17.9
Achieve lower total ownership costs	3.3	3.2	10.5	3.0	9.9	3.8	12.5	3.4	11.1	3.7	12.2
Decrease outages/interruption	3.9	4.4	17.2	3.8	14.7	3.9	15.2	4.8	18.7	3.5	13.5
∑ Technical Importance			**243**		**241**		**237**		**249**		**252**
% Technical Importance			**34%**		**33%**		**33%**		**50%**		**50%**
Relative Weight (1-5 scale)			**4.8**		**4.8**		**4.7**		**4.9**		**5.0**

Source: Field Data (2015)

Table 4.8 Sustainability and Technical Consideration of Engineer

Sustainability Consideration Technical Consideration

Potential Stakeholders Requirement	Importance (1-5 scale)	Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econ.)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	3.0	12.0	3.7	15.0	3.0	12.0	2.2	9	1.5	6.0
Minimize environmental impact	3.7	4.0	15.0	4.0	15.0	1.6	6.0	2.4	9.0	1.6	6.0
Increase Property rate	3.1	2.9	9.0	2.9	9.0	3.9	12.0	2.9	9.0	3.9	12.0
Improve occupants comfort	4.2	3.8	16.0	3.8	16.0	1.9	8.0	3.8	16.0	3.8	16.0
Reduce energy consumption	4.5	4.4	20.0	5.5	25.0	4.4	20.0	4.4	20.0	3.3	15.0
Lower project capital costs	3.4	3.5	12.0	4.7	16.0	3.5	12.0	3.5	12.0	4.7	16.0
Reduce energy costs	4.9	2.1	10.0	4.1	20.0	4.1	20.0	4.1	20.0	3.1	15.0
Meet regulatory requirement	3.5	2.6	9.0	3.4	12.0	1.7	6.0	3.4	12.0	2.6	9.0
Diversify investment portfolios	3.7	2.2	8.0	4.4	16.0	2.2	8.0	3.3	12.0	4.4	16.0
Increase occupant health	3.3	3.6	12.0	2.7	9.0	1.8	6.0	3.6	12.0	2.7	9.0
Increase energy efficiency	4.6	4.4	20.0	3.5	16.0	3.5	16.0	3.5	16.0	3.5	16.0
Comply with policy or legislation	3.2	3.8	12.0	3.8	12.0	1.9	6.0	2.8	9.0	1.9	6.0
Increase return on investment (ROI)	4.0	3.8	15.0	3.8	15.0	5.0	20.0	3.8	15.0	3.8	15.0
Provide a secure energy supply	4.5	3.5	16.0	2.7	12.0	3.5	16.0	3.5	16.0	3.5	16.0
Achieve lower total ownership costs	3.3	3.7	12.0	2.7	9.0	3.7	12.0	3.7	12.0	2.7	9.0
Decrease outages/interruption	3.9	2.3	9.0	3.1	12.0	1.5	6.0	3.0	11.9	2.3	9.0

∑ Technical Importance 207 229 186 211 191 % Technical Importance 33% 37% 30% 52%

48% Relative Weight (1-5 scale) 4.5 5.0 4.1 5.0 4.5 Source: Field Data (2015)

