PHOTOVOLTAIC ADOPTION IN THE GHANAIAN BUILDING INDUSTRY: PERCEPTIONS AND RELATIONAL DYNAMICS OF INNOVATION ADOPTION-DECISION FACTORS

By

Naa Adjeley Ashiboe-Mensah BSc (Hons.)

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Author

Naa Adjeley Ashiboe-Mensah BSc *(Hons.)*

Supervisors

Rev. Dr. F.D.K. Fugar *(PhD MPhil BSc FGhIS MHRS MNIQS MFIG)*

Dr. E. Adinyira *(PhD BSc)*

Doctoral Thesis Submitted to the College of Architecture and Planning in Fulfilment of the Requirements for the Award of a Degree of
Doctor of Philosophy

DECLARATION

I hereby declare that this submission is my own work towards the PhD 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 acknowledgement has been made in the text.

ASHIBOE-MENSAH, NAA ADJELEY
(20064609)

Student Name & ID	Signature	Date

Certified by:

REV. DR. F.D.K. FUGAR

Lead Supervisor's Name	Signature	Date

DR. E. ADINYIRA

Co- Supervisor's Name	Signature	Date

Certified by:

PROF. J. AYARKWA

Head of Department's Name	Signature	Date

DEDICATION

"We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant, than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature add to ours."-John Salisbury

This thesis is dedicated to**:**

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and

Mary Emmeline Saah (my Mum)

You have certainly been the giants who have raised me up. You are the greatest example of God's unending love to me and I love you both dearly.

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Now to Him who is able to do exceedingly abundantly above all that we ask or imagine, according to the power that works in us, to Him be glory... forever and ever. Amen.

(Ephesians 3: 20 & 21)

ABSTRACT

In Ghana, where there is a need to decrease demand on the national grid and also increase the renewable component of the nation's energy mix, photovoltaics[1] seem like a plausible means of achieving both goals simultaneously especially by incorporating them in new buildings in urban areas. However, experiences with solar energy technology adoption and diffusion globally reveal that adoption and diffusion are influenced by a wide variety of factors that may be social, cultural, economic, technical and institutional; and an appreciation of the factors that play a role in a given context within which the technologies are to be adopted is essential to their successful adoption and diffusion. Consequently, an understanding of the innovation behaviour of potential adopters of this technology is relevant so as to manage the innovation diffusion process adequately. For this reason, this research identifies and evaluates the potential factors that may influence photovoltaic adoption in the Ghanaian building industry. Guided by Rogers' (1995) diffusion of innovation theory and a framework by Hartmann *et. al.*, (2006), the research employed both quantitative and qualitative research methods to achieve the research aim which is to describe and understand the potential factors that may influence photovoltaic adoption in the Ghanaian building industry. The quantitative aspect involved the use of a cross-sectional survey of clients, architects, electrical and mechanical engineers in the Ghanaian building industry. A total of one hundred and thirty-two valid responses were obtained and the data obtained were analysed using Relative Importance Indices, Pearson chi-square, Fisher's exact test, Cramer's V and Mann-Whitney U statistical tests. In the qualitative aspect of the study, a holistic multiple case study research design was employed. The study focussed on three products in the Ghanaian building industry: prestressed beams and blocks for floor construction, pozzolana cement and asphaltic

[1] Photovoltaics are a type of solar technology that generates electricity using sunlight

shingles. Data was collected using semi-structured interviews. In all, twelve individuals (clients, consultants and supplier representatives) were interviewed and thematic analysis was used as the tool for data analysis. In the survey, the worldwide web was identified as the most prevalently used communication channel and information from consultants/other building participants was rated as the most reliable channel. The certainty of an innovations future performance was rated as the most important factor in a decision to adopt or reject it. Seventy-five percent (75%) of respondents knew about photovoltaics technology and although there was a generally favourable perception of the technology, actual adoption was approximately twenty-three percent (23%). The case study revealed that although the innovation attributes had an important influence on the adoption or rejection on the cases studied, the extent of influence is dependent on the other factors which relate to the context and the communication channels used, hence, the context is most relevant in view of the modulations of the other adoption factors. The major contribution of the study to academia is that it tests and extends the innovation diffusion theory by applying it within a new context- the Ghanaian building industry. Furthermore, Hartmann *et. al*.'s (2006) framework is tested within a different country and among private rather than public clients thereby focussing on a social system different from that of Hartmann and his colleagues. Practically, the results of the study can be used to guide change agents' promotional efforts through the formulation of principles discerned from the patterns in the data collected that could guide future action.

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ABBREVIATIONS

ABCECG	–	Association of Building and Civil Engineering Contractors, Ghana
AC	–	alternating current
AESL	–	Architectural and Engineering Services Limited
AIACBC	–	American Institute of Architects (Chesapeake Bay Chapter)
BiPV	–	building integrated photovoltaics
BOS	–	balance of payments
BRRI	–	Building and Road Research Institute
BS	–	British Standard
CBMWU	–	Construction Allied Workers Union
CO_2	–	carbon dioxide
DC	–	direct current
ESDP	–	Energy Sector Development Programme
GDP	–	gross domestic product
GhIE	–	Ghana Institution of Engineers
GhIS	–	Ghana Institution of Surveyors
GIA	–	Ghana Institute of Architects
MoT	–	Ministry of Transport
MWRWH	–	Ministry of Water Resource Works and Housing
NEB	–	National Energy Board
NGO	–	non-governmental organisation
PNDC	–	Provisional National Defence Council
PV	–	photovoltaics
RET	–	renewable energy technology

REDP	–	Renewable Energy Development Programme
TUC	–	Trade Union Congress
UNFCCC	–	United Nations Framework Convention for Climate Change
VAT	–	Value Added Tax

GLOSSARY

Building integrated photovoltaics – the application of photovoltaics which involves the architectural, structural and aesthetic incorporation of photovoltaics into buildings

Communication channels – the means by which a new idea or knowledge about an innovation gets from one individual to another

Complexity – the degree to which an innovation is perceived as difficult to understand and use

Consequence – a change that occurs to an individual or social system as a result of the adoption or rejection of an innovation

Decision – that which occurs when an individual engages in activities that lead to a choice to adopt or reject an innovation

Discontinuance – a decision to reject an innovation after it has previously been adopted

Gold plating – the coupling of energy efficiency with other costly features rather than it being available separately as required by the neo-classical paradigm assumption that all goods are separately available

Grid-connected photovoltaic system – a photovoltaic system which is connected to a large independent grid (typically the public electricity grid)

Implementation - that which occurs when an individual puts an innovation into use

Innovation – An idea, practice, or object that is perceived as new by an individual or other unit of adoption

Innovation adoption – A decision to make full use of an innovation as the best course of action available

Innovation diffusion – the process by which an innovation is communicated through certain channels over time amongst the members of a social system

Invention – the development of a new idea for a product or process

Knowledge – that which occurs when an individual learns of an innovation's existence and gains some understanding of how it functions

Low energy buildings – buildings that use less energy than traditional or average contemporary buildings

Market failures – the conditions of a market that violate one or more of the neoclassical economic assumptions that define an ideal market for products and services

Market barriers – the conditions that account for the slow adoption and diffusion but are not based on market failures

Observability – the degree to which the results of an innovation are visible to others

Off-grid photovoltaic systems - a photovoltaic system which is not connected to a large independent grid (typically the public electricity grid)

Opinion leadership – the degree to which an individual is able to influence other individuals' attitudes or overt behaviour informally in a desired way with relative frequency

Persuasion – that which takes place when an individual forms a favourable or unfavourable attitude towards an innovation

Photoelectric effect – an effect where electrons are emitted from solids, liquids or gases when they absorb energy from light

Photovoltaic effect – the conversion of light into direct current electrical power

Rate of adoption – the relative speed with which an innovation is adopted by members of a social system

Rejection – a decision not to adopt an innovation

Relative advantage - the degree to which an innovation is perceived as better than the idea it supersedes

Social system – the set of interrelated units that are engaged in joint problem solving to accomplish a common goal

Sustainable development – a principle which involves living, producing and consuming in a manner that meets the needs of present needs of the present without compromising the ability of future generations to meet their own needs

Take back effect/Rebound effect - the behavioural or systematic responses to the introduction of new technologies/measures that increase the efficiency of resource use thereby offsetting the beneficial effects of the new technology/measure

Trialability – the degree to which an innovation may be experimented with on a limited basis

Whole building design/ integrated approach – the use of an integrated building design process which is a collaborative, integrated design process that uses a project team rather than one person to make decisions in all stages of a project's planning and delivery starting with design and the integration of a building's components and systems so as to optimize its performance

Zero energy buildings – buildings that on average over the course of a year do not use any imported energy (energy that is not generated by the building itself)

CHAPTER ONE

INTRODUCTION

1.1 The Significance of Innovation and Innovation Diffusion in the Construction Industry

According to Newton (1999), innovation in construction has become a fourth competitive dimension in addition to the traditional time, cost and quality trade-offs models. Like other industries, innovation within construction offers the opportunity for organizations to succeed and survive within a competitive and complex business environment. However, there are difficulties to effectively managing and diffusing innovations within the industry (Taylor & Levitt, 2005). These difficulties stem from the fragmented structure and project processes and adversarial relationships which are typical of the construction industry (Hartman et al., 2006). The undue emphasis on cost and time by clients has also stunted innovation in the industry. Consequently it has been realised that there is the need to consciously manage the innovation process. This means that managers of innovation have to be aware of the specific circumstances and factors influencing the possibilities to innovate in order to exploit and enhance these possibilities. This has led to researches to investigate the critical factors that contribute to successful innovation and diffusion. In the light of this, various studies (Tatum, 1987; Slaughter, 2000; Peansupap, 2004; Dulaimi et. al., 2003, Hartmann et. al., 2006) have explored the contingencies surrounding innovation and diffusion in the construction industry. The differing conditions of the Ghanaian construction industry require similar investigative studies. This gap in

knowledge is what this study seeks to address by investigating the factors surrounding the adoption of photovoltaics within the Ghanaian building industry.

1.2 Background to the Study

Many studies have attested to the fact that renewable energy sources are more than enough to meet current energy demands worldwide although the estimates of such potential vary in literature (Johansson et al., 2004). Aside their enormous potential, renewables offer further advantages in that they "enhance diversity in energy supply markets, secure long term sustainable energy supplies and reduce local and atmospheric emissions" (Goldemburg, 2000). Furthermore, under certain conditions such as in developing countries and rural areas, renewables are more cost-effective sources of energy for the provision of energy services. They also create new employment opportunities and offer possibilities for local manufacturing of equipment (Johansson et al., 2004; Turkenburg, 2000). These advantages can however only be gained if their inherent capacity for coming into being actually does occur.

Solar energy technologies are one such group of renewable energy technologies that has gained renewed interest. Recent trends in the application of solar technologies in the generation of energy have been towards the development of Building integrated Photovoltaic (BiPV). These are solar products that can be directly integrated in a building for example as roofing material so as to obtain dual use of the product for energy production and other functions of the building structure.

Ghana has relatively abundant solar resource by virtue of its geographical location within the tropics: Latitude 4^{o} and 12^{o} N and longitude 30^{o}W and 1^{o}E. It experiences

an annual solar radiation of 16 – 29MJ/m^2 and a daily solar irradiation of 4 – 6kWh/m^2 (Edjekumhene & Brew-Hammond, 2001). This resource has barely been exploited and buildings offer a wide range of diverse applications of this solar resource. Residential developments like Sweden's Bo01 housing estates, Eco city in China and Eco village in Australia are but a few examples that have utilised such technologies like roof integrated solar panels and solar heaters to harness the sun's energy for lighting, heating and cooling of buildings.

1.3 Research Problem

In 1965, when the Akosombo dam was constructed, electricity was in excess and individuals were encouraged to get connected to the grid. Since then, Ghana has seen an expanding economy and population growth (Energy Commission Ghana, 2006). The situation today is one in which Ghana has had to go through four power crisis; the last of which was due to shortage in generation capacity rather than drought induced low water levels attributed to the others (Brew-Hammond & Kemausuor, 2007). Consequently, there has been the need to broaden the sources and types of energy supplies to include more renewable solutions.

BiPV offers a plausible means of decreasing demand on the national grid (hydroelectric power) while also increasing the renewable component of the nation's energy mix simultaneously especially by incorporating them in new buildings in urban areas. In spite of the technical knowledge available to achieve this goal, the diffusion and adoption of these technologies worldwide and especially in Ghana have been below expectations.

Experiences with solar technology adoption and diffusion globally and in rural areas of Ghana reveal that diffusion and adoption are influenced by a wide variety of factors that may be social, cultural, economic, technical and institutional; and an appreciation of the factors that play a role in a given context within which the technologies are to be adopted is essential to their successful adoption and diffusion.

Such studies on adoption and diffusion behaviour which focus on Ghana thereby incorporating peculiarities of the context are limited in literature and focus on rural adoption but those that relate directly to its building industry are absent (Edjekumhene & Brew-Hammond, 2001; Bawakyillennuo, 2007)

1.4 Purpose Statement

This study therefore identified and evaluated the potential factors that relate to the innovation adoption as related to specifically the Ghanaian building industry. An understanding of these factors are necessary in order to accelerate the technology adoption process of photovoltaics through more effectively designed programmes, demonstration projects, channels of distribution, marketing strategies, and policy incentives.

1.5 Research Questions

The prime question that this research investigated is:

How can the adoption of photovoltaics by clients and professionals in the Ghanaian building industry be influenced?

This primary research question is investigated using the following sub-research questions:

1. What are the factors that influence the adoption of an innovation by clients and professionals within the Ghana building industry?
    i. Which channel of information on innovations is most used by clients and professionals and which of them is rated most reliable?
    ii. Which building participant wields the most influence relative to the others in decision-making on innovations?
    iii. Which is the most significant of the innovation adoption-decision factors relative to each other?
    iv. Is there a difference between clients and consultants on the importance of the most important adoption-decision factors?
    v. How and why are certain innovations adopted or rejected within the Ghanaian building industry
2. What are the perceptions of clients and professionals within the Ghanaian building industry about the attributes of photovoltaic energy technology?
    i. What is the level of awareness about photovoltaics within the Ghanaian building industry?
    ii. Is there a relationship between the awareness of photovoltaics and the type of building participant?
    iii. Is there a relationship between the awareness of photovoltaics and the level of education?
    iv. Which channels provided most clients and professionals with awareness of photovoltaics?
    v. What is the level of adoption of photovoltaics within the Ghanaian building industry?

vi. Is there a relationship between the adoption-decision and the building participant that takes the final decision?

vii. Which innovation attributes are most well rated with regard to photovoltaics?

viii. Is there a difference between adopters and non-adopters on the perception of photovoltaics?

By understanding the factors that are important to decision-making among clients and professionals, the adoption of photovoltaics can be enhanced by improving the significant factors. In many cases choices have to be made on how resources should be allocated when improving these various factors, hence understanding the relative importance of these factors will furthermore help determine how priorities should be set where resources are limited. Also understanding the perceptions that clients and professionals have about photovoltaics will help appreciate their adoption behaviour and where perceptions are wrong or can be improved, efforts can be made in this regard.

1.6 Research Aim

The aim of this research is to determine and evaluate the potential factors that influence photovoltaic adoption in the Ghanaian building industry.

1.7 Research Objectives

1) To undertake a critical review of literature to define the status, context and existing knowledge surrounding the development and use of photovoltaic technology.

2) To identify an appropriate theoretical framework: the critical concepts associated with the diffusion and adoption of innovations and the relationships between them
3) To undertake a critical review of literature to provide a characterisation of the specific context (Ghanaian building industry) within which the research is to be undertaken.
4) To identify and examine channels of information on innovations in the Ghanaian building industry.
5) To identify and assess the building participants involved in innovation adoption-decision in the study area.
6) To determine factors that influence innovation adoption-decision within the in the study area.
7) To determine the level of awareness of photovoltaics in the Ghanaian building industry.
8) To identify from which channels clients and professionals first learnt of photovoltaics.
9) To determine the level of photovoltaic adoption in the study area.
10) To assess the perceptions of building participants with regard to photovoltaics in the study area.

1.8 Scope

The study was conducted within the confines of following scope:

- The study was limited to clients and professionals within the Ghanaian building industry :including architects, mechanical and electrical engineers rather than groups and organisations

1.9 Research Method Overview

Overall the study employed both a quantitative survey and qualitative case study research design. The findings of the two approaches were compared, discussed and conclusions drawn. The details of the key research stages [Figure 1.1] are presented below:

1.9.1 Literature review

Published literature were reviewed to ascertain the development and global status of the photovoltaic industry. This was done to discover the major challenges facing the industry and the contributions that could be made thereof by this study. Literature was also sought on the organisation of the Ghanaian building industry in order to characterise the study context and help identify the relevant participants for the study.

1.9.2 Conceptual framework

Published literature on innovation and innovation diffusion in general and those found within the construction context was critically reviewed to provide background for the study and aid in the development of a conceptual framework and research questions for the study. Although analysts may seek to isolate diffusion and adoption factors of photovoltaics without integrating them into a broader theoretical framework, this study chose to integrate the study into the broader framework by Rogers (2003) and Hartmann et al., (2006). Drawing from existing studies,

relationships linking the various concepts in the conceptual framework were explained. These then led to the construction of the research questions.

1.9.3 Quantitative Analysis

The quantitative stage of the study comprised a survey that involved one hundred and thirty two (132) participants of the Ghanaian building industry. The aim of the stage was to elicit the perceptions of the participants with regard to the innovation's attributes and also evaluate the significance of the innovation adoption and diffusion related factors within the industry.

1.9.4 Qualitative Analysis

In the qualitative stage of the research, a holistic multiple case design was used to determine how and why certain selected innovations were adopted/rejected within the Ghanaian building industry. The innovations included pre-stressed fast floors, asphaltic roof shingles and pozzolana. The cases provided illustrations of innovation adoption in the Ghanaian context and the results helped understand the factors and circumstances that are likely to influence the adoption of photovoltaics in the Ghanaian building industry.

1.10 Thesis Layout

This thesis comprises six chapters [Figure 1.2] which have been organised as follows:

Chapter one presents an overview of this thesis by briefly outlining the background to the study, research problem, purpose statement, research aim and objectives, scope, methods and an outline of the entire thesis.

Chapter two then looks at the development and global status of photovoltaic technology. The ability to successfully put an innovation into practice depends on a number of contingencies which have to be detected and understood and a conceptual framework that outlines the nature of the possible contingencies is also presented in Chapter two.

Chapter three discusses the Ghanaian building industry in order to provide a description of the specific context within which the study is undertaken.

Chapter four addresses the research approach adopted in the study and the method of inquiry and data collection employed to achieve the key objectives of the study.

Chapter five sets forth analysis of the data gathered and the results and finally chapter six summarises the findings that emerged from the study, the major contributions to knowledge that are made and opportunities for further research.

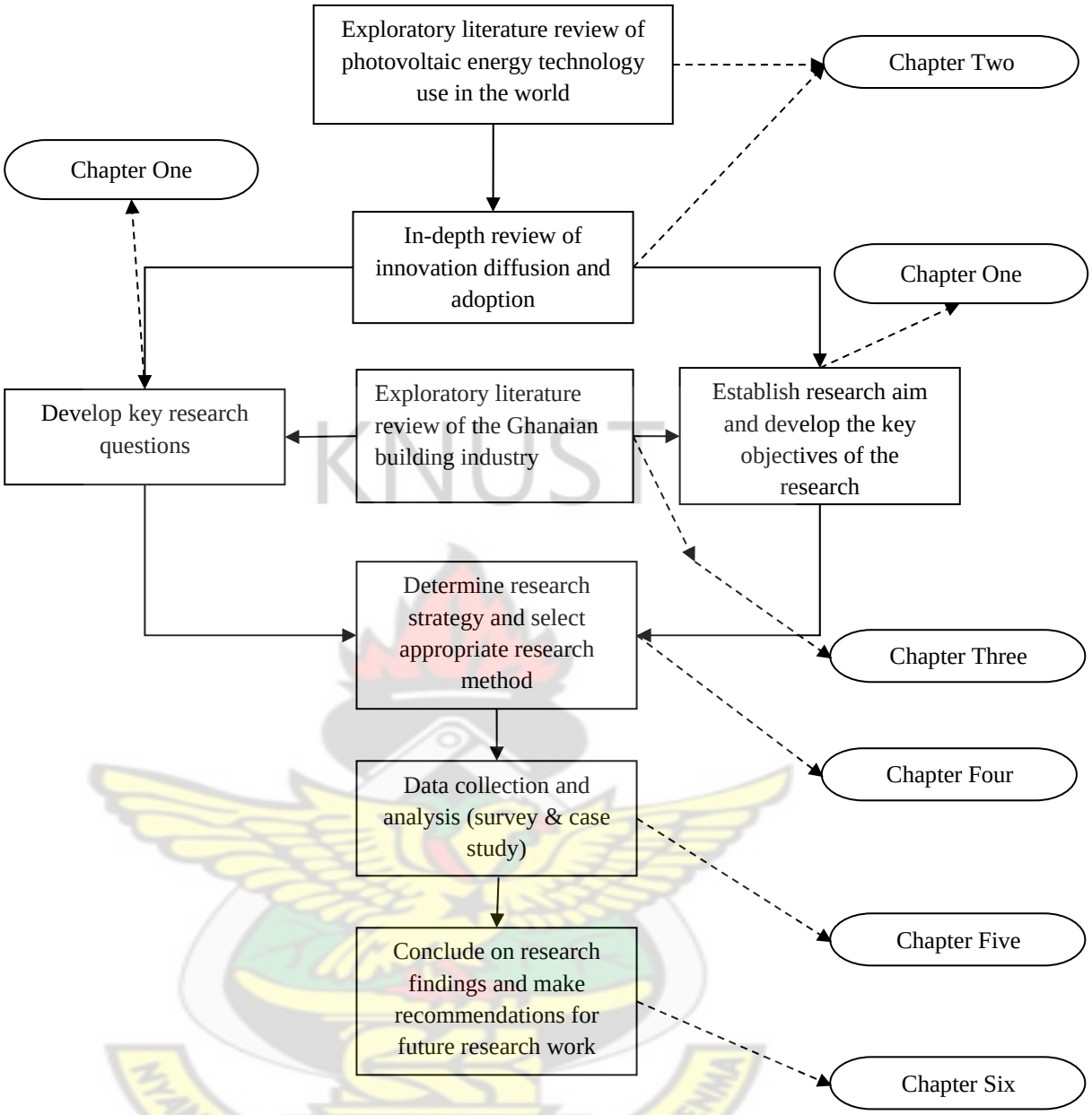

Figure 1.1 Flow Diagram of Research Process

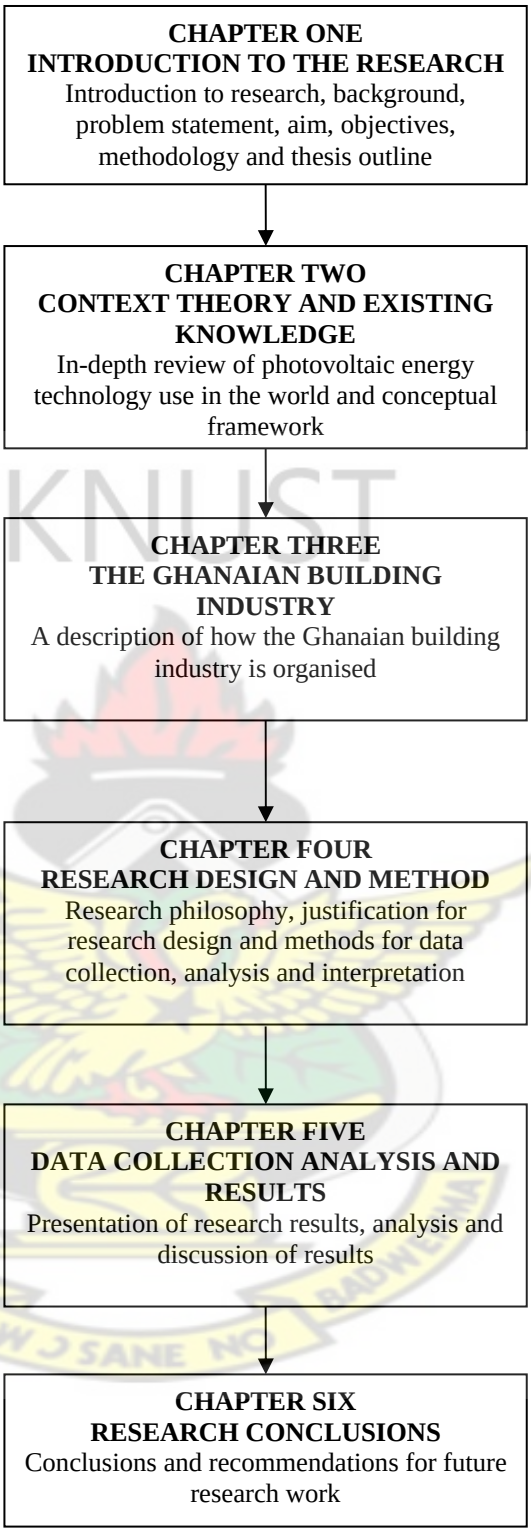

Figure 1.2 Outline of the Thesis

CHAPTER TWO

CONTEXT THEORY AND EXISTING KNOWLEDGE

2.1 CONTEXT

2.1.1 Introduction

Energy is a key resource for sustainable development and poverty alleviation (Ogunlade & Youba, 2001; Oparaku, 2006) but its uncontrolled use has adverse consequences for the economy and environment. Therefore, the key determining factor for energy investment in most countries is not just the least cost of energy production but job creation potential and environmental friendliness of the technologies. The environmental consequences of energy has become especially of concern given the issues of climate change and countries' commitment to the Kyoto agreement to reduce CO_2 emissions and green house gases. Consequently, attention has been turned to the research, development and use of more environmentally friendly energy generating technologies and those for the provision of energy services. The main thrust of this Chapter is to review the literature on issues that relate to the research, development and diffusion of these technologies in general and photovoltaic technology in particular so as to contextualize the problem of this study. The Chapter also presents the conceptual framework that guided the study.

2.1.2 Energy and Buildings

Buildings account for more than forty percent (40%) of global energy use and one-third of global greenhouse gas emissions and according to Perez-Lobard et al., (2008) the upward trend of building energy demand is expected to grow given the growth in population, increasing demand for building services and comfort, and the

rise in time spent inside buildings. Consequently, energy efficiency and renewable sources can play a major role in satisfying the energy demands of buildings especially since buildings present significant and cost-effective opportunities for reductions in gas emissions compared to other sectors (Sustainable Building and Climate Initiative, 2009). Hence more attention is being given to the design and construction of low energy buildings, zero energy buildings and in ambitious cases buildings that are net producers of energy (World Business Council for Sustainable Development, 2007). Furthermore, emphasis is now being placed by clients more on "an economic whole-life-cost in preference to the cheapest possible constructional design" (Mbelede, 2010). Therefore, energy-efficient and renewable energy technologies are being introduced into buildings in order to reduce future energy costs and in response to environmental and social issues related to the use of energy.

2.1.3 The Origin of Energy Conservation, Energy efficiency and Renewable Energy Concerns

The imperative to conserve energy is as old as the use of energy however the modern era of conservation and renewable energy use began with the oil crisis of the 1970s. These crises obliterated the misconception that the supply of energy would always lead demand and so energy prices would see continuous reduction; and brought to the fore the risks associated with the use of fossil fuels. After the oil crisis of the 1970s, the interest in energy efficiency and renewable energy waned but was re-ignited in the 1980s owing to the environmental hazards of fossil fuel use such as pollution and global warming. This realisation was spurred on by the advancement of the principle of sustainable development, which has become a key guiding principle for policy in the 21st century (Twidell & Weir 2006). This principle is

broadly defined by Twidell & Weir (2006) as living, producing and consuming in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs. Under this principle human activity should make positive contributions to human economic, social and environmental well-being.

Present energy generation and use fall short of the expectations of this guiding principle of sustainable development due to the following arguments:

- The finite nature of fossil fuel stocks means that the present patterns of energy consumption and growth is not sustainable in the long term,
- The harm of emissions i.e. high concentrations of carbon dioxide (CO_2) and other gases in the atmosphere are likely to produce the increases in the earth's temperature (green house effect), and lead to lack of ecological sustainability/ climate change i.e. the destruction of the earth's current ecology as a consequence of increase in temperature

The above arguments drove the need to expand renewable energy supplies and use energy more efficiently as part of the actions set out by UN framework convention on climate change (UNFCCC).

2.1.4 Energy and the Role of Renewable Energy Technologies

Initial efforts at tackling inadequate energy supply issues have focussed on end-use energy conservation and efficiency because the money spent on these usually offer better long-term benefit than money spent on increased generation and supply capacity (Twidell & Weir, 2006). On the other hand, end-use energy efficiency alone, in spite of it advantages, cannot sufficiently bridge the gap between energy

supply and demand. This is especially important in the light of arguments that state that energy efficiency will eventually lead to 'rebound' or 'take-back' effect [1](Herring, 2006). Supplies therefore have to be increased and renewable energy sources are being considered as alternatives to conventional fossil fuels.

Studies (Turner, 1999; Johansson et al., 2004) have attested to the fact that renewable energy sources are more than enough to meet current energy demands worldwide although the estimates of such potential vary in literature. Aside their enormous potential, renewables offer further advantages in that they "enhance diversity in energy supply markets, secure long term sustainable energy supplies and reduce local and atmospheric emissions." Furthermore, under certain conditions such as in developing countries and rural areas, renewables are more cost-effective sources of energy for the provision of energy services. They also create new employment opportunities and offer possibilities for local manufacturing of equipment (Goldemberg et al., 2000). These advantages can however only be gained if their inherent capacity for coming into being actually does occur. Hence there must be a demand for these resources as well as appropriately developed technology for their conversion and use (Johansson et al., 2004; Turkenburg, 2000).

Incorporating renewable and energy efficient technologies into buildings present a situation in which changes are likely to be introduced into the way in which the building process is organised. It requires a break-away from the norm and involves some uncertainty and risk given the newness of the technologies within the sector. Hence though advantageous, these new technologies may be perceived as having undesirable consequences by individuals and organisations involved in the building

[1] This is a greater use in energy due to improvements in energy efficiency which lowers the implicit price of energy thus making it more affordable.

process. Also given the reputation that the construction industry has of being averse to change and innovation, introducing these new technologies will face some resistance (Blayse & Manley, 2004; Hartmann et al., 2006). The process of change then needs to be actively managed to ensure that individuals and organisations are ready for change and also that the change is accepted and implemented smoothly.

The first stage in the change process is to assess renewable options available to a particular region, country or locality. This is important because renewable energy systems will only be practical if they are designed to match the environmental energy flows occurring in a particular region, country or locality (Twidell & Weir, 2006). The following section reviews Ghana's energy policy in order to ascertain the renewable energy options available in the country.

2.1.5 Ghana Renewable Energy Policy

The production, supply and use of energy is an important influence to Ghana's aim of becoming a middle income economy by 2020 since there exists a direct link between energy use, economic growth and standard of living (Energy Commission Ghana, 2006). In developing countries, renewable energy sources possess the potential to contribute to sustainable development through rural development, lower health costs (linked to air pollution), energy independence and climate change mitigation. Consequently, governments, multilateral organisations, industry and NGOs which are pursuing energy, environment and development agendas are vigorously advocating the use of renewable energy technologies (Martinot et. al., 2002). In Ghana too, renewable energy use plays a major part of energy plans and policies that will push forward the Energy Ministry's vision of developing an energy economy that "would ensure sustainable production, supply and distribution of high

quality services to all sectors of the economy in an environmentally friendly manner for Ghana's future while making significant contribution to the country's export earnings" (Energy Commission Ghana, 2006).

Presently, Ghana's strategic national energy plan includes specific objectives for renewable energy as well. Part of the objectives of the plan is to secure and increase future energy security by diversifying sources of supply and to accelerate the development and utilisation of renewable and energy efficiency technologies. The strategy is to develop indigenous and renewable energy sources from solar, small and medium sized hydro, wind, biomass and municipal solid waste (Energy Commission Ghana, 2006).

Various energy policies have guided the development of renewable energy technologies (RETs) in Ghana over the years and Bawakyillennuo (2007) categorizes Ghana's energy policy development into three phases: 1983-1991; 1996-2000 and 2001 onwards. The development of the first national policy on renewable energy technologies began with the enactment of the Provisional National Defence Council (PNDC) Law 62. The law established the National energy board (NEB) with the mandate to develop and demonstrate renewable energy projects throughout Ghana. The energy sector development programme (ESDP) marked the second phase of Ghana's energy development. This phase saw the development of the renewable energy development programme (REDP): the overall policy framework which guided RETs from 1996. The programme included evaluation, support and demonstration of potential RETs, promotion of renewable energy industries and the development of an information database on renewable energy sources, technologies, end use patterns and the like. From 2001 renewable energy policies were formulated

under the energy policy framework: Energy for poverty alleviation and economic growth- policy frameworks, programmes and projects. Within this framework, RETs were of special concern and actions were formulated within the framework to accelerate the development and utilisation of renewable energy sources.

With regard to PV in particular the policy measures included demonstration projects, research and education, economic instruments such as custom duty exemptions on solar panels and VAT exemptions on complete PV systems. Under the policy frameworks briefly mentioned above, measures and instrument such as subsidies, taxes and duty waivers were employed to implement renewable energy policies in Ghana. Nonetheless, due to the heavy reliance on government budgetary allocations and donor funding, these frameworks have faced some challenges and have not been potent enough to encourage the commercialisation and widespread use of RETs. It is envisaged that further measures will be implemented to remove fiscal and market barriers and increase government funding for RETs so as to encourage private sector participation in RETs development.

The prior sections of this chapter have established through a review of literature the importance of energy and challenges that hinder a sustainable energy future. The use of energy in buildings and their role in the promotion of energy efficiency and renewable energy are also briefly discussed; as well as the renewable energy and renewable options available in Ghana by reviewing its energy policy. The following section discusses the development of one such renewable energy technology that is feasible in Ghana and which can be exploited to meet its renewable energy policy agenda.

2.2 SOLAR PHOTOVOLTAIC TECHNOLOGIES, COSTS AND DYNAMICS

2.2.1 Introduction

Oparaku (2006) describes photovoltaics as one of the best means of providing electricity in a clean manner and virtually everywhere in the world. Photovoltaic systems are modular, easy to use, operate without noise and emissions, and can be deployed in both rural and urban environments either as stand-alone or grid-connected systems (Twidell & Weir, 2006). Despite this, a key challenge of the energy sector in Ghana is that solar energy is barely exploited to supplement the energy requirements of the country hence its inclusion among the renewable energy sources that are to be developed for use. Conditions throughout the country are ideal for the exploitation of solar energy and technologies to harness solar energy have been demonstrated in Ghana. These technologies include solar water heaters, solar water pumps, solar refrigeration, solar lighting and photovoltaics for the production of electricity (Essandoh-Yeddu, 1997, Tse, 2000). Solar PV for electricity production in buildings is the main focus of this research given the interest that has currently developed with respect to this application (Martinot & Sawin, 2009). The following section presents a description of the technology as well as the dynamics surrounding it.

2.2.2 Research and Development

Aside nuclear power, geothermal energy and tidal motion, the world's energy sources are all derived from the sun (McDaniels, 1984). Solar technologies have been around for centuries and until about 150 or 200 years ago solar energy was the world's sole energy source (Silvi, 2008). Solar energy is a versatile resource and can

be used to generate electricity, heat, cold, steam, light, ventilation or hydrogen; all dependent on the availability of efficient and low cost technologies, effective energy storage technologies and high efficiency end-use technologies (Johansson et al., 2004).

The most widely used active solar power technologies today can be placed into two major categories comprising solar thermal technologies and photovoltaic (solar electric) technology. The solar thermal technology collect and store solar energy as heat and is the technology employed in water heating and space conditioning whilst photovoltaic technologies convert sunlight directly to electricity.

2.2.3 Solar Photovoltaic Technology

Solar photovoltaics convert light energy from the sun into electricity by photoelectric effect[2]; an effect discovered by French physicist Edmund Becquerel in 1839 (Parkinson & Lloyd, 2001). Of the three main photoelectric processes (photo emissivity, photoconductivity and the photovoltaic effect), the photovoltaic effect [Figure 2.1] is the most widely used to produce electricity from sunlight. This effect occurs when light falls on the boundary between two substances and causes electrons to be transferred from one side of the boundary to the other. This causes a P-N junction to be formed as one substance looses electrons and becomes positively charged and the other gains excess electrons and becomes negatively charged. The resulting imbalance produces an electromotive force which causes current to flow when connected to a circuit.

[2] the conversion of light into direct current electrical power by photovoltaic materials

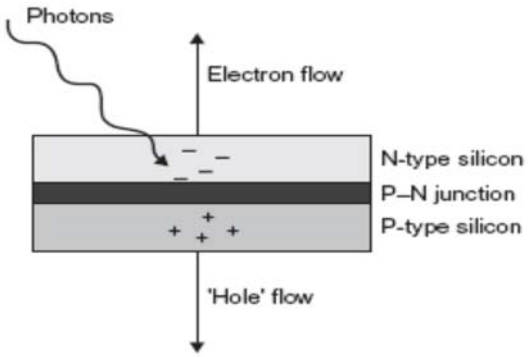

Figure 2.1 The Photovoltaic Cell adapted from (Beggs, 2009)

The first solar cell for direct conversion of the incident solar radiation into electricity was developed by Chapin, Fuller and Pearson of the Bell Telephone Laboratory in 1954. Due to the high cost of production, the technology was initially produced to be used in providing electricity for space applications in which there was more concern for a reliable, lightweight and long lasting means of electricity production rather than for cost. In 1959, the first successful Vanguard satellite carried 108 solar chips, providing 0.5W of power (McDaniels, 1984). Presently, solar PVs can be found in diverse applications including wrist watches, telecommunication, building integrated systems and grid electricity production of varying capacities.

2.2.4 The Global Status of Photovoltaic Applications

The solar PV industry is one of the fastest growing industries in the world growing six fold from 2004 to 2008. In 2008, overall investment in solar PV technology was 32% of the $120 billion invested in renewable energy worldwide. The leaders in PV production include China, Germany, Japan, Taiwan and USA respectively. The market for solar PV is made up of a number of niche-markets, some of which are as yet not economic and hence have artificial assistance from governments, utilities or industry. These markets as outlined by Oliver & Jackson (1999), include satellite,

remote industrial (telecommunications, cathodic protection, water pumping and treatment), remote communities, solar home systems, remote houses, other remote, consumer products and grid connected applications. Oparaku (2006) however, categorized the markets as grid connected systems, off-grid industrial applications, rural electrification in developing countries and consumer applications.