Table 4.9 Sustainability and Technical Consideration of Quantity Surveyors

Sustainability Consideration Technical Consideration

Potential Stakeholders

Requirement	Importance (1-5 scale)	Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	3.4	13.7	3.7	14.7	3.7	14.7	3.4	13.7	2.5	10.0
Minimize environmental impact	3.7	3.0	11.3	3.6	13.3	3.2	12.0	2.7	10.0	3.6	13.3
Increase Property rate	3.1	2.3	7.0	1.5	4.7	3.1	9.7	1.8	5.7	3.0	9.3
Improve occupants comfort	4.2	3.5	14.7	3.1	13.0	2.6	11.0	3.5	14.7	3.1	13.0
Reduce energy consumption	4.5	3.5	16.0	3.5	16.0	4.1	18.7	3.5	16.0	3.5	16.0
Lower project capital costs	3.4	2.4	8.0	1.7	5.7	2.5	8.3	1.7	5.7	2.2	7.3
Reduce energy costs	4.9	2.9	14.0	2.2	10.7	3.6	17.3	3.2	15.3	3.6	17.3
Meet regulatory requirement	3.5	5.0	17.3	5.3	18.7	2.7	9.3	3.0	10.7	4.0	14.0
Diversify investment portfolios	3.7	3.4	12.3	2.9	10.7	3.5	12.7	2.0	7.3	3.0	11.0
Increase occupant health	3.3	4.9	16.3	3.0	10.0	2.5	8.3	3.6	12.0	3.6	12.0
Increase energy efficiency	4.6	3.5	16.0	2.6	12.0	4.1	18.7	3.8	17.3	3.5	16.0
Comply with policy or legislation	3.2	4.4	14.0	3.8	12.0	2.5	8.0	3.2	10.0	3.2	10.0
Increase return on investment (ROI)	4.0	3.7	14.7	3.3	13.0	5.0	20.0	3.3	13.0	3.3	13.0
Provide a secure energy supply	4.5	2.1	9.3	2.7	12.0	2.7	12.0	3.2	14.7	2.7	12.0
Achieve lower total ownership costs	3.3	1.8	6.0	1.8	6.0	3.0	10.0	2.4	8.0	2.4	8.0
Decrease outages/interruption	3.9	4.8	18.7	3.6	14.0	3.2	12.7	3.7	14.3	3.6	14.0
Sum of Technical Importance	**209**	**186**	**203**	**188**	**196**						
% Technical Importance		**34%**	**49%**		**51%**					**35%**	**31%**
Relative Weight			**5.0**		**4.5**		**4.9**		**4.8**		**5.0**

Source: Field Data (2015)

Table 4.10 Sustainability and Technical Consideration of Facilities Managers

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	4.0	16.3	5.1	20.5	4.6	18.5	4.7	18.8	2.9	11.8
Minimize environmental impact	3.7	3.1	11.8	4.2	15.5	3.2	12.0	2.9	10.8	3.0	11.3
Increase Property rate	3.1	2.5	7.8	3.8	11.8	4.2	13.0	1.9	6.0	2.6	8.0
Improve occupants comfort	4.2	4.5	19.0	3.2	13.5	4.6	19.5	4.4	18.5	5.1	21.5
Reduce energy consumption	4.5	4.8	21.5	3.5	16.0	4.0	18.0	4.0	18.0	3.5	16.0
Lower project capital costs	3.4	3.7	12.5	2.7	9.0	3.7	12.5	3.1	10.5	4.0	13.5
Reduce energy costs	4.9	4.0	19.5	3.3	16.0	4.4	21.5	4.2	20.5	3.3	16.0
Meet regulatory requirement	3.5	1.7	6.0	2.9	10.0	2.2	7.8	1.9	6.5	2.2	7.8
Diversify investment portfolios	3.7	2.9	10.5	2.5	9.0	3.8	14.0	2.4	8.8	3.1	11.3
Increase occupant health	3.3	3.9	13.0	3.9	13.0	3.6	12.0	3.9	13.0	4.2	14.0
Increase energy efficiency	4.6	4.3	19.5	3.5	16.0	4.3	19.5	4.1	19.0	4.3	19.5
Comply with policy or legislation	3.2	2.0	6.3	3.2	10.0	1.9	6.0	2.1	6.8	2.4	7.8
Increase return on investment (ROI)	4.0	2.9	11.5	3.1	12.3	4.1	16.3	3.6	14.3	4.0	16.0
Provide a secure energy supply	4.5	3.5	16.0	3.5	16.0	3.5	15.8	4.2	19.0	2.5	11.5
Achieve lower total ownership costs	3.3	3.2	10.5	3.0	9.8	4.0	13.3	3.8	12.5	3.2	10.5
Decrease outages/interruption	3.9	2.8	11.0	2.8	10.8	3.1	12.0	3.5	13.5	2.4	9.5
Sum of Technical Importance			**213**		**209**		**232**		**216**		**206**
% Technical Importance			**33%**		**32%**		**35%**		**51%**		**49%**
Relative Weight			**4.6**		**4.5**		**5.0**		**5.0**		**4.8**