1. Grid connected systems - Grid connected PV systems can further be broken down into grid connected distributed/decentralised PV systems which supply power to buildings [Figure 2.2] and loads connected to the utility grid, and grid connected centralised systems which are installed as alternatives to conventional centralised power systems or to strengthen the utility distribution system (Oparaku, 2006). These applications consist mainly of residential rooftop systems. In 2008, grid connected systems represented the fastest growing power generation technology, with 70% increase in existing capacity, which is a six fold increase in global capacity since 2004. The market leaders in this category include Spain, Germany, USA, South Korea, Japan and Italy (Martinot & Sawin, 2009).
2. Off-grid industrial applications -These are made up of mainly stand-alone generators for electricity generation for telecommunications, telemetry, traffic signs, geographical positioning systems, corrosion prevention, water desalination and similar applications. They constitute about 15% of the PV market. The main advantages of these applications are their high reliability and low servicing requirement
3. Rural electrification - Rural electrification represent 7% of the PV market and are very much advocated in developing countries where they are a cost-

effective option compared to extending the grid especially in widely disperse settlements. They provide energy services for lighting, water pumping, telecommunication and health care.

4. Consumer applications – These applications are varied consisting of substitution of batteries in small devices, electrification of recreational vehicles and sailing boats. They represent 7% of the PV market. (Oparaku, 2006; Nwetta et al., 2010)

2.2.4.1 Solar Photovoltaic in Developing Countries

Much of solar PV applications are found in the industrialised world (Germany, Spain, Japan, USA, and South Korea) but applications are gaining a lot of support in developing countries for expanding their power system networks especially for rural electrification using off-grid systems [Figure 2.3]. In remote areas PV systems are cost-effective since grid-connection costs may be high due to distances, system losses and maintenance. The dispersed nature of the solar resource makes it adaptable to distributed generation of electricity in developing countries. In distributed electricity generations

1. the generator can be sited close to end users, thus reducing transmission and distribution costs and electrical losses
2. sites for small generators are easier to find
3. planning and installation time is reduced
4. they offer environmentally clean and low-noise power source
5. excess generated electricity can be sold back to the grid

6. from the users perspective, power is readily available and likely to be more reliable

Distributed generation however has to be regulated to ensure quality supply, network reliability and safety as distributed generation is capable of back feeding into the transmission and distribution system during power outage (Oparaku, 2006).

2.2.5 Challenges of Photovoltaic Technology

In spite of the advantages of solar PV, it is prudent to take into consideration that new and emerging technologies face some initial setbacks in their implementation and solar PV is no exception. More than four decades of global PV use has revealed some constraints which are outlined below:

2.2.5.1 Economic and Financial Constraints

The high initial cost of PV, as well as storage system where available has militated against its widespread even though the life cycle costs may be cost-effective. Costs are however expected to reduce as ambitious implementation targets in identified niches are expected to lead to increased production capacities, technological learning and improved economies of scale. These expectations are based on the reduced average costs of PV systems since the 1970s. As costs have decreased, photovoltaics have mainly been used in off-grid locations and for rural electricity supply in developing countries where they are cost-effective compared to conventional sources of energy. Access to finance is also a constraint to PV adoption. Finance, where available, is accompanied by high interest rates (Oliver & Jackson, 1999, Oparaku, 2006).

2.2.5.2 Technical Constraints

Currently, PV panels have low module efficiencies[3] between 5-15% for commercially available solar panels. Research is however ongoing to develop modules of higher efficiencies (Cooke et al., 2007). There is also the need for relatively large surface areas of land for collection of sunlight; land areas which may not be available or expensive (McDaniels, 1984).

Renewable energy technologies, photovoltaics inclusive; require storage systems for times when energy is not generated. This is due to the intermittent nature of renewable energy sources. There are various energy storage technologies including hydrogen (H_2), batteries, flywheels, ultra capacitors, pumped hydro, and compressed gas (Turner, 1999); though these increase the cost of the already expensive system.

Also local manufacture of PV modules and system components are as yet not available in most developing countries. The systems are mostly imported at high costs and are also affected by high import duties which add to already high initial costs of the systems. In addition, local technical manpower is also inadequate and not developed in certain instances to support the design, installation and monitoring of systems (Oparaku, 2006).

Another technical constraint is the energy investment required in the manufacture of PV modules in addition to the carbon dioxide (CO_2) emissions. However, Turner (1999) shows that the technology is able to payback its original energy investments and emissions produced during its manufacture hence photovoltaics offer a more

[3] Module efficiency refers to the amount of sunlight reaching the solar cell that is actually converted to electricity

environmentally prudent option for energy generation than fossil fuels (Alsema & Nieulaar, 2000).

2.2.5.3 Social and Political Constraints

Many people are still not aware of the technical viability and commercial availability of PV to meet electrical needs. Furthermore, in cases where there is the knowledge of the technology, individuals are reluctant to invest financially in such technologies given the uncertainty and hence risks associated with adopting such 'untested' technologies.

For PV and renewable technologies to gain widespread acceptance, support from governments through the development of energy policies with associated regulatory and institutional frameworks is required. In the absence of adequate funds, political will is necessary to create the right policy, regulatory and market environment to encourage private sector participation in the adoption of renewable energy technologies (Oparaku, 2006).

2.2.6 Solar Systems and buildings

2.2.6.1 Whole Building Design/ Integrated Approach

The commercial relationships between the many specialists involved in the building market are intricate and critical in sparking action on energy efficiency and use of renewable energy. The building market is however diverse and complex and is characterized by the fragmentation within sections of the value chain and non-integration among them (Baiden, 2006). The complexity of interaction among these participants is one of the greatest barriers to energy efficient and renewable energy

buildings (World Business Council for Sustainable Development, 2007).

Where energy efficiency and renewable energy issues form part of project objectives, incorporating energy efficiency and renewable energy sources is most often the responsibility of different professionals – each carrying out his or her job independently with little or no input from one another. The architect for instance may be responsible for energy efficient measures in the building envelope whilst the mechanical engineer caters to the heating, ventilation and air-conditioning systems. As a result, in spite of major technical improvements, the full potential for energy efficiency and inclusion of renewable energy technologies has not been realized.

In construction, team and process integration has been suggested by industry reports as a potential approach to improved performance (Egan 1998; Egan 2002; Strategic Forum for Construction 2003). Based on this premise it may be assumed that in the same vein an integrated approach to energy efficiency and renewable energy integration in buildings will offer better improvement since the approach will encourage interdependence of the professionals and foster a shared responsibility and accountability towards improved energy performance in buildings. An area currently being explored is the possibility of applying 'integration' to improve energy efficiency and RET inclusion whilst still meeting other reliability and cost requirements of buildings by encouraging integration of professionals and their knowledge in order to optimize energy efficiency.

This has led to the development and research into the concept of whole–building integration. It is an approach adopted from the automobile industry by the National Renewable Energy Laboratory of USA. It is a concept based on the integration of a building's components and systems so as to optimize its performance. The system

uses an integrated building design process which is a collaborative, integrated design process that uses a project team rather than one person (i.e. the architect) to make decisions in all stages of a project's planning and delivery starting with design. This approach considers all stages of the building life-cycle – site selection, construction, maintenance and demolition in the design stage (National Renewable Energy Laboratory, 2009).

The concept of whole-building or integrated approach means that solar systems become part of a general building design and the solar elements cannot be separate elements that are added after the building is done. The solar systems become integrated into the building envelope often due to the need to make them economically feasible (Wakamatu & Nitta, 1996; Hestnes, 1999). This "integration" of solar systems initially sought to make these systems as invisible as possible; however recent trends have alternatively used these systems to enhance the aesthetic features of buildings (Wakamatu & Nitta, 1996; Hestnes, 1999).

2.2.6.2 Building Integrated Photovoltaic Technology (BiPV)

There is currently growing attention being paid to BiPV which is small but the fastest growing niche/segment of some markets with more than 25MW installed in Europe (Martinot & Sawin, 2009). It is expected to be the largest application of grid connected PVs. PV can be applied to buildings either by mounting them onto existing structures and materials or integrated into the building. Building integration involves the architectural, structural and aesthetic incorporation of photovoltaics into buildings where the photovoltaics serve as true construction elements such roofs, facades, shading devices or skylights [Figure 2.4]. Aside electricity generation, the

photovoltaics are expected to provide complementary functions of weather protection, thermal insulation, noise protection and daylight modulation (Pagliaro et al., 2010).

BiPV have progressed from rigid standardized thick solar panels to include modules that range from rigid to flexible types of varied colours. A system is made up of the modules and a balance-of-systems made up of power related hardware such as inverters, controllers and area related costs like wiring and interconnections, installation and site preparation. The electrical connection system is normally on the backside of the module or the edge of the panes (Pagliaro et al., 2010).

Modules are made up of arrays of crystalline solar cells or thin film cells. The crystalline cells are the older of the two technologies and though more affected by high temperatures and cloudy skies are more widely adopted than thin film cells which are less affected by these conditions. The thin film cells are however expected to gain advantage and increased market share because they require less materials and energy during production. Aside the above technologies, two other emerging technologies include organic (plastic) solar cells and dye sensitized solar cells (Pagliaro et al., 2010).

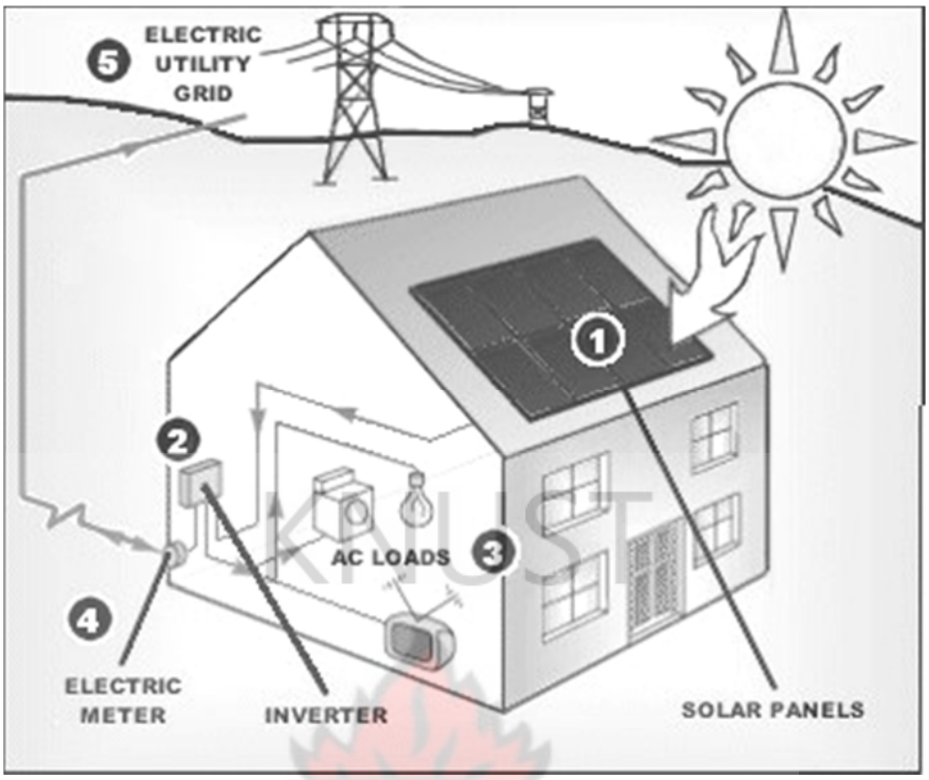

Figure 2.2 A Grid-connected Photovoltaic system

Source: Marvel Green Energy, 2011

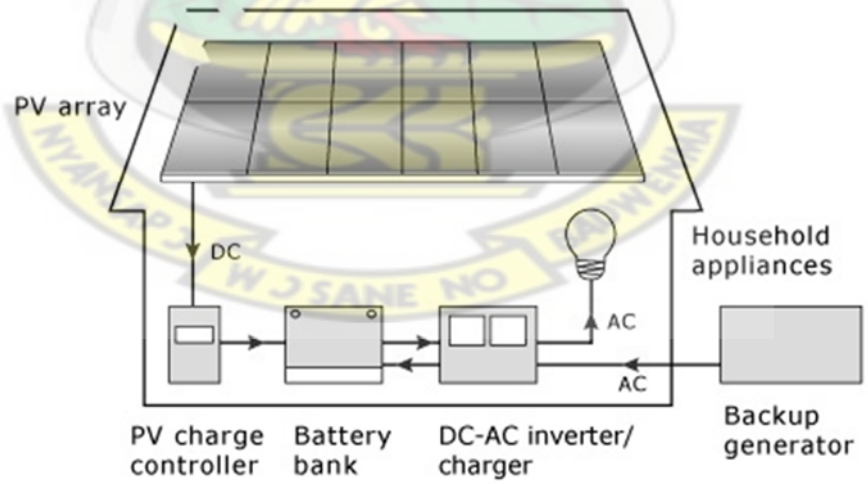

Figure 2.3 An Off Grid-connected Photovoltaic system

Source: Manoj Solar Show Room, 2011

A major challenge of BiPV is its high cost that is further swelled by additional cost of balance of systems (BOS). Otherwise, BiPVs are reliable and almost maintenance free. Compared to centralised photovoltaics, BiPVs are advantageous as they eliminate the need for additional land area, distribution and transmission lines, and do not require expensive support structures. Transmission and distribution loses are also reduced since power is generated at the point of use (Oliver & Jackson, 2001).

Examples of buildings that currently have incorporated BiPV systems are Vatican Paolo IV hall in Italy, Trondheim University of Science Technology in Norway, Ferdinand Braun Institute in Berlin and a number of residential houses in Switzerland, Germany, Japan, Netherlands, United States of America and the like.

Figure 2.4 A BiPV system in Netherlands

Source: Henemann, 2008

The market for BiPV is small with low penetration but holds a large potential for growth and is currently very competitive with no dominant players. A variety of past and present policy initiatives and ambitious targets have been set across the globe to increase BiPV diffusion: the “thousand roofs” programme by Germany, the 70,000 PV roofs by the Japanese Ministry of Trade and Industry, 1,000,000 solar roofs by the USA and the like. These initiatives have been supported through the provision of tax credits, grants and low interest loans all in a bid to encourage the deployment of solar technologies. It is expected that these initiatives will increase demand leading to the expansion of production facilities and subsequently reduced cost so as to make photovoltaics competitive to conventional electricity sources in the future (Jackson & Oliver, 2000).

2.2.7 Prospects for Building Integrated Photovoltaics in Ghana

Current uses of solar energy in Ghana include crop drying and production of electricity for water heating, telecommunication, water pumping, lighting, ventilation, electric fencing, computing and office equipment. These uses however represent less than 1% of energy supply in Ghana and hence the vast supply of this resource remains largely unexploited (Essandoh-Yeddu, 1997; Energy Commission Ghana, 2006).

In Ghana where there is a need to decrease demand on the national grid and also increase the renewable component of the nation’s energy mix, BiPV seems like a plausible means of achieving both goals simultaneously especially by incorporating them in new buildings in urban areas. Currently solar energy in the form of photovoltaics is used for rural electrification since they present cost-effective

solutions to electricity supply compared to extending the national grid (Energy Commission Ghana, 2006). Although photovoltaic applications in buildings are not currently cost-effective except under conditions where financial incentives are provided, they may offer a viable substitute as a supplement to the grid in urban areas in Ghana where the supply is fraught with challenges of frequent interruptions and low currents. Presently, some individuals and organisations supplement energy from the grid using diesel generators even though photovoltaics offer a more sustainable option. Experiences with photovoltaic electrification projects in rural areas however have revealed that barriers exist to the penetration of photovoltaics and hence the actual use of photovoltaic is below expectations. Nevertheless, these examples show that there is the need to actively influence the adoption and diffusion of photovoltaics if prospects are to be achieved.

2.2.8 The Role of Policy in Energy Efficiency and Clean Energy Issues

Over the years since energy efficiency and clean energy sources have gained renewed interest because of climate change, it has been realised that achieving the potential goes beyond the availability of relevant technologies. As much as there are real environmental issues underpinning the need for more reliable sources of energy, decisions that have to be made hinge on the degree to which present and future societies need to balance these environmental benefits with economic trade-offs (Johansson et al., 2004).

The markets for such technologies in certain instances are now developing and often face market barriers and failures. These barriers and failures, which may be behavioural, organisational or financial, provide explanations for the difference in actual investments for energy efficiency and clean energy choices observed in

current energy markets and markets as described/predicted in economic theory (Brown, 2001). It has become apparent that policies are necessary to support these new markets and move them towards self sustenance. The development of energy policy must be approached from an interdisciplinary perspective, delicately balancing technological, economic, political, and social considerations and utilizing growth in knowledge and technology in a manner consistent with our overall social goals (Dennis, 2006).

2.2.8.1 Market Failures and Barriers

Market failures are conditions of a market that violate one or more of the neoclassical economic assumptions that define an ideal market for products and services such as rational behaviour, costless transactions and perfect information (Brown, 2001). They can be caused by misplaced incentives, distortionary fiscal and regulatory policies, unpriced cost such as air pollution, unpriced goods such as education, training and technological advances, and insufficient and imperfect information.

Market barriers also account for the slow adoption and diffusion but are however not based on market failures and include capital market imperfections, low interest in energy issues among consumers and incomplete markets for products (Brown, 2001). According to Brown (2001) and Golove & Eto (1996), many of the barriers and failures especially those associated with information can be viewed as transaction costs associated with energy decision making. These include the cost of gathering and processing information, making decisions, and designing and enforcing contracts relating to the purchasing and installation of energy-related

technology. The various barriers and failures as categorized by Golove & Eto (1996) are:

1. Misplaced or split Incentives
2. Financing
3. Market structure
4. Regulation
5. Custom and Information
6. "Gold plating" and inseparable features

Neoclassical economists argue that market failures are a prerequisite for government intervention. When it comes to issues of energy efficiency and clean energy technology adoption, proponents have emerged to support the need for governments' intervention to ameliorate market barriers and failures so as to reduce the gap between customers' actual investments and what is in the customer's own interest and attain socially desirable levels of investment. They maintain that the barriers and failures are substantial and hence require government intervention to

- counteract the effects of market failures
- reduce transaction costs and
- help individuals help themselves

Some public policies and measures that have been proposed and currently in place consists of

- fiscal incentives
- price controls
- technical research and development

- publicity and educational measures
- legislations encompassing public and private sectors, and individuals and organisations

Although other products and services also face obstacles that hinder their adoption, government intervention in energy efficiency and clean energy technology has received considerably more attention because of their widespread environmental, national security and macroeconomic repercussions (Brown, 2001). Furthermore, energy like labour, capital and other natural resources remains a critical underpinning of nations' economic and social well-being and therefore remains a continuing priority for governments.

The rationales for policy intervention however do not justify any particular intervention. In fact, advocates promote a combination of multiple, complimentary interventions since in actual situations many barriers operate simultaneously and therefore the choice of any intervention should not be done in the abstract but should be informed by rigorous systematic investigation of context specific barriers (Golove & Eto, 1996). Understanding the barriers to the market penetration of energy efficiency and clean energy sources is essential to defining potentially effective policies.

2.2.9 The Need for Photovoltaic Adoption and Diffusion Research in the Ghanaian Building Industry

The adoption and implementation of energy efficient technologies by individuals, firms and smaller units present proven economic benefits. Paradoxically, literature shows that there is a significant difference in the levels of investment in energy

efficiency that appear to be cost effective based on engineering-economic analysis and the levels actually occurring – the energy efficiency gap or paradox (Jaffe & Stavins, 1994). In other words, individuals are reluctant to invest in energy efficient technology even though these technologies have been proven to be profitable and less risky than other investments. Literature contains information on the energy efficiency gap and the barriers responsible for this condition (Shama, 1983; Hirst & Brown, 1990; DeCanio, 1998; Van Soest & Bulte 2001).

Although the literature on the paradox essentially relates to energy efficiency technologies it has raised important issues on the "irrational" adoption behaviour of individuals and firms; an issue that is of relevance to renewable energy technologies and the potential challenges that exist if PV technologies are to be adopted and diffused in the Ghanaian building industry. As mentioned in section 2.2.6.2 countries such as Japan, Germany and USA having faced these challenges in PV adoption and diffusion have put in place certain relevant policies. Section 2.2.8.1 on market barriers and failures above also provided the basis for arguments for government interventions and the relevance of policies.

As seen in section 2.1.5, past policies on PV in Ghana have demonstrated the technical viability of the technology whilst the current policy is aimed at increasing the use of the technology. Efforts by the government have been largely constrained by limitations on government budget and funding [Section 2.1.5] and there is the need for more private investment and participation. This can be achieved by encouraging clients and professionals to incorporate PV technologies in their building projects. Nonetheless, continued support is needed from government in the

form of political will to create the right policy, regulatory framework and market environment to encourage private sector participation of this sort [section 2.2.5.3].

In the light of this, there is the need for rigorous systematic investigations to inform the policy-making process as explained in section 2.2.8.1 as well as change agents promotional efforts. Such investigations in Ghana are few and those that relate to the Ghanaian building industry are absent. Therefore this study is one such investigation that will provide information that can be used to inform and guide policy formulation relating to the adoption and diffusion of photovoltaics in the Ghanaian building industry.

The following section reports on prior research findings on innovation adoption and diffusion; the main theory that will be drawn on to guide the understanding of the problem outlined above. At the end of the section the specific research questions that this study sought to address are clearly identified and formulated.

2.3 THEORETICAL FRAMEWORK: INNOVATION DIFFUSION

2.3.1 Introduction

With the proliferation of a wide number and variety of new technologies required to deal with the complexity of problems currently faced by the world, a lot of interest has been shown in the process a new technology goes through from invention, diffusion and widespread commercialisation - the innovation process. The linear model of innovation has been one of the first conceptual frameworks developed to understand the relationship between science, technology and economy.

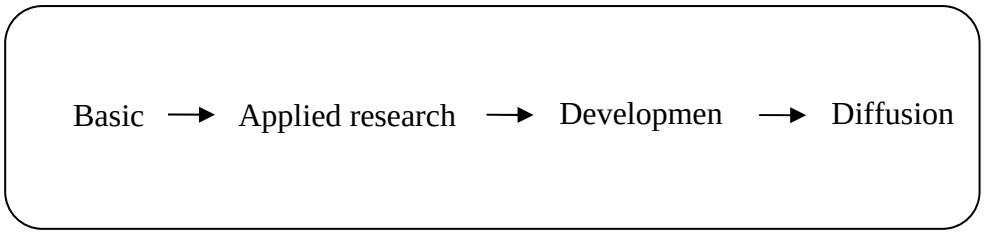

Figure 2.5 Linear Model of Innovation

Source: Godin, 2006

The model developed in stages based on the contributions of several authors from the natural sciences, economics, management and sociology (Godin, 2006). Although criticized for its linear nature it still remains relevant in categorising the innovation process into its component stages for study: Invention (development of a new idea for a product or process), innovation (bringing an invention into commercial use or an invention brought into commercial use) and diffusion (the spread of innovation into industry). In this study the focus is on the diffusion stage of the innovation process and how the theoretical understanding of the diffusion of innovations can be used to evaluate the factors that may influence PV adoption and diffusion in the Ghanaian building industry.

In the study, literature relating to innovation diffusion in general and within the construction industry in particular was reviewed. The main issues of concern dealt with in literature were

a. What causes individuals to adopt innovations invented by others?
b. What determines the rate of diffusion within an industry?

2.3.2 Innovation Diffusion

Introducing PV into buildings in Ghana involves the need to influence potential adopters, who are in this case the individuals and organisations involved in the building process. Consequently, an understanding of the innovation behaviour of these individuals and organisations is relevant so as to manage the innovation diffusion process adequately given the importance of innovation to organisational competitiveness and effectiveness (Panuwatwanich, 2008) as well as the importance of construction to national growth and development (Ahadzie, 2007). The major concept that relates to the issue being investigated is *innovation diffusion.* Several empirical studies have confirmed the varied rates and nature of innovation diffusion and of acceptance of different inventions depending on the determinants of diffusion, which may be economical, social and/or institutional (Rogers, 2003; Wolfe, 1994; Van de ven et. al., 1999).

The basic paradigm for studying diffusion was set forth by the study of a hybrid of corn by Ryan & Gross (1943) but the subsequent study of innovations in general and specifically innovation diffusion is not confined to any single discipline, there is broad literature and vast interest in this area of study and so there is no one theory of innovation but several circumscribed theories and models that apply under different conditions (Rogers, 2003; Nutley et. al., 2002). Collectively, the studies seek to understand the relative innovativeness of individuals and organisations and the relative adoptability of different innovations. Consequently, this understanding of the reason some individuals and organizations are likely to adopt a given innovation than others or why an innovation is more likely to be adopted than another informs

how the adoption decision and implementation can be influenced (Downs & Mohr, 1976).

Rogers (1995) defines diffusion as "the process by which an innovation is communicated through certain channels over time amongst the members of a social system". By virtue of the variation in the elements of diffusion i.e. the innovation, the communication channels, time and the social system, the rate of diffusion of one innovation may not necessarily be the same as another innovation. According to Hall (2005), the diffusion process is important in "understanding how conscious innovation activities by firms and government institutions, activities such as funding research and development, transferring technology, launching new products or creating new processes, produce the improvements in economic and social welfare that they were intended for". In addition, advocates of an innovation explore the dynamics of diffusion in order to accelerate change and avoid implementation pitfalls (Leonard-Barton, 1982).

2.3.3 The Elements of Diffusion

Understanding innovation diffusion requires an understanding of the four main elements that are involved in the process. The elements are identifiable in every diffusion research study, campaign or programme (Rogers, 2003). The elements are the innovation, communication channels, time and the social system which are explained in the following sections.

2.3.3.1 Innovation

An innovation is defined as the adoption of means or ends that are new to the adoption unit (Downs & Mohr, 1976) and may be an idea, practice or a technology

like PV. Alternatively, Edquist (1997) describes innovations as new creations of economic significance that may be technological or organizational. Schumpeter (1939) also describes innovation as the setting up of a new production function. In construction management literature, Slaughter (2000) defines innovation as "the actual use of nontrivial change or improvement in a process, product or system that is novel to the institution developing the change". Although defined variedly in literature the common theme that runs through the definitions is the idea/object of 'perceived newness" that consequently leads to the risk and uncertainty associated with innovations. Rogers' (2003) definition of innovation is however adopted for the purposes of this research. He defines an innovation as an idea, practice or object that is perceived as new by an individual or other unit of adoption. His definition is used because 'newness' is expressed as a perception rather than an objective measurement of the time lapse since an idea's first use or discovery. Furthermore, 'newness' is not just limited to the knowledge of the idea but is expressed also in terms of persuasion or a decision to adopt. This definition is appropriate for the study because although solar PV is by no means a new technology, it is perceived as new in the Ghanaian building industry.

Innovations may take many forms and there is an abundance of typologies in literature which may be based on *type* (is it a product, service or process innovation?), *extent* (is it an incremental, semi-radical or radical improvement?), and *novelty* (is it new to the firm, industry, or world?) (Shaw, 2010). There are as many as eight categories (for example reformulated/new parts/new merchandising/new improvements/new products/new user/new market/new customers) and as few as two categories (for example discontinuous/continuous) proposed by various studies

as typologies for innovation (Garcia & Calantone, 2001). Within construction related literature, Slaughter (1998) categorises innovations in terms of *extent* as 'incremental' (small, and based on existing experience and knowledge), 'radical' (a breakthrough in science or technology), 'modular' (a change in concept within a component only), 'architectural' (a change in links to other components or systems), or 'system' (multiple, integrated innovations). However, it is important to note that typologies based on *extent* are relative to the adoption unit. What one adoption unit perceives as incremental may be perceived as radical by another (Garcia & Calantone, 2001). Consequently, in characterising innovations in this study, the delineation between product (new products or services introduced to meet an external user or market need), and process innovations (new elements introduced into an organisation's [adoption unit's] product or service operations) were made (Damanpour, 1991). Even with regard to this typology, it should be emphasised that the distinction is not clear cut in practice and the adoption of a product innovation for example may result in innovation of the process used to generate the product (i.e. a process innovation) (Milling & Stumpfe, 2000).

2.3.3.2 Communication Channels

Diffusion is a type of communicative process which involves an individual or other unit of adoption that has knowledge of, or has experience using the innovation and another individual or other unit that does not yet have knowledge of or experience with the innovation. The aim is then to pass this knowledge between these two individuals or adoption units, hence a communication channel is the means by which the new idea or knowledge about the innovation gets from one individual to another (Roger, 2003).

2.3.3.3 Time

The diffusion process involves a time dimension that is recognized rather than ignored as is done in most other behavioural research. This time dimension is exposed in

a. the innovation-decision process by which an individual passes from first knowledge of an innovation through to its adoption or rejection;
b. the innovativeness of an individual or other unit of adoption compared with other members of a system, and
c. an innovation's rate of adoption in the system that is the number of members of the system that adopt an innovation within a given time period.

(Rogers, 2003)

2.3.3.4 Social System

The social system refers to the set of interrelated units that are engaged in joint problem solving to accomplish a common goal. These interrelated units may be individuals, informal groups, organisations and/or subsystems (Rogers, 2003). The social system that is the focus of this study is the building industry made up of individuals and groups all engaged in different activities but bound together with a common goal of on-time delivery of buildings which are also cost-effective.

The social system serves as a boundary within which an innovation diffuses and in a diffusion study, can be used as means of delineating or defining the scope of the study. The social system is also important to diffusion studies since its social structure and consequently communication structure, norms, change and opinion leaders and the type of innovation decisions influence the diffusion process and

outcome. The social system also allows for the consequences of diffusion to be observed.

2.3.4 The Study of Innovation Diffusion

The diffusion process has been studied from a number of different perspectives that emphasize its different aspects relative to the use to which the results are to be employed. The diversity of models of process, and the variety of underpinning ways of seeing, have the potential to generate useful insights from empirical study and each perspective captures some aspect of every innovation and diffusion context (Finchman, 1992; Nutley et.al., 2002); therefore, the choice of any one perspective is valid as long as the contingent conditions for the perspective is taken into consideration. Four perspectives as outlined by Hall (2005) are further discussed but there are more views that have informed innovation diffusion over the years as shown in [Table 2.1]. The four perspectives as outlined by Hall (2005) include the historical, economical, sociological and network theoretical perspectives.

The economic perspective of diffusion "views the process as the cumulative or aggregate result of series of (rational) individual calculations that weigh the incremental benefits of adopting a new technology against the cost of change, often in an environment characterized by uncertainty (as to the future path of the technology and its benefits) and by limited information (about both the benefits and costs and even about the very existence of the technology)" (Hall, 2005 pp. 462). Within this perspective, innovation and diffusion are defined as economic decisions

Table 2.1 Some Research Traditions Relevant to Diffusion of Innovations

Research Tradition	Academic Discipline	"Diffusion of Innovations" conceptualized (as)
Rural sociology	Sociology	Influence of social norms and values on adoption decisions; networks of social influence
Medical sociology	Sociology	As above. Specifically, the norms relationships and shared values that drive clinician behaviour
Communication studies	Psychology	Structure and operation of communication channels and networks; Interpersonal influence
Marketing	Interdisciplinary (psychology & economics)	Products and services, and the adoption decision as a rational (quasi-economic) analysis of costs and benefits.
Development studies	Interdisciplinary (anthropology, sociology, economics, political science, information and communications technology)	To include an exploration of the political, technological, and ideological context of the innovation and any dissemination program, and of particular innovations' different meaning and social value in different societies
Health promotion	Interdisciplinary (social psychology, epidemiology, marketing)	The "Reach" and "uptake" of positive lifestyle choices in populations targeted by health promotion campaigns
Evidence-based medicine	Clinical epidemiology	Filling a "knowledge gap" or "behaviour gap" in targeted clinicians
Structural determinants of organisational "innovativeness"	Organisation and management	Organisational attributes influencing "innovativeness", like size, slack resources and hierarchical versus decentralized lines of management
Studies of organisational process, context and culture	Interdisciplinary (organisation & management, anthropology, sociology)	The exploration of an organization's innovativeness concentrated on the "softer," nonstructural aspects of its makeup, especially the prevailing culture and climate, notably in relation to leadership style, power balances, social relations, and attitudes toward risk taking

Table 2.1 Cont'd

Inter-organisational studies (networks and influence)	**Interdisciplinary (organisation & management, sociology)**	**As an organization's innovativeness in relation to the influence of other organizations, particularly interorganizational communication, collaboration, competition,and norm setting: This area applied social network theory to the level of the organization**
Knowledge utilisation	Interdisciplinary (organisation & management, sociology, information and communications technology)	As the construction and distribution of knowledge
Narrative studies	Interdisciplinary (anthropology, sociology, literature)	As the telling, retelling and interpretation of stories. Innovators as characters (heroes, underdogs) in a story of change. Innovation as social drama.
Complexity studies	Interdisciplinary (ecology, social psychology, systems analysis)	as the emergent continuity and transformation of patterns of interaction, understood as complex responses of humans relating to one another in local situations. Derived from general systems theory

Source: Greenhalgh et. al., 2004

because of their “closeness to economic use” and the emphasis in this perspective is on the costs and benefits associated with adopting the innovation. Consequently within this framework, innovations that have high benefits and lower costs or provide competitive advantage are expected to have higher diffusion rates than those with low benefits and high costs.

This traditional thinking has dominated energy efficiency and clean energy policy-making as the economic discipline has been noted to provide the theoretical background and serve as a tool to support decision-making process and policy-making, hence, economics plays a prominent role in climate change issues and analyses (Marechal, 2007). Furthermore, the relationship between economic growth and technical progress is well recognised in economic thought and technical change is seen as endogenous to an economic system (Dosi, 1982; Jocabsson & Johnson, 2000).

The traditional thinking that has dominated energy efficiency and clean energy policy making has been based on neoclassical economic perspectives that focus on how changes in relative prices influence technology choice. The critical assumption of neoclassical economic perspective is the existence of rational optimizing agents both households and firms. This thinking as observed in empirical research does not always hold true hence the existence of the energy paradox/gap and market failures described in previous sections.

An alternative framework based on evolutionary economics has been advocated to complement the mainstream economic perspective and to offer explanations where it falls short. Evolutionary economics has been suggested as a more appropriate and

comprehensive framework for analyses since an evolutionary-inspired approach to technological change acknowledges the role of systemic interdependencies, heterogeneity of agents and historical contingencies. This framework posits the concept of bounded rationality which assumes that agents are not fully informed and will not include all possibilities in their considerations for performing any behavioural or economic act owing to the constraints of time and energy required for gathering full information. Consequently, agents thus rely on routines, habits, heuristics, imitation and experience to come to an economic decision which can be implemented in limited horizon in time and scale. The consequence of this to technical change is that finding and using suitable technology at the right price involves cost, risk and effort. The process involves search, experimentation, induction of new information, learning and adapting the technology to different scales, new inputs and scale conditions and different product demands (Lall & Pietrobelli, 2005).

This economic view of cost-benefit analysis as a basis for decision-making is highly entrenched in practice but is limited by the fact that not all costs and benefits can be quantified. Furthermore, the decision to adopt a technology is not based purely on the economic factors of costs and benefits. In the case of PV the benefits that relate to aesthetics cannot be quantified and externalities such as reduced green house gases emissions have as yet not attained financial values. Furthermore, studies have shown that there are instances where individuals and organisations do not show "rationality" in decision-making (Van den Bergh & Bruinsma, 2008). Although the economic perspective to diffusion is relevant it is limited in its ability to account for individual and organisations innovation adoption behaviour.

In marketing literature, which Hall (2005) places under the economic perspective, focus is on understanding how to encourage customers to purchase new products and technologies and how to detect or forecast success in the market place. Consequently, the factors emphasized in this literature include media information, the role of social networks and change agents as well as characteristics of the product itself. Specialists in technology tend to reflect this perspective since their interest lies in encouraging the adoption of particular new technologies such as PV due to the relevance to policy and societal goals.

There is also the sociological and organizational perspective to the study of diffusion that points to conditions that may influence the adoption-decision at the individual and organizational levels. These conditions may relate to the characteristics or attributes of the innovation or to other external or social conditions. These determinants include:

1. The relative advantage of the innovation
2. Its compatibility with the potential adopters' current way of doing things and with social norms
3. The complexity of the innovation
4. Trialability, the ease with which the innovation can be tested by potential adopter
5. Observability, the ease with which the innovation can be evaluated after trial
6. Whether the decision is made collectively, by individuals or a central authority
7. The communication channels used to acquire information about an innovation, whether mass media or interpersonal

8. The nature of the social system in which the potential adopters are embedded, its norms, and the degree of interconnectedness
9. The extent of change agents' promotional efforts

This perspective is more comprehensive since it not only identifies the features of the innovation that determine its ultimate success or failure but provides a larger framework that recognises the role of economic and non-economic factors.

Altogether these perspectives provide answers to the basic theoretical question in diffusion research: what are the determinants of adoption and implementation of an innovation? (Downs & Mohr, 1976) The factors vary depending on the industry and decision makers involved and hence the variables have to be investigated for a particular sector, innovator or innovation (Koebel et al., 2004). In this study the focus is on the photovoltaic technology (the innovation) within the building industry in Ghana (the social system). This assessment is essential to the viability of the PV technology as studies relating to renewable and non-renewable technologies have revealed that the viability of a technology cannot be assessed purely based on its technical and economic potential but on a complex dynamic that includes environmental, institutional and social factors (Painuly & Fenhann, 2002; Johansson et al., 2004).

2.3.5 The Classical Diffusion Theory

It is from the above literature on innovation diffusion that the theory that is used in this study is elicited. It is the classical diffusion theory as proposed by Rogers (2003). It draws from a wide range of disciplines to provide a comprehensive structure for understanding adoption and diffusion (Fichman, 1992). It has influenced many other adoption and diffusion theories, provides a majority of the

relevant variables and is one of the most widely cited of the diffusion theories (Straub, 2009). Furthermore, the decision to use the classical theory of diffusion was informed by the characteristics of the technology and the locus of adoption of interest in this study. Although the theory has been criticised for its linear nature and a pro-innovation bias, according to Fichman, (1999) the classical diffusion perspective is appropriate and provides strong results when the research examines individual adoption and independent-use technologies which impose a comparatively small knowledge burden on would-be adopters. Consequently, the classical diffusion theory was employed in this study since the units of adoption of interest are clients and professionals in the Ghanaian building industry and the technology, photovoltaics, imposes a relatively small knowledge burden as compared to computer application programmes for example which require extensive learning before usage.