Table 4.11 Sustainability and Technical Consideration of Architects

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	5.0	20.0	5.0	20.0	5.4	21.5	3.2	13.0	5.0	20.0
Minimize environmental impact	3.7	5.4	20.0	5.4	20.0	5.0	18.5	4.4	16.5	6.3	23.5
Increase Property rate	3.1	4.0	12.3	5.1	15.8	6.6	20.2	2.6	7.9	3.7	11.4
Improve occupants comfort	4.2	4.8	20.0	4.8	20.0	4.8	20.0	5.1	21.5	6.0	25.0
Reduce energy consumption	4.5	3.7	16.5	3.3	15.0	3.2	14.4	3.5	15.9	4.0	18.0
Lower project capital costs	3.4	4.8	16.4	4.8	16.4	5.6	18.8	3.1	10.4	5.6	18.8
Reduce energy costs	4.9	3.5	17.0	4.1	20.0	4.8	23.5	4.8	23.5	4.4	21.5
Meet regulatory requirement	3.5	5.9	20.5	6.7	23.5	6.7	23.5	5.7	20.0	6.7	23.5
Diversify investment portfolios	3.7	3.1	11.4	4.6	16.7	5.0	18.5	4.1	14.9	3.1	11.4
Increase occupant health	3.3	3.4	11.4	3.9	12.9	4.3	14.4	5.2	17.2	6.0	20.0
Increase energy efficiency	4.6	3.3	15.0	4.8	22.0	5.1	23.5	5.1	23.5	5.1	23.5
Comply with policy or legislation	3.2	3.8	12.0	3.8	12.0	4.5	14.1	3.4	10.8	3.8	12.0
Increase return on investment (ROI)	4.0	2.3	9.0	2.5	9.9	3.2	12.9	3.5	14.1	2.9	11.4
Provide a secure energy supply	4.5	3.8	17.0	3.8	17.0	5.5	25.0	5.5	25.0	5.2	23.5
Achieve lower total ownership costs	3.3	2.1	6.8	2.8	9.2	3.2	10.4	3.2	10.4	4.0	13.2
Decrease outages/interruption	3.9	2.5	9.9	4.0	15.7	4.0	15.7	5.5	21.3	4.0	15.5
Sum of Technical Importance			**235**		**266**		**295**		**266**		**292**
% Technical Importance			**30%**		**33%**		**37%**		**48%**		**52%**
Relative Weight			**4.0**		**4.5**		**5.0**		**4.6**		**5.0**

Source: Field Data (2015)

Table 4.12 Sustainability and Technical Consideration of Researchers/Policy Makers

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	5.0	20.0	5.0	20.0	5.0	20.0	4.0	16.0	4.4	17.6
Minimize environmental impact	3.7	4.3	16.0	4.1	15.2	4.3	16.0	4.3	16.0	3.6	13.6
Increase Property rate	3.1	2.9	9.0	3.5	10.8	3.9	12.0	1.9	6.0	2.9	9.0
Improve occupants comfort	4.2	2.1	9.0	3.3	13.8	2.1	9.0	1.4	6.0	3.0	12.6
Reduce energy consumption	4.5	5.5	25.0	4.2	19.0	5.5	25.0	5.5	25.0	4.2	19.0
Lower project capital costs	3.4	2.7	9.0	3.7	12.6	3.5	12.0	2.7	9.0	3.7	12.6
Reduce energy costs	4.9	5.1	25.0	3.3	16.0	5.1	25.0	5.1	25.0	3.3	16.0
Meet regulatory requirement	3.5	1.7	6.0	1.7	6.0	1.7	6.0	1.7	6.0	1.7	6.0
Diversify investment portfolios	3.7	1.6	6.0	2.1	7.8	2.5	9.0	1.6	6.0	1.6	6.0
Increase occupant health	3.3	1.2	4.0	2.5	8.4	1.2	4.0	1.2	4.0	2.3	7.6
Increase energy efficiency	4.6	5.5	25.0	3.5	16.0	5.5	25.0	5.5	25.0	3.5	16.0
Comply with policy or legislation	3.2	1.9	6.0	1.9	6.0	1.9	6.0	1.9	6.0	1.9	6.0
Increase return on investment (ROI)	4.0	2.0	8.0	3.8	15.2	2.0	8.0	2.0	8.0	3.8	15.2
Provide a secure energy supply	4.5	5.5	25.0	4.2	19.0	5.5	25.0	5.5	25.0	4.2	19.0
Achieve lower total ownership costs	3.3	2.7	9.0	2.2	7.2	3.7	12.0	2.7	9.0	2.7	9.0
Decrease outages/interruption	3.9	4.0	15.6	3.7	14.4	3.7	14.4	4.1	16.0	4.6	18.0
∑ Technical Importance			**218**		**207**		**228**		**208**		**203**
% Technical Importance			**33%**		**32%**		**35%**		**51%**		**49%**
Relative Weight			**4.8**		**4.5**		**5.0**		**5.0**		**4.9**