According to Rogers, the rate of adoption of innovations is dependent on perceived attributes of innovation, the type of innovation decision, communication channels, the nature of the social system and the extent of change agents' promotion efforts. In addition to Roger's theory, the theoretical considerations in this study depart from the work of Hartman et. al., (2006) in which a conceptual framework of the innovation decision process of construction clients is presented. The work by Hartmann et. al. (2006) was informed by Roger's (1995) work.

In the framework, Hartman et al., (2006) argues that the adoption behaviour of clients may be traced to the links between context, communication and perception. In other words, the appropriate information sources or how innovation attributes are

perceived depend on a range of contextual factors: the environment, organisation and technology.

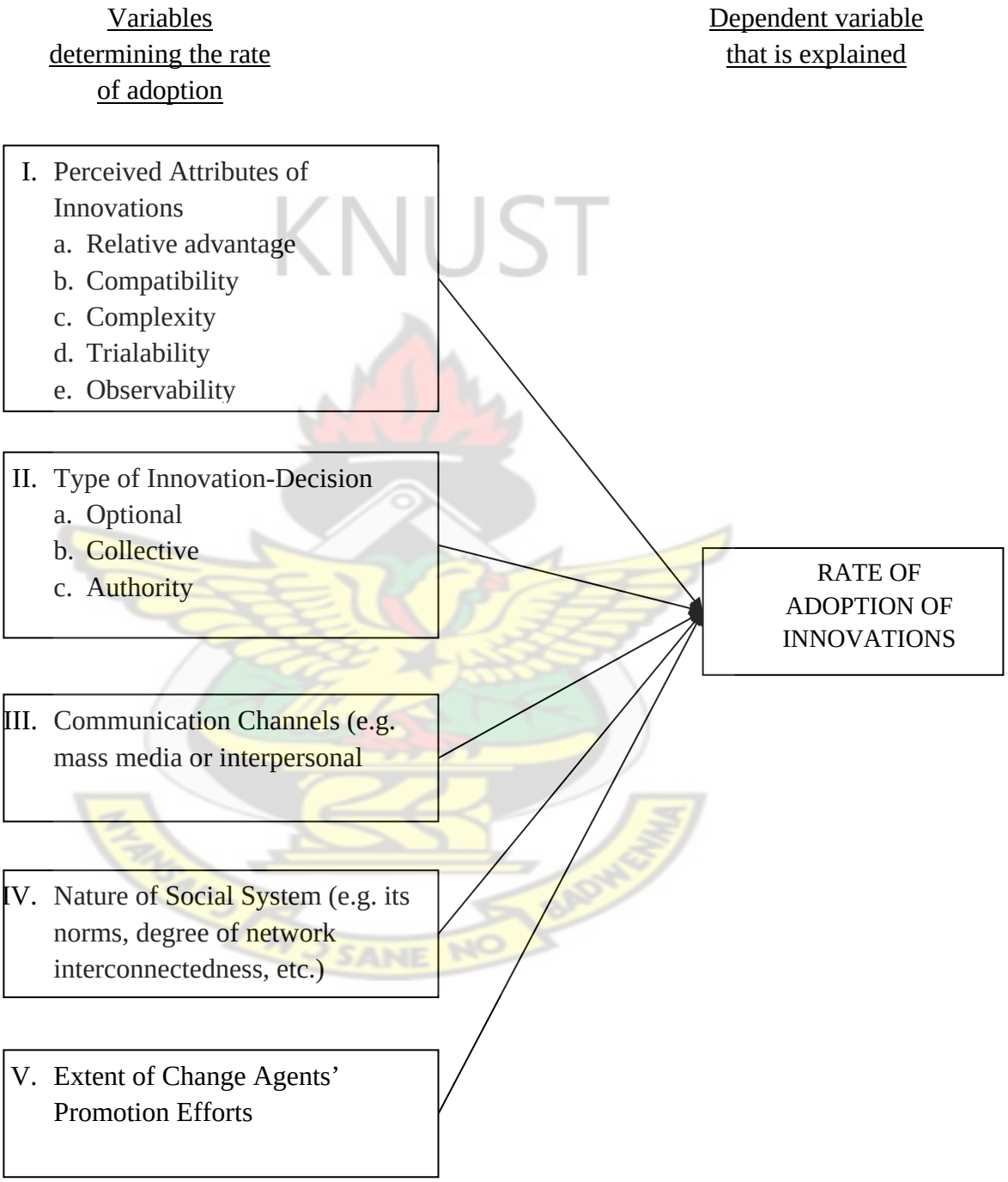

Figure 2.6 Variables Determining the Rate of Adoption of Innovations

Source: Rogers, 2003

This emphasis on the role of context is what informs the choice of this framework since diffusion research often focuses on the characteristics of the innovation than on the context (Green et. al., 2009). Hartmann et al. (2006)'s framework is graphically represented in Figure 2.10 and the three concepts and their relationship to the adoption decision is explained; however the adoption and innovation decision process is first discussed since it forms a basis for the framework.

2.3.6 The Adoption and Innovation-decision Process

The speed of diffusion is measured as the number of members of a social system that adopt an innovation within a given time period and so diffusion can be considered as a series of adoptions. The study of the adoption process and the factors that influence the *adoption-decision* is therefore of importance to innovation diffusion. The *adoption process* according to Rogers (2003) is the mental processes that an individual goes through from first hearing about an innovation up to final adoption.

The *innovation-decision process* is conceptualized as a decision process that involves the steps that potential adopters go through in making a decision on whether to adopt or reject an innovation: an individual or unit of adoption passes from the first knowledge of an innovation to a decision to adopt or reject, to implementation of the new idea and the confirmation of the decision. This process is made up of five sequential steps: knowledge (exposure to the innovation and an understanding of how it works), persuasion (this occurs when a favourable or unfavourable attitude is formed toward the innovation), decision (this occurs when an individual or adoption unit engages in activities that result in the decision to adopt or reject an innovation), implementation (this occurs when an innovation with a favourable evaluation is actually put to use) and confirmation (this occurs when the

individual or innovation unit seek to reinforce the decision made or reverse the decision if exposed to conflicting messages about the innovation).

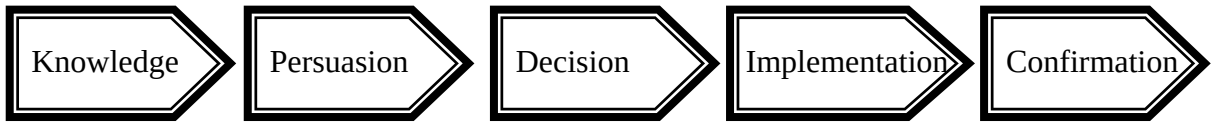

Figure 2.7 The Innovation-decision process

Source: Rogers, 2003

These actions within the model essentially are driven by communication activity and the decision to adopt or reject an innovation is influenced by varied factors that can all be grouped into three main categories: influences that relate to the characteristics of the innovation, influences that relate to the social system within which the decision-making unit is found and influences that relate to the characteristics of the decision-making unit.

The uniqueness of this type of decision-making from other types lies in the perceived newness of the innovation, and the uncertainty associated with this newness (Rogers, 2003).

2.3.7 Hartman et al. Conceptual framework of the Innovation Adoption

Hartman et al. (2006) framework as stated earlier is based on Roger's model above although it focuses on the first three stages of the innovation-decision process.

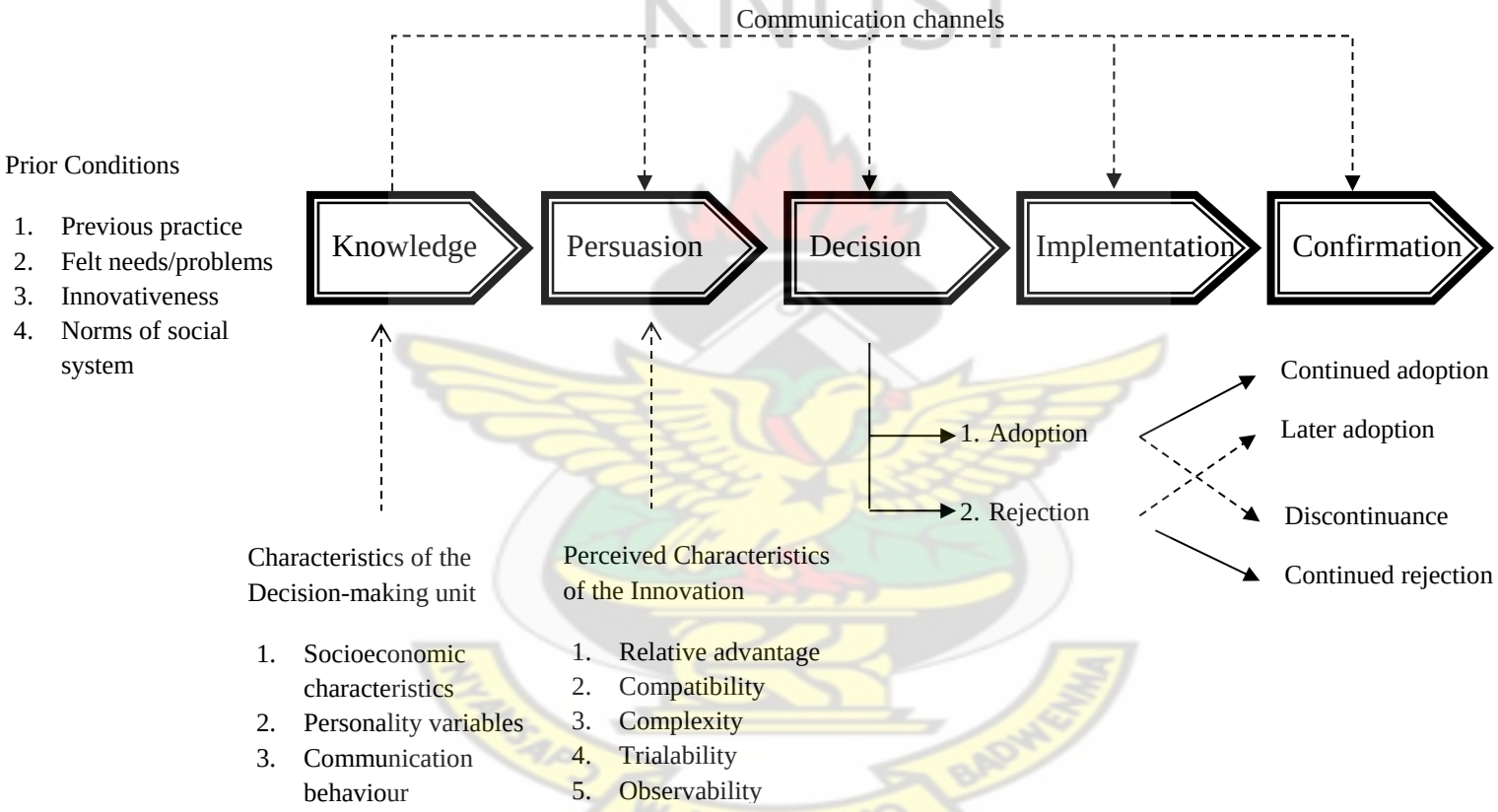

Figure 2.8 A Model of the five stages in the Innovation-Decision Process indicating the factors that influence the process (Rogers, 2003)

2.3.7.1 Communication Channels

Seeking (knowledge) and processing information (persuasion) about an innovation represent the first steps of the adoption process. In fact, Rogers (1995) describes the innovation-decision process as an information seeking and processing activity in which an individual seeks information in order to decrease the uncertainty about the innovation. The quality of these activities is essential to adoption and is dependent on the communication characteristics within the social system of which the adoption unit is a part. The adoption and implementation of an innovation is only possible if potential adopters are aware of its existence as well as its values and benefits. The source, mode and quality of communication therefore determine the adopter's

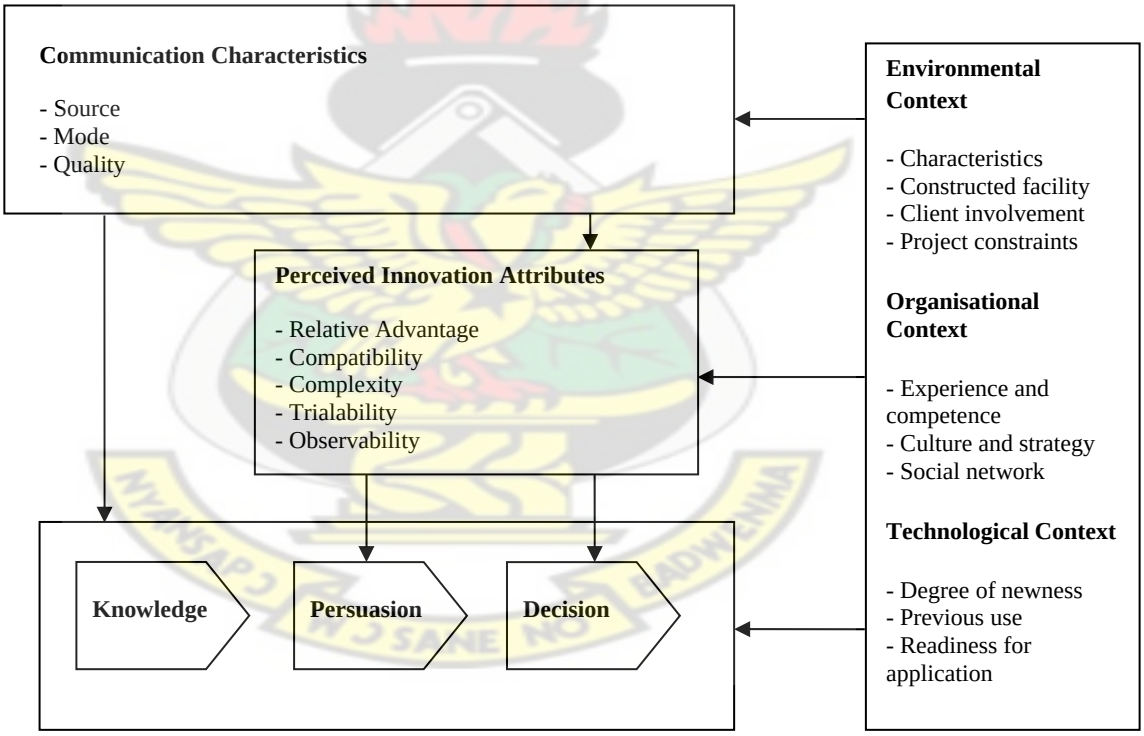

Figure 2.9 Conceptual framework of the innovation adoption process of construction clients (adapted from Hartman et al., 2006)

knowledge of the innovation, how the adoption unit perceives the attributes of the innovation and consequently the evaluation of the innovation and the propensity to its adoption. In construction, there may exist communication channels between

stakeholders such as clients, suppliers or business partners and other project participants, government agencies and research institutions in addition to personal sources such as friends or near peers. Written communication such as print media, letters and emails and oral communication via telephone or face-to-face comprise the modes of communication. Interpersonal contacts and word-of-mouth communication have a greater effect on the development of perceptions whilst mass media and written communication aid the creation of awareness (Rogers, 2003).

2.3.7.2 Innovation Attributes

Innovations attributes refer to specific characteristics associated with an innovation and are measured as perceived by the potential adopter of an innovation. Although there are other factors that affect innovation adoption, innovation attributes have been shown to explain significant variance in adoption decisions (Dearing, 2007). Five standard attributes have been defined by Rogers (2003):

1. The relative advantage of the innovation
2. Its compatibility with the potential adopters' current way of doing things and with social norms
3. The complexity of the innovation
4. Trialability, the ease with which the innovation can be tested by potential adopter
5. Observability, the ease with which the innovation can be evaluated after trial

Of the five attributes, relative advantage, compatibility, and complexity have been most strongly associated with adoption decisions.

2.3.7.3 The Context of Innovation Adoption

The adoption and diffusion processes occur within a specific social context or system and hence are influenced by contextual factors that according to Hartman et al. (2006) can be assigned to three context levels: the environment, the organisation and the technology. At the environmental level the project-based nature of construction affects adoption behaviour and the adoption process is always connected to the construction process. For example the constraints of the project such as time and budget affect the adoption process, and characteristics of the constructed facilities are expected to affect the perception of innovation attributes. When time is limited, the adoption process must be quickened and so adequate evaluation during the persuasion stage maybe absent. Also, on an already expensive project with stringent cost restraints, the cost of an innovation may become a more important attribute than on a project with less restricted cost constraints.

On the organisational level the experience and competence of the adopter are influential factors in that where an adopter is experienced and has high competence an innovation is more likely to seem less complex. This is because the adopter is better able to understand the technology. The innovativeness of the adopter or the willingness to innovate also comes into play at the organisational level in that adopters that show an innovation-oriented culture and strategy are more likely to come to a favourable innovation decision. The organisational structure also plays a role in innovative behaviour (Taylor & Levitt, 2005). For instance on a project where power and control is concentrated in one person or a few individuals the range of new ideas considered is limited. Especially in a hierarchical structure top leaders may not be well placed to identify or suggest relevant innovations.

On the technological level the degree of newness has considerable effect on the perceived innovation attributes and the information sources used for communication. With an increased degree of newness, prior usage of the innovation is important since this allows for trial and evaluation of the new technology and hence a higher probability of implementation in future projects.

2.3.8 Research Gap and Issues to be Investigated

The chapter has demonstrated the role that photovoltaics can play in creating a sustainable energy future in the world and Ghana but it also highlights the challenges to attaining the aim of incorporating photovoltaics into the energy system. The chapter shows that the challenges are varied but a major challenge is photovoltaic commercialisation and diffusion. Consequently the chapter went on to introduce the diffusion of innovation theory and how this theory is relevant to understanding the commercialisation and spread of photovoltaics.

Following from this literature review, the research questions then that originated from the problem and the theoretical framework and which have been investigated in this study are:

- What are the factors that influence the adoption of an innovation by clients and professionals within the Ghana building industry?
    - Which channel of information on innovations is most used by clients and professionals and which of them is rated most reliable?
    - Which building participant wields the most influence relative to the others in decision-making on innovations?
    - Which is the most significant of the innovation adoption-decision factors relative to each other?

- Is there a difference between clients and consultants on the importance of the most important adoption-decision factors?
- How and why are certain innovations adopted or rejected within the Ghanaian building industry

- What are the perceptions of clients and professionals within the Ghanaian building industry about the attributes of photovoltaic energy technology?
  - What is the level of awareness about photovoltaics within the Ghanaian building industry?
  - Is there a relationship between the awareness of photovoltaics and the type of building participant?
  - Is there a relationship between the awareness of photovoltaics and the level of education?
  - Which channels provided most clients and professionals with awareness of photovoltaics?
  - What is the level of adoption of photovoltaics within the Ghanaian building industry?
  - Is there a relationship between the adoption-decision and the building participant that takes the final decision?
  - Which innovation attributes are most well rated with regard to photovoltaics?
  - Is there a difference between adopters and non-adopters on the perception of photovoltaics?
  - Is there a difference between adopters and non-adopters on the perception of photovoltaics?

Rogers (2003) classical diffusion theory and Hartmann et al. (2006) framework as outlined earlier were used as a guide in the investigative process to identify and evaluate the factors that may potentially influence photovoltaic adoption in the Ghanaian building industry. The use of the theory of diffusion of innovation in investigating the adoption of photovoltaics is limited and those that pertain to the Ghanaian building industry are absent. This study therefore extends the use of the theory applying it to a new context.

Hartmann et al. (2006) focused on a public client and employed a qualitative approach to their investigation. However, the present study extends their work to include other building project participants. The current study argues that the decisions pertaining to the design and construction of building projects is a collective process that includes other participants apart from the client and although the client is the initiator of the project, technical decisions are largely informed by the other project participants especially where the client is inexperienced. Therefore, investigations of the determinants of innovation adoption and diffusion and their significance should solicit the opinions of clients as well as the other industry participants and the framework offered by Hartmann et al. (2006) can guide the identification of the variables to be used in the investigative process. Also the study employs a quantitative analytical framework in addition to a qualitative approach for investigations in this study and focuses on a product rather than a process innovation. The influence of the change agent's promotional efforts is as well incorporated in Hartmann et al.'s (2006) framework.

The subsequent chapters three and four present the context of the study and the method used in this study.

CHAPTER THREE

THE GHANAIAN BUILDING INDUSTRY

3.1 Introduction

This chapter describes the organisation of the Ghanaian building industry: the activities and processes together with the participants involved. Often, discussions on these refer to the construction industry since the building industry is a facet of this larger industry and often the features and processes coincide. A survey of building technologies and materials in Ghana are also presented in the chapter. The aim of the chapter is to contextualise the study and also to provide a justification for the population that was selected for the survey.

3.2 The Ghanaian Construction Industry

The construction industry is regarded as relevant to development and a mainspring for economic growth (Ofori, 1990; Anaman and Osei-Amponsah, 2007; Agbodjah, 2008). Key findings in the revised annual estimates for GDP 2011 for instance revealed high growth in construction of twenty-percent (20%) [Table 3.1] with approximately two billion Ghana cedis[1] (Ghana Statistical Services, 2012). The industry also provides significant employment to skilled and un-skilled labour as well as infrastructure and facilities for the other sectors of the economy. The industry is also recognised by the Government of Ghana as a priority for foreign and private investment (Anvuur et al., 2006).

[1] This figure is based on GDP at 2006 prices and is approximately $1,219,800,000 (GHS/USD exchange rate as at Dec. 2011=0.6099)

The industry is made up of all individuals and organisations involved in the design, construction, maintenance and renovation of buildings and infrastructure. Items within the industry are commonly classified as buildings and works (Ofori, 1996), although the Public Procurement Act makes no such distinction and the organisation and processes related to both classifications often coincide. Whilst the purpose of building projects is to enclose space and to create an environment conducive to the performance of a specified activity, works are basically items of infrastructure that support the carrying out of economic, social and other activities (Ofori, 1996).

Table 3.1 Industry's Distribution of GDP and Growth Rate of GDP

	Distribution of GDP (at basis price)				Growth Rate of GDP (at 2006 prices)			
	2008	2009	2010	2011*	2008	2009	2010	2011#
INDUSTRY	20.4	19.0	19.1	25.9	15.1	4.5	6.9	41.1
Mining and quarrying	2.4	2.1	2.3	8.5	2.4	6.8	18.8	206.5
Manufacturing	7.9	6.9	6.8	6.7	3.7	-1.3	7.6	13.0
Electricity	0.5	0.5	0.6	0.6	19.4	7.5	12.3	-0.8
Water and Sewerage	0.8	0.7	0.8	0.8	0.8	7.7	5.3	2.9
Construction	8.7	8.8	8.5	9.2	39.0	9.3	2.5	20.0

* Revised April 2012

Source: Ghana Statistical Services, 2012

The activities of the Ghanaian construction industry are managed by two construction ministries: the Ministry of Water Resources, Works and Housing (MWRWH) which is responsible for housing infrastructure, and the Ministry of Transportation (MoT) which is responsible for roads and civil related infrastructure.

MWRWH is responsible for the formulation and co-ordination of policies and programmes for the development of the country's infrastructure requirements and also monitors and evaluates the performance of public and private agencies with regard to the execution and attainment of these policy and programme objectives (Agbodjah, 2008).

In Ghana, the construction industry has developed into two sectors: the formal sector which utilises a variety of procurement routes and the informal sector with an approach more akin to the historical approach of master craftsmen engaging labour in product delivery (Tipple et al., 1998; Agbodjah, 2008). The formal sector which is the focus of this research is made up of contractors, consultants, materials and product suppliers, real estate developers and other organisations who all contribute directly or indirectly to product delivery.

3.3 The Organisation of Building Industry

The construction industry is large and complex with many varied organisations, professionals and representative bodies. This feature of the construction industry carries on into the building industry. In the building industry, distinction is normally made between residential and non-residential/commercial buildings. Residential buildings refer to buildings used as dwellings whilst non-residential/commercial buildings refer to buildings with a wide range of end uses including schools, hospitals, hotels, offices, factories, sports centres and health centres. This section involves an explanation of the activities and participants involved in the design and construction of a building project as well as the objectives at the various stages of the process.

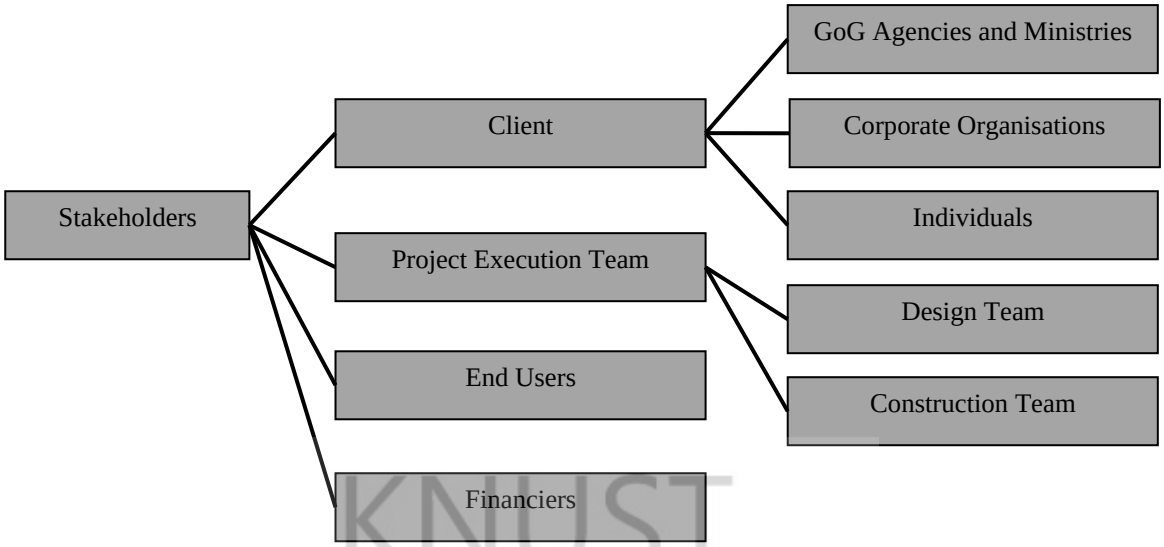

Figure 3.1 The relationship between the Stakeholders in the Ghanaian Building Industry

Source: Agbodjah, 2008

3.3.1 Parties Involved in a Building Project

Construction activities have a project-based nature; meaning that they involve bringing together different individuals and organisations for a relatively short time. The composition of these project teams normally change from project to project and even from stage to stage within a single project but the key players are normally the client, consultants and the contractor.

3.3.1.1 Client

Masterman (2002) defines the client as "the organisation, or individual, who commissions the activities necessary to implement and complete a project in order to satisfy its/his needs and then enters into a contract with the commissioned parties." The decisions of the commissioned parties are therefore taken with the purpose of achieving the client's objectives of functional satisfaction, aesthetic satisfaction, completion on time, completion on budget, and value for money (Walker, 2007). The client is the initiator of the construction process, the individual or group

financing the project. Clients in the industry are heterogeneous and vary in size, interests and motivation (Ofori, 1996). They can be classified according to their main reason for investing in a project and in Ghana, according to Gyadu-Asiedu (2009), four main clients are distinguishable: the government, real estate developers, investors (usually financial companies that decide to invest their excess capital into building construction) and owner occupiers (individuals who decide to build their houses to live in). However a more general and succinct distinction between public and private clients can be made which still accounts for the four categories identified above.

Government of Ghana agencies and ministries may be seen as public sector clients and in Ghana the government is the major construction client (Laryea, 2010). Typically, the motivation for this category of clients is not profit but they still seek to obtain value for money in their dealings for reasons of public accountability. In Ghana, public sector projects are therefore guided by the Public Procurement Act 2003 Act 663.

Private clients may be further divided into corporate and individual clients depending on whether the project execution is controlled by a group rather than an individual. Corporate clients may be families, religious and social organisations or companies. For some of these clients, profit may not be the sole motivating factor; they would value the item of construction according to the satisfaction they expect to derive from it or may be more interested in the prestige and recognition associated with the building product. For other clients like property developers, who build directly for sale or rent, and investors, profit or long term income is the incentive (Ofori, 1996).

3.3.1.2 Consultant

A generic definition of consulting is given by Greiner and Metzger (1983) as "an advisory service contracted for and provided to organizations by specially trained and qualified persons who assist, in an objective and independent manner, the client organization to identify management problems, analyze such problems, and help, when requested, in the implementation of solutions." However, with respect to the construction industry, a consultant is an expert who may be responsible for design (architectural, structural or services) or cost control. The consultant may be a person, group of persons or a company who charges a fee for providing technical advice or a service for the project (Sengupta & Guha, 2002). Consultants who may be employed on a building project may include but are not limited to architects, project managers, structural engineers, services engineers (electrical and mechanical engineers) and quantity surveyors.

In Ghana, several individuals and firms provide such consultancy services and these may belong to professional institutions such as Ghana Institute of Architects (GIA), Ghana Institution of Surveyors (GhIS) and Ghana Institution of Engineers (GhIE).

3.3.1.3 Contractor

A contractor may be a person or group of persons or company with a formal contract to undertake the construction. The contractor may be responsible for supplying labour and material and providing and overseeing staff if needed (Hendrickson & Au, 1989; Sengupta & Guha, 2002).

In Ghana, individual contractors or construction firms that wish to undertake public projects are required to register and be classified into appropriate categories commensurate with their resource base and the type of works they undertake

(Gyadu-Asiedu, 2009). The classification system is supposed to ensure that each contractor is classified and easily identified based on a minimum resource pool of labour and equipment commensurate with his class (Addo-Abedi, 1999). There are two major categories of contractors: road contractors licensed by Ministry of Transport; and building and civil engineering contractors licensed by Ministry of Water Resources, Works and Housing (Dansoh, 2005).

Aside the two organisations, contractors and construction companies may also belong to the Association of Building and Civil Engineering Contractors, Ghana (ABCECG). It is the umbrella employer organisation of building and civil contractors in the country with the main function of negotiating/ bargaining on behalf of their members, with the Construction Allied Workers Union (CBMWU) of Trade Union Congress (TUC) for the Collective Agreement which is done bi-annually (Agbodjah, 2008).

3.3.2 Building Project Procurement

The construction process involves the translation of the client's needs and intentions, first into documents and other information and later into the physical item (Ofori, 1996). The process may be organised in several ways and the sequence of activities may also differ from one project to another depending on the type of client, design input, size of project, time available, availability of resources, nature of project, legal requirements, financial commitment of client, sources of funds, previous experience and desire for change, level of quality required, certainty, flexibility, level of risk and value of proposed work (Walker, 2007; Agbodjah, 2008).

In general, the separated/traditional/conventional method of procurement is widespread; however several exceptions exist to this general organisation of the

building process [Figure 3.2]. They include the integrated systems like Design and Build; management-oriented systems like management contracting, construction management and project management; and discretionary systems (Baiden, 2006). These procurement systems describe the different methods, process and procedures for designing and constructing a client's project. They also provide the organisational structure of project teams: the individual roles, responsibilities and authority (Rashid et al., 2006). The procurement systems are adequately discussed by Baiden (2006).

In Ghana as is the case generally, the traditional/conventional procurement system is used for the majority of works (Ameyaw, 2009). Whereas the private clients have no explicitly laid down procedures for procurement of works, the public clients are regulated through the use of the Public Procurement Act 663. The application of the Act is mandatory for works, goods and services procured for public entities or with public funds except in very exceptional circumstances.

In the procurement of works which in this case includes building, the Act outlines four methods of procurement: competitive, two-stage, restricted and single source procurement. In all these methods, the Act encourages the development of some sort of specifications, plans, drawings and designs that provide the technical or quality characteristics of the works to be procured. It is upon this basis that standard tender documents are prepared for tendering processes and contractors selected for the construction of the project. Although detailed characteristics of a project cannot be developed before contractor selection in all cases, it is preferred whenever possible. This means then that the Act essentially encourages the use of the traditional procurement system.

Although private clients are not bound by the Public Procurement Act 663, some prefer to follow the competitive procurement procedures stipulated by the Act so as to provide their procurement processes with some level of transparency. This process is a sequential one in which detailed drawings and specifications are used to solicit competitive bids for construction. Even with informal clients or clients in less structured environments who prefer to employ direct labour to undertake construction rather than the use of formal contracts, the designs, plans and drawings are normally finalised prior to the actual start of the construction.

This study focuses on the traditional/conventional procurement system in view of the preference for the traditional mode of procurement in Ghana.

3.3.2.1 Traditional Procurement

In this type of procurement system, the responsibilities for design and construction are carried out by separate organisations and the stages of feasibility study, preliminary design, documentation, construction and handing-over do not coincide but follow each other [Figure 3.3]. The client employs the services of independent consultants who design the project and prepare tender documents. The tender documents serve as a basis on which contractors then bid to carry out the project; normally for a lump sum. The successful contractor then enters directly into a contractual agreement with the client and is supervised by the design consultants. The architect often serves as the leader of the project and represents the client to implement the design process and ensures that the project is delivered on time and on budget. Each member of the project team has contractual relations with the client.

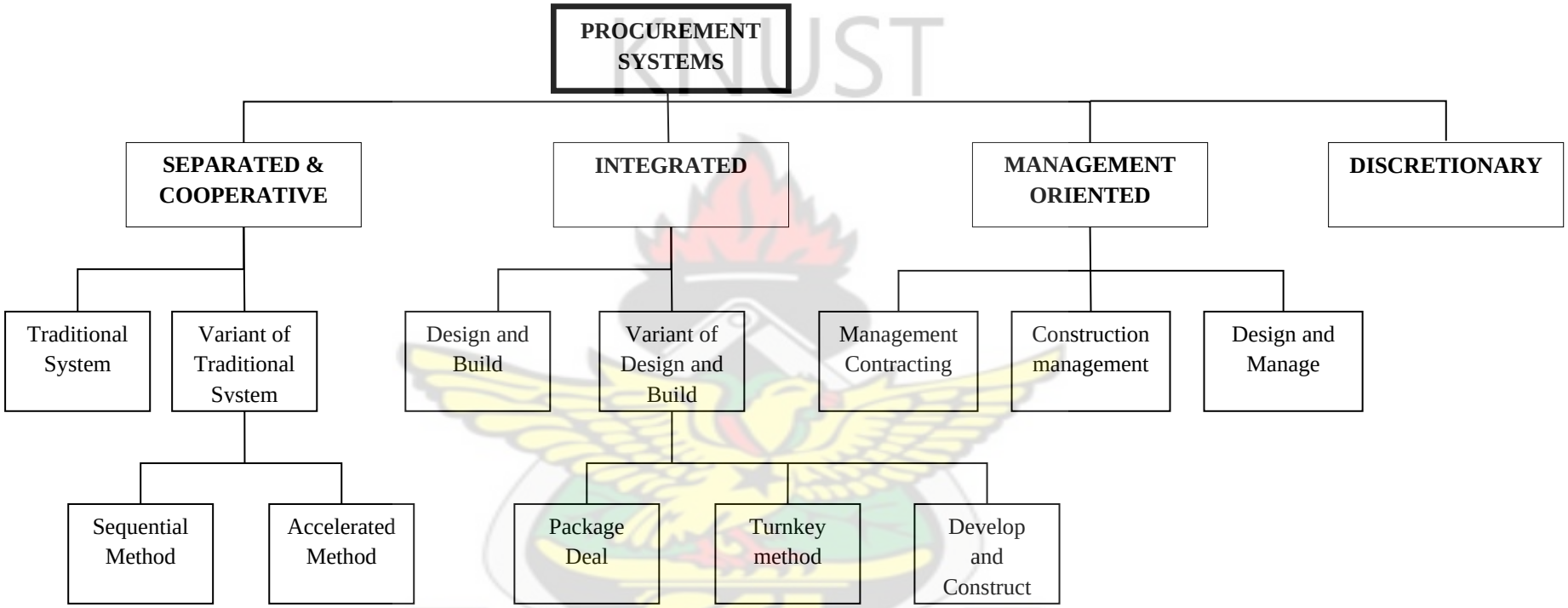

Figure 3.2 Building Procurement Systems

Source: Rashid et al. 2006; Baiden, 2006

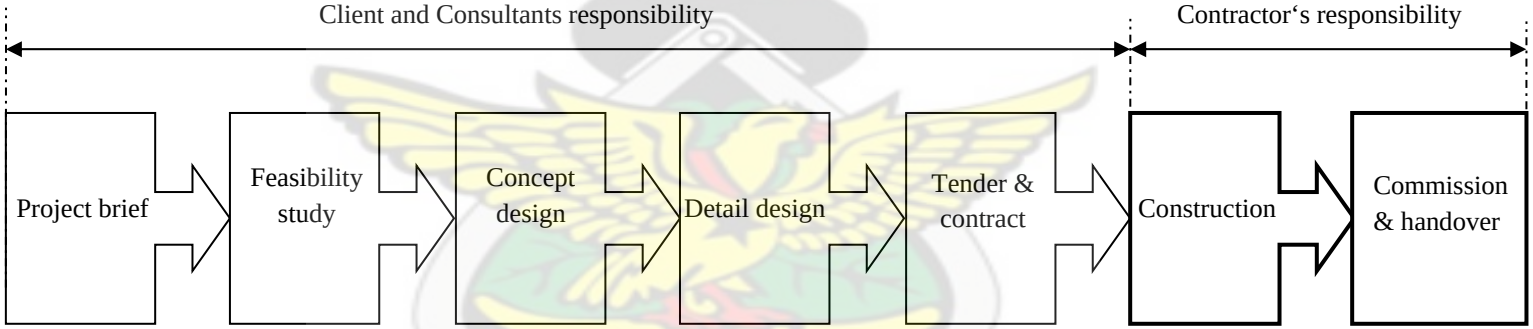

Figure 3.3 The Linear Process of the Traditional Procurement System

Source: Rashid et al., 2006

By virtue of the nature of the traditional procurement system, it affords the following advantages:

- The system is well established, easy to understand and familiar to most project participants
- The client has a clear idea of the total cost of the project before committing to it
- A firm contractual date is set since the entire volume of work is known and adequate plans can be made for the construction stage
- The client is assured of quality since he is able to retain control of the design and construction of the project
- Interim valuations, variations and changes to the contract are easily identified and relatively easy to handle due to the availability of a bill of quantities. The system also lends itself to better cost control
- Since contractors compete for the job, the client has the advantage of obtaining a competitive price for the project.

The traditional procurement system however has a number of disadvantages which are the basis for the introduction of alternate systems. The disadvantages include:

- Because construction starts only after the design has been fully completed, the traditional system is considered slow and time consuming
- The manner of organisation of the system lends itself to adversarial attitude among the individuals involved.
- The contractor is unable to contribute his expertise to the project design since he only comes in after design is complete

3.3.3 The Design Process[2]

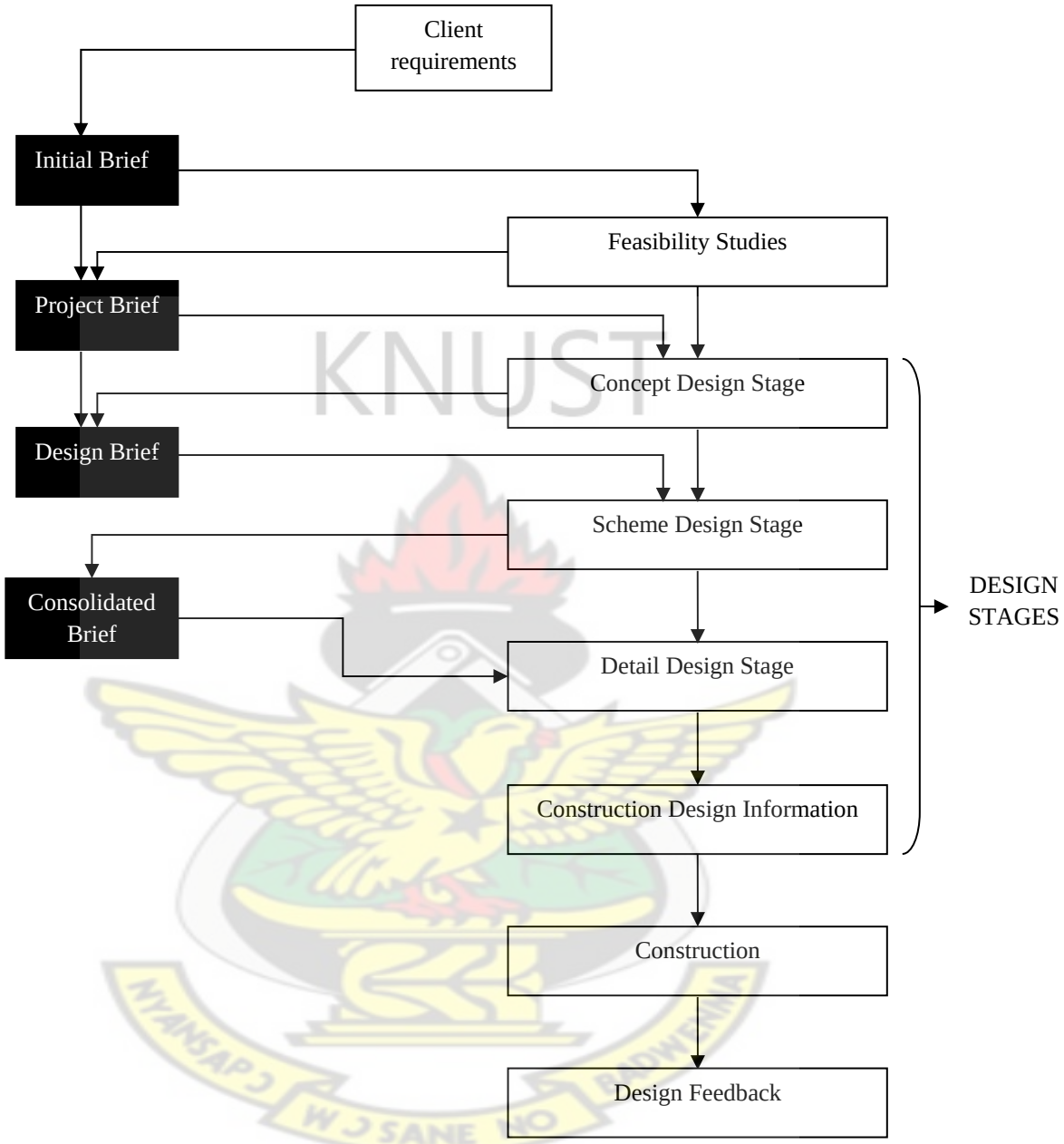

Figure 3.6 The Design Process

Source: Bonney, 2011; British Standards Institute Staff, 1996

The construction process is often divided into a number of stages: conceptual, design, construction, and operation and maintenance stages (Ofori, 1996). The four

[2] The process presented in this section is a generic one. The extent and level of detail of the process varies from project to project

stages can be further divided into sub stages: inception and initial brief, feasibility study and brief development, scheme design, detail design, construction information, construction and post-construction (British Standards Institute Staff, 1996). Where the traditional procurement system is used, the design stages are separate from the construction and have to be completed prior to construction. Consequently, all the details and decisions regarding the project, for instance a decision to incorporate photovoltaics in the building, will be made in the design stages. It is for this reason that the design process is the focus of this section.

The design process is iterative and made up of stages that all projects go through [Figure 3.6]. However, the extent and level of detail of activities within each stage varies from project to project (Bonney, 2011). Hence understanding of this generic design process is relevant to understanding the design in the Ghanaian building industry. Although the conceptual, scheme and detail design as well as construction design information stages make up the design stages, the various stages and briefs of the overall plan of work are described in the following sections.

3.3.3.1 The Briefing Process

The initial brief is a preliminary statement which maybe a broad statement of intent or comprehensive technical statement of the client's requirements. This statement rarely has sufficient information to develop a design (British Standards Institute Staff, 1996).

The project brief is a statement covering the technical and managerial intentions derived from and meeting the requirements of the initial brief. It is more specific than the initial brief and marks the starting point for the development of a design brief (British Standards Institute Staff, 1996).

The design brief is a document derived from and compatible with the project brief, that defines all design requirements. It is a comprehensive technical interpretation of the project brief for the component disciplines within the design team (British Standards Institute Staff, 1996).

The consolidated brief is the final brief resulting from the brief development process and is the basis for detailed design. A thorough briefing process should ensure that a comprehensive consolidated brief is developed and approved by the client in order to reduce the likelihood of disruptive late changes. This final report should contain

a. introduction (purpose of the client report and its significance to the client);
b. list of principal participants (client, architect, engineer, planning supervisor, other consultants);
c. identification of design personnel and other significant resources;
d. research undertaken and outcome;
e. discussion of options, constraints and conclusions;
f. description of proposed design solution
g. cost plan;
h. on-going design programme;
i. drawings;
j. supporting calculations

(British Standards Institute Staff, 1996).

3.3.3.2 Feasibility Studies Stage

A feasibility study involves the preliminary investigations of a number of project options to determine the optimum solution and how easily and conveniently the project can be done. Evaluations are made based on the adequacy of the designs in

terms of technical issues, cost, quality and time constraints. In dire circumstances, the development of the project may be discontinued in the light of negative results of feasibility studies. The output of this stage is a project brief.

3.3.3.3 Concept Design Stage

At this stage of design, the project brief is used to guide the development of a number of suitable concept design options using methods such as group working or brainstorming. These options are then evaluated to determine the best solution that best fits the client's key success criteria and complies with statutory requirements. The output of the stage is the design brief (British Standards Institute Staff, 1996).

3.3.3.4 Scheme Design Stage

At this stage of design, the concept design information is converted into a workable solution by developing and detailing the concept design. Decisions are made on planning arrangements, appearance, spatial relationships, loading, construction methods, outline specification and costs. The deliverables of this stage is the consolidated brief. This stage marks the end of the development of the final design (British Standards Institute Staff, 1996).

3.3.3.5 Detail Design and Construction Design Information Stages

These stages involve the detailing of the deliverables from the scheme design stage. By the end of these stages the design team is expected to produce a detail design specifications, plant and equipment specifications, detail design intent drawings, cost estimate for the detail design and all documents necessary for the tendering process. All relevant product information, fabrication drawings and specifications should have been prepared and all design activities should have been completed by the end of these stages (British Standards Institute Staff, 1996).

3.3.3.6 Construction

The design related aspect of this stage is the evaluation of performance and quality to ensure that the building meets requirements as described in the design detail report and construction design information. The commissioning of the project upon construction demonstrates the workability of the design (Bonney, 2011).

3.3.3.7 Design Feedback

This stage involves a systematic means of collecting feedback that can be used to inform future designs. The feedback stage highlights the good aspects of the design as well as aspects that need to be improved and is considered a critical facet of the design process (ibid).

3.4 Building Technologies and Building Materials in Ghana

Building types and methods in Ghana have been determined by the nature of the social structure and religious ideology, the available materials, changing technology, the range of economic activity as well as foreign influences. Owing to the influence of these factors building methods and types have gone through distinct stages of development (Schreckenbach & Abankwa, 1983). The individual choice of a type of building material depends on the cost, availability and the individual's ability to pay for it (Ghana Statistical Services, 2005)

In rural areas, although there is some variety in residential structures, people typically stay in some version of a residential compound consisting of a number of structures that create an enclosure around an open courtyard. A typical compound comprises a kitchen, bathroom, living areas and sleeping rooms. Round houses are more common in northern areas whereas rectangular ones are common in southern and central regions. Construction materials used in traditional houses vary and range

from packed mud, earthen bricks to cement blocks for the walls; rough timber or bamboo poles for the roof frames and mud, palm branches and aluminium sheets for the covering. Mud is however the most popular material in traditional architecture (Schreckenbach & Abankwa, 1983; Farrar, 1996; Salm and Falola, 2002; Acquaah-Harrison, 2004).

Religious structures such as shrines are most often the most striking buildings in a given area and are elaborate buildings with artwork and regalia adorning the walls, furniture and floors. In the northern areas some mosques were designed using triangular clusters of mud pinnacles with protruding wooden spokes held together by horizontal wooden crosspieces (Farrar, 1996; Salm and Falola, 2002).

Urban architecture is however different from that in the rural areas owing to social and cultural influences of a greater variety. Urban centres tend to have more heterogeneous architectural environment than rural settlements. Although there are traditional rural patterns, these exist side by side with modern structures residences designed for nuclear families. These include nineteenth-century colonial style buildings, multilevel elegant mansions of the elite, with large porches, lush green gardens and whitewashed walls as well as modern glass and steel skyscrapers and apartment complexes. There are also modest single and multi-storey brick and cement houses. Also present are impressive administrative and commercial buildings (Farrar, 1996; Tipple et al., 1998; Salm and Falola, 2002).

3.4.1 Building Materials

Mud is a traditional material for walls, floors and roofs with various techniques depending on the developer's financial position, local skills, climate and availability of materials. The use of this material has however been prohibited in urban areas

(Ofori, 1985). Cement, steel reinforcement and aluminium roofing sheets are key building materials in Ghana (Ofori 1985; Tipple & Korboe, 1998). The average conventional building in Ghana today has a reinforced concrete frame and sandcrete blockwall infill. The various materials used in the construction in Ghana are presented in **Table 3.3** together with their uses and the levels of usage of some materials are presented in **Table 3.2**.

Table 3.2 Level of Material Usage in Ghana

MATERIAL	PERCENTAGE OF MATERIAL USE		
	Country	Rural	Urban
Outside Wall Construction			
Mud brick/earth	48.6	74.7	21.6
Cement blocks/concrete	39.6	16.5	65.4
Wood	3.9	2.6	5.3
Sandcrete/Landcrete	2.8	2.7	2.9
Roof			
Corrugated metal sheets	60.7	56.5	65.3
Thatch/palm leaves/raffia	18.0	30.8	3.7
Slate/asbestos	13.1	3.9	23.5
Floors			
Cement/concrete	72.0	59.0	85.6
Earth/Mud brick	23.8	38.2	7.7
Terrazzo	2.7	-	-
Vinyl	0.7	-	-
Ceramic tiles	0.5	-	-

Source: Acquaah-Harrison, 2004

Table 3.3 Building Materials in Ghana

BUILDING MATERIALS	USES
Sand	For concrete and mortar mixes and block making
Gravel	A source of fine and course aggregates for concrete mixes
Laterite	For monolithic floor and wall building material, sundried laterite blocks and burnt bricks
Clay and clay products	For burnt bricks and roof tiles
Kaolin (china clay)	For the production of sanitary ware and wall tiles
Stones	A source of aggregate and are in some cases used for the construction of load bearing elements in buildings
Grass and leaves	For thatching in roofs and for the construction of fences
Fruits and barks	For plastering and as wall and floor stabilizer
Bamboo	For the construction of storage barns, framework for wattle and daub construction, roof structure and fencing
Timber	For timber frame construction, windows, doors and their frames, roof structure and as floor and wall finishes
Stabilized soil blocks	For wall construction
Cement (Portland, pozzolana and the like)	For mortar and concrete mixes
Concrete	For building frame
Asbestos-cement	For roofing and pipes
Aggregates	For concrete mixes
Metals (steel and aluminium are the most commonly used)	For structural framework, reinforcement bars, pipes, conduits, roofing sheets, doors, windows and their frames
Bituminous products	For damproof membranes/ courses, special flooring
Glass	Mainly for glazing
Plastics	For rainwater, waste and drainage pipes
Paints	For protection of surfaces and decorative effects

Source: Schreckenbach & Abankwa, 1983

3.4.2 Building Technologies

There are several different building technologies in Ghana. Those that can be described as typically indigenous technologies and normally found in rural settings include:

a. Bamboo posts and beams with roofs covered in thatch or palm fronds. This technology is used in structures that are put up for cooking areas, general storage and animal shelters. The technology as an open shelter also serves as bathrooms.

b. 'Klabaxo' is a type of construction by 'Anlo' fishermen. It comprises of thatch construction for the whole house and is used as temporary housing. The walls are made of plaited coconut or palm leaves with a timber frame structure of posts and beams.

c. Wattle and daub construction is made up of a timber or bamboo framework with wet moulded mud balls worked into the framework. The building is normally covered with a thatch or shingle roof.

d. 'Atakpame' is a construction technology in the south of Ghana using wet mud balls moulded in layers. A similar method of building with mud balls is carried out in the north. The difference in construction lies in the width of the walls and plan of the building: typically round or rectilinear in the north and rectangular in the south. The roofs are made of thatch or mud in the north or with corrugated iron sheets on a timber structure in the south. This technology developed in the south because of the problems associated with the wattle and daub construction. Wattle and daub required more skill and

was tedious. Furthermore termites attacked the timber framework of buildings constructed using wattle and daub.

(Schreckenbach & Abankwa, 1983; Farrar, 1996; Salm and Falola, 2002)

Other building technologies within the Ghanaian building industry include timber frame construction, stone construction, cement block construction, unfired and fired brick construction and sawn timber construction. These technologies gained acceptance and in certain cases displaced indigenous construction because they are relatively easier, faster and give better quality assurance (Manu et al., 2009). Currently though reinforced concrete frame and sandcrete blockwall infill construction is the most common.

3.5 Implications of Ghanaian Building Industry Characteristics on Study

On construction projects, the decision-making process involves a large number of specialists with varied interests and idiosyncrasies. The construction process and product is therefore related to the organisational structure since the organisational structure determines how people work together to produce the output that forms the basis on which decision is made. While the client is often responsible for making the final decisions, he takes these decisions based on the advice of consultants (Walker, 2007). Consequently, the adoption of photovoltaics will depend to a large extent on the decisions of the client and his consultants and so they are the focus of the study.

As mentioned earlier in Section 3.3.2, the traditional form of procurement is common in the Ghanaian building industry and so the choice of the population of the study is made taking this into consideration. In this system the contractor is brought in after decisions are made and so is not part of the decision-making process; thus

not a subject in this study. The client by virtue of his role as the initiator and responsibility in making major decisions is part of the study. The architect and electrical/mechanical engineer are selected among the consultants to also be part of the study: the architect because of his role as the project leader and representative of the client, and the electrical/mechanical engineer because photovoltaics are regarded as electrical installations and within his purview.

The methods of the research and the role these selected individuals played in the study are described in the subsequent chapter.

CHAPTER FOUR

RESEARCH DESIGN AND METHOD

4.1 Introduction

This chapter presents the methods used for the research which were a survey of four hundred and twenty-two (422) building participants and a holistic multiple case study of the adoption of three innovations in the Ghanaian building industry. The chapter provides details of the survey and case study, the principles and procedures as well as tools that were employed in achieving the objectives of the study. It also presents the philosophical worldview adopted in the study with its basic considerations and how the worldview shaped the approach to research.

4.2 Research Philosophy

In any research project it is important to justify the choice of research methods and techniques that are employed in the research. This justification depends on the theoretical perspectives (also called paradigms or worldviews) that the researcher brings to the work (Morgan & Smircich, 1980; Guba & Lincoln, 1994; Crotty, 2010). The theoretical perspective refers to "the philosophical stance informing the methodology and thus providing a context for the research process and grounding its logic and criteria" (Crotty, 2010). The theoretical perspective derives from the ontological and epistemological assumptions as shown in Figure 4.1.

Ontology involves the philosophy of reality; epistemology addresses how we come to know that reality while methodology identifies the particular practices used to attain knowledge of it (Krauss, 2005). In dealing with epistemological assumptions

the questions regarding the relationship between the observer and the observed, how we come to know and what counts as knowledge are tackled.

The theoretical perspective adopted in this study is that of positivism albeit a more tempered form of positivism referred to as post-positivism.

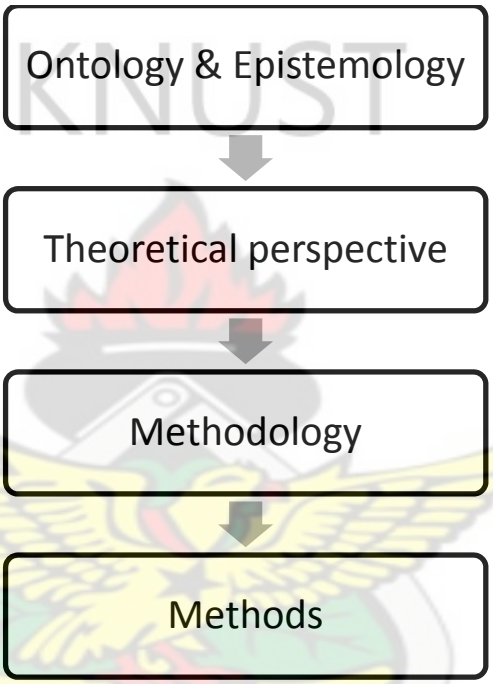

Figure 4.1 Basic Elements of Any Research Process (Crotty, 2010)

At the ontological level this study adopted a critical realist position that holds that there exists a 'reality out there' independent of the observer (i.e. the observed and observer are independent) and that this external world comprises of pre-existing hard and tangible structures. This reality is however "imperfectly apprehendable because of flawed human intellectual mechanisms and the fundamentally intractable nature of phenomenon" (Guba & Lincoln, 1994). This means that one cannot be sure that ultimate truth has been uncovered; however, that reality is "out there" cannot be doubted (Guba, 1990).

The researcher holds an epistemological position which emphasises the need for the researcher to acquire knowledge of the subject of study objectively from a detached position and the repeatability of the research (i.e. it advocates the use of natural science methods to the study of the social world) (Lincoln & Guba, 1994; Baiden, 2006). The ability to do this in practice is recognised as being difficult given the evidence provided by Heisenberg Uncertainty Principle and Bohr Complementarity Principle (Guba, 1990; Crotty, 2010). As a result, objectivity becomes an ideal that can only be achieved relatively closely by ensuring consistency with existing scholarly tradition and submitting the inquiry to peer critique and judgement.

Methodologically, a modified experimental/manipulative approach where "questions and/or hypotheses are stated in advance in propositional form and subjected to empirical tests (falsification) under carefully controlled conditions" is used (Guba, 1990 pp. 20). However, emphasis is placed on critical multiplism where inquiry relies on many different sources – of data, investigators, theories and methods – as possible to reduce the likelihood of distorted interpretations.

The choice of philosophy has implications for the study. According to Lincoln and Guba (1994), it defines for the inquirer what they are about and what falls within the limits of legitimate inquiry. The implications of the chosen theoretical perspective on practical research issues are outlined in Table 4.1.

4.3 The Reasoning of the research

Deductive and inductive reasoning are different but equally valid routes to drawing conclusions in a scientific research (Babbie, 2008). These approaches involve logic (theory) and observation (data) and how these two pillars of science are related in a piece of research.

Table 4.1 Paradigm Position on Selected Practical Issues

ISSUE	POSTPOSITIVISM
Inquiry aim	Explanation: prediction and control
Nature of knowledge	Non-falsified hypotheses that are probable facts or laws
Knowledge accumulation	Accretion, generalisations and cause-effect linkages
Goodness or quality criteria	Internal and external validity, reliability and objectivity
Values	Excluded/ Value free

Source: Guba & Lincoln, 1994

All research works include some theory or data: however the links between theory and data and how they are used differ. Clearly defining or being aware of how the theory and data fit into the research process produces a study that is better designed, understood and conducted. This section provides a discussion on the link between theory and data in order to outline the use of existing knowledge in the form of literature study and its link to data collection within this research.

This study employed a deductive approach [Figure 4.2]: the logical model in which specific expectations of hypotheses/propositions are developed on the basis of general principles (Babbie, 2008). In the study, research hypotheses/propositions were deduced from theory through the process of logical reasoning (Miller & Brewer, 2003). The objective of the research was to test the classical diffusion theory and Hartmann et al.'s (2006) framework in a new context of the Ghanaian building industry, hence, the theory as presented in chapter two was used as a framework for the entire study, an organising model for the research questions and the data collection (Creswell, 2009).

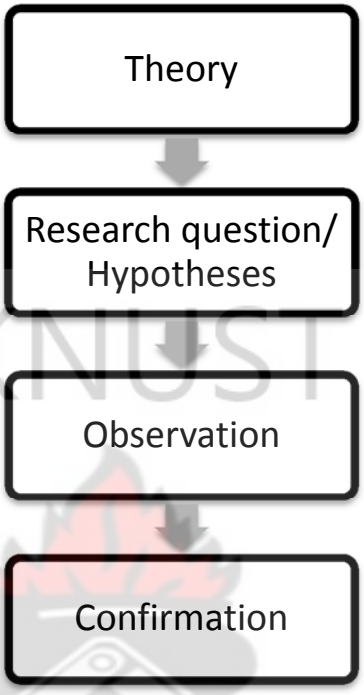

Figure 4.2 Deductive Thinking in Research

Source: Babbie, 2008

4.4 The Research Method

Many methods are available; and although one method is no better than another, some methods are best suited to specific issues and have an elective affinity with certain philosophical perspectives. The selection of this study's research methods was guided by philosophical assumptions, an evaluation of previous studies and the research aim and objectives [Figure 4.3].

Considering the emphasis placed on critical multiplism dictated by the theoretical perspective selected, a mixed method approach in which the methods compensate for each others' biases is ideal. Therefore, the study employed the use of two methods of inquiry for the research: survey and case study methods of research. Adequate efforts

were also made to reduce the biases by adhering to the requirements of reliability and validity, and submitting the inquiry to peer critique.

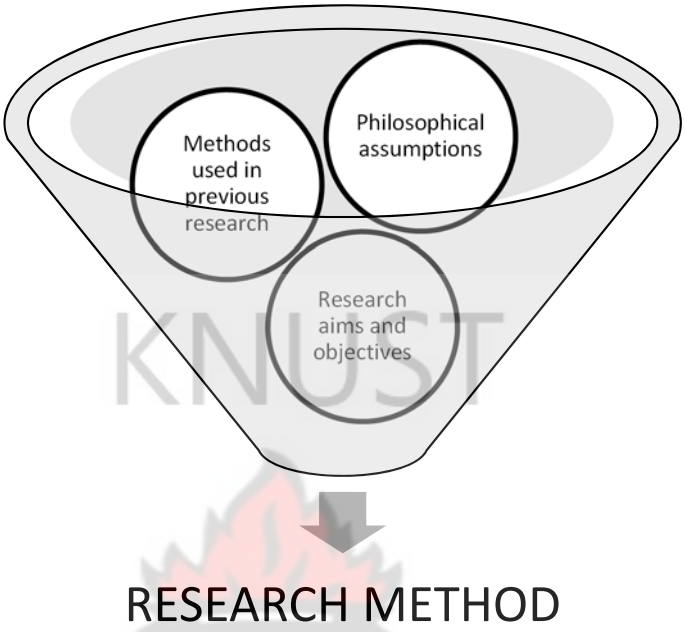

Figure 4.3 Choosing a Research Method

Source: Rogers, 2003; Creswell, 2009

The following section outlines the selection criteria for the method used in this inquiry: previous research was first explored to find the approaches available and the selection criteria proposed by Yin (2009) were then used to select the appropriate method.

4.4.1 Selection of research method

In diffusion research, two major research approaches are applicable- Variance research and Process research depending on the aim of the research (Gopalakrishnan & Damanpour 1994, Subramanian & Nilakanta, 1996). Whereas variance research involves data gathering and analysis that consists of determining the covariances (correlations) among a set of variables, process research seeks to determine the sequence of a set of events over time (Rogers, 2003). Consequently, variance

research involves quantitative methods which measure variables by assigning numerical values to behaviour and process research involves qualitative methods.

Yin (2009)'s selection of a research method is based on three conditions: a) the type of research question posed, b) the extent of control an investigator has over actual behavioural events, and c) the degree of focus on contemporary as opposed to historical events.

Table 4.2 Relevant Situations for Different Research Methods

Method	Form of Research Question	Requires Control of Behavioural Events?	Focuses on Contemporary Events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/no
History	How, why?	No	No
Case study	How, why?	No	Yes

Source: Yin, 2009

Going by Yin's (2009) first condition, some of the questions that the empirical portion of the research focused on were "what" questions that centred 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. Surveys were 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 PV adoption in the Ghanaian building industry were not available. There was also a "how" and "why" question

which favours the use of case studies, experiments or histories. However, case study was selected because of the lack of control of the researcher over events and the fact that the phenomenon studied was a contemporary one. The choice of the case study strategy was also informed by the complex and multivariate nature of the explanatory theory employed in the research and the presence of many more variables than data points. A situation that is overcome by the case study since the inquiry embraces this complexity by investigating the phenomenon within its real-life context.

In addition, the choice of the survey and case study methods were appropriate in the light of the aim of the study which was to describe and understand the potential factors that influence photovoltaic adoption in the Ghanaian building industry. The survey was a cross-sectional one with data collected at one point in time rather than over time and involved the use of a structured self-administered questionnaire. It involved a survey of the adoption behaviour and perceptions of architects, electrical/mechanical engineers and clients within the building industry of Ghana with regard to photovoltaic energy technologies. The case study was a holistic multiple case study involving three cases and the use of semi-structured interview.

4.5 Phase 1: Survey Design

4.5.1 Questionnaire Design

As mentioned in section 0 the instrument used for this study was a structured questionnaire that was designed specifically for the study. The nine (9) page questionnaire was made up of a preamble explaining the purpose and structure of the questionnaire; and three sections or parts: Part A dealt with questions on communication channels and the significance of other factors that influence

innovation adoption-decision; Part B was on the source and level of PV knowledge and attributes of photovoltaic energy technologies while Part C solicited for background information on respondents. A cover letter was also included as part of the questionnaire to explain its purpose. The questionnaire contained a total of fifteen (15) and seventeen (17) questions for clients and consultants respectively. The development of the questionnaire went through a number of stages outlined as follows:

a. Preliminary informal interviews were conducted to discuss people's perceptions and experiences related to the use and adoption of solar technologies in buildings in Ghana. Those interviewed included employees at the Ghana Energy Foundation and Energy Commission, building professionals and researchers. These interviews brought to light the issues surrounding energy generation and use in Ghana and hence helped identify clearly the research problem (the low levels of PV adoption in Ghana) to be investigated and the major issues the questionnaire was to tackle. The research problem identified guided and focused the literature review. The interviews also ensured that the problem identified was directly relevant to the Ghanaian context.
b. A review of literature on other surveys and interviews, especially those conducted on similar topics of study, was conducted. The aim was to have an idea of how questions were paraphrased and generated, and also of the format of the survey instrument. The literature review also provided the theoretical framework of the research and the relevant variables included in the instrument. The theoretical framework made it easier to identify new information that may extend the boundaries of the selected framework.

Furthermore, the framework also presented the options of method available for the study and provided a reference point around which the discussion of the results and findings were centred.

c. A draft of the questionnaire was developed and reviewed following guidelines provided by Fowler (1995). The questionnaire was then pretested. At this stage the main aim was to determine whether the questions were easily and consistently understood by asking the individuals involved to say in their own words what they thought the questions were asking.

d. Finally the questionnaire was formally field tested on fifteen (15) clients and professionals from each category of respondents of the main survey and some researchers in the building industry. The formal field testing was in two stages. In the first stage, ten (10) clients and professionals were first asked to complete the questionnaire and thereafter led through a discussion by the researcher or asked to complete an assessment form [Appendix 2] on the adequacy of the instrument: the instructions, questions and answers provided. Based on the comments by the respondents, the questionnaire was modified and retested on five (5) clients and professionals. At the second stage of the pre-test the questionnaire was converted to a web-based questionnaire using an internet survey tool (Kwiksurveys). The aim of the pre-test was also to test this mode of data collection after which the questionnaire was finalised.

4.5.2 Sampling and sampling procedures

4.5.2.1 Defining the population and sample frame

The research problem of this study dealt with the clients and professionals that are involved in decision-making that relates to building design within the building

industry. As indicated in chapter three, the client together with the architect and other consultants who serve as advisors are responsible for making decisions concerned with the design of a building. Consequently, the building clients, architects and electrical/mechanical engineers were the focus of the study and made up the population of the study as indicated previously in Section 3.5. The total population is however unknown since the total number of clients, architects, electrical and mechanical engineers within the Ghanaian building industry 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.

4.5.2.2 Sampling frame and sampling procedure

The sampling frame was made up of clients, architects and electrical/mechanical engineers. The architects and electrical/mechanical engineers were selected based on the list of members as at February, 2011 provided by their various professional institutions: Ghana Institute of Architects (GIA) and Ghana Institute of Engineers (GhIE) respectively. There were five hundred and eighty-six (586) architects on the list provided by GIA and twenty-four (24) electrical and mechanical engineering firms[1] on the list from GhIE. In the case of the clients, there was no immediately accessible list hence architects surveyed were asked to provide names of clients they worked with to develop an ad-hoc list. In addition, emails were sent out to nine hundred (900) contacts requesting participation in the survey by eligible individuals,

[1] The list provided by the GhIE was made of electrical/mechanical engineering consulting firms within the building industry rather than individual electrical/mechanical engineers.

in order to supplement the list of clients provided by the architects and electrical/mechanical engineers. In all seventy-five (75) names of clients were obtained.

Aside the problem of an unavailable formal list of building clients, other problems were encountered during sampling: The list provided by the GhIE was made of electrical/mechanical engineering consulting firms within the building industry rather than individual electrical/mechanical engineers. This problem of clustering was addressed by including all the electrical/mechanical engineers in each firm on the list (Israel, 1992a). Also, the telephone contacts provided for some firms were incorrect or out of use and some firms were no longer in business whilst other firms were not included in the list. Efforts were made to update the list as much as possible by asking electrical/mechanical engineers surveyed to provide information on the colleagues and contact details omitted from the list. The internet and telephone directory were also consulted for information on contact details of firms that were missing from the list. In all, questionnaires were sent out to twelve (12) out of twenty-four (24) firms.

With regard to the GIA list, some email addresses provided in the list of architects were also incorrect whilst other architects had no accompanying email address or telephone contact detail. Where possible, the architects with incorrect email addresses were contacted via telephone for their email addresses.

Once the sampling frame was obtained and corrections made, the sample used in the study was selected using stratified sampling, which is a probability sampling method in which the population is split into groups (strata) and then a random (without replacement) sample selected from each group (strata). This procedure was

employed to ensure that the sample selected deliberately accounted for the different groups that made up the study population.

4.5.2.3 Sample Design

Sample Size Determination

The aim of sample size determination is to ensure that the sample size calculated is adequate enough to precisely estimate population parameters (Naing et al., 2006). By virtue of the need to estimate the precision of the sample estimates, probability sampling was employed in selecting the sample.

Minimum sample size was calculated using the following formula developed by Cochran (1963):

Equation 4.1 Sample Size Determination Based on Proportion

$$n = \frac{(Z_{0.05})^2 p(1-p)}{E^2}$$

n = sample size

Z = the z-score from a normal distribution table at 95% confidence interval (1.96)

p = degree of variability/distribution in the population of the attribute(s) being measured, 0.50 was selected since this value of 'p' is the maximum variability in any population and gives a higher sample size than if the true variability of the population attribute (which in this case is unknown) were used (Israel, 1992b).

E = sample error/level of precision which is assumed to be 0.1 for the study (Nani, 2009)

The level of precision selected determines the width of the confidence interval of the calculated estimate. Ideally, a narrower confidence interval is desired since it is an

indicator of a good estimate of the population parameter required. However, in the case of resource limitations, investigators may use a large level of precision (Naing et al., 2006). In this study therefore, the large precision of 10% used was in the light of limitations especially those pertaining to the availability of research subjects.

Equation 4.1 was used instead of the **Equation 4.2** because the later requires a good estimate of the population variance which is unavailable in this case. Besides as mentioned earlier the sample size formulae based on proportions using a maximum variability produces a more conservative sample size than that using the sample size of the mean (Israel, 1992b).

Equation 4.2 Sample Size Determination Based on the Mean (Israel, 1992b)

$$n = \frac{(Z_{0.05})^2 \sigma^2}{E^2}$$

n = sample size

Z = the z-score from a normal distribution table at 95% confidence interval (1.96)

σ = the variance of an attribute in the population

E = sample error/level of precision

Therefore minimum sample size

$$n = \frac{(1.96)^2 0.5(1-0.5)}{0.1^2}$$

$$n = 96$$

Sample Size Allocation

The calculated minimum sample size of ninety-six (96) was the total for the stratified sample of architects, clients and electrical/mechanical engineers hence, the number of elements from each stratum had to be allocated to the sample. Two methods can be employed in the allocation: Proportionate and Disproportionate allocation methods (Hair et al., 2011). In the Proportionate allocation method, the sample size

of each stratum is calculated such that its proportion to the total sample size is the same as the proportion of the size of the stratum to the population, whilst Disproportionate allocation method allocates the sample without regard for the proportion but rather based on a judgement of the relative importance of the various strata (e.g. economic importance) or the variability of the data in each stratum (Hair et al., 2011).

In this study, the choice of disproportionate sample size allocation based on the researcher's judgement of relative importance of the various strata was made. This was because the variances for each stratum could not be calculated in order to use disproportionate size allocation method based on variance. In the case of the proportional sample size allocation, the fraction of units falling into each stratum was readily available however the allocation for clients and engineers was just too small [Table 4.3].

Table 4.3 Sample Size Allocation to Strata

Strata	Target Population	Proportion of Population	Proportionate Sample Size*	Disproportionate Sample Size*
Architects	329	0.780	75(78%)	39(40.5%)
Building services engineers (electrical/mechanical)	18	0.042	4(4%)	18(19%)
Clients	75	0.178	17(18%)	39(40.5%)
Total	422	1.000	96	96

* Calculations have been rounded off

Data Collection

Actual data collection was carried out using dual methods. The initial distribution of the questionnaires was done via email and then a second phase involved the distribution of hard copies of the questionnaire. In the case of email distribution, respondents were first sent an introductory email informing them of the impending survey and explaining the purpose of the survey. Subsequently, a second email containing a hyperlink to access the survey was sent followed by two reminder emails a week apart. Respondents who failed to respond to the questionnaire were then contacted by telephone.

Some respondents expressed preference for hard copies of the questionnaire and were therefore furnished with them. In all three hundred and twenty-nine (329) questionnaires were distributed to architects, eighteen (18) to electrical/mechanical engineers and seventy-five (75) to clients. Although only thirty-nine (39) architects and thirty-nine (39) clients were required to respond based on the minimum sample size calculated [Table 4.3], all three hundred and twenty-nine (329) architects and seventy-five (75) clients were surveyed. This was done to cater for any possibility of lower response rates because of the use of internet based questionnaires which is an uncommon data collection method in Ghana.

Once the questionnaires were distributed, respondents each received reminders through emails, short message services (sms) and telephone calls to complete the questionnaire. In total, sixty-nine (69) completed questionnaires were received from architects, eighteen (18) from electrical/mechanical engineers and fifty (52) from clients.

4.5.2.4 Questionnaire Response Rate

In all four hundred and twenty-two (422) questionnaires were distributed, out of which one hundred and thirty-nine (139) were returned. As indicated earlier a combination of drop-in and e-mail/web-based data collection methods were used for the distribution of the questionnaire.

Table 4.4 Response Rate

Respondent Groups	Questionnaires Distributed	Questionnaires Returned	Response Rate
Architect	329	70	21%
Electrical/Mechanical engineers	18	18	100%
Clients	75	52	69%
Total	422	140	33%

The survey was a voluntary response survey and hence clients and professionals could choose not to respond to the questionnaires. One hundred and thirty-two of the questionnaires returned were usable because the web based nature of the questionnaire ensured that all questions were answered. In the cases where non web-based (hard copies) questionnaires were used, they were inspected to ensure that they were appropriately completed.

In order to facilitate the response rate, the following approaches were employed:

- The questionnaire was carefully designed and pretested to ensure that they could easily be understood and completed by respondents.
- Respondents were notified prior to the survey and the importance of the survey was also established in the pre-notification.

Reasonable efforts were made to enhance the response rate. The average response rate obtained was sixty-three percent (33%) which is lower than that obtained by Nani, 2009 (44%) who conducted a study within the Ghanaian building industry. The choice of data collection technique (internet survey) may have accounted for this difference. Nevertheless, the study response rate is comparable to questionnaire surveys conducted by post in the construction industry (response rate of 20% – 30%) (Akintoye and Fitzgerald, 2000) and more importantly the total size of respondents is adequate since the size is above the calculated sample size of ninety-six (96). The analysis and discussion of results are presented in Chapter Five.