Source: Field Data (2015)

Table 4.13: Importance, Impact And Technical Importance of Housing Clients

Sustainability Consideration Technical Consideration

Potential Stakeholders Requirement

Facilitates renewable energy	4.0	3.6	14.4	4.5	17.9	3.6	14.4	3.9	15.8	3.1	12.3
Minimize environmental impact	3.7	4.4	16.4	4.4	16.4	3.1	11.4	3.6	13.4	4.6	17.2
Increase Property rate	3.1	2.7	8.4	2.2	6.9	3.9	12.1	1.9	5.9	3.0	9.3
Improve occupants comfort	4.2	4.8	20.0	4.5	19.0	4.2	17.5	4.9	20.5	5.0	21
Reduce energy consumption	4.5	5.1	23.0	4.8	21.5	3.7	16.5	4.4	20.0	5.2	23.5
Lower project capital costs	3.4	3.5	11.9	2.3	7.9	3.3	11.1	3.5	11.9	3.1	10.5
Reduce energy costs	4.9	4.1	20.0	3.9	19.0	3.9	19.0	4.6	22.5	4.6	22.5
Meet regulatory requirement	3.5	2.7	9.6	3.8	13.2	2.8	9.9	2.7	9.6	3.1	10.8
Diversify investment portfolios	3.7	2.9	10.8	2.8	10.4	4.9	18.0	3.1	11.2	3.5	12.8
Increase occupant health	3.3	4.1	13.7	4.4	14.8	3.8	12.8	4.1	13.7	4.6	15.2
Increase energy efficiency	4.6	4.4	20.0	4.0	18.5	3.5	16.0	5.2	24.0	5.2	24
Comply with policy or legislation	3.2	4.5	14.3	6.5	20.5	5.6	17.8	5.3	16.7	5.0	15.8
Increase return on investment (ROI)	4.0	2.9	11.4	2.9	11.4	4.0	16.0	3.5	13.8	3.4	13.4
Provide a secure energy supply	4.5	4.8	21.7	4.3	19.2	3.7	16.9	4.5	20.2	4.0	17.9

Achieve lower total ownership costs 3.3 3.2 10.5 3.0 9.9 3.8 12.5 3.4 11.1 3.7 12.2 Decrease outages/interruption 3.9 4.4 17.2 3.8 14.7 3.9 15.2 4.8 18.7 3.5 13.5

∑ Technical Importance 243 241 237 249 252 % Technical Importance 34% 33% 33% 50% 50% Relative Weight (1-5 scale) 4.8 4.8 4.7 4.9 5.0 Source: Field Data (2015)