4.6 Phase 2: Case Study Design

The second method of inquiry used in this study was the Case Study research strategy. The Case Study research strategy is an empirical enquiry that investigates a contemporary phenomenon within its real-life context especially when the boundaries between the phenomenon and the context are not clearly evident (Yin, 2009). As mentioned prior, the overall theoretical perspective selected in the research (that is post positivism) encourages a mixed methods approach. Furthermore, both qualitative and quantitative approaches have been employed in research on innovation diffusion (Gopalakrishnan & Damanpour 1994, Subramanian & Nilakanta, 1996). Consequently, case study was used in addition to the survey method so that the two methods compensate for each other's biases and limitations. The case study offered the opportunity to draw upon as fully as possible the experiences gained in the adoption of innovations within the context of the study. Rather than asking people what they have generally done under certain circumstances as was the case in the survey, the case study sought to focus on events and situations with regard to particular innovations in the Ghanaian building industry

and elicit from the respondents their specific experiences. This approach compliments the survey research method used by providing more depth and roundedness of understanding in addition to the broad understanding of surface patterns provided by the survey (Mason 2002).

4.6.1 Components of the Case Study Design

The design of a case study according to Yin (2009) is made up of the following five components:

1. The case study questions
2. The case study propositions
3. The units of analysis
4. The logic linking the data to the propositions; and
5. The criteria for interpreting the findings

The rest of this text and the next chapter describe these various components as they relate to the case study that was conducted.

4.6.1.1 The Case Study Questions

The main study question that this case study sought to answer was:

"Why certain selected innovations were adopted or rejected within the Ghanaian building industry" and the objective of the study was "to identify the factors that influenced the adoption of these innovations within the Ghanaian context". The results of the case study will help understand the factors and circumstances that are influenced the adoption of selected products in the Ghanaian building industry. This knowledge can then be used to inform how photovoltaic adoption can be influenced. Often studies of innovation adoption and diffusion focus on individual factors and

their effects but a major concern of the case study was to understand how the factors act together to influence an innovation decision.

4.6.1.2 The Units of analysis

The unit of analysis defines what the "case" is. In this study, the focus was on three innovations within the Ghanaian construction industry. These were Prestressed concrete blocks and beams (fast floors), asphaltic shingles (a type of roof cladding) and pozzolana cement. The study followed a holistic multiple case study design and comprised the three (3) cases mentioned above.

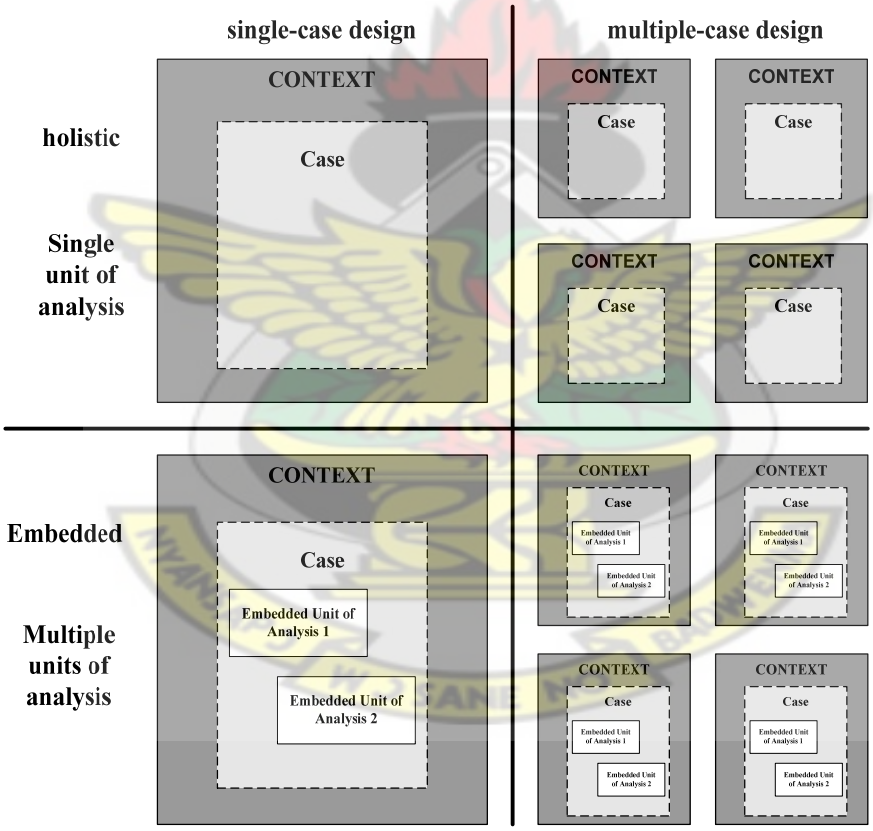

Figure 4.4 Types of Case study designs (Yin, 2009)

The choice of this design was informed by the fact that the evidence from multiple cases is considered more compelling and robust because of the opportunity the design offers for replication logic.

The choice of the products in this study was made so as to be comparable to photovoltaic technology in some way. Given the major emphasis placed on economics in energy efficiency and renewable energy issues, it is upon the basis of economics that the three products are selected. The fast floor and pozzolana cement were therefore selected because their influence on cost is one of the main attributes used to market them[2]. Consequently, the two products are expected, in view of the cost savings they offer and if cost is a major factor for adoption, to have gained acceptance in the industry thereby catering for literal replication of the proposition. The roofing material was chosen to offer theoretical replication in view of its high initial cost[3].

4.6.1.3 The Study Propositions

Although the proposition relied on to select the cases in this study was based on the traditional economic view of diffusion, this study relied on Roger (2003)'s classical diffusion of innovation theory and Hartman et al. (2006)'s framework as described in Chapter Two for the study propositions and to guide the design and data collection process of the case study. This framework includes the narrow economic view of innovation adoption in addition to a more comprehensive and holistic view that makes room for influences relating to the attributes of the innovation and other external or social conditions.

[2] Fast floors according to their producers have the potential to provide cost savings of up to thirty percent compared to traditional insitu floors (IPCP Limited). The initial cost of the ex factory price of pozzolana cement as at August 2012 was GH₵9.00 ($4.66 at a rate of 1.9305) and cost of Portland cement GH₵16.00 ($8.29 at a rate of 1.9305) and hence incorporating pozzolana in mortar at a ratio of 2:1 provides a cost saving of about 14.5%

[3] Cost of only the shingles as at August 2012 was GH₵28.39/m^2 ($14.71 at a rate of 1.9305) whilst aluminium roofing sheets cost approximately GH₵10.20/ m^2 ($5.28 at a rate of 1.9305) and galvanised roofing sheets cost approximately GH₵3.70/ m^2 ($1.92 at a rate of 1.9305)

Rogers (2003) claimed that the perceived attributes of an innovation, the type of innovation decision, communication channels, the nature of the social system and the extent of the change agents' promotional efforts determine the rate of diffusion. Accordingly, the acceptance or rejection of the fast floors, roof system and pozzolana cement in the Ghanaian building industry (which is the social system in this instance) may be attributed to the perceptions of their attributes, the type of innovation decision involved, the type of communication channels used, and the extent of the change agents' promotional efforts rather than the narrow issue of financial costs and benefits. These variables are however not mutually exclusive and the delineation offered by Rogers (2003) provides a simple categorisation that makes the study of the phenomenon easier. In the real-life context all the variables interact and hence; create a complex situation that is better portrayed by Hartman et al. (2006)'s framework and which is best suited to the case study strategy.

The goal of defining and using a guiding theory was to place the case study in an appropriate research literature and enhance the process of comparison between the results of the survey and case study. The theoretical framework also helped to identify the criteria for the selection and screening of potential cases and variables of interest and hence data to be collected. Although the study was designed to solicit information on as many of the variables outlined by the theory, the perceived innovation attributes and how they influence innovation decision were of prominent focus. The use of theory also helped minimize substantive bias that could have affected the design and conduct of the case study (Yin, 2009).

4.6.1.4 Data Collection

The data collection technique employed in the study was semi-structured interview.

The choice of semi-structured interview was because of the fluid nature of interviews and the ability to elicit direct quotations from people about their experiences, opinions and feelings (Patton, 2002). The flexible nature of interviews also encourages participants to participate more fully and comprehensively in the study (Baiden, 2006). This study employed the use of semi-structured interview because of the advantages it offers over the alternate choices as described in Table 4.5.

Table 4.5 Types of Interviews

Type of interview	Main characteristics
Structured	- data collected through formal style of questioning; - little scope for probing responses; - supplementary questions required to obtain more details and pursue new aspects; - respondents choose an answer from alternatives; and - same wording and question for all interviewees;
Semi- structured	- data collected through both formal and informal styles of questioning; - responses can be written and supplemented with recording; - responses limited to subject in question but interviewee is free to add more details if the need be; - provides more details about issue being investigated; - respondents provide topical answers; and - all respondents receive the same major issues.
Unstructured	- data collected through informal style of questioning; - recording responses is most suitable; - respondents say as much as they wish after a brief introduction by the interviewer; - they can be monologues with few prompts to ensure completion of statements; - answers are provided by respondent in any order they so wish; and - brief introduction of same key issues to all respondents.

Source: Baiden, 2006

Instrumentation

Interview study guides were developed and served as checklists to direct questioning during the semi-structured interviews to ensure that all relevant issues were covered.

However, the interviews were flexible enough to allow the interviewer to pursue other relevant lines of inquiry when they arose during the interview but persistent questioning was avoided to eliminate bias. This approach which was also used by Baiden (2006) increased the flexibility of the interviews and enabled more relevant data to be gathered in a relaxed atmosphere. The issues addressed in the interview guides were based on the independent variables identified by Rogers (2006) in the theoretical framework and guided by the questionnaire used in the survey. Each of the interview guides were slightly different to cater for the different categories of respondents interviewed and were pretested on three respondents with little corrections.

Sample and Sampling procedure

The semi-structured interview solicited knowledge from consultants, the experiences of clients who had gone through the decision process and the change agents/suppliers on the factors that influence the fast floors, asphaltic shingles and pozzolana cement adoption in the Ghanaian building industry.

The study sample was not meant to be statistically representative as is the case in the survey but rather the sample adequacy was judged based on its ability to help in understanding the process surrounding innovation decision-making. Given this aim, the sample size was selected so as to be made up of enough people to saturate the issues explored and provide adequate data for the study. Other issues taken into consideration were the location of the respondents and their willingness to participate. In all, twelve clients, professionals and suppliers were selected to be interviewed.

The sample technique used was more of a combination/mixed approach rather than one overarching technique (Miles & Huberman, 1994). This approach was selected because of its flexibility and its ability to meet multiple interests and need. Stratified sampling was used to identified subgroups that had to be represented in the sample. There were three groups of interest: the adopter/potential adopter (project clients/owners of projects in which the products were adopted or rejected), consultants and change agents/suppliers. The stratified nature of the sample facilitated some comparisons across the groups and triangulation to improve validity by looking at the research question from varying dimensions. Within each sub-group different methods were used. In the case of the adopters/rejecters, opportunistic sampling was used whilst the consultants were stratified and then selected based on convenience. However, in order to ensure credibility, the consultants were all expected to have at least ten years working experience in the industry. The three consultant categories were architects, structural engineers and quantity surveyors. Architects were selected in the light of their role as lead consultants in construction projects in the Ghanaian building industry [Refer to Section 3.3.2.1]. The structural engineers were selected because two of the cases of study selected (pozzolana and fast floor) were civil related products and the quantity surveyors were selected because they provide advice on cost-related issues which were the basis for the selection of the cases of the study. The suppliers were selected using intensity sampling: a technique which provides rich (but not deviant or extreme) examples of the phenomenon of interest.

The twelve respondents included:

- Three clients who either adopted or rejected one of the innovations

- Six (6) consultants within the Ghanaian building industry made up of two architects, two civil engineers and two quantity surveyors.
- Three supplier representatives of the innovations

All the respondents were located and worked either in Accra or Kumasi except in the case of the agent for pozzolana who was located in Winneba. Nine of the interviews were conducted face-to-face and the remaining three were telephone interviews. The three telephone interviews were due to the inability of the respondents to conveniently make time for face-to-face interviews despite numerous attempts to do so. The different interviewees provided different perspectives and provided the opportunity to cover the broad range of issues that were the focus of the study. The results of the interviews are provided in the ensuing chapter.

4.7 Research validation

This section presents the principles that were used to judge the quality of the research and to ensure valid propositions, inferences and conclusions. It addresses the questions that can be asked about the validity of this research. It is however to be noted that there are varied interdependent areas of validity, and a trade off is often necessary. Throughout the research the issues of validity were pursued as much as possible but, it is recognised that the concept of validity is an ideal state that cannot be perfectly achieved (Brinberg & McGrath, 1985). The major issues of quality include reliability and validity.

4.7.1 Reliability

Reliability is concerned with the repeatability and consistency of measures used in the research. Although it cannot be computed, it can be estimated using a variety of estimators. In the case study reliability was improved through the use of a case study

protocol. In the survey, the Cronbach's alpha is employed as an estimator of reliability as it is the most widely used in research. It is used to assess the reliability of the two scales on perceptions and adoption-decision factors in the questionnaire. The results are as presented in Table 5.40 and Table 5.41. The average inter-item correlation for the adoption-decision factors scale is 0.27 whilst that of the attributes scale is 0.99. The higher inter correlation of the perceived attributes scale is an indication of the narrow nature of its content since this scale items represent only perceived attributes whilst the lower value for the adoption-decision factor scale is because of the differences in content. However, the high intercorrections indicate adequate reliability of measures.

Table 4.6 Reliability Test for Adoption-Decision Factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.926	.926	37

Table 4.7 Reliability Test for Attributes

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
1.000	1.000	23

4.7.2 Validity

Validity is a concept that refers to the quality of various conclusions that are reached based on a research project and refers to the best available approximation to the truth of a given proposition, inference or conclusion. The types of validity include construct validity, conclusion validity, external and internal validity.

4.7.2.1 Construct validity

This refers to "the degree to which inference can legitimately be made from the operationalizations in your study to the theoretical constructs on which those operationalizations are based" (Trochim, 2005). In other words, construct validity deals with how well the concepts of interest are translated to reality (ibid). Convergent and discriminant validity are subtypes of construct validity. According to Trochim (2005), evidence provided for these two subtypes is sufficient evidence to demonstrate construct validity. The following efforts were made to ensure construct validity:

- Operational measures were adapted from previous studies and based on conceptual definitions with strong theoretical grounding. In the survey, all constructs as much as possible were measured with multiple items to avoid mono-method bias. Some measures however had single items owing to the need to reduce the length of the questionnaire. However, the constructs with broader content areas had multiple measures.
- Formal and informal pilot studies were also employed to ensure face and content validity [Section 4.5]

Evidence for convergent and discriminant validity of the survey is provided by inter-item correlations in Table A6-3 of Appendix Six. Generally, for an individual item, inter-item correlations between the item and other items of the same construct are higher than inter-item correlations between the item and other items of different constructs.

In satisfying the requirements of construct validity for the case study, multiple sources of evidence were used (interviews of architects, civil engineers, quantity

surveyors and clients), a chain of evidence was maintained (ensuring that the evidence presented can be easily and logically traced from research questions to conclusion or vice versa through the use of adequate cross referencing) and the draft case study report was reviewed by some the key informants who took part in the study. These procedures helped ensure that accurate information was obtained as much as possible and the likelihood of reporting false information was reduced there by increasing the construct validity of the study.

4.7.2.2 Internal Validity

Internal validity refers to the inferences about causal relationships and is important in studies with the purpose of establishing causal relationship (Trochim, 2005). This study exhibits a low internal validity in the use of survey research which is limited in its ability to conclusively establish causal relationships. The survey was however intended to be more of a descriptive study aimed at describing innovation related characteristics and behaviour of clients and professionals within the building industry rather than establishing the causal relationships between innovation related concepts. In the case study however, pattern-matching was the major tool used to enhance internal validity.

4.7.2.3 External validity

This refers to conclusions that deal with generalisations and the degree to which conclusions from the study can be extended to other persons in other places and times; specifically your population of interest (Trochim, 2005). In order to ensure external validity, good sampling procedures were employed as much as possible in the survey: defining a good sample frame, random selection of sample and the like.

However, the inadequacy of the sampling frame and non response provided some limitations to the extent of generalisation. A good sampling frame is one that is complete, accurate and up-to-date. Some members of the target population had a zero chance of inclusion in the sample, a situation that violates a condition for a probability sample and affects the extent to which results could be generalized. Efforts were also made to reduce non response as much as possible [Refer to Section 4.6]. The use of replication logic in the case study enhanced its external validity.

4.7.2.4 Conclusion Validity

Conclusion validity deals with the degree to which conclusions drawn about the relationships (not necessarily causal) in the data are reasonable (Trochim, 2005). Its aim is to avoid the occurrence of Type 1 (identifying a relationship when there is none) and Type 2 (failing to identify a relationship that actually exists) errors and the wrong estimation of the magnitude of a relationship and its associated degree of confidence (Tuuli, 2009). In order to improve conclusion validity, efforts were made to improve reliability thereby increasing effect size. In addition, appropriate sampling procedures and statistical tests were employed.

CHAPTER FIVE

DATA ANALYSIS AND DISCUSSION

5.1 Introduction

This chapter presents details of the analysis and results obtained from both the survey and case study conducted in this study.

5.2 Phase 1: Survey Analysis

The data preparation and analysis process are illustrated in Figure 5.1

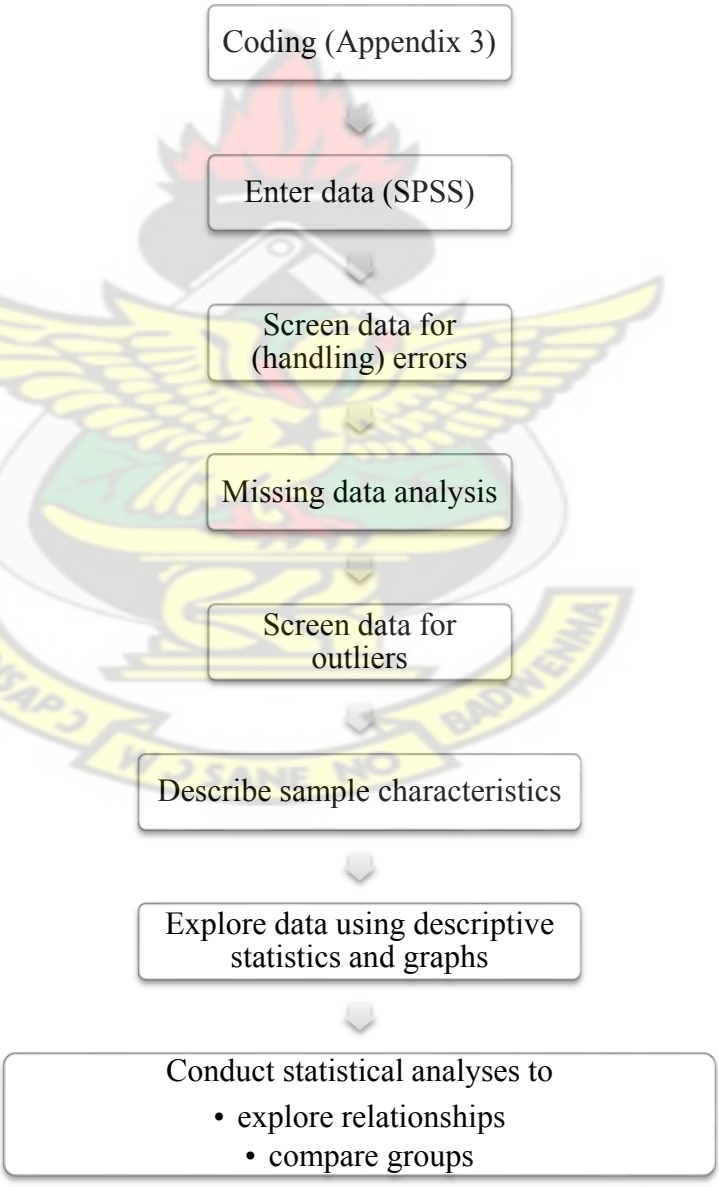

Figure 5.1 Flow Diagram for Survey Data analysis

5.2.1 Missing Data Analysis

Missing data refers to "data that are missing for some (but not all) variables and for some (but not all) cases" (Allison, 2001). The major problems associated with missing data are the threats that they pose to internal validity (mainly issues of statistical power) and external validity (the ability to generalize results to a target population). As mentioned in Section 4.6.5, missing values were minimized as much as possible through questionnaire design, by inspecting questionnaires when they were collected to ensure they were appropriately completed; and with regards to the web-based questionnaire, ensuring respondents completed relevant prior questions before proceeding to subsequent ones. In spite of these precautions, three percent of the total data values were missing and this section describes how they were dealt with in this study.

In analysing missing data, two major issues were considered:

- The prevalence of the missing data
- The patterns of missing data and missing data process

(Hair et al., 2006; McKnight et al., 2007)

The following process was followed in dealing with the missing data:

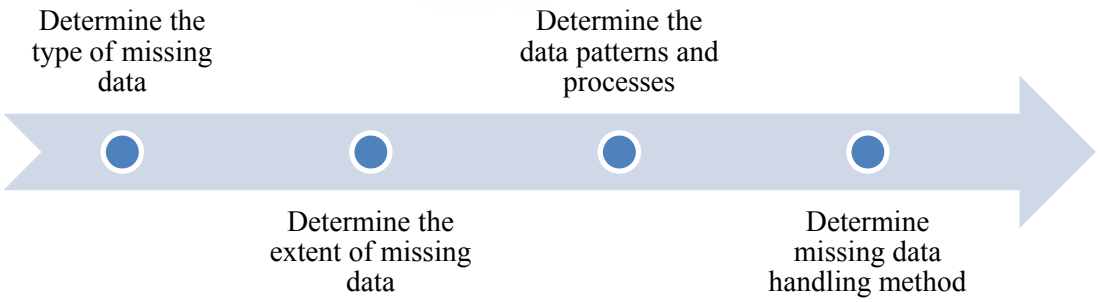

Figure 5.2 Missing Value Analysis Process

5.2.1.1 Determining the Type of Missing Data

The type of missing data influences the strategy/method for dealing with them (Acock, 2005) hence the importance of diligently classifying the missing data. Hair et al., (2006) classify missing data into those that are part of the research design and under the control of the researcher and those with "causes" and impacts that are unknown.

Missing data that result due to the design of a questionnaire may be because of skip patterns where respondents skip non applicable questions. These missing data result essentially because of the need to define a subpopulation under investigation. For instance question five [Appendices 1] was used to define the subpopulation of members of the building industry who knew about photovoltaics. Under this design, skip patterns were used to drop some survey participants from further analysis because they were not aware of photovoltaics and so were not in the subpopulation of interest. These types of missing data were coded '97' and were eliminated from the data before describing any problems with missing values (Acock, 2005).

The second type of missing data are the ones which should be included in the data set but are missing for a variety of reasons which may not be known to the researcher. It is this category of missing data that is problematic and is the focus of the following sections on missing data analysis.

5.2.1.2 Determining the Extent of Missing Data

The impact of missing data is related to the extent of "missingness". Generally though not in all cases, greater amounts of missing data are expected to have a larger impact on a study's generalizability and statistical inference (McKnight et al., 2007).

This study was made up of one hundred and forty (140) cases/respondents with one hundred and eleven (111) variables coming to a total of fifteen thousand five hundred and forty (15,540) data values. Of these, four hundred and ninety (490) data values were missing representing approximately three percent of the total data values [Table A4-1 of Appendix 4]. Most variables had missing values ranging from 1 (0.7%) to 20 (14.29%). The cases had missing values ranging from as low as 0 (0%) to as high as 111(100%). Cases 56, 58, 61, 62, 67, 75, 116 and 123 had high levels of missing data (approximately 10% and above) and were hence deleted from the data [Appendix 4]. Once the deletions were done, one hundred and thirty-two cases remained. Overall missing values were one hundred and fifty-three (153) which is approximately one percent (1%) of the total and considered low since it is below ten percent (10%) (McKnight et al., 2007).

5.2.1.3 Determining Missing Data Patterns and Processes

Another issue that relates to the impact of missing data (that is validity of inferences) is the actual process or mechanism that causes missing data (McKnight et al., 2007). Assumptions had to be made about the manner in which the missing values were lost in order to make a decision on the missing data method to be used; that is whether the data are missing completely at random (MCAR), missing at random (MAR) or not missing at random (NMAR) (Schafer & Olsen, 1998).

MAR means that the probabilities of missingness depend on data values that are observed in the dataset but not on the ones that are missing, MCAR means that the probabilities of missingness depend neither on the data values observed in the dataset nor on the ones that are missing and NMAR means that missingness depends on the actual value of the missing data (Scheffer, 2002; Acock, 2005).

The indicator variable statistics in SPSS missing value analysis was used to provide an indication of how the pattern of missing data in one variable affected the values of another variable. The crosstabulations of categorical variables versus indicator variables were used to determine whether there were differences in missing values among categories. The information provided by examining the crosstabulations indicated that the data did not appear to be missing completely at random because strong as well as a large number of differences were observed among categories of some variables. Consequently, the data were assumed to be either MAR or MNAR and not MCAR. According to McKnight et al., (2007), MAR is unlikely or unknown in sample surveys where intensive follow-up of non-respondents to decipher the causes for non-response is not done. Since intensive follow-up of respondents was not done in this case, the data was assumed to be MNAR.

5.2.1.4 Missing Data Handling Method

An exclusion strategy which is a traditional method of handling missing data was used in dealing with missing data in this study. This strategy is not an optimal solution (Acock, 2005) however, the choice of the strategy was based on the simplicity and prevalence of this method and also because of the low level of missing data (1%).

Pair-wise deletion was used rather than list-wise exclusion strategy because Pair-wise utilises all available information. It is a deletion method that discards data only at the level of the variable, not the observation (McKnight et al., 2007). It therefore preserves a greater proportion of cases while list-wise uses only complete cases in analysis thereby reducing statistical power, estimating larger standard errors and wider confidence intervals (Allison, 2001). To have used list-wise deletion meant

that only eighty-three (83) cases could have been used in the analysis- a number less than the required sample size of respondents of ninety-six (96).

5.2.2 Identification of Outliers

Outliers are case scores that are extreme and therefore have a much higher impact on the outcome of any statistical analysis. They are especially important in the case of continuous variables because extreme observations bias the mean statistics. The box plot shows no presence of outliers in the only continuous variable in the study [Figure 5.3].

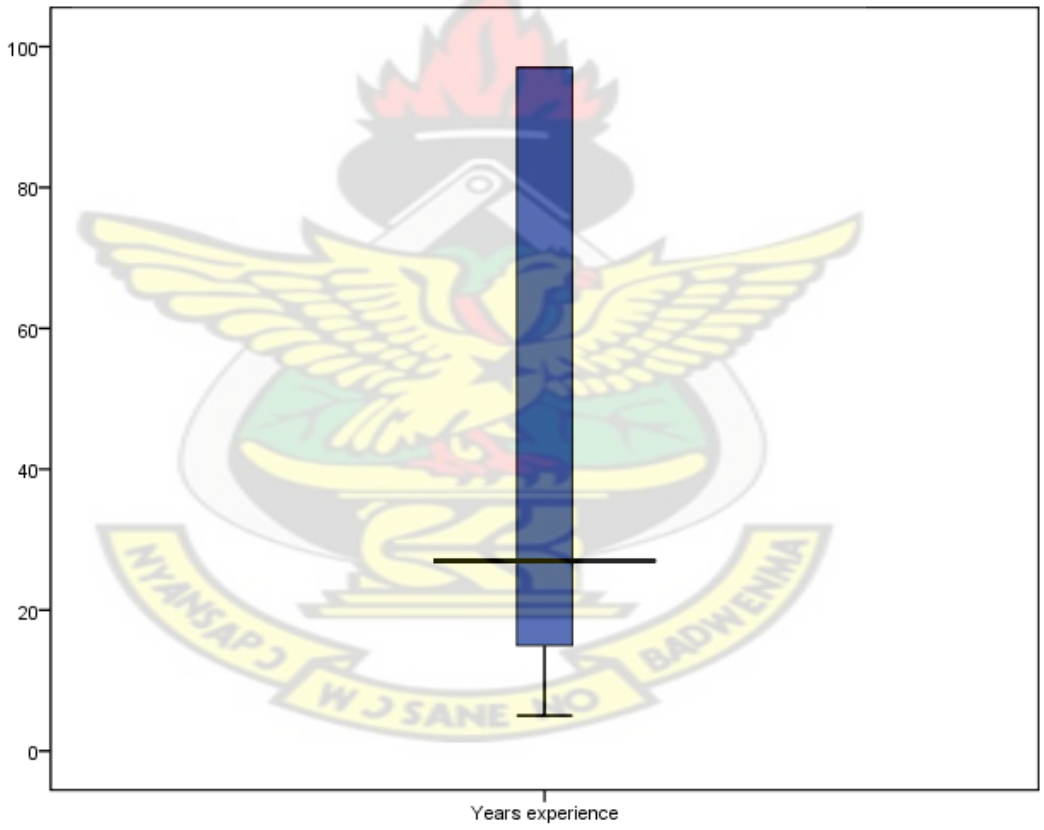

Figure 5.3 Box Plot of Consultants' Years of Work Experience

5.2.3 Description of Sample Characteristics

The sample used in the analysis consisted of clients, architects, mechanical and electrical engineers as previously described in section 4.6. This section gives a brief

summary of the characteristics of the final sample that was used in the analysis of the data. In all, one hundred and thirty-two (132) cases were used in data analysis and Figure 5.4 to Figure 5.7 together provides a pictorial summary of how the characteristics of the sample are distributed.

The final sample used for analysis had approximately forty-nine (49%), thirty-seven percent (37%) and fourteen percent (14%) of respondents being architects, clients and electrical/mechanical engineers respectively [Figure 5.4]. Most respondents, thirty-two percent (32%), were between the ages of thirty-one to forty years (31-40) [Figure 5.5] and forty-five percent (45%) had masters degrees [Figure 5.6]. Over half of clients and architects had bachelors and masters degrees respectively while over seventy percent of the electrical/mechanical engineers were split between bachelors and masters degrees [Figure 5.7].

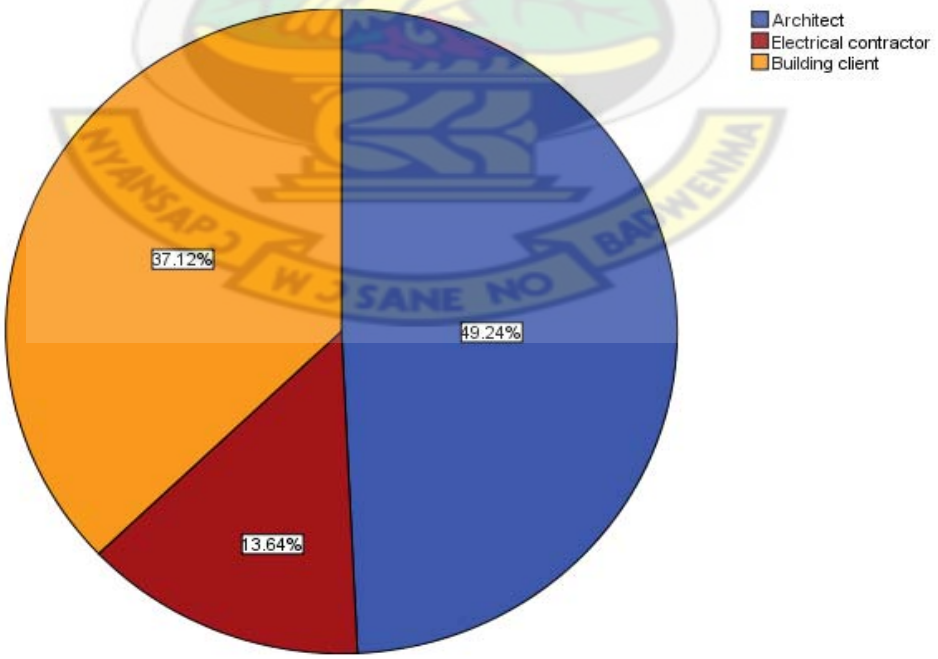

Figure 5.4 Pie Chart of Building Participants

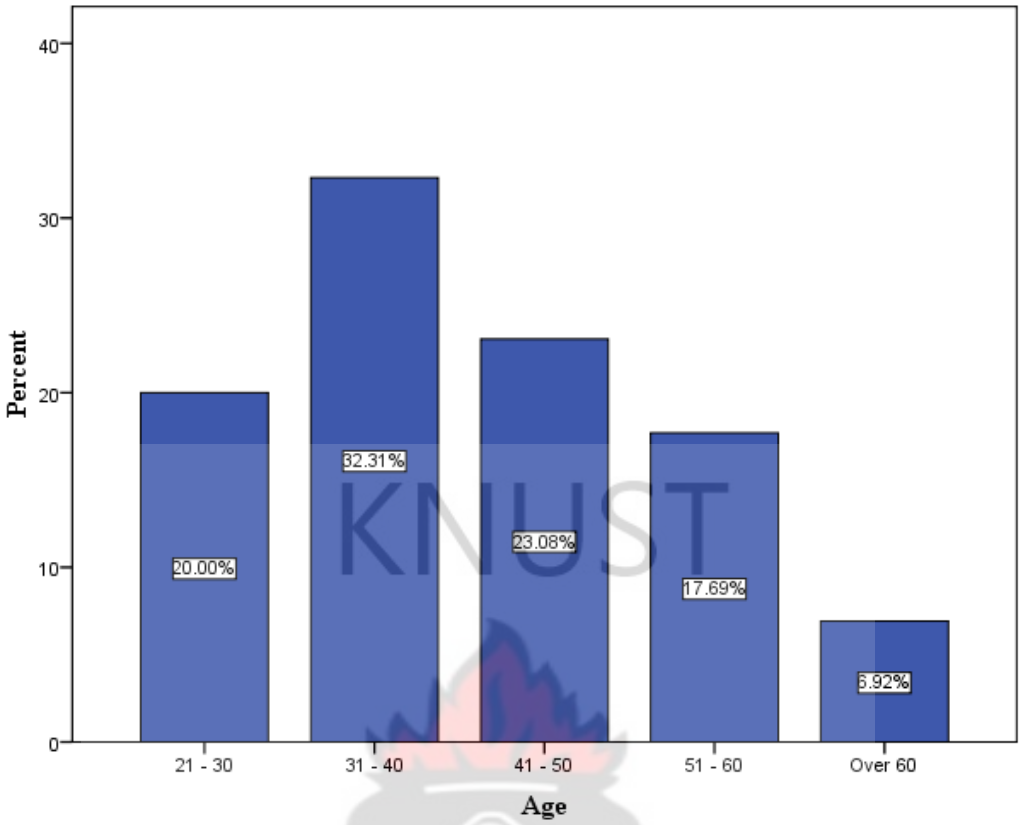

Figure 5.5 Bar Chart of Age Distribution

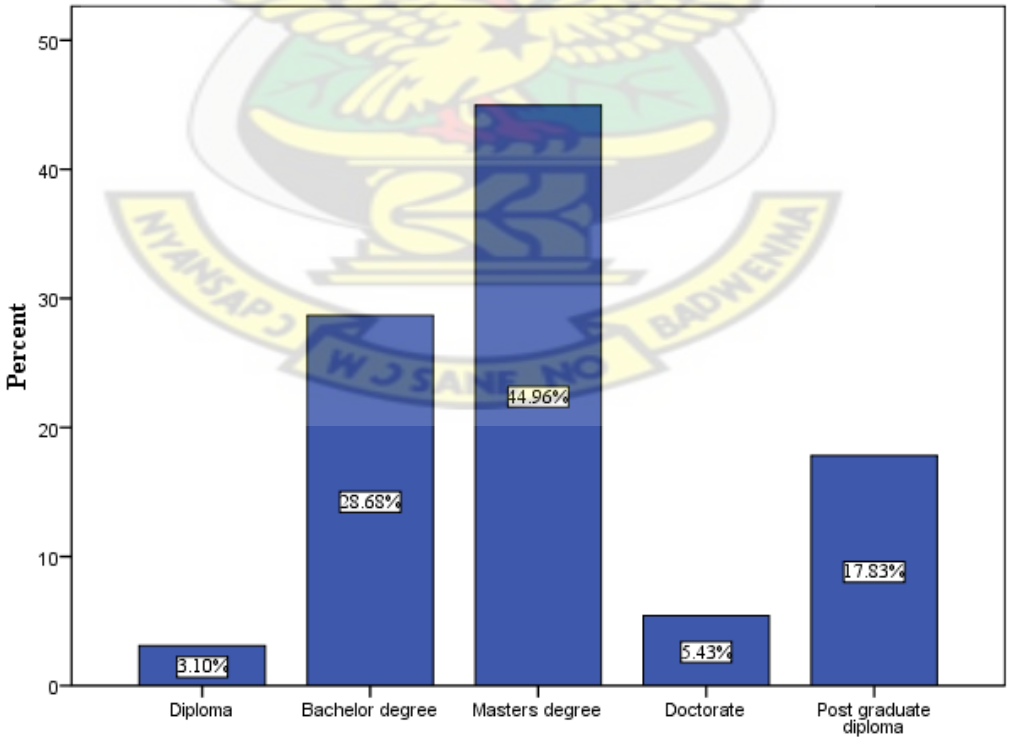

Figure 5.6 Bar Chart of Highest Educational Level Attained

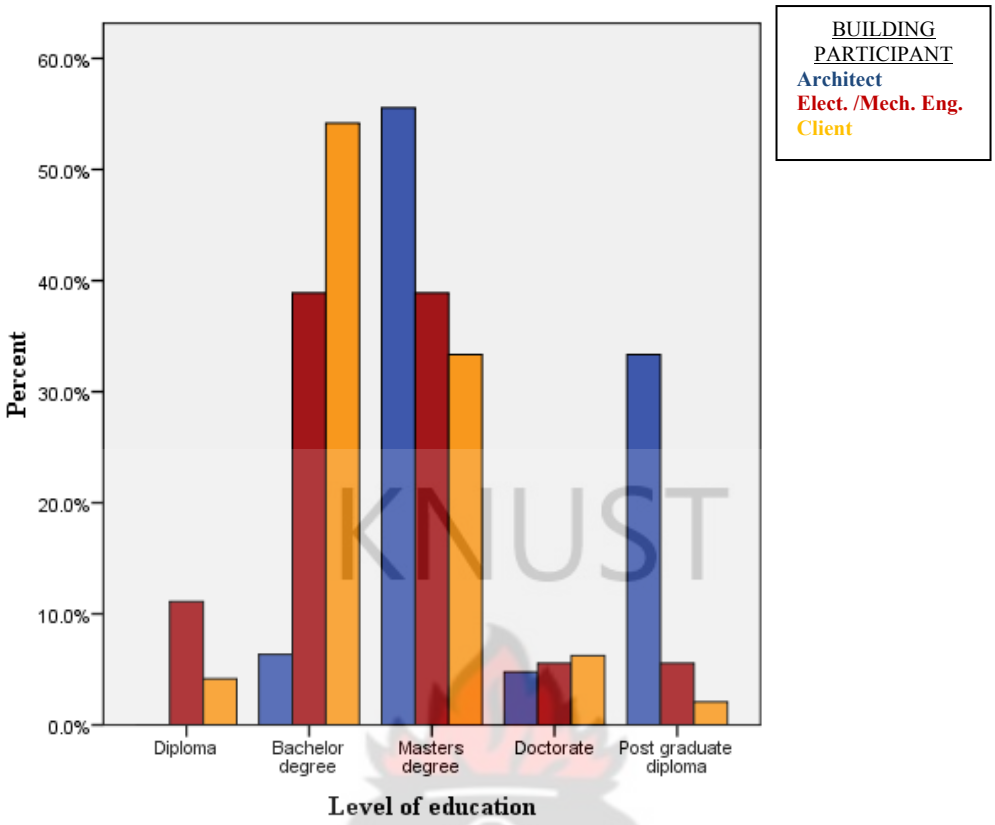

Figure 5.7 Bar Chart of Education Level Across Building Participants

5.2.4 Selection of Statistical tests

There are a variety of statistical tests available for the analysis of a set of data. However, the appropriate test was selected taking into consideration the type of research questions to be answered, the format of the questions used to generate the data, the nature of the variable and the assumptions that have to be met for each statistical technique (Pallant, 2001). The above considerations are important since the appropriate descriptive and inferential statistics differ for different considerations and the use of the wrong technique increases the risk of making wrong conclusions in the research.