Table 4.14: Importance, Impact And Technical Importance of Engineer

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econ.)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	3.0	12.0	3.7	15.0	3.0	12.0	2.2	9	1.5	6.0
Minimize environmental impact	3.7	4.0	15.0	4.0	15.0	1.6	6.0	2.4	9.0	1.6	6.0
Increase Property rate	3.1	2.9	9.0	2.9	9.0	3.9	12.0	2.9	9.0	3.9	12.0
Improve occupants comfort	4.2	3.8	16.0	3.8	16.0	1.9	8.0	3.8	16.0	3.8	16.0
Reduce energy consumption	4.5	4.4	20.0	5.5	25.0	4.4	20.0	4.4	20.0	3.3	15.0
Lower project capital costs	3.4	3.5	12.0	4.7	16.0	3.5	12.0	3.5	12.0	4.7	16.0
Reduce energy costs	4.9	2.1	10.0	4.1	20.0	4.1	20.0	4.1	20.0	3.1	15.0
Meet regulatory requirement	3.5	2.6	9.0	3.4	12.0	1.7	6.0	3.4	12.0	2.6	9.0
Diversify investment portfolios	3.7	2.2	8.0	4.4	16.0	2.2	8.0	3.3	12.0	4.4	16.0
Increase occupant health	3.3	3.6	12.0	2.7	9.0	1.8	6.0	3.6	12.0	2.7	9.0
Increase energy efficiency	4.6	4.4	20.0	3.5	16.0	3.5	16.0	3.5	16.0	3.5	16.0
Comply with policy or legislation	3.2	3.8	12.0	3.8	12.0	1.9	6.0	2.8	9.0	1.9	6.0
Increase return on investment (ROI)	4.0	3.8	15.0	3.8	15.0	5.0	20.0	3.8	15.0	3.8	15.0
Provide a secure energy supply	4.5	3.5	16.0	2.7	12.0	3.5	16.0	3.5	16.0	3.5	16.0
Achieve lower total ownership costs	3.3	3.7	12.0	2.7	9.0	3.7	12.0	3.7	12.0	2.7	9.0
Decrease outages/interruption	3.9	2.3	9.0	3.1	12.0	1.5	6.0	3.0	11.9	2.3	9.0
∑ Technical Importance			**207**		**229**		**186**		**211**		**191**
% Technical Importance			**33%**		**37%**		**30%**		**52%**		**48%**
Relative Weight (1-5 scale)			**4.5**		**5.0**		**4.1**		**5.0**		**4.5**

Source: Field Data (2015)

Table 4.15: Importance, Impact And Technical Importance of Quantity Surveyors

Potential Stakeholders Requirement				Sustainability Consideration				Technical Consideration			
Facilitates renewable energy	4.0	3.4	13.7	3.7	14.7	3.7	14.7	3.4	13.7	2.5	10.0
Minimize environmental impact	3.7	3.0	11.3	3.6	13.3	3.2	12.0	2.7	10.0	3.6	13.3
Increase Property rate	3.1	2.3	7.0	1.5	4.7	3.1	9.7	1.8	5.7	3.0	9.3
Improve occupants comfort	4.2	3.5	14.7	3.1	13.0	2.6	11.0	3.5	14.7	3.1	13.0
Reduce energy consumption	4.5	3.5	16.0	3.5	16.0	4.1	18.7	3.5	16.0	3.5	16.0
Lower project capital costs	3.4	2.4	8.0	1.7	5.7	2.5	8.3	1.7	5.7	2.2	7.3
Reduce energy costs	4.9	2.9	14.0	2.2	10.7	3.6	17.3	3.2	15.3	3.6	17.3
Meet regulatory requirement	3.5	5.0	17.3	5.3	18.7	2.7	9.3	3.0	10.7	4.0	14.0
Diversify investment portfolios	3.7	3.4	12.3	2.9	10.7	3.5	12.7	2.0	7.3	3.0	11.0
Increase occupant health	3.3	4.9	16.3	3.0	10.0	2.5	8.3	3.6	12.0	3.6	12.0
Increase energy efficiency	4.6	3.5	16.0	2.6	12.0	4.1	18.7	3.8	17.3	3.5	16.0
Comply with policy or legislation	3.2	4.4	14.0	3.8	12.0	2.5	8.0	3.2	10.0	3.2	10.0
Increase return on investment (ROI)	4.0	3.7	14.7	3.3	13.0	5.0	20.0	3.3	13.0	3.3	13.0
Provide a secure energy supply	4.5	2.1	9.3	2.7	12.0	2.7	12.0	3.2	14.7	2.7	12.0
Achieve lower total ownership											