5.2.4.1 Test of Statistical Assumptions

Statistical techniques for data analysis can be categorized into Parametric or Non-parametric techniques and the choice between the categories is based on a number of assumptions that have to be tested. Test assumptions underlying data analysis techniques help to determine whether the statistical techniques that were considered for data analysis were appropriate. Pallant (2010) outlines the following as the assumptions that have to be met for a parametric technique to be used:

- Data or observations have to be measured at the interval or ratio level
- Subjects or cases that are observed must be randomly selected
- Each subject must provide a score for both related pairs of variables
- Observations that make up the data must be independent of one another i.e. each must not be influenced by another
- The data should be normally distributed (Normality)
- The relationship between the two variables must be linear (Linearity)
- The variability of scores for one variable X should be similar at all values of another variable Y (Homoscedasticity)
- The variability of scores for each group should be similar (Homogeneity)

Given that the data in this study are largely measured at the nominal and ordinal levels rather than at the interval or ratio levels, the analytic techniques considered fall within the non-parametric category. In the case of the likert scale items, non-parametric techniques are used although researchers often use parametric techniques making assumptions that the interval between values or categories can be presumed equal (Jamieson, 2004). Furthermore, some arguments are made to the effect that the sample size and distribution are of more importance than level of measurement in

determining whether to use parametric or non-parametric data (Jamieson, 2004). In this research, the presumption of equal values was not made given that the numbers in the scale items represent verbal statements and although the sample size is relatively large, the distribution of variables was most often skewed.

Although the stringent assumptions of parametric techniques were relaxed, there was still the need to ensure that the sample used was obtained randomly and the observations made were independent of one another.

5.2.5 Data Analysis

The major analytical techniques used in the data analysis were relative importance index (relative rank index), chi-square test of significance and Mann-Whitney U-test.

Relative importance index is a non-parametric technique that is important in the built environment research field and is used to compare importance levels (Idrus et al., 2011a). It is an index that is calculated from the importance levels selected from a likert type scale by respondents and involves calculating the weighted average of each factor and dividing it by the upper scale of measurement (Shash, 1993; Mangitung, 2010). The index is a viable option for ordinal data in which means and standard deviations are not appropriate (Idrus et al., 2011b). The index has a value between zero (0) and one (1) or may be converted to percentages. The technique was used for all likert type scale questions. The formula for calculating the index is as follows:

$$RII = \frac{1}{nN}\left(\sum_{i=1}^{n} l_i x_i\right)$$

Source: Mangitung, 2010

RII = relative importance index

n = the maximum likert scale

N = the total number of responses

i = 1, 2 ... n

l_i = Likert scale i.e. the constant expressing the weight given (for example l_1 = not important and l_5 =highly important)

x_i = the frequency of the ith response

The Pearson Chi-square test of independence was used to explore certain relationships in the data. The test determines if two categorical variables are related by comparing the frequencies of cases in the various categories of one variable across the different categories of another (Pallant, 2010). An additional assumption of this test is that the minimum expected cell frequency should be 5 or greater or at least 80% of the cells should have expected frequencies of 5 or more. Where this assumption was violated, Fisher's exact test was used as an addition to verify the results obtained from the chi-square test.

Pearson chi-square tests the hypothesis that H_o: the two variables are independent (Healey, 1993). Hence, rejection of this hypothesis provides support for the existence of some relationship between the variable. The decision criterion required that the significance be less than 0.05 ($p<0.05$) in order for the null hypothesis to be rejected. In addition, the Cramer's V statistic was used to assess the strength of the relationships where they existed.

Mann-Whitney U test is a hypothesis test of significance for the two sample case and is based on the ranking of sample scores hence, adequate for ordinal data (Healey, 1993). It is one of the most powerful nonparametric tests given that it is more susceptible to lower Type II errors than many other tests (Korin, 1975). The

technique tests the hypothesis that H_o: The populations from which the variables are drawn are identical on the variable of interest (Healey, 1993).

In the Mann-Whitney U test, the null hypothesis states that there is no difference between the medians of the populations that the samples came from whilst the alternate hypothesis states that there is a difference between the medians of the populations that the samples came from. The U statistic indicates any difference and the significant values determine whether the differences between the two categories vary significantly at a 95% significance level. Where the significance value (p) is less than the reference probability of 0.05, the result is statistically significant and the null hypothesis is rejected. What this result implies is that the populations vary significantly in their evaluation of a particular factor. Where p is greater than 0.05, the null hypothesis is not rejected and there is no significant difference between the categories. Table 5.1 shows how the techniques are used in this research and which research questions they answered.

5.2.5.1 Communication Channels

Table 5.2 presents a ranking of the various communication channels according to the frequency with which they are used by respondents. However, Table 5.3 shows that the ranking of reliability of the communication channels do not follow the order in which they are mostly used. Overall, "Internet" and "Consultants/other building participants" were rated first for frequency of use and reliability respectively. Clients however more frequently obtained information by observing other building projects whilst the Engineers found manufacturers' brochures to be the most reliable communication channel.

Table 5.1 Descriptive Statistics/Statistical Tests

Research Question	Level of Measurement	Descriptive Statistic/Statistical Test
What are the factors that influence the adoption of an innovation by clients and professionals within the Ghana building industry?		
Which channel of information on innovations is most used by clients and professionals	Ordinal	RII
Which channel of information on innovations is rated most reliable?	Ordinal	RII
Which building participant wields the most influence relative to the others in decision-making on innovations?	Ordinal	RII
Which is the most significant of the innovation adoption-decision factors relative to each other?	Ordinal	RII
Is there a difference between clients and consultants on the importance of the most important adoption-decision factors?	Ordinal/nominal	Mann-Whitney U test
What are the perceptions of clients and professionals within the Ghanaian building industry about the attributes of photovoltaic energy technology?		
What is the level of awareness about photovoltaics within the Ghanaian building industry?	Nominal	Frequency distribution
Is there a relationship between knowledge of PV and the type of building participant?	Nominal/Nominal	Pearson Chi-Square test for independence Cramer's V
Is there a relationship between knowledge of PV and level of education?	Nominal/Nominal	Pearson Chi-Square test for Independence
Which channels provided most clients and professionals with first knowledge of photovoltaics?	Nominal	Frequency distribution
What is the level of adoption of photovoltaics within the Ghanaian building industry?	Nominal	Frequency distribution
Is there a relationship between the adoption-decision and the building participant that takes the final decision?	Nominal	Pearson Chi-Square test for independence
Which innovation attributes are most well rated with regard to photovoltaics?	Ordinal	RII
Is there a difference between adopters and non-adopters on the perception of PV?	Ordinal/Nominal	Mann-Whitney U test

The results indicate that respondents do have a variety of communication channels available to them and that they discriminate between communication channels in terms of the frequency of use and the perceptions they have of the channel's reliability. Although respondents are prone to frequent use of internet they do not accord the channel the same level of reliability. They regard consultants/other building participants as being more reliable. The internet is more frequently used probably because it most likely offers a cheaper and readily available option to the use of consultants/other building participants. On the other hand, the face-to-face nature and the consultants' reputation as an expert may be the reason behind this selection as the most reliable channel of information. The implications of this differentiation, becomes relevant to the adoption process. Where promotional agents seek to increase "awareness-knowledge" (information that an innovation exists) amongst respondents, the internet is a more appropriate option whereas the use of consultants/other building participants may be more appropriate to increase the likelihood of influencing the decision to adopt or reject an innovation.

This is because the reliability of the channel is important especially at the persuasion and adoption-decision stages when clients and professionals actively seek "how-to" knowledge (information necessary to use an innovation properly) required to make a decision to adopt or reject an innovation and hence will refer to the communication channels they find more reliable. According to ... such interpersonal channels are especially appropriate and preferred for energy markets since these channels present "the opportunity for a technical expert to explain in everyday language the capacity required by a household or business, the amount of energy generated in a day by the system, and a responsible way of using the system to enable the owner to utilize the full potential of the system throughout its lifetime" (Ndzibah, 2013 pp. 38)

Table 5.2 Communication Channels (Frequency of Use)[1]

Architect			Client			M&E Eng			Total		
Channel	RII	Rating	Channel	RII	Rating	Channel	RII	Rating	Channel	RII	Rating
WWW1	0.882	1	**OBS1**	0.891	1	**WWW1**	0.889	1	**WWW1**	0.874	1
MAN1	0.872	2	**WWW1**	0.857	2	**MAN1**	0.882	2	**OBS1**	0.864	2
OBS1	0.856	3	**PEER1**	0.850	3	**JOU1**	0.870	3	**MAN1**	0.824	3
CON1	0.851	4	**ADVERT1**	0.844	4	**SSR1**	0.815	4	**PEER1**	0.823	4
JOU1	0.821	5	**CON1**	0.769	5	**OBS1**	0.815	4	**CON1**	0.813	5
SSR1	0.805	6	**MAN1**	0.741	6	**PEER1**	0.815	4	**ADVERT1**	0.774	6
PEER1	0.805	6	**CLI1**	0.680	7	**CON1**	0.796	7	**JOU1**	0.770	7
TRA1	0.759	8	**SSR1**	0.673	8	**SEM1**	0.784	8	**SSR1**	0.758	8
ADVERT1	0.723	9	**JOU1**	0.667	9	**ADVERT1**	0.778	9	**CLI1**	0.690	9
SEM1	0.692	10	**SEM1**	0.565	10	**CLI1**	0.745	10	**TRA1**	0.674	10
CLI1	0.682	11	**UNI1**	0.558	11	**TRA1**	0.704	11	**SEM1**	0.656	11
UNI1	0.590	12	**TRA1**	0.551	12	**UNI1**	0.593	12	**UNI1**	0.578	12

[1] Please refer to Appendix Three for the definition of the codes used in the table

Table 5.3 Reliability of Communication Channels[2]

Architect			Client			M&E Eng			Total		
Channel	RII	Rating	Channel	RII	Rating	Channel	RII	Rating	Channel	RII	Rating
CON1	0.856	1	**CON1**	0.804	1	**MAN1**	0.888	1	**CON1**	0.839	1
JOU1	0.840	2	**WWW1**	0.773	2	**CON1**	0.875	2	**JOU1**	0.806	2
MAN1	0.812	3	**MAN1**	0.757	3	**SEM1**	0.875	2	**MAN1**	0.802	3
SEM1	0.809	4	**JOU1**	0.745	4	**JOU1**	0.847	4	**WWW1**	0.786	4
UNI1	0.807	5	**TRA1**	0.736	5	**WWW1**	0.825	5	**SEM1**	0.781	5
WWW1	0.785	6	**PEER1**	0.735	6	**UNI1**	0.800	6	**UNI1**	0.772	6
TRA1	0.772	7	**UNI1**	0.716	7	**TRA1**	0.760	7	**TRA1**	0.758	7
OBS1	0.735	8	**SEM1**	0.709	8	**SSR1**	0.738	8	**PEER1**	0.721	8
SSR1	0.725	9	**OBS1**	0.698	9	**PEER1**	0.700	9	**OBS1**	0.715	9
PEER1	0.716	10	**SSR1**	0.651	10	**OBS1**	0.680	10	**SSR1**	0.699	10
ADVERT1	0.606	11	**ADVERT1**	0.642	11	**CLI1**	0.613	11	**ADVERT1**	0.619	11
CLI1	0.577	12	**CLI1**	0.635	12	**ADVERT1**	0.600	12	**CLI1**	0.603	12

[2] Please refer to Appendix Three for the definition of the codes used in the table

The result of the internet as the most widely used channel deviates from the expectations of Rogers (2003). According to his expectation, a developing country such as Ghana where certain mass media channels are not widely accessible, interpersonal channels may be more frequently used than mass communication channels such as internet. It is however important to note that the population from which the sample for the study was taken is a relatively cosmopolitan one with wide access to mass media channels since most work in major cities and Czinkota, (2012) acknowledges this change in trend towards increased internet use in developing countries.

Therefore, in order to create widespread awareness about photovoltaics, more frequently used channels (e.g. worldwide web or internet) should be employed whilst the more reliable channels (consultants) should be used when the objective is to better influence adoption. Also, it may be necessary to treat architects, clients and engineers differently when disseminating information since they have slight differences in their rankings. This is because the differences in rankings of the communication channels are indications of the preferences the different categories of building participants; therefore, any efforts at disseminating information within any of these categories should be adapted to suit the preferences and perceptions of the particular category since the transfer of knowledge is most effect when it is informed by an understanding of the preferences of the audience (Borden., 2006).

Although a comparison is not made on the importance of the communication channels at different stages of the innovation decision process, the results of this study is consistent with the general expectations that though mass media channels such as the internet may be more widely used for awareness creation, interpersonal channels such as Consultants/other building participants are more important at the

persuasion stage and decision-making stages (Brancheau, & Wetherbe, 1990; Rogers, 2003).

5.2.5.2 Influence of Building Participants

Architects are identified as the building participants with the most influence on the decision to adopt or reject an innovation [Table 5.4]. This perception is constant within the different categories of respondents surveyed and is consistent with the fact that the traditional procurement system is most prevalent in Ghana. In this system, the architect is often the leader of the team and responsible for the design of the building; hence the reason for their high influence. Although the client is the initiator of the project and most often the financier, he probably wields less influence than the architect in this instance because most often he lacks the requisite expertise in building. Where, however, the client is more knowledgeable of the development process he/she is likely to be extremely more influential.

The contractor aptly has a low influence given that he is only introduced into the team once the design is complete. In the Ghanaian environment, lenders, insurers and bankers have the least influence in adoption-decision because even though they provide funding, their influence does not extend to decisions about the project except in rare cases. Consequently, any attempt to influence project related decisions should be geared at those who have the most say in decision-making: the architect, client and project manager.

5.2.5.3 Adoption-Decision Factors

Generally, most of the factors have high relative indices [Table 5.5]; an indication of the fact that they are all important to the adoption-decision and constitute evidence in favour of the relevance of the theory from which the factors were taken.

Table 5.4 Level of Influence of Building Participants on Adoption-decision[3]

Architect			Client			M&E Eng			Total		
Building Participant	RII	Rating	Building Participant	RII	Rating	Building Participant	RII	Rating	Building Participant	RII	Rating
ARC3	0.948	1	**ARC3**	0.900	1	**ARC3**	0.856	1	**ARC3**	0.916	1
PM3	0.809	2	**CLI3**	0.813	2	**CLI3**	0.811	2	**PM3**	0.803	2
SE3	0.791	3	**PM3**	0.800	3	**PM3**	0.789	3	**CLI3**	0.800	3
CLI3	0.788	4	**SE3**	0.783	4	**EE3**	0.789	3	**EE3**	0.777	4
EE3	0.782	5	**EE3**	0.766	5	**ME3**	0.733	5	**SE3**	0.774	5
ME3	0.782	5	**CONT3**	0.755	6	**SE3**	0.682	6	**ME3**	0.745	6
QS3	0.769	7	**QS3**	0.729	7	**QS3**	0.656	7	**QS3**	0.738	7
CONT3	0.628	8	**ME3**	0.698	8	**CONT3**	0.567	8	**CONT3**	0.667	8
LEND3	0.500	9	**LEND3**	0.561	9	**LEND3**	0.494	9	**LEND3**	0.523	9

[3] Please refer to Appendix Three for the definition of the codes used in the table

Nevertheless, certainty of an innovation's future performance and its quality compared with alternatives are the most important factors to decision-makers when deciding on an innovation except in the case of mechanical and electrical engineers. They regard compatibility with construction codes and standards and cost-in-use (continuing cost) as the most important factors probably because mechanical and electrical installations constitute a major portion of a buildings' operational cost and also because a service such as electricity must be installed according to standards and codes to avoid any hazards. There is however a consensus amongst the categories of participants that the influence of opinion leaders is the least significant factor. Consistent with literature is the fact that the factors rated as most important are innovation attributes since these factors have been shown to explain significant variance in adoption decisions (Dearing, 2007). However, factors that relate to the context such as "client acceptance", "manufacturers' technical support" and "prior experiences with similar products/materials/practice" are rated within the first ten most important factors. This highlights the need for commensurate emphasis on contextual factors not merely innovation attributes as important considerations to encourage innovation adoption (Green et. al., 2009).

Cost, time, and quality are three of the most important performance related parameters in the building industry (Rashid et al., 2006) and it is expected that items related to them will feature prominently in the top rankings of respondents. However, only quality and cost-related items can be found in the top five important factors. Overall, cost savings derived is ranked 5th whilst the other cost-related items such as cost-in-use, initial cost, constraints on project cost are ranked tenth (10th) or greater. The mechanical and electrical engineers are more preoccupied with continuing cost or cost-in-use of a product with a ranking of two (2) than clients with

a ranking of ten (10) who directly or indirectly bear the cost of the building during its operation. The clients regard cost savings derived and the possible profit to be gained as more important than the continued cost of the adopting the innovation. The item related to time is ranked 15th by architects, 19th overall, 21st by clients and 29th by the mechanical and electrical engineers.

Although the results of this study deviate somewhat from the construction industry's emphasis on the traditional time, cost and quality trade-offs models it is important to note that a building is a capital intensive venture, more so in a country such as Ghana where it represents the single most important investments that individuals make. Furthermore, buildings such as homes are especially regarded as future security and inheritance for posterity. Consequently, individuals will be more preoccupied with ensuring that such investments are of high quality and made to last as long as possible.

A major point to note for architects is the high ranking of client acceptance and aesthetic (visual) impact. Given that the client is most often the financier and consumer of the building, the architect is bound to crave the acceptance of the client. Aesthetic (Visual) impact is also important to architects because the building is a statement of an architects' expertise and serves as a means of advertisement and so any innovation must add to the general aesthetic appeal.

What these results mean then is that any promotional effort directed at clients and architects must emphasise the future performance and quality related to the alternatives of the innovation being introduced. Where the decision-makers are electrical and mechanical engineers however, emphasis must be placed on the cost-in-use and compatibility with requisite standards and codes.

Table 5.5 Adoption-Decision Making Factors[4]

Architect			Client			M&E Eng			Total		
Factor	RII	Rating	Factor	RII	Rating	Factor	RII	Rating	Factor	RII	Rating
FUTPERF4	0.942	1	FUTPERF4	0.922	1	COMSTAN4	0.922	1	FUTPERF4	0.927	1
QUAL4	0.902	2	QUAL4	0.882	2	CONTCOST4	0.900	2	QUAL4	0.894	2
CLIACC4	0.867	3	COSTSAV4	0.858	3	QUAL4	0.900	2	CLIACC4	0.857	3
VISIM4	0.867	3	PROFIT4	0.850	4	FUTPERF4	0.889	4	KNOW4	0.849	4
MANSUP4	0.843	5	CLIACC4	0.848	5	MANSUP4	0.878	5	COSTSAV4	0.843	5
KNOW4	0.843	5	KNOW4	0.846	6	KNOW4	0.878	5	EXP4	0.835	6
EXP4	0.840	7	EXP4	0.833	7	SAFEIM4	0.867	7	COMSTAN4	0.829	7
FAIL4	0.840	7	SAFEIM4	0.833	7	COSTSAV4	0.856	8	MANSUP4	0.829	8
COSTCON4	0.828	9	COMSTAN4	0.821	9	ABREC4	0.844	9	SAFEIM4	0.829	9
COSTSAV4	0.828	9	CONTCOST4	0.800	10	CLIACC4	0.844	9	CONTCOST4	0.826	10
CONTCOST4	0.825	11	MATSAV4	0.800	10	COSTCON4	0.833	11	FAIL4	0.814	11
SAFEIM4	0.816	12	CONTUSE4	0.796	12	EXP4	0.822	12	COSTCON4	0.805	12
COMSTAN4	0.810	13	LABSAV4	0.792	13	COMPCP4	0.789	13	VISIM4	0.805	12
COMPCP4	0.806	14	FAIL4	0.792	13	PROFIT4	0.778	14	COMPCP4	0.795	14
REDTIME4	0.778	15	MANSUP4	0.791	15	INICOST4	0.778	14	PROFIT4	0.785	15
CONTUSE4	0.769	16	PROX4	0.788	16	FAIL4	0.778	14	CONTUSE4	0.776	16
CONPREF4	0.762	17	COMPCP4	0.784	17	GRNHSE4	0.778	14	MATSAV4	0.770	17
MATSAV4	0.752	18	ABSEE4	0.784	17	PROX4	0.767	18	CONPREF4	0.764	18
PROX4	0.741	19	INICOST4	0.776	19	NORED4	0.767	18	REDTIME4	0.763	19
PROFIT4	0.738	20	CONPREF4	0.771	20	CONPREF4	0.756	20	PROX4	0.762	20

[4] Please refer to Appendix Three for the definition of the codes used in the table

Table 5.5 Cont'd

Architect			Client			M&E Eng			Total		
Factor	RII	Rating	Factor	RII	Rating	Factor	RII	Rating	Factor	RII	Rating
CONTIME4	0.738	21	REDTIME4	0.767	21	ABSEE4	0.756	20	ABSEE4	0.754	21
ABSEE4	0.731	22	VISIM4	0.763	22	MATSAV4	0.753	22	INICOST4	0.753	22
STAT4	0.729	23	COSTCON4	0.763	23	WASTE4	0.744	23	LABSAV4	0.749	23
INICOST4	0.728	24	WASTE4	0.759	24	CONTUSE4	0.744	23	WASTE4	0.740	24
ABTRY4	0.728	24	ABREC4	0.751	25	INSACC4	0.744	23	ABREC4	0.737	25
WASTE4	0.725	26	STAT4	0.743	26	LABSAV4	0.729	26	ABTRY4	0.727	26
LABSAV4	0.722	27	INSACC4	0.742	27	ABTRY4	0.711	27	GRNHSE4	0.722	27
GRNHSE4	0.705	28	ABTRY4	0.731	28	VISIM4	0.700	28	STAT4	0.718	28
ABREC4	0.697	29	GRNHSE4	0.725	29	REDTIME4	0.694	29	NORED4	0.711	29
BPATACC4	0.694	30	NORED4	0.725	29	CONTIME4	0.678	30	CONTIME4	0.707	30
NORED4	0.684	31	FIRSTUSE4	0.696	31	NEW4	0.644	31	INSACC4	0.688	31
FIRSTUSE4	0.677	32	BPATACC4	0.685	32	FIRSTUSE4	0.644	31	BPATACC4	0.680	32
INSACC4	0.629	33	CONTIME4	0.678	33	BPATACC4	0.622	33	FIRSTUSE4	0.680	33
NEW4	0.600	34	NEW4	0.657	34	STAT4	0.611	34	NEW4	0.628	34
FASC4	0.533	35	LENACC4	0.596	35	LENACC4	0.556	35	LENACC4	0.548	35
LENACC4	0.510	36	FASC4	0.555	36	FASC4	0.533	36	FASC4	0.542	36
OPLEAD4	0.424	37	OPLEAD4	0.470	37	OPLEAD4	0.500	37	OPLEAD4	0.452	37

The Mann-Whitney U test was used to test if there was a significant difference between consultants and clients with regard to the top three most significant factors. Where the two categories are only randomly different, the mean ranks are roughly equal; therefore, the small difference between the mean ranks [Table 5.6] gives an indication of a difference between groups which can be attributed to chance.

Table 5.6 Difference between Client and Consultant Responses[5]

	BLDGPAT2	N	Mean Rank	Sum of Ranks
QUAL4	Client	51	64.86	3308.00
	Consultant	81	67.53	5470.00
	Total	132		
CLIACC4	Client	48	62.83	3016.00
	Consultant	79	64.71	5112.00
	Total	127		
FUTPERF4	Client	51	65.33	3332.00
	Consultant	81	67.23	5446.00
	Total	132		

The two-tailed significance value estimates the probability of obtaining a Z value equal to or more extreme (in absolute value) if there is no difference. Given that the significance values are greater than 0.05 [Table 5.7], the null hypothesis that there is no significant difference is not rejected.

What this means is that on the three most important factors, consultants and clients do not have significant differences in their perceptions of importance and there is general agreement between the two groups on the importance of the three factors.

[5] Please refer to Appendix Three for the definition of the codes used in the table

Table 5.7 Mann-Whitney U Test Statistics for Difference between Client and Consultant Responses

	Mann-Whitney U	Z	Effect size $r = \frac{z}{\sqrt{N}}$	Asymp. Sig. (2-tailed)
QUAL4	1982.000	-.444	0.04	.657
CLIACC4	1840.000	-.304	0.03	.761
FUTPERF4	2006.000	-.364	0.03	.716

5.2.5.4 Knowledge of Photovoltaic

From the results obtained, ninety-nine (99) out of one hundred and thirty-two (132) which represents seventy-five (75%) of respondents are aware of the PV technology [**Error! Reference source not found.**].

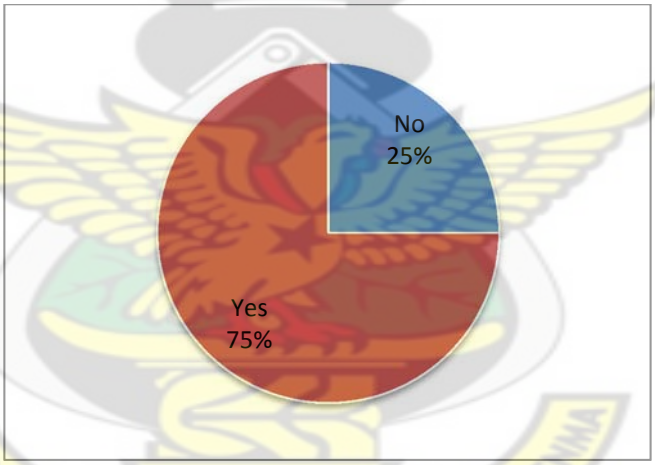

Figure 5.8 Awareness of PV

This level of awareness is much higher than that obtained by Ndzibah, (2013). In his study, about forty percent of respondents had some knowledge of PV. This disparity can be attributed to the difference in the characteristics of the respondents of the two studies. While Ndzibah, (2013) focused on a diversity of respondents with both rural and urban backgrounds this study respondents were drawn from an urban population and were cosmopolitan in nature. Furthermore, a larger percentage of respondents were consultants in the building industry. The study therefore, then went on to

investigate if the awareness of the technology is associated with the type of building participant in other words whether the awareness of the technology depended on the type of building participant. Cross tabulation and Pearson Chi-square test were used to test the null hypothesis that the two variables were independent. An examination of the cross tabulation results [Table 5.8] shows that the percentage who are aware or not of PV changes across the columns between clients and consultants. This result provides evidence of a possible relationship between awareness and building participants (i.e. potential adopter) and Pearson chi-square tests if this is a significant relationship.

The chi-square result gave a significance value of 0.03 which is less than 0.05 [Table 5.9] hence; the null hypothesis that the two variables are independent is rejected.

What the result means is that there is some relationship between the variables. The strength of relationship was therefore measured using Cramer's V. Cramer's V indicates a small association of 0.261 that is significant ($p < 0.05$) [

Table **5.10**].

An odds ratio, which is the ratio of the odds of an event occurring in one group compared to another, was also calculated. An odds ratio[6] of 3.37 was obtained which indicates that an individual who knows about photovoltaics is 3.37 times more likely to be a consultant. This is probably because consultants by virtue of their profession are required to be abreast with new trends and ideas.

[6] Odds ratio = (Consultants who know about PV/Consultants who do not know about PV) / (Clients who know about PV/Clients who do not know about PV)

Table 5.8 Awareness of PV * Building Participant Cross Tabulation

			Building Participant		
			Client	Consultant	Total
Awareness of PV	No	Frequency	20	13	33
		Expected Frequency	12.8	20.2	33.0
		% within Awareness of PV	60.6%	39.4%	100.0%
		% within Building Participant	39.2%	16.0%	25.0%
		% of Total	15.2%	9.8%	25.0%
	Yes	Frequency	31	68	99
		Expected Frequency	38.2	60.8	99.0
		% within Awareness of PV	31.3%	68.7%	100.0%
		% within Building Participant	60.8%	84.0%	75.0%
		% of Total	23.5%	51.5%	75.0%
Total		Frequency	51	81	132
		Expected Frequency	51.0	81.0	132.0
		% within Awareness of PV	38.6%	61.4%	100.0%
		% within Building Participant	100.0%	100.0%	100.0%
		% of Total	38.6%	61.4%	100.0%

Table 5.9 Awareness of PV * Building Participant Chi Square Test of Independence

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.958[a]	1	.003
Continuity Correction[b]	7.765	1	.005
N of Valid Cases[b]	132		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.75.
b. Computed only for a 2x2 table

Table 5.10 Awareness of PV * Building Participant Strength of Association

		Value	Approx. Sig.
Nominal by Nominal	Cramer's V	.261	.003
N of Valid Cases		132	

According Rothfield (2010) the propensity to adopt PV technology was associated with the level of education and therefore, the study also investigated if the awareness of the technology is associated with the level of education of respondents. The cross tabulation [Table 5.11] showed that the percentage of clients and professionals that are aware or not of PV changes across the columns. Although this result provides evidence of a possible relationship between awareness and level of education of respondents, Pearson chi-square tests of the null hypothesis that the two variables are independent resulted in a significance level of 0.543 [Table 5.12].

Since $p > 0.05$, the null hypothesis is not rejected meaning that the relationship indicated in the cross tabulation may be due to chance. In view of the violation of Chi-square assumption of expected counts greater than 5, the Fisher's exact test was also used to confirm the results of the chi-square. The result of this test confirmed a non significant value of 0.576 meaning that there is no evidence for a relationship between PV awareness and level of education [Table 5.12].

The results show that respondents first learnt about PV from a wide variety of channels but a good number of the respondents were first introduced to PV technology through a University/research institute level [Table 5.13].

These results indicate that a majority of people are aware of the existence of PV but consultants are more informed than clients. Therefore, any awareness campaigns should be more geared towards clients since they are less likely to know about photovoltaics. There is also the indication that efforts at knowledge creation should shift from awareness creation to focus more on provision of "how-to knowledge". This type of knowledge is what is required if clients and professionals need to make informed decisions about PV technology.

Table 5.11 Awareness of PV * Level of education Cross tabulation

			Level of education					
			Diploma	Bachelor degree	Masters degree	Doctorate	Post graduate diploma	Total
Awareness of PV	No	Frequency	1	10	15	0	4	30
		Expected Frequency	.9	8.6	13.5	1.6	5.3	30.0
		% within Awareness of PV	3.3%	33.3%	50.0%	.0%	13.3%	100.0%
		% within Level of education	25.0%	27.0%	25.9%	.0%	17.4%	23.3%
		% of Total	.8%	7.8%	11.6%	.0%	3.1%	23.3%
	Yes	Frequency	3	27	43	7	19	99
		Expected Frequency	3.1	28.4	44.5	5.4	17.7	99.0
		% within Awareness of PV	3.0%	27.3%	43.4%	7.1%	19.2%	100.0%
		% within Level of education	75.0%	73.0%	74.1%	100.0%	82.6%	76.7%
		% of Total	2.3%	20.9%	33.3%	5.4%	14.7%	76.7%
Total		Frequency	4	37	58	7	23	129
		Expected Frequency	4.0	37.0	58.0	7.0	23.0	129.0
		% within Awareness of PV	3.1%	28.7%	45.0%	5.4%	17.8%	100.0%
		% within Level of education	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	3.1%	28.7%	45.0%	5.4%	17.8%	100.0%

Table 5.12 Awareness of PV * Level of Education Chi-Square Test of Independence

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	3.087[a]	4	.543	.556
Fisher's Exact Test	2.873			.576
N of Valid Cases	129			

a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is .93.

Table 5.13 Source of PV Knowledge

Source of PV knowledge	Frequency	Percent
University/research institute	29	29.90%
World wide web/internet	11	11.34%
Journal/technical publication	10	10.31%
Peers/friends	10	10.31%
Advertisement (television, newspaper, radio etc.)	8	8.25%
Don't remember	7	7.22%
Consultants/fellow building participants	5	5.16%
Trade show/building exhibition	4	4.12%
Sales and supplier representative	4	4.12%
Seminar/conference	3	3.09%
Manufacturers' brochures	3	3.09%
Senior secondary school	2	2.06%
Client	1	1.03%
Total	97	100.00%

5.2.5.5 Level of PV Adoption and Perceptions of PV Attributes

In spite of the high level of knowledge on photovoltaics [**Error! Reference source not found.**], the level of adoption [Table 5.1] is not commensurate with the level of PV knowledge.

Table 5.14 Level of PV Adoption

	Frequency	Percent
Rejection	25	18.90
Adoption	30	22.70
Not applicable	77	58.30
Total	132	100.00

Approximately twenty-three percent of the one-hundred and thirty-two (132) respondents had adopted PV [Table 5.14]. Although Edjekumhene & Brew-Hammond (2001)'s study does not provide specific figures, it indicates that PV adoption is uncommon in the Ghanaian building industry. Twenty-three percent adoption in this study may seem inconsistent with Edjekumhene & Brew-Hammond (2001)'s study but the discrepancy may be as a result of the characteristics of the respondents surveyed. The respondents are all literate with formal educational backgrounds ranging from Diplomas to Doctorates [Figure 5.7]; and according to Rogers (2003) literacy and more years of formal education are likely characteristic of earlier adopters.

The study also investigated if the adoption of the technology is associated with the building participant that took the final adoption-decision that is whether particular participants are more prone to adopting photovoltaics than others.

Table 5.15 shows that some but not all of the percentage of respondents who adopted or rejected PV changed across the columns of building participants who took the final decision. Although this result provides evidence of a possible relationship between adoption of the technology and the building participant that took the final decision, Pearson chi-square test and Fisher's Exact test were used to test if the

possible relationship alluded to in the crosstabulations was significant or due to chance.

Table 5.15 Adoption-Decision * Final Adoption Decision-maker Crosstabulation[7]

			FINDEC						
			Client	Project manager	Architect	Quantity surveyor	Electrical engineer	Mechanical engineer	Total
ADOCHA1	Rejection	Frequency	13	0	7	1	0	0	21
		Expected Frequency	12.1	1.3	5.4	.4	.4	1.3	21.0
		% within ADOCHA1	61.9%	.0%	33.3%	4.8%	.0%	.0%	100.0%
	Adoption	Frequency	14	3	5	0	1	3	26
		Expected Frequency	14.9	1.7	6.6	.6	.6	1.7	26.0
		% within ADOCHA1	53.8%	11.5%	19.2%	.0%	3.8%	11.5%	100.0%
Total		Frequency	27	3	12	1	1	3	47
		Expected Frequency	27.0	3.0	12.0	1.0	1.0	3.0	47.0
		% within ADOCHA1	57.4%	6.4%	25.5%	2.1%	2.1%	6.4%	100.0%

[7] Please refer to Appendix Three for the definition of the codes used in the table

The significance levels obtained were 0.133 and 0.150 for Chi-square and Fisher's exact tests respectively [Table 5.16]. Since $p > 0.05$ in both cases, we fail to reject the null hypothesis that the two variables are independent meaning that the relationship indicated in the cross tabulation may be due to chance.

Table 5.16 Adoption-Decision * Final Adoption Decision-maker

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	7.928[a]	5	.160	.133
Fisher's Exact Test	7.016			.150
N of Valid Cases	47			

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .45.

The perceptions of building participants were then evaluated to determine respondents' assessment of PV technology with regard to certain attributes. Table 5.17a, Table 5.17b and Table 5.17c show a generally favourable attitude (i.e. over 50% of the respondents rated the attributes as good or better) towards photovoltaics but the initial cost show a very unfavourable attitude. This subjective assessment by participants generally coincides with objective assessments of PV as an environmentally friendly technology with an expensive initial cost (Oliver & Jackson, 1999; Alsema & Nieulaar, 2000; Oparaku, 2006). This goes to show that respondents have a well informed perception of the technology. The extremely low assessment of the initial cost also provides some explanation for the low adoption of photovoltaics by building participants especially since building construction is an already expensive venture even without the added cost of photovoltaic incorporation. According to Ndzibah (2013), it would take a medium income earning tenant in Ghana four years to pay back a basic solar system compared to the average electricity bill per month.