	3.3	1.8	6.0	1.8	6.0	3.0	10.0	2.4	8.0	2.4	8.0 costs
Decrease outages/interruption	3.9	4.8	18.7	3.6	14.0	3.2	12.7	3.7	14.3	3.6	14.0
Sum of Technical Importance	**209**	**186**	**203**	**188**	**196 % Technical Importance**					**35%**	**31%**
34%	**49%**	**51%**									
Relative Weight			**5.0**		**4.5**		**4.9**		**4.8**		**5.0**

Source: Field Data (2015)

Table 4.16: Importance, Impact And Technical Importance of Facilities Managers

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	4.0	16.3	5.1	20.5	4.6	18.5	4.7	18.8	2.9	11.8
Minimize environmental impact	3.7	3.1	11.8	4.2	15.5	3.2	12.0	2.9	10.8	3.0	11.3
Increase Property rate	3.1	2.5	7.8	3.8	11.8	4.2	13.0	1.9	6.0	2.6	8.0
Improve occupants comfort	4.2	4.5	19.0	3.2	13.5	4.6	19.5	4.4	18.5	5.1	21.5
Reduce energy consumption	4.5	4.8	21.5	3.5	16.0	4.0	18.0	4.0	18.0	3.5	16.0
Lower project capital costs	3.4	3.7	12.5	2.7	9.0	3.7	12.5	3.1	10.5	4.0	13.5
Reduce energy costs	4.9	4.0	19.5	3.3	16.0	4.4	21.5	4.2	20.5	3.3	16.0
Meet regulatory requirement	3.5	1.7	6.0	2.9	10.0	2.2	7.8	1.9	6.5	2.2	7.8
Diversify investment portfolios	3.7	2.9	10.5	2.5	9.0	3.8	14.0	2.4	8.8	3.1	11.3
Increase occupant health	3.3	3.9	13.0	3.9	13.0	3.6	12.0	3.9	13.0	4.2	14.0
Increase energy efficiency	4.6	4.3	19.5	3.5	16.0	4.3	19.5	4.1	19.0	4.3	19.5
Comply with policy or legislation	3.2	2.0	6.3	3.2	10.0	1.9	6.0	2.1	6.8	2.4	7.8
Increase return on investment (ROI)	4.0	2.9	11.5	3.1	12.3	4.1	16.3	3.6	14.3	4.0	16.0
Provide a secure energy supply	4.5	3.5	16.0	3.5	16.0	3.5	15.8	4.2	19.0	2.5	11.5
Achieve lower total ownership costs	3.3	3.2	10.5	3.0	9.8	4.0	13.3	3.8	12.5	3.2	10.5
Decrease outages/interruption	3.9	2.8	11.0	2.8	10.8	3.1	12.0	3.5	13.5	2.4	9.5
Sum of Technical Importance			**213**		**209**		**232**		**216**		**206**
% Technical Importance			**33%**		**32%**		**35%**		**51%**		**49%**
Relative Weight			**4.6**		**4.5**		**5.0**		**5.0**		**4.8**

Table 4.17: Importance, Impact And Technical Importance of Architects

Potential Stakeholders Requirement				Sustainability Consideration					Technical Consideration		
Facilitates renewable energy	4.0	5.0	20.0	5.0	20.0	5.4	21.5	3.2	13.0	5.0	20.0
Minimize environmental impact	3.7	5.4	20.0	5.4	20.0	5.0	18.5	4.4	16.5	6.3	23.5
Increase Property rate	3.1	4.0	12.3	5.1	15.8	6.6	20.2	2.6	7.9	3.7	11.4
Improve occupants comfort	4.2	4.8	20.0	4.8	20.0	4.8	20.0	5.1	21.5	6.0	25.0
Reduce energy consumption	4.5	3.7	16.5	3.3	15.0	3.2	14.4	3.5	15.9	4.0	18.0
Lower project capital costs	3.4	4.8	16.4	4.8	16.4	5.6	18.8	3.1	10.4	5.6	18.8
Reduce energy costs	4.9	3.5	17.0	4.1	20.0	4.8	23.5	4.8	23.5	4.4	21.5
Meet regulatory requirement	3.5	5.9	20.5	6.7	23.5	6.7	23.5	5.7	20.0	6.7	23.5
Diversify investment portfolios	3.7	3.1	11.4	4.6	16.7	5.0	18.5	4.1	14.9	3.1	11.4
Increase occupant health	3.3	3.4	11.4	3.9	12.9	4.3	14.4	5.2	17.2	6.0	20.0
Increase energy efficiency	4.6	3.3	15.0	4.8	22.0	5.1	23.5	5.1	23.5	5.1	23.5
Comply with policy or legislation	3.2	3.8	12.0	3.8	12.0	4.5	14.1	3.4	10.8	3.8	12.0
Increase return on investment (ROI)	4.0	2.3	9.0	2.5	9.9	3.2	12.9	3.5	14.1	2.9	11.4
Provide a secure energy supply	4.5	3.8	17.0	3.8	17.0	5.5	25.0	5.5	25.0	5.2	23.5
Achieve lower total ownership costs	3.3	2.1	6.8	2.8	9.2	3.2	10.4	3.2	10.4	4.0	13.2
Decrease outages/interruption	3.9	2.5	9.9	4.0	15.7	4.0	15.7	5.5	21.3	4.0	15.5