Table 5.17a Perceptions of PV Attributes[8]

STATISTICS	PROFIT	FUTPERF	LABSAV	WASTE	COSTREC	REDTIME	COMPCP	CONTUSE	STAT	INICOST
Mode	3	3	3	3	4/5	3	3	4	4	1
Mode frequency	13	18	16	14	13	16	16	15	15	20
Rating < good (frequency)	12	5	13	4	10	17	13	8	7	28
Rating > good (frequency)	16	19	9	23	26	8	15	22	21	11
Rating ≥ good (frequency)	29	37	25	37	32	24	31	36	34	15
Total response with opinions	41	41	38	41	42	41	44	44	41	43
Total response	46	47	48	48	48	48	48	48	47	48
% Mode	31.70	43.90	42.10	34.14	30.95	39.02	36.36	34.09	36.58	46.51
% Rating < good	29.26	12.19	34.21	9.75	23.80	41.46	29.54	18.18	17.07	65.11
% Rating > good	39.02	46.34	23.68	56.09	61.90	19.51	34.09	50.00	51.21	25.58
% Rating ≥ good	70.73	90.24	65.78	90.24	76.19	58.53	70.45	81.81	82.92	34.88
Interpretation of Mode	Good	Good	Good	Good	Very Good/ Excellent	Good	Good	Very Good	Very Good	Poor

[8] Please refer to Appendix Three for the definition of the codes used in the table

Table 5.17b Perceptions of PV Attributes

STATISTICS	FIRSTUSE	FAIL	CONTCOST	QUAL	COMPSTAN	GRNHSE	ABSEE	NORED	COSTSAV
Mode	3	3	5	4	3	5	2/3/4/5	5	5
Mode frequency	15	15	17	17	14	25	10	25	15
Rating < good (frequency)	10	13	6	9	8	7	13	4	10
Rating > good (frequency)	15	11	28	28	21	35	20	33	23
Rating ≥ good (frequency)	30	26	39	36	35	41	30	39	34
Total response	48	48	48	48	47	45	47	47	47
Total response with opinions	40	39	45	45	43	42	43	43	44
% Mode frequency	37.50	38.46	37.78	37.78	32.55	59.52	23.25	58.13	34.09
% Rating < good	25	33.33	13.33	20.00	18.60	16.66	30.23	9.30	22.72
% Rating > good	37.50	28.21	62.22	62.22	48.83	83.33	47.51	76.74	52.27
% Rating ≥ good	75	66.67	86.67	80.00	81.39	97.61	69.76	90.69	77.27
Interpretation of Mode	Good	Good	Excellent	Very Good	Good	Excellent	Fair/Good /Very Good/ Excellent	Excellent	Excellent

Table 5.17c Perceptions of PV Attributes[9]

STATISTICS	VISIM	ABTRY	MATSAV	SAFEIM
Mode	3	3	3 / 4	3
Mode frequency	15	14	11	13
Rating < good (frequency)	13	12	16	7
Rating > good (frequency)	15	12	12	21
Rating ≥ good (frequency)	30	26	23	34
Total response	46	44	47	47
Total response with opinions	43	38	39	41
% Mode frequency	34.88	36.84	28.20	31.70
% Rating < good	30.23	31.57	41.02	17.07
% Rating > good	34.88	31.57	30.76	51.21
% Rating ≥ good	69.76	68.42	58.97	82.92
Interpretation of Mode	Good	Good	Good/ Very Good	Good

[9] Please refer to Appendix Three for the definition of the codes used in the table

Nevertheless, evidence of adoption within the sample suggests that the high initial cost of photovoltaics may not be a hindrance for adoption in every circumstance. Promotional efforts then should seek to identify potential adopters who may not be largely influenced by the high initial costs of photovoltaics. Adoption by such potential adopters may then contribute to the economies of scale required to reduce initial cost of photovoltaic energy technologies in Ghana.

The next analysis sought to find out which of the five attributes from Rogers (2003)'s were well rated with regard to PV technology [Table 5.18]. It can be seen from the table that the consultants and clients had differing perceptions of the attributes of PV. The relative indices can however be seen to be numerically close to each other indicating that on the average, differences in the ratings of the attributes are not much. Whilst the consultants rated 'Observability' as the best and 'Trialability' as the worst attributes, clients rated 'Relative advantage' and 'Observability' as the best and worst attributes respectively. The clients may have rated the 'Observability' as the worst because they are less likely to be able to spot PV installation than the architects.

Finally, a Mann-Whitney U test was conducted to find out if there were significant differences between adopters and non-adopters with regards to their ratings of PV attributes.

Table 5.18 Relative Importance of PV Attributes

Consultant			Client			Total		
Attribute	RII	Rating	Attribute	RII	Rating	Attribute	RII	Rating
Observability	0.682	1	**Relative Advantage**	0.688	1	**Relative Advantage**	0.675	1
Relative Advantage	0.672	2	**Reduced Complexity[10]**	0.667	2	**Observability**	0.665	2
Reduced Complexity[2]	0.661	3	**Compatibility**	0.656	3	**Reduced Complexity[2]**	0.662	3
Compatibility	0.652	4	**Trialability**	0.633	4	**Compatibility**	0.653	4
Trialability	0.581	5	**Observability**	0.600	5	**Trialability**	0.589	5

[10] Complexity was measured as the ease of use of the product. Hence high ratings connoted reduced complexity

Table 5.19 Mann-Whitney U Mean Rank[11]

	ADOCHA1	N	Mean Rank	Sum of Ranks
PROFIT	Rejection	24	31.58	758.00
	Adoption	28	22.14	620.00
	Total	52		
FUTPERF	Rejection	24	31.42	754.00
	Adoption	29	23.34	677.00
	Total	53		
LABSAV	Rejection	25	31.80	795.00
	Adoption	29	23.79	690.00
	Total	54		
WASTE	Rejection	25	30.96	774.00
	Adoption	29	24.52	711.00
	Total	54		
COSTREC	Rejection	25	32.84	821.00
	Adoption	29	22.90	664.00
	Total	54		
REDTIME	Rejection	25	32.76	819.00
	Adoption	29	22.97	666.00
	Total	54		
COMPCP	Rejection	25	33.26	831.50
	Adoption	29	22.53	653.50
	Total	54		
CONTUSE	Rejection	25	31.80	795.00
	Adoption	29	23.79	690.00
	Total	54		
STAT	Rejection	25	32.60	815.00
	Adoption	28	22.00	616.00
	Total	53		
INICOST	Rejection	25	31.94	798.50
	Adoption	29	23.67	686.50
	Total	54		

[11] Please refer to Appendix Three for the definition of the codes used in the table

Table 5.19 Cont'd

	ADOCHA1	N	Mean Rank	Sum of Ranks
FIRSTUSE	Rejection	25	31.12	778.00
	Adoption	29	24.38	707.00
	Total	54		
FAIL	Rejection	25	30.66	766.50
	Adoption	29	24.78	718.50
	Total	54		
CONTCOST	Rejection	25	31.50	787.50
	Adoption	29	24.05	697.50
	Total	54		
QUAL	Rejection	25	31.38	784.50
	Adoption	29	24.16	700.50
	Total	54		
COMPSTAN	Rejection	25	32.88	822.00
	Adoption	29	22.86	663.00
	Total	54		
GRNHSE	Rejection	25	30.60	765.00
	Adoption	27	22.70	613.00
	Total	52		
ABSEE	Rejection	25	33.28	832.00
	Adoption	29	22.52	653.00
	Total	54		
NORED	Rejection	25	31.98	799.50
	Adoption	29	23.64	685.50
	Total	54		
COSTSAV	Rejection	25	33.74	843.50
	Adoption	29	22.12	641.50
	Total	54		
VISIM	Rejection	25	33.38	834.50
	Adoption	28	21.30	596.50
	Total	53		
ABTRY	Rejection	25	33.00	825.00
	Adoption	27	20.48	553.00
	Total	52		

Table 5.1920 Cont'd

	ADOCHA1	N	Mean Rank	Sum of Ranks
MATSAV	Rejection	25	34.04	851.00
	Adoption	29	21.86	634.00
	Total	54		
SAFEIM	Rejection	25	31.76	794.00
	Adoption	29	23.83	691.00
	Total	54		

Nine out of twenty-three items had significant values greater than 0.05 which means that the null hypothesis is not rejected and there is no significant difference between adopters and non-adopters regarding these items. The items, certainty of future performance, labour savings derived, waste, difficulty of continued use, difficulty of first use, failure, cost-in-use, quality compared with alternatives and impact on safety; all had small effect sizes which may have accounted for the inability to detect differences. On the other hand, the items with significant values less than 0.05 had medium effect sizes, therefore making it easier to detect some difference between adopters and non-adopters [Table 5.20].

The relatively wide differences in the mean ranks provide support for the hypothesis that the two categories are different however; the direction of difference is completely contradictory to what is stated in theory. In Rogers (2003)'s theory, adopters are expected to have more favourable perceptions towards the technology than non-adopters. The only possible explanation that can be provided for this anomaly is that respondents who have adopted or rejected PV technology and have provided their perceptions may not necessarily be those who took the final decision

to adopt or reject, hence; their positive or negative perceptions do not coincide with the type of adoption-decision taken.

Table 5.20 Mann-Whitney U Test Statistics[a]

	Mann-Whitney U	Z	Effect size $r = \frac{z}{\sqrt{N}}$	Asymp. Sig. (2-tailed)	Exact Sig. (2-tailed)
PROFIT	214.000	-2.285	0.32	.022	.022
FUTPERF	**242.000**	**-1.949**	**0.27**	**.051**	**.052**
LABSAV	**255.000**	**-1.909**	**0.26**	**.056**	**.056**
WASTE	**276.000**	**-1.536**	**0.21**	**.125**	**.125**
COSTREC	229.000	-2.366	0.32	.018	.017
REDTIME	231.000	-2.332	0.32	.020	.019
COMPCP	218.500	-2.552	0.35	.011	.010
CONTUSE	**255.000**	**-1.908**	**0.26**	**.056**	**.056**
STAT	210.000	-2.556	0.35	.011	.010
INICOST	251.500	-1.973	0.27	.049	.049
FIRSTUSE	**272.000**	**-1.601**	**0.22**	**.109**	**.110**
FAIL	**283.500**	**-1.395**	**0.19**	**.163**	**.166**
CONTCOST	**262.500**	**-1.777**	**0.24**	**.076**	**.075**
QUAL	**265.500**	**-1.722**	**0.23**	**.085**	**.086**
COMPSTAN	228.000	-2.385	0.32	.017	.016
GRNHSE	235.000	-1.969	0.27	.049	.048
ABSEE	218.000	-2.559	0.35	.011	.010
NORED	250.500	-2.019	0.27	.044	.043
COSTSAV	206.500	-2.768	0.38	.006	.005
VISIM	190.500	-2.915	0.40	.004	.003
ABTRY	175.000	-3.056	0.42	.002	.002
MATSAV	199.000	-2.896	0.39	.004	.003
SAFEIM	**256.000**	**-1.888**	**0.26**	**.059**	**.059**

a. Grouping Variable: ADOCHA1
b. Effect sizes 0.1= small 0.3= medium 0.5=large

Table 5.21 Building Participant * Final Decision Maker * Adoption-Decision Cross tabulation

ADOPTION-DECISION			FINAL DECISION MAKER					
			Client	Project manager	Architect	Quantity surveyor	Electrical engineer	Mechanical engineer
Rejection	BLDGPAT	Architect	11	-	7	0	-	-
		Electrical contractor	0	-	0	1	-	-
		Building client	2	-	0	0	-	-
	Total		13	-	7	1	-	-
Adoption	BLDGPAT	Architect	6	0	4	-	1	1
		Electrical contractor	7	2	0	-	0	2
		Building client	1	1	1	-	0	0
	Total		14	3	5	-	1	3

The summary of results from the survey as follows:

1. The internet/world wide web was identified as the most frequently used and Consultants/other building participants as the most reliable communication channels
2. Architects were rated most influential building participants to decision-making on innovations
3. Certainty of an innovation's future performance was rated the most important factor in the adoption-decision of an innovation and consultants and clients did not differ significantly in their perceptions of the importance of the three most important adoption-decision factors
4. Seventy-five percent of the respondents surveyed were aware of PV technology and this awareness was found to be associated with the type of building participant but not with the level of education of the participant
5. Universities/research institutes were found to have provided most clients and professionals with their first knowledge of PV technology
6. Approximately twenty-three percent (23%) of the respondents surveyed had adopted PV technology and there was not strong enough evidence to support the hypothesis that the type of adoption-decision and the building participant that made the final decision were in some way associated.
7. The innovation attribute, relative advantage, was found to be the most well rated with regard to PV
8. It was found that there existed a significant difference between adopters and non-adopters on a majority of the perceived attributes

5.3 Phase 2: Case Study Analysis

This section presents the analysis of the data collected through the case study conducted as well as the interpretation and discussion of the findings.

5.3.1 Method of Analysis

Yin (2009) stresses the importance of a broader analytic strategy to guide the analysis of case study data. In this study, the general analytical strategy used relied on the theoretical propositions that led to the case study. Within this broader strategy, the specific analytic technique used a pattern matching logic and employed thematic analysis, a tool that is "independent of theory and epistemology and can be applied across a range of theoretical and epistemological approaches" as well as different methods (Braun & Clarke, 2006). Thematic analysis is a "method for identifying, analysing, and reporting patterns (themes) within data." The analysis involved comparing the patterns obtained from the data through thematic analysis to the patterns predicted by the theoretical framework used in the study.

In this research the items that were identified as themes were items that captured something important about the data in relation to the research question and their relevance was not based on their prevalence within the dataset (Braun & Clarke, 2006). The thematic analysis was used to provide an account of the communication channels used in each case, the clients and professionals involved in decision-making, the relevant positive and negative attributes of each case and other contextual factors relevant to the adoption/rejection decision within the data. These themes were identified using a deductive approach which is driven by the theoretical framework and were identified at a semantic or explicit level that relies on the

surface meanings rather than looking beyond or searching for deeper meanings of what has been said.

Data analysis comprised examining, categorising, tabulating and testing evidence to address the initial study propositions. Due to the relatively small amount of data to be analysed, the analysis was done manually. The process followed in analysing the data is described below.

- The interviews were first transcribed (a verbatim account of all utterances).
- The transcribed interviews were all read through to provide a general sense of the information they contained
- The materials were then organised into segments of text (coding) then classified into themes using tables. The codes used were based on the theoretical framework used while still being open to unusual and unexpected subjects. These codes were then grouped under themes- context, change agents' promotional efforts, the type of decision, communication channels and attributes.
- The results of each interview were then compared and contrasted and interpretations made by comparing results to that of the survey and the theoretical framework.

5.3.2 Results and Analysis

This section presents results of the interview and is divided into five sections. The first section gives details of the respondent characteristics, three of the sections present the result as it relates to each case and the fifth section presents the discussion and interpretation of the results.

5.3.2.1 Interview Respondents

A summary of respondents characteristics are provided in Table 5.24, Table 5.22 and Table 5.23.

Table 5.22 Characteristics of Client Respondents

REFERENCE	RESPONDENT	EDUCATION	PROFESSION	DECISION
CLI-1	Client respondent for Fast Floor	-	Programmer	Rejection
CLI-2	Client respondent for Pozzolana	BSC Civil Engineering	Civil Eng	Adoption (discontinuance)
CLI-3	Client respondent for Shingles	BSC Social Science	Business woman	Adoption

Table 5.23 Characteristics of Supplier/Change Agent Respondents

REFERENCE	RESPONDENT	PROFESSION
SUP-1	Supplier for Fast Floor	The respondents were employees in middle management positions within the company and chose to remain anonymous
SUP-2	Supplier for Pozzolana	
SUP-3	Supplier for Shingles	

Table 5.24 Characteristics of Consultant Respondents

REF	PROFESSION	EDUCATION	PROFESSIONAL QUALIFICATIONS	YEARS EXPERIENCE
CE-1	Civil Engineer & Senior Lecturer	BSc Civil Engineering MSc Structural Engineering PhD Civil Engineering (earthquake)	Ghana Institution of Engineers (Member) American Society of Civil Engineers (Associate Member) American Concrete Institute (Member)	19
CE-2	Civil Engineer	BSc Civil Engineering MSc Structural Engineering	Ghana Institution of Engineers (Member)	25
ARC-1	Architect	BSc Architecture PG Dip Architecture	Ghana Institute of Architects (Member)	15
ARC-2	Architect & Lecturer	BSc Architecture PG Dip Architecture MBA (Project Management)	Ghana Institute of Architects (Member)	26
QS-1	Quantity Surveyor	BSC Building Technology Certificate in Construction Engineering MSc Construction Management	Ghana Institution of Surveyors (Fellow)	27
QS-2	Quantity Surveyor	BSC Building Technology PG Dip Project Management MBA (Construction and Real Estate)	Ghana Institution of Surveyors (Fellow)	28

Table 5.25 Summary of results on Knowledge, Use and Perceptions of Acceptance

Interviewee	Knowledge			Use			Perceptions of Acceptance			Comments
	FF	S	P	FF	S	P	FF	S	P	
QS-1	√	√	√	Y	N	N	D	N*	N	*Not quite accepted yet
QS-2	√	√	√	Y	Y*	N	Y	Y	D	*designed but not built
ARC-1	√	√	√	Y	Y	N	Y	Y	D	
ARC-2	√	√	√	Y	Y	N	Y	Y	D	
CE-1	√	√	√	Y			D	-	N	
CE-2	√	-	-	Y	-	-	Y	-	-	Said he was more familiar with FF and choose not to speak about the others
CLI-1	√	-	√	N			Y	-	-	The clients and suppliers provided information only with regard to the products for which they were selected
CLI-2	-	-	√	-	-	Y	-	-	N	
CLI-3	-	√	-	-	Y	-	-	Y	-	
SUP-1	√	-	-	Y	-	-	Y	-	-	
SUP-2	-	-	√	-	-	Y	-	-	N	
SUP-3	-	√	-	-	Y	-	-	Y	-	
Interpretation of Symbols: Y- Yes N- No D- Don't know or declined to respond FF – Fast floor/ prestressed beams and blocks S – Shingles P - Pozzolana										

5.3.3 Case One: Prestressed Beams and Blocks (Fast floors) [Figure 5.9]

5.3.3.1 Innovation description

According to Raju (2006) the development of cracks in reinforced concrete due to incompatible strains of steel and concrete was perhaps the origin of the development of prestressed concrete which is "basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree." This prestressing is normally introduced by a process called tensioning. The idea of prestressing was first suggested by Mandl, an Austrian engineer in 1896 and today has several applications as structural members in buildings including arches, roofs, trusses and floors (which is the focus in this research) as well as some specialised uses in bridges, roads, dams, transmission poles, railway sleepers, nuclear pressure vessels, water-retaining structures, airport runways and the like. This research focuses on members used in

buildings which belong to the class of prestressed members called pre tensioned members. The wires are pre tensioned before concrete is cast around it and then cut once the concrete cures. This is in contrast to the other class of prestressed beams in which the wires are tensioned after the concrete cures. These are called post tensioned members (Balaguru et al., 2008).

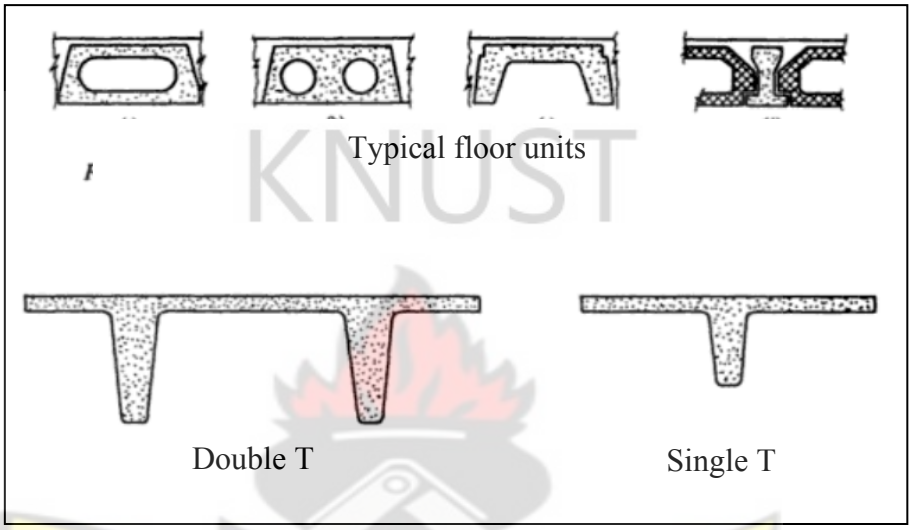

Figure 5.9 Types of Prestressed floor units

Source: Abeles & Bardhan-Roy, 1998

The most prominent advantage of prestressed members is the increased resistance to shearing and flexural cracks. Prestressed members also have improved durability especially in members exposed to corrosive atmospheres or aggressive ground conditions. Furthermore, the cross-section of members can be smaller since less steel is used and the overall weight of the member is reduced since the weight of the prestressed steel is only a fraction of the weight of reinforcement that it replaces (1/5 to 1/3 the amount of steel). Consequently, there is a reduction in dead load which in turn reduces design loads and the cost of foundations (Abeles & Bardhan-Roy, 1998; Raju, 2006). This reduced requirement for steel may in certain cases enhance the economy of the prestressed concrete as compare to reinforced concrete. However, costs due to the need for high-strength concrete, high tensile steel, anchorages and

other equipment necessary for production may offset any economic advantages that may be gained from the reduced use of concrete and steel. A challenge is that the advantage of using comparatively shallow and slender sections may enhance susceptibility to flutter because of reduced natural frequency of vibration and in certain cases lead to dynamic instability either due to wind excited oscillation or vibration of some other origin unless adequate damping is introduced (Abeles and Bardhan-Roy, 1998).

In Ghana, Ital Pre-stress Concrete Products (IPCP/Trasacco) was the first company to mass-produce prestressed concrete products for sale in the Ghanaian construction industry. Prior to this, though uncommon, there were instances of use (most often specialised use) as was the case of the Kwame Nkrumah University of Science and Technology Unity Hall. However, the 'modern era' of the fast floors in Ghana especially in buildings began in 1997 when they were re-introduced by IPCP.

5.3.3.2 Results of Analysis

Table 5.26, Table 5.27, Table 5.28 and Table 5.29 provide a list of contextual factors, attributes and communication channels associated with the fast floor adoption decision.

Table 5.26 Communication Channels Associated with Fast Floors[12]

Interviewees/Communication channels	CON	WWW	UNI	SEM	ADVERT	PEER	SSR
QS-1	-	-	√	√	-	-	-
QS-2	√	-	√	√	√	-	-
ARC-1	-	-	√	-	-	-	-
ARC-2	-	-	√	-	-	-	-
CE-1	-	-	√	-	√	-	-
CE-2	-	-	√	-	-	-	-
CLI-1	-	√	-	-	-	√	-
SUP-1	√	√	-	√	-	-	√

Table 5.27 Contextual Factors Associated with Fast Floors

FACTOR	INFLUENCE ON ADOPTION
Constraints on project time (QS-1),	The perception of reduced build time associated with the product depended on the project constraints related to time. Where time was irrelevant especially with homebuilders such as CLI-1 who preferred to take his time building, this attribute was not perceived as an advantage
Manufacturers support (QS-1 QS-2 CLI-1 SUP-1),	The suppliers of Trassaco (SUP-1) provided support in various forms for potential adopters- They provided consultancy, installation and training services. An example of how adoption is affected by these is that the perceived complexity of the product is reduced through increased knowledge and understanding
Proximity of supplier (CE-1)	This factor was cited as relevant especially for potential adopters outside of Accra especially at the time when the only supplier was situated in Accra. The cost of transporting the products eroded the savings and hence reduced the perceived relative advantage of cost and the likelihood of adoption
Supply (QS-1,QS-2, SUP-1)	At a point in time, demand for the product outstripped supply and one had to wait for long periods after ordering the product to receive it. This also affected the time savings associated with the product
Use of opinion leaders (QS-1, QS-2)	The suppliers of fast floors employed the use of opinion leaders. They organised seminars and workshops for building consultants who in lieu of their expert knowledge have influence on decision making in projects they are involved in
Regulatory framework (CE-1,CE-2, ARC-1)	They ensured that they fit within the regulatory framework by getting recognised by standards board and engaging in research activities to ensure that the products fit expected standards. This improved the attribute of compatibility with existing standards and norms

[12] Interpretation of Codes: CON- Consultants/ other building participants, WWW- Internet, UNI- Universities and research institutions, SEM- Seminars and workshops, ADVERT- Advertisements, PEER- Peers, SSR- Sales and supplier representatives

Table 5.28 Favourable Attributes Associated with Fast Floors

Positive/Favourable Perceptions	
Relative advantage	Reduction in build/construction time* (ARC-1, ARC-2, QS-1, QS-2, CE-1, CE-2)
	Cost savings (QS-1,QS-2, CLI-1)
	No formwork needed (QS-2)
Observability	Easily seen during construction (CE-1)
	The use of the product by the supplier on his own project helped improve confidence in the product (QS-2)
Complexity	Artisans need some orientation to use it but it takes a day/less than a day (QS-2)

*Major attribute

Table 5.29 Unfavourable Attributes Associated with Fast Floors

Negative/Unfavourable Perceptions	
Relative advantage	Reduced density and water-tightness (CE-2)
	Need for upfront high initial cost (CE-2)
	Less easily altered (ARC-1, ARC-2, CLI-1)
	Less easily used on fluid designs with curves (More suited to modular construction) (ARC-1)
	Negative impact on safety (QS-2)
Complexity	Stairs anchorage is less easily done and there is the need for special jointing for earthquake resistance (CE-1, CE-2)
Observability	Once the floor is screeded you are not able to tell the type of floor it is (ARC-1)

5.3.4 Case Two: Asphalt Roof Shingles [Figure 5.10]

5.3.4.1 Innovation description

The origins of asphaltic shingles can be traced to the development of composition roofing in the United States in the mid-19th century. Hence, asphaltic shingles are also known as composition roofing. These earlier versions were produced in long strips, packaged in rolls and commonly known as “rolling roof”. However, in 1903, the first individual asphalt shingles were produced by Herbert M. Reynolds who hand-cut rolls of rolling roofing into individual shingles (National Park Services, 1999).

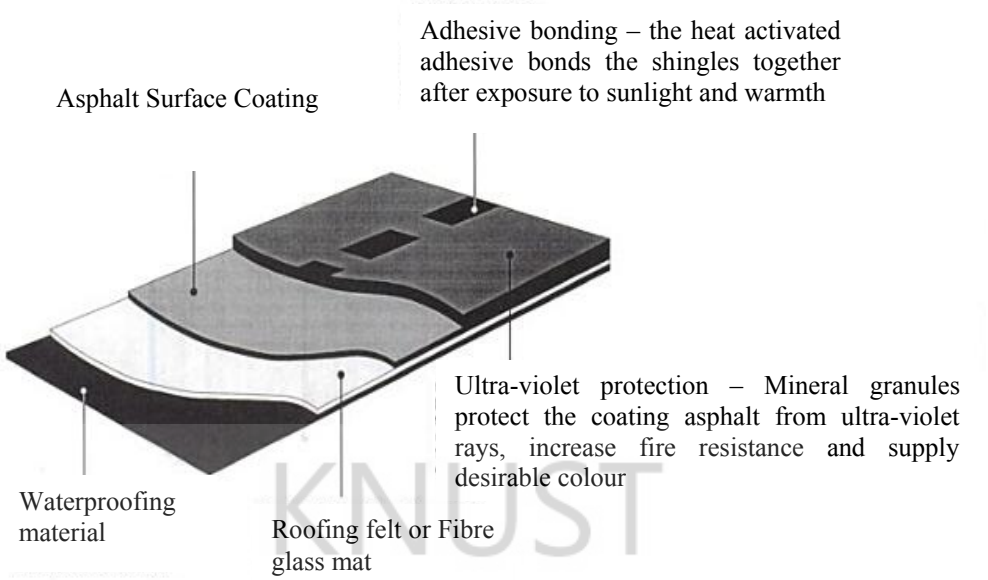

Figure 5.10 Components of an Asphaltic Shingle

Source: Atcheson, 1995

Currently, asphalt shingles are available as either organic or fibreglass types. The two types are all made with asphalt and require a solid wood deck to be laid but they differ in the materials used for their base mats. Organic shingles have their base mat made of either a cellulose fibre mat or tough asphalt-saturated roofing felt, coated on both sides with asphalt whilst Fibreglass shingles have base materials of fibreglass saturated and covered with flexible asphalt. Both are then surfaced with mineral granules. Asphaltic shingles were primarily organic types until the fibreglass types were introduced in the 1950s (Atcheson, 1995, Marshall 2008)

Shingles have the advantage of being attractive, versatile and wind- and fire-resistant with a normal life expectancy of fifteen (15) to twenty (20) years for organic shingles and twenty (20) to thirty (30) years for fibreglass shingles (Atcheson, 1995) They also perform well in all types of climate and are available in a wide variety of colours, shapes and textures (Marshall, 2008).

The introduction of shingles in Ghana is difficult to trace given that prior to the

introduction of suppliers in the country, it was imported for use on a small scale by individuals for their projects. However, according to some of the respondents, even in the early 2000s the use of shingles was diminutive and there were very few suppliers (CLI-3, SUP-3, QS-2)

5.3.4.2 Results of Analysis

Table 5.30, Table 5.31, Table 5.32 and Table 5.33 provide a list of contextual factors, attributes and communication channels associated with the asphaltic shingle adoption decision.

Table 5.30 Contextual Factors Associated with Shingles

FACTOR	INFLUENCE ON ADOPTION
Lack of adequate suppliers in the initial stages (QS-2, SUP-2)	The lack of suppliers in the initial stage of the diffusion of the shingles meant that most adopters had to import the product thereby increasing its expense
Regulatory framework (ARC-1, ARC-2)	Lack of proper regulation of imports means that some types of shingles not compatible with the climate are brought in
Availability of good quality plywood (ARC-2)	Lack of good quality plywood has the potential to influence the adoption and the performance of the product because it is a requisite for using shingles.

Table 5.31 Communication Channels Associated with Shingles[13]

Interviewees/Communication channels	UNI	OBS	ADVERT	CLI
QS-1	√	-	-	-
QS-2	-	-	-	-
ARC-1	√	√	-	-
ARC-2	-	-	-	-
CE-2	-	-	-	-
CE-2	-	-	-	-
CLI-3	-	√	-	-
SUP-3	-	√	√	√

[13] Interpretation of Codes: UNI- Universities and research institutions, OBS- Observing other building projects, ADVERT- Advertisements, CLI- Client

Table 5.32 Favourable Attributes Associated with Shingles

Positive/Favourable Perceptions	
Relative advantage	Aesthetic appeal* (ARC-1, ARC-2, QS-2, CLI-3)
	Provides cooler internal temperature (CLI-3)
	Flexible and malleable (ARC-1)
	Lighter (ARC-2)
	Requires less sophisticated structural system because its lighter (ARC-2)
	Positive impact on status/image (ARC-1)
Observability	Easily visible in buildings (ARC-1, CLI-3, SUP-3)
Compatibility (perception in relation to existing practices)	Similar to concrete tiles (ARC-2)
Complexity	An ordinary carpenter can fix it (ARC-2)

*Major attribute

Table 5.33 Unfavourable Attributes Associated with Shingles

Negative/Unfavourable Perceptions	
Relative Advantage	Expensive (for the affluent) (QS-2, ARC-1)
	Algae growth (CLI-3, ARC-1)
	In case of later alterations, getting the same colour may be difficult (ARC-1)
	Leakages (ARC-1, ARC-2),
	Quality plywood (ARC-1, ARC-2)

5.3.5 Case Three: Pozzolana

5.3.5.1 Innovation description

Pozzolana as described by Atiemo (2005) is "any siliceous or aluminous material which reacts with lime in the presence of water to form cementitious compounds." Pozzolana was discovered by the Romans and as far back as the 3rd century BC the Romans used Pozzolana instead of sand in concrete and mortared gravel work and in monuments such as the Pantheon and Baths of Caracalla (Encyclopaedia Britannica Online, 2012).

Pozzolanas may either be naturally occurring from volcanic materials such as tuff or

trass or produced artificially from clays, shale, bauxite waste and the like. In Ghana Pozzolana is artificially produced from clay or bauxite waste (Atiemo, 2005, Bediako et al., 2011). Pozzolanas do not, by themselves, have any cementing value but have the ability to react with calcium hydroxide and water at ambient temperatures to give cementitious products (Atiemo, 2005; Reeves et al., 2006). Therefore, pozzolana is used with ordinary Portland cement either by inter-grinding Portland cement clinker and pozzolana or by intimately and uniformly blending Portland cement and pozzolana in their powdered form (Gambhir, 2004).

Pozzolana is relatively cheaper due to its reduce energy intensity, utilises waste materials and improves the quality of mortar and concrete as follows:

- improved resistance to chemical agencies, sulphates and sea water,
- lower heat of evolution/hydration,
- higher degree of water tightness,
- good resistance to expansion,
- high tensile strength than Ordinary Portland Cement
- does not react or corrode fittings because it has no free lime)

(Punmia et. al., 2003, Reeves et. al., 2006).

Its major challenge, however, is that the rate of gain of compressive strength is slower although its compressive strength may be comparable with ordinary portland cement if the concrete is produced with care under controlled conditions (Gambhir, 2004)

In Ghana, pozzolana was initially introduced by the Building and Road Research Institute (BRRI) in the early 2000s after over thirty years of research and

development into the use of local raw materials for pozzolana production. Currently the product is produced commercially by Pozzolana Ghana Limited which was established in 2007. The impetus for pozzolana research, development and commercialisation in Ghana was the need for a durable but cheaper cementitious material for construction especially housing.

5.3.5.2 Results of Analysis

Table 5.34, Table 5.35, Table 5.36 and Table 5.37 provide a list of contextual factors, attributes and communication channels associated with the pozzolana adoption decision.

Table 5.34 Contextual Factors Associated with Pozzolana

FACTOR	INFLUENCE ON ADOPTION
Time	The suppliers of pozzolana have been in existence for a short-time. The previous suppliers (BRRI) were doing so on a small scale to whip up interest in the product
Dominance of the existing product	Ghana Ordinary Portland Cement has been the only cement in Ghana for a very long time so for people to shift from its use is difficult
Availability of Ordinary Portland Cement	Pozzolana cannot be used on its own hence, the availability of Ordinary Portland Cement will influence the ability to adopt the product

Table 5.35 Communication Channels Associated with Pozzolana[14]

Interviewees/Communication Channels	CON	WWW	UNI	SEM	ADVERT	PEER	MAN
QS-1	-	-	-	√	-	-	-
QS-2	-	-	√	-	-	-	-
ARC-1	√	-	-	-	-	-	-
ARC-2	-	-	-	√	-	-	-
CE-1	-	-	-	-	-	-	-
CE-2	-	-	-	-	-	-	-
CLI-1	-	√	-	-	-	-	-
CLI-2	-	-	-	-	√	√	-
SUP-2	√	√		√			√

[14] Interpretation of Codes: CON- Consultants/ other building participants, WWW- Internet, UNI- Universities and research institutions, SEM- Seminars and workshops, ADVERT- Advertisements, PEER- Peers, MAN- Manufacturers Technical Support

Table 5.36 Favourable Attributes Associated with Pozzolana

Positive/Favourable Perceptions	
Relative advantage	Cost savings* (CLI-1, CLI-2, SUP-2)
	Quality compared with others e.g. compressive strength (SUP-2, CLI-2)

*Major attribute

Table 5.37 Unfavourable Attributes Associated with Pozzolana

Negative/Unfavourable Perceptions	
Compatibility	Time taken to attain strength (CE-1, CLI-2, SUP-2)
	It is not a substitute for Ordinary Portland cement (ARC-2, CE-1, QS-1)
Observability	There are few examples of demonstration projects which have used pozzolana and where they are used the product is not visible when work is done (ARC-1, CE-1)

5.3.6 Interpretation and discussion

In this case study, the main objective was to understand how the innovation diffusion factors as described by Rogers (2003) influence the adoption decision in real-life contexts. The study was especially focussed on how the factors related to each other in real-life situations with special interest in the role of the context. This was in the light of the importance that Hartmann et. al., (2006) attached to the context rather than solely focusing on the innovation attributes. Like Hartmann et. al., (2006)'s case study, the innovations studied were within the construction industry and involved building clients. However, this study goes further to build on his work and to test the developed framework within a different country and among private rather than public clients thereby focussing on a social system different from that of Hartmann et. al., (2006). The cases also included investigations of an instances of rejection and not just adoption and investigation of product innovation rather than a process innovation. This study also investigates how the type of decision and change agents' promotional efforts fit into the framework.

As in the case of the framework, factors identified involved those relating not just to innovation attributes but also to communication channels and most importantly to the context thereby providing evidence to the link between these three factors. In fact, the context was identified as the main factor from which the others drew their influence. In other words the context of the adoption decision determines the extent and direction of influence that the factors relating to communication channels and innovation attributes have on the adoption decision. The following are the results obtained from this study:-

The decision to adopt an innovation is not a detached activity but is actually connected with others that together constitute a process an individual goes through in order to come to a decision to adopt or reject an innovation.

In all three cases, the three stages of Hartmann et. al., (2006)'s framework could clearly be identified in the interviews with the clients that took decisions on the products. The stages were present whether the final decision was adoption or rejection of the innovation. There was also the presence of felt need/dissatisfaction with a present circumstance which was stated by Rogers' (2003) but absent in Hartmann et al., (2006)'s framework. This is evident in the CLI-2's interview.

> *"I had heard about it several times I even had the contact number of the one who was promoting it but I never called him. I kept it on my phone, one day I needed work done on my site, cement was too expensive, then I said 'ah let me give pozzolana a try'."*- CLI-2

Although, he had knowledge of pozzolana it was not until he became dissatisfied with the high price of ordinary Portland cement that he finally decided to adopt pozzolana. Felt need does not always follow after knowledge is obtained but may in

fact be the catalyst that propels a potential adopter to seek knowledge of an innovation to satisfy the felt need.

However, the adoption process is not necessarily in a linear pattern as depicted by the framework and the stages may overlap with each other or be separated by varied periods of time. The process may also terminate at any point or stage.

In the cases of CLI-2 and CLI-3 the knowledge stage of the adoption process did not end after adoption. CLI-2 actively sought for more information about pozzolana and how it is used in order to understand why it failed when he used it for his building. In the case of CLI-3, she also sought information about how to deal with the problem of algae growth on her roof cladding. These instances provide additional evidence of the nonlinear nature and overlapping of the stages of adoption as indicated by Hartman et. al., (2006).

Not all potential adopters experience all the stages of the adoption process. Although QS-2, for instance, had knowledge of pozzolana, she had neither adopted the product nor formed an attitude towards it. She had not experienced the persuasion stage even though she had adequate awareness and how-to knowledge of the product.

> *"If you were in the position of the client and you were to make a decision about pozzolana what would it be?"*- Interviewer
>
> *"Interesting question. I haven't thought about it. I don't know. It's something I haven't thought about."*- QS-2

Knowledge may be classified into awareness, how-to and principle knowledge and at least awareness knowledge is imperative if adoption is likely to be made.