Sum of Technical Importance 235 266 295 266 292 % Technical Importance 30% 33% 37% 48% 52% Relative Weight 4.0 4.5 5.0 4.6 5.0

Table 4.18: Importance, Impact And Technical Importance of Researchers/Policy Makers

Potential Stakeholders Requirement	Importance (1-5 scale)	Sustainability Consideration						Technical Consideration			
		Social Impact	Technical Importance (social)	Environmental Impact	Technical Importance (Env)	Economic Impact	Technical Importance (Econs)	Electrical Impact	Technical Importance (Elect)	Build Envelop Impact	Technical Importance (Build)
Facilitates renewable energy	4.0	5.0	20.0	5.0	20.0	5.0	20.0	4.0	16.0	4.4	17.6
Minimize environmental impact	3.7	4.3	16.0	4.1	15.2	4.3	16.0	4.3	16.0	3.6	13.6
Increase Property rate	3.1	2.9	9.0	3.5	10.8	3.9	12.0	1.9	6.0	2.9	9.0
Improve occupants comfort	4.2	2.1	9.0	3.3	13.8	2.1	9.0	1.4	6.0	3.0	12.6
Reduce energy consumption	4.5	5.5	25.0	4.2	19.0	5.5	25.0	5.5	25.0	4.2	19.0
Lower project capital costs	3.4	2.7	9.0	3.7	12.6	3.5	12.0	2.7	9.0	3.7	12.6
Reduce energy costs	4.9	5.1	25.0	3.3	16.0	5.1	25.0	5.1	25.0	3.3	16.0
Meet regulatory requirement	3.5	1.7	6.0	1.7	6.0	1.7	6.0	1.7	6.0	1.7	6.0
Diversify investment portfolios	3.7	1.6	6.0	2.1	7.8	2.5	9.0	1.6	6.0	1.6	6.0
Increase occupant health	3.3	1.2	4.0	2.5	8.4	1.2	4.0	1.2	4.0	2.3	7.6
Increase energy efficiency	4.6	5.5	25.0	3.5	16.0	5.5	25.0	5.5	25.0	3.5	16.0
Comply with policy or legislation	3.2	1.9	6.0	1.9	6.0	1.9	6.0	1.9	6.0	1.9	6.0
Increase return on investment (ROI)	4.0	2.0	8.0	3.8	15.2	2.0	8.0	2.0	8.0	3.8	15.2
Provide a secure energy supply	4.5	5.5	25.0	4.2	19.0	5.5	25.0	5.5	25.0	4.2	19.0
Achieve lower total ownership costs	3.3	2.7	9.0	2.2	7.2	3.7	12.0	2.7	9.0	2.7	9.0
Decrease outages/interruption	3.9	4.0	15.6	3.7	14.4	3.7	14.4	4.1	16.0	4.6	18.0
∑ Technical Importance			**218**		**207**		**228**		**208**		**203**
% Technical Importance			**33%**		**32%**		**35%**		**51%**		**49%**
Relative Weight			**4.8**		**4.5**		**5.0**		**5.0**		**4.9**