"How-to knowledge" about function and usage of an innovation is vital to attain a

favourable attitude towards an innovation and understanding the functional principles of a new idea and the way to use it properly reduces the perceived complexity of the innovation and increases the likelihood of adoption, as the adopter is more able to judge the effectiveness of the idea. However, without "how-to" and "principle" knowledge, a decision about the product can be taken but without a potential adopters' awareness of the existence of an innovation, adoption is impossible. This is very evident in the project environment where the client employs consultants to provide expert advice and manage the project hence the client is not required to have "how-to" or "principle" knowledge. It is also evident that although the consultants had knowledge of the principle of pre-stressing and its use in the fast floors, the client CLI-1 only possessed awareness and how-to knowledge. According to QS-2 in some cases, some clients are only aware of a product and solicit the help of experts to advise them on the decision to take.

> *"...sometimes clients really delegate everything to the consultant so they would evaluate assess and come with a proposal and they would accept"*- QS-2

> *"...the floor most clients really can't tell the difference so it's entirely up to the technical people to give them the pros and cons of it"* – ARC-2

SUP-1 and SUP-2 understood this condition and tried to remove the need for "how-to" and "principle" knowledge of their potential adopters and facilitate adoption by providing support, consultancy and expert services to clients. This observation which is peculiar to the building environment and other environments akin to it is of notable importance. Promotional efforts on knowledge dissemination within such an environment should recognise that although "awareness" knowledge is necessary for both clients and consultants, there may be instances where "how-to" knowledge should be more focussed on consultants rather than clients since consultants may

better appreciate this knowledge and may be more influential to decision-making

The communication characteristics within a social system strongly affect whether a potential adopter becomes known with an innovation and how this individual perceives the attributes of the innovative solution.

It is the communication channels that trigger the adoption process and the source, mode and quality of the communication influences both persuasion and adoption or rejection. In the case study, some consultants expressed the opinion that they attached importance to the information on innovations depending on its sources. ARC-2 stated

> *"I don't take whatever I hear on the radio or see on the telly. No I don't. ... For instance I have been invited to a shop around this area. They've called me to come and look at the product they have. When I get there I'll take the technical information. That is what will advise me. I don't care whatever I've read they put on the bill boards because half of the time they won't tell you the truth."*- ARC-2

Contrary to Hartmann et. al., (2006) in this case study, the mode of the information did not seem to make much of a difference. Instead the mode was more likely to affect the quality of the information which was what was important to the interviewees. Oral information is more likely to be diluted or corrupted as it is passed on than written information.

> *"...if you tell people to use pozzolana and Portland cement in the ratio 2:1, two (bags of) Portland cement to one (bag of) pozzolana, (they usually) the one who is buying is not the final consumer people who buy from us are usually distributors then in selling to the final consumers they tend to dilute the message. Sometimes you get to a point where the final consumer turns the ratio upside down and now it becomes two (bags of) pozzolana to one (bag of)*

Portland cement. I have witnessed a real estate developer who bought and gave it to his mason for a massive house construction and then the mason now turned the ratios upside down and everything came down. And now the top management were not willing to buy again to make repeat purchases from us."- SUP-2

Some clients and consultants alike used and were influenced by written and oral, mass and interpersonal channels. CLI-1 for example became aware of fast floors through an oral/interpersonal channel (a friend) but used written/mass media channel (internet) and oral/interpersonal channels to obtain more information about the product. For him, what was more important was the background or how qualified and credible the source was. However, it is worth noting that the mode may become relevant amongst potential adopters who may not be literate (influence of the context). In this study all the participants were literate.

The perception of innovation attributes affects the evaluation of a new idea and the propensity to its adoption.

This proposition is clearly evident amongst the clients. CLI-1 considered the fast floor because he perceived it as a more advantageous solution compared to insitu concrete because it could offer cost savings.

"What was it about the fast floors that made you consider using it?" - Interviewer

"It was purely on cost, purely on cost. When I read about it I learnt that compared to the traditional method I could save about thirty percent on it." – CLI-1

CLI-2 adopted pozzolana because he perceived it as more advantageous because of the cost savings and compressive strength it provided.

"It was the cost and also the fact that my friend had told me his research was producing results because I know what concrete strength means and if you tell me you get this concrete strength from pozzolana I understand it. So I believed that ok it works" – CLI-2

CLI-3 adopted the shingles because of its perceived advantage of being aesthetically pleasing.

"What was it about shingles that influenced you to adopt the product?" - Interviewer

"The beauty ('na εyε mi fε') I used to see it. It was flat, it was thin, it was simple and it has character. If you look there are different types of shingles. Some of them are one colour and with these earlier ones with the green like this you see three different shades of green. It's not a flat colour it's got character. It was just beautiful. I appreciated it for the beauty" – CLI-3

However, attributes are not stable features of an innovation or sure determinants of their adoption. Where an innovation has many perceived attributes at the same time, the adopter evaluates the innovation based on the significance accorded to each attribute.

Attributes as explained by Rogers (2003) are not assessed objectively but as perceived by the adopter. This perception then may change from one adopter/potential adopter to the other for a particular innovation. For instance, with the fast floors, CE-1's perception of observability was positive/ favourable whilst ARC-1's perception was negative/unfavourable [Table 5.28 & Table 5.29]. Consequently, it is important to understand how potential adopters "see" an innovation and according to Wejnert, (2002) the perceptions of innovations are influenced by the characteristics of potential adopters and it is therefore important to consider the interaction between the characteristics of both the innovation and the

potential adopters.

There were also instances where an adopter had different perceptions of attributes of an innovation. For example CLI-2's perceptions were related to both cost savings and compressive strength [Table 5.36]. The evaluation of the potential adopter then is based on attributes the individual accords most significance. In the case of CLI-1 whose perceptions were related to both cost and future performance (how easily future alterations could be done) [Table 5.28 & Table 5.29], he chose to reject the fast floors because the future performance of the product and its ability to be altered was more important than the cost savings.

> *"It's mainly because of the future changes to the structure. When I came to Accra I had a conversation with Michael and he said later if you want to alter the structure it's difficult. That really influenced me, you never know the future. Maybe you want to turn it from residential to offices or something and it becomes a stumbling block"*- CLI-1

Pagani, (2004) observe similar results from evidence based on third generation mobile multimedia services that the perceptions of different attributes may not be accorded similar significance and the attributes regarded as more important by potential adopters are more influential to adoption of an innovation.

Even when innovations are perceived favourably, this does not guarantee adoption.

> *"...and I used them for my personal projects like my house some apartments I made, a property of my husband's mother that is my mother in law. In fact they were personal projects. It's so expensive that when I take these government projects I don't use them"*- CLI-3

> *"I don't use them on government projects. The only government projects I used them on was the AU village and even that was because it was funded by...and the money was immediately available"*- SUP-3

This is evident in the case of CLI-3 who did not adopt shingles in every project in spite of her fascination and favourable attitude towards the product. She stated that although she used the product for her own personal projects and recommended it to others she did not use it on government projects. SUP-3 also provided similar information. In these cases the project characteristics which is a factor that relates to the context determines the influence that the perception though favourable had on the decision to adopt the product on the project.

Ultimately all the above propositions depend on the context.

The context refers to the circumstances surrounding the adoption decision and the conditions under which the propositions regarding the communication channels and perceived attributes hold. Felt need/dissatisfaction which was mentioned earlier is an example of a contextual factor. Hartmann et. al., (2006) define the context at three levels based on the TOE framework by Tornatzky & Fleischer (1990): the technological (internal and external technologies of the firm), organisational (the characteristics and resources of the firm or the internal descriptive measures about the organisation) and environmental (external context in which the organisation conducts its business) levels. This framework was developed with firms rather than individual clients and professionals as adopters/potential adopters therefore this delineation is adapted slightly to suit the circumstances of this study. It should be noted however that this delineation accorded to the contextual factors is merely descriptive and pedagogic- to aid in studying them. What is most important is to understand how all these factor saffect the adoption decision.

In this study the context are divided into three levels as well: the technological,

project and extra-project levels. The technological level refers to all technologies[15] available to the potential adopter, project level refers to all factors that are project-related and extra-project factors are those that emanate from sources beyond or outside the project.

The technologies available especially those with which the potential adopter is already familiar with serves as a frame of reference and determines how the potential adopter perceives the attributes of an innovation.

> *"With regards to the shingles once again it's the same thing if you are to use or constructing with concrete tiles you go through the same process as you do for shingles. The advantage of the shingles is that it is lighter than the concrete tiles and therefore the woodwork or the structural system doesn't have to be as sophisticated as what is required for concrete tiles but other than that it is basically the same thing. An ordinary carpenter will be able to do it..."*-ARC-2

ARC-2, for instance, in describing the installation of shingles likens it to concrete roof tiles and so his familiarity with concrete roof tiles makes it easy to understand the installation of shingles thereby reducing his perception of complexity and therefore level of associated risk. Wejnert, (2002) corroborates these findings and affirms that people are naturally cautious in approaching novelty and therefore the rate of adoption is indirectly related to the novelty or "radicalness" of an innovation.

Also, though it is not mentioned directly, in the case where the adoption of the innovation depends on the use of another as is the case of pozzolana, the availability of the other product (ordinary Portland cement) may influence the adoption of the pozzolana.

[15] Technology in this context refers to the application of scientific knowledge for practical purposes and not just the machinery or equipment developed from such scientific knowledge

The project context deals with the characteristics and resources available to the project such as the parties involved in the project as well as their characteristics, the project constraints and even the type of facility and its use.

> *"But on the issue of the shingle roofing material I'd say that sometimes it's the particular building use and what may seem to be more appropriate. For example I'm doing a warehouse for a client, the perception of a warehouse (it does well with just your aluminium with its clean lines) it's not about aesthetics of the roof so you want to go with the shingle roofing so sometimes the usage of a particular building lends itself to what kind of material you want to use."*- ARC-1

The availability of competent personnel in the project also determines whether a product can be adopted or not. A project with competent personnel is more likely to offer less resistance to a product due to a lack of understanding.

> *"Sometimes I make a comparison with the automatic cars - automatic cars were very popular all over the world but here in Ghana the mechanical people who would work on cars were not familiar with the technology so they would always bad mouth it."*- ARC-1

The extra-project factors are all factors that are external to the project such as the industry, government and regulatory framework and the forces acting in the environment in which the project is undertaken. Wejnert, (2002 pp. 310) affirms that "iinovations are not independent of their environmental context but... and their successful transfer depends on their suitability to the new environments they enter during diffusion" A typical example is the status of the construction industry as described:

> *"...usually the thing with precast is that it gives you very fast construction time so any time there is a* ***boom in construction****, that is when it come in vogue... It's always been associated with the boom"* – CE-2

"Fast floor for instance if you go to KNUST all the annexes were built of fast floor slabs in those days except that the ***construction industry dipped*** *and for a long time it was not in the system until Trasacco started it"*- ARC-2

Identifying all the specific factors within each context level in one study is impossible however it is evident from the above that the communication channels and perceived attributes are influenced by contextual factors.

<u>The type of decision and the change agent's promotional efforts also influence decision making and are in turn influenced by the context</u>

The type of decision and the change agent's promotional efforts are variables that Rogers (2003) identifies as influencing the decision process but Hartmann et. al., (2006) fail to capture in their framework. These two variables like the others are influenced by the context.

In this study, the innovation-decisions of the clients were optional and there is no direct evidence of the case of how the type of decision (optional, collective or authority innovation decision) affected the adoption process. However, CLI-2 makes a statement that provides some indirect evidence to support this proposition.

"...then I heard in the news that the factory or the private firm that bought the franchise from BRRI were complaining that people were not patronising pozzolana and they were trying to ***get the government to see how they could enforce contractors doing government projects to buy pozzolana****"*- CLI-2

The above seems to suggest that the suppliers knew that once the type of decision was altered from an optional to an authority innovation decision, more contractors were likely to adopt and use pozzolana.

The project factors such as the parties involved in the project, their experience and competence and extra-project factors such as the regulatory framework affect the type of innovation-decision. The decision may be autonomous and optional as is the

case of the clients interviewed or collective as is the experience of the consultants or authoritative (this study has no examples of this case). A knowledgeable client might not need to solicit the input of consultants to evaluate and take a decision on the innovation whilst an uninformed client may involve his/her consultants. The regulatory framework if tight might make decisions about innovations authoritative as is the case of asbestos roofing sheets which have been banned in many countries.

Change agents desire to influence an individual's adoption-decision in a desirable direction and the extent of their promotional efforts determines their success or otherwise. One of the factors attributed to the lack of acceptance of pozzolana and the acceptance of fast floors is the extent of promotional efforts.

> *"What do you think has been a driving force in acceptance of the Fast Floors"*- Interviewer
>
> *"I think it is their own promotion that has help because they have done different seminars, workshops, they have gone round consulting firms. In the beginning they did a lot to promote it. I think they had a documentary probably on tv, so yes you get it in your office, you hear about it at the workshop it's on tv"* – QS-2
>
> *"Our promotional efforts too have not been the best I must be honest so its influence has just been a little."* – SUP-2

An important function of the change agents and their promotional efforts in this study was the provision of technical support through expert advice, installation and training. These aided and stabilized adoption and prevented discontinuance by increasing the potential adopter's ability to evaluate the innovations and also, the perceived complexity of the product is reduced through increased knowledge and understanding. In the case of pozzolana where these promotional efforts were minimal, acceptance was low and discontinuance was present. Even for the

consultants who were already familiar with the products, promotional efforts were important in identifying which products were readily available in the country.

Promotional efforts are, nevertheless, not independent of the context. The sources of communication available to the change agent's for promoting the innovation depends on the context. In this context of the case study, a wide variety of communication channels were available. The only channels that were not mentioned in the interviews were journals and trade shows. One of the reasons may be that these two channels are not as wide spread or immediately easily accessible as the other channels. Tradeshows in Ghana especially those that relate solely and directly to building and construction are few and occasional. The context also influences the kinds of programmes included in promotional efforts. In the case study context where a major issue was dissatisfaction with the human application and lack of understanding of innovations due to lack of adequate training of artisans, training or provision of expert advice was important for adoption and correct implementation.

5.4 Cross Analysis

The results of the survey and case study are complementary and together offer better explanations for the factors that influence the adoption-decision process. With regard to the reliability of the communication channels, the two methods seem to agree on consultants as the most reliable and advertisements and clients as least reliable. The results of the two methods do not just corroborate each other but the case study demonstrates how this disparity in frequency and reliability rating is relevant to the adoption process. ARC-2 as a case in point indicated that although he is privy to information on innovations via radio and television advertisements, his decision to adopt or reject an innovation is not made based on information provided through this

channel because of his low regard for this channel in terms of the reliability of the information offered. This means that communication channels employed should be selected by change agents for promotional efforts based on the channels used by the potential adopters of interest as well as the level of reliability accorded to them by the potential adopters.

Again, results of the survey indicate that universities and research institutes are the least used communication channels. However, in the case study all the consultants for instance obtained knowledge of fast floors from this channel. This might seem to suggest that the two results are contradictory but if the role of the context is taken into consideration, it is understandable how a purportedly least used channel is a major channel for a particular product. The consultants are by their very professions expected to be trained to know as many building technologies as possible in order to provide expert advice. This training for all of the consultants occurred in the university where the study of building technologies was a prerequisite; necessary to develop expertise in the field of construction.

The lessons from this study affirms the gratification perspective to mass media research which assumes that people are aware of different channels that can fill a particular need; they evaluate these channels and content and select the channel that they believe will provide the gratifications they seek . In this perspective, channels have normative images that are unrelated to the level of use (Perse & Courtright, 1993). So channels like internet may be used frequently its ability to eliminate spatial barriers to information flow but may not be regarded as equally reliable.

The architect was identified as the most influential building participant in the survey. The building participants that were identified as influential in the innovations studied in the case study were the client, architect and civil engineer. The extent to which the

client or consultants influenced decision making depended on the level of delegation and responsibility accorded them by the client and the type of innovation involved. In a project where the client involves no consultants and takes decisions alone, the use of consultants as opinion leaders might not have any influence. Identifying the relevant stakeholders and their value to the decision-making process offers change agents the opportunity to use such stakeholders as instruments that can be harnessed to influence adoption (Walker et. al., 2008). For instance, the selection of an opinion leader to help in promotional efforts or the selection of the clients and professionals who should be the focus of promotional efforts should depend on the role the individual plays in the building project.

The survey provides the significance of factors that influence innovation adoption but promotional efforts should not solely be aimed at improving the most significant factors such as the attributes of an innovation. Rather promotional efforts of change agents should be adapted to suit the peculiarities of the context as well.

Conceptual Framework for Innovation Adoption of Clients and professionals Within the Ghanaian Building Industry

Following from the results obtained and evidence from the case study, Hartmann et. al., (2006)'s framework was adapted and refined. The adapted framework still includes the perceived attributes, communication channels and context in addition to the change agents' promotional efforts. The type of innovation decision is not included in the framework because of the lack of direct evidence in the case study to illustrate its influence.

The three main factors (perceived attributes, communication channels and the change agents' promotional efforts) are embedded within the context to illustrate the fact that their extent and direction of influence derives from the context.

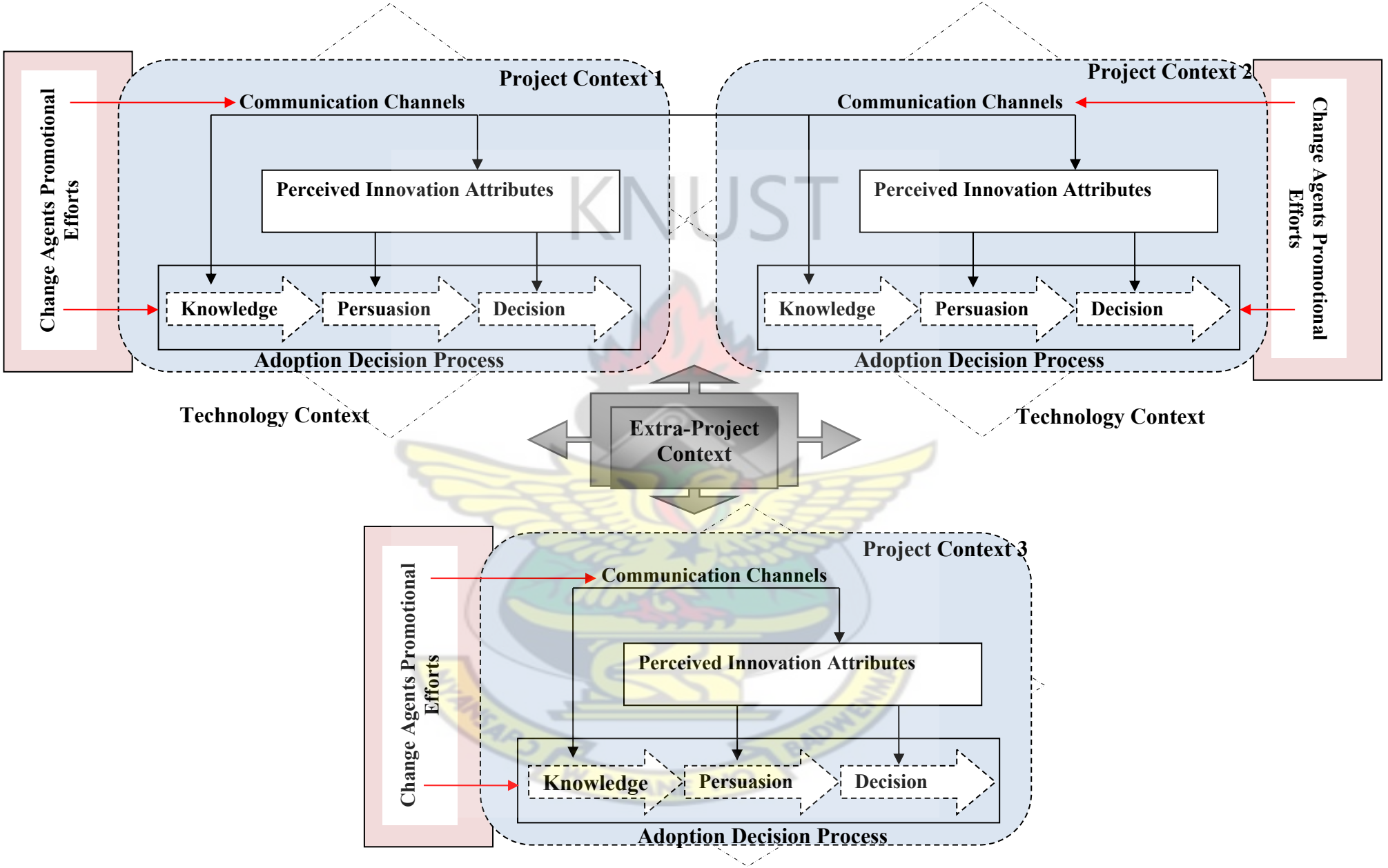

Figure 5.11 Conceptual Framework for Innovation Adoption of Clients and professionals Within the Ghanaian Building Industry

The framework also keeps in perspective the relationship across projects. The communication channels serve to transfer knowledge and circumstances involved in one project to the other hence, the connection between Projects 1 and 2. This link in between communication channels may not be present across all projects. The promotional efforts of change agents as seen in the framework influenced adoption through the communication channels and the adoption-decision process and the change agent and his/her efforts may or may not be part of the project

5.4.1 Implications for influencing photovoltaic adoption in the Ghanaian building industry

The most important lesson to be learnt from the results of this study is that although there are general principles that can guide PV promotional efforts, a lucid understanding of the context as well as the interaction between factors is fundamental to influencing PV adoption. Therefore any efforts at PV promotion must first understand the context surrounding the potential adopters of interest. This will help better organise promotional efforts for particular potential adopters or help change agents to target potential adopters whose contexts are more likely to enhance PV adoption.

Although, the initial cost of PV has been often identified as the major obstacle to adoption of the technology (Ndzibah, 2013) it is evidenced in the case of shingles and by Wejnet, (2002) that cost related variables are relative to the economic situation of potential adopters. This then explains why there are cases of adoption of PV within the study despite perceptions of high initial cost. Potential adopters with little cost constraints are more likely to adopt PV than those with tight constraints on project costs hence promotional efforts should be targeted at such clients and professionals with the means to afford the technology (Project level).

Promotional efforts should also be geared towards ensuring that current technology available supports PV adoption. The question of whether the current electrical distribution system allows for grid-connected PV systems that feed into the grid must be tackled (Technology level). At the extra project level, promotional efforts should include influencing policy, regulations and legislation. For instance, policies that subsidise electricity from the national grid and consequently make PV generated electricity all the more expensive should be a cause for concern for change agents (Edjekumhene & Brew-Hammond 2001) and the lack of a current feed-in-tariff system. The success of PV adoption in Germany has been driven by its fee-in-tariff policy (Ndzibah, 2013).

Aside the fundamental knowledge of the particular context of interest, there are some general principles that can be gleaned from the survey and case study. The Ghanaian building industry has quite a wide variety of communication channels available that can be used for PV promotion. However, it is imperative that the characteristics of these channels be also taken into account. For instance, the credibility and reliability of a source should be paramount in order to encourage positive perceptions of PV technologies. The use of consultants especially architects should be employed actively given that they are regarded as the most reliable sources of information and also because architects are regarded as most influential in the innovation decision. The use of consultants is especially important in this instance because PV systems need to be adequately designed to meet clients' requirements and this requires in-depth knowledge of photovoltaic module behaviour, battery characteristics, among others therefore the perceptions of complexity involved in adoption are likely to be unfavourable. The use of consultants to facilitate client decision-making as done in the case of the fast floors will greatly influence adoption.

When it comes to the issue of attributes, an important finding is that the influence that an attribute has on adoption depends on the significance accorded it by potential adopters and the significance accorded is related to the context surrounding the adoption process. The issue of cost which has often been named as a major challenge to PV adoption is not a hindrance to adoption in all circumstances the case. As revealed by the survey, the future performance of an innovation is regarded as paramount and there was evidence of adoption of photovoltaics despite high initial costs; in the case study it was observed that shingles were adopted under certain circumstances even though it was perceived as more expensive than its alternatives. The key then to influencing the adoption of PV is to identify the particular attribute of interest to the potential adopter and find the means to improve the potential adopter's perception of the attribute.

Taking cognisance of the process nature of the innovation decision is also of importance because this means that the influence of adoption is relevant at all stages of the decision process. Provision of relevant information, for instance, should remain paramount even beyond adoption of the technology. Besides providing knowledge of PVs, it is also important, as observed in this study and affirmed by Ndzibah, (2013), to provide support services such as training, installation and maintenance especially in the context of the Ghanaian building industry where the expertise of artisans are in question. These services will a) reduce the perceived complexity of PVs at the persuasion stage and therefore enhance evaluation of the product and increase the likelihood of adoption and b) guarantee proper implementation/adoption of the product and continued satisfaction thereby ensuring continued adoption.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Photovoltaic energy technologies have been identified as a viable option for energy production in Ghana especially in the light of increasing energy demands, an over reliance on the national grid, the availability of the energy resource and new applications of building integrated systems. It is this potential for photovoltaic use in the Ghanaian building industry that informed this study's primary research question of how the adoption of photovoltaics by clients and professionals in the Ghanaian building industry be influenced?

This chapter presents conclusions and recommendations on the results from the study. The contributions that the study makes to theory and practice are also provided as well as the limitations of the study.

6.2 Research Conclusions and Contribution

The main aim of this research was to determine and evaluate the potential factors that influence photovoltaic adoption in the Ghanaian building industry in order to know how the adoption process of photovoltaics in the Ghanaian building industry can be influenced. The study employed a mixed method, quantitative survey and qualitative case study, research design to achieve its aim and involved a review of literature on the context surrounding Photovaltaic energy technology and innovation diffusion and adoption. The literature review aspects of the study have provided a comprehensive compilation of the context, status and existing knowledge of PV technology as well as details of a relevant guiding theoretical framework which can

serve as useful reference given the contemporary nature of the issue at hand. The major outcome of the study is an innovation adoption framework that draws together the relevant factors that need to be considered to influence adoption in Ghanaian building industry. The study also provides a ranking of the factors, communication channels and building participants associated with adoption in the study area. The results and understanding gained through this research have both theoretical significance and practical implications for PV adoption and diffusion related promotional efforts in the Ghanaian building industry.

6.2.1 Theory

The use of the theory of diffusion of innovation in investigating the adoption of photovoltaics especially in the Ghanaian building industry is limited and mostly confined to rural areas. This study therefore adds to knowledge by extending the use of the Classical diffusion theory (Rogers, 2003) and Hartman et. al. (2006)'s framework by applying it to a new context [comprehensive frameworks that analyze diffusion taking the insights provided by others and the interaction of the different adotpion related variables into consideration (Wejnert, 2002). Hartmann et al. (2006)'s framework was based on case studies in the Netherlands and among public sector clients. In this study the Ghanaian urban environment presents a different social system and the focus on private clients provided a means to refine and validate Hartmann et. al.(2006)'s framework by testing it under different conditions. This is a significant contribution because there is the need for any innovation framework to be flexible and adaptable to the specific context in which it is applied since the findings of any diffusion research cannot invariably be transferable to new contexts and settings (Fichman, 1992).

The research showed that although the factor rated as most important for adoption (innovation's future performance) is related to the innovation characteristics, the interaction between the innovation, its attributes and its potential context is more valid and useful than the mere focus on innovation attributes. Another contribution of the study is the finding that the traditional cost-time-quality factors do play a major role in decision making amongst the respondents but a role that is subordinate to the certainty of future performance which is of utmost importance according to respondents of the study.

6.2.2 Practice

The main aim of the study was to discern patterns and formulate principles to guide future action especially principles that can inform change agents' promotional efforts. However, educational and scientific institutions together with policy makers, the private sector and civil society all have major contributions to make if renewable energy technologies such as photovoltaics are to be adopted and used effectively and the results of this study offer possible interventions.

Manufacturers and suppliers of building products, government and its allied agencies, and innovation champions can use the results of the study to influence their marketing and promotional efforts. For instance, the results on the most widely used and reliable communication channels provide the appropriate channels to use for knowledge dissemination. On the other hand, the understanding of the innovation characteristics and attributes that potential clients and customers find most important can help manufacturers and suppliers produce and supply products that are suited to customer expectations.

The study results are also useful for identifying professionals and professional bodies within the building industry who may be better positioned to champion adoption of innovations. As shown in the case of fast floors, architects' expertise in technical matters and their role on building projects, make them well placed to play a distinctive role in the innovation-decision process by disseminating especially "how-to knowledge' which is essential to an individual's decision to adopt or reject an innovation.

Furthermore, the results are relevant to focus policy initiatives on factors more likely to better influence adoption. In the case of Photovoltaics, the attributes were shown to have generally favourable attitudes but the weights as shown by the Relative importance indices (0.58-0.68) [Table 5.17a, Table 5.17b and Table 5.17c] are just average rather than good or excellent ratings. This might be detrimental to the adoption of PV technology especially because of its high initial cost. If PV technology is to be worth their high initial cost, they must offer better than average ratings with regard to their attributes. Its future performance should be better compared to its alternatives and should be clearly visible to potential adopters through the use of demonstration projects. Government policy then may include installation of the technology on public projects and institutions. Initial cost could be reduced by the introduction of financial policy interventions such as subsidies and tax rebates. This may be a determining factor in whether PV technology is adopted or not especially in the Ghanaian environment where access to capital is a challenge.

The most important lesson for practice is that understanding the specific context within which an innovation is to be diffused increases the ability to influence the process or adapt the innovation to suit the particular context. Often policy interventions or promotional efforts are targeted at improving innovation

characteristics and their perceptions without regard to contextual factors. A case in point is the provision of financial subsidies to reduce the initial cost and subsequent cost-effectiveness of PV when alternatively PV competitiveness can be increased by reviewing the cost of conventional energy supply to reflect its cost of production- an intervention that relates to the context.

Finally, the information and results of this thesis is relevant to educators and trainers of innovation diffusion related courses such as communication and development studies. The literature review on the Photovoltaic technology is also informative and pertinent to renewable technology related courses especially for students in building and construction.

6.3 Limitations and Recommendations for future research

The theoretical perspective adopted in this study with its emphasis on critical multiplism requires the use of planned multiple approaches on different levels so as to compensate for the biases of a given theory, method, data or investigator. This was however achieved only at the level of the method in this study because the level of complexities and expense involved made it difficult to achieve in a single research project, a point reiterated by Abs (2010) and Patry (2005). This limitation however opens up many avenues for further research:

- The theory of diffusion of innovation is extensive in its propositions and concepts; hence, fitting it within a single research study presents a challenge. This study focuses on just a portion and so there remains a need for further research in this area within the context of the Ghanaian building industry- especially identifying all relevant contextual factors and how they influence adoption.

- Ideally, research on innovation diffusion should employ a longitudinal study of the diffusion process to cater for the time factor. However, this study employed a cross-sectional approach to the study, an approach which is nevertheless valid in diffusion research although it does not account for the element of time.
- The current study only investigates the perceptions of architects, clients, mechanical and electrical engineers with regard to PV technology but the perceptions of other building project participants such as contractors and project managers who are involved in decision-making in non-traditional procurement systems are relevant hence more studies are needed in this regard. There is also the opportunity to conduct more case studies on other innovation typologies such as process innovations with the study area.
- The discovery that the traditional cost-time-quality factors play a subordinate role to the certainty of future performance should be investigated to ascertain if this result is peculiar to the population studied or represents a genuine change from emphasis on short-term performance indicators to more long-term life-cycle related indicators.
- Response rate was lower amongst architects because some members of the architect population were difficult to access while some others were apathetic towards the survey.

6.4 Conclusion

This study by no means solves the problem of the low adoption and slow diffusion of photovoltaics in Ghana but it has made significant inroads and opened up a relevant area for continued investigation. The results provided by the study most

importantly the framework developed, allow a lucid understanding of adoption and a better opportunity for influencing the process – an opportunity that is optimised by embracing the complexity of the adoption process and appreciating the interactions of the various factors. The successful integration of building integrated photovoltaics into the Ghanaian building industry to the benefit of both adopters and change agents hinges on this ability to embrace the complexity of the adoption process.

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APPENDIX ONE QUESTIONNAIRES AND INTERVIEW GUIDE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF ARCHITECTURE AND PLANNING DEPARTMENT OF BUILDING TECHNOLOGY

Dear sir/madam

QUESTIONNAIRE SURVEY- EVALUATING THE FACTORS THAT INFLUENCE THE ADOPTION OF PHOTOVOLTAICS IN THE GHANAIAN BUILDING INDUSTRY

I am currently undertaking research into how adopters and potential adopters perceive photovoltaics (a type of solar technology that generates electricity from sunlight) in the Ghanaian building industry. The research will assess the relative importance of the attributes of an innovation (new product, material or practice) to its adoption and how adopters and potential adopters perceive photovoltaics.

As part of the research, I am conducting a questionnaire survey to seek input from building participants (clients, architects, contractors and electrical engineers) within the industry in Ghana. Since only a limited number of qualified professionals are sampled, your experiences and perceptions on the subject are very important to this research. The research will provide information on the attributes of photovoltaics that are most important to building participants and ultimately offer recommendations on how to accelerate the technology adoption process in the Ghanaian building industry.

I would be grateful if you could kindly devote about thirty (30) minutes to complete the enclosed questionnaire and return it as soon as possible. Your response will be treated as STRICTLY CONFIDENTIAL. The information will be used for academic purposes only, as one part to a university research project. Only a consolidated summary of the results may be published, i.e. no names of participating individuals will be referred to and only the aggregate groups will be reported. A summary of the findings will be made available to you upon request.

Should you have any questions, please feel free to contact me by phone on 0200487365 or by email at naaadjeleyashiboe@yahoo.co.uk or naashiboe-mensah.carp@st.knust.edu.gh.

Thank you very much for your participation in the survey.

Yours sincerely,

Naa Adjeley Ashiboe-Mensah
PhD candidate
Dept of Building Technology
KNUST
Private Mail Bag
Kumasi

Rev. Dr. F. D. K. Fugar
Project Supervisor
Dept of Mechanical Engineering
KNUST
Private Mail Bag
Kumasi

Questionnaire Survey

Information for Respondents

Purpose of the Survey: This survey aims to gather data for evaluating the factors that influence photovoltaic adoption within the Ghanaian building industry. Your response will help to determine the significance of each factor and how photovoltaics rate with regard to its attributes.

Confidentiality: The information will be used for academic purposes only. Your answers will be kept completely confidential. Results will be aggregated and presented as summaries only and individual respondents or their respective firms will not be identified.

Questionnaire structure: This questionnaire contains 8 pages consisting of three main parts. Part A requests information on the information sources and factors that influence innovation adoption decisions, Part B is on photovoltaics whilst Part C solicits some background information.

PART A

Q1. How often do you refer to the following sources or channels for information on new products, materials and practices?

3 = Frequently 2= Once a while 1= Never

		3	2	1
i.	Consultants/other building participants			
ii.	Trade shows/ building exhibitions/science shows			
iii.	Clients			
iv.	World wide web/ internet			
v.	Sales and supplier representatives			
vi.	Seminars and conferences			
vii.	Universities and research institutes			
viii.	Journal and technical publications			
ix.	Advertisements (television, newspapers, radio etc)			
x.	Observing other building works			
xi.	Peer-information i.e. friends			
xii.	Manufacturers' brochures			

Q2. Please rate the reliability of information that is provided by the following information sources or channels on new building and construction products, materials and practices.

5= high reliability 4= good reliability 3= average reliability 2 = poor reliability
1= not reliable 0= not applicable

		5	4	3	2	1	0
i.	Consultants/fellow building participants						
ii.	Trade shows and building exhibitions						
iii.	Clients						
iv.	World wide web/ internet						
v.	Sales and supplier representatives						
vi.	Seminars and conferences						
vii.	Universities and research institutes						
viii.	Journal and technical publications						
ix.	Advertisements (television and newspapers)						
x.	Observing other building works						
xi.	Peer-information i.e. friends						
xii.	Manufacturers' brochure						

Q3. Please indicate the level of influence the following building participants have on the decision to adopt a new product, material or practice on a building project.

5= highly influential 4= very influential 3=average influence 2=influential
1=not influential 0= not applicable

		5	4	3	2	1	0
i.	Client						
ii.	Project manager						
iii.	Architect						
iv.	Quantity surveyor						
v.	Structural engineer						
vi.	Contractor						
vii.	Lenders, insurers and bankers						
viii.	Electrical engineer						
ix.	Mechanical engineer						

Q4. Please rate the importance of the following factors to your decision to use a new product, material or practice.

5 =highly important 4= very important 3=average importance 2=important 1=not important 0= not applicable

		5	4	3	2	1	0
i.	Impact of product, material or practice on profitability						
ii.	Certainty of its future performance						
iii.	Labour savings derived from the product/material/practice						
iv.	Prior experiences with similar product/material/practice						
v.	Waste reduction potential of the product/material/practice						
vi.	Ability to recover the cost of the product/material						
vii.	Influence of opinion leaders e.g. political leaders						
viii.	Constraints on project time						
ix.	Reduction in build time						
x.	Compatibility with preferred construction practices						
xi.	Acceptance of other building participants						
xii.	Difficulty/ease of continuing use of the product/material						
xiii.	Consumers' preference for the product or material						
xiv.	Manufacturers' technical support						
xv.	Source and proximity of the source of the product/material						
xvi.	Impact of product, material or practice on image/status						
xvii.	The degree of newness of the product /material						
xviii.	Initial cost of the product/material						
xix.	Acceptance of lenders, bankers and insurers						
xx.	Difficulty/ease of first use of the product/material						
xxi.	The risk of failure associated with using the product/material or practice						
xxii.	Acceptance of building inspectors						
xxiii.	Continuing cost of the product/material (Cost-in-use/running cost)						
xxiv.	Quality compared with alternatives						
xxv.	Acceptance of clients						
xxvi.	Constraints on project cost						
xxvii.	Compatibility with construction codes and standards						
xxviii.	Greenhouse gases/CO2 reduction potential of the product/material/practice						
xxix.	Ability to see the product/material in use in other projects						
xxx.	Noise reduction potential of the product/material/practice						
xxxi.	Cost savings derived from the product/material/practice						
xxxii.	Visual/aesthetic impact of the product/material						
xxxiii.	Ability to try the product/material						
xxxiv.	Knowledge/understanding of the product/material/practice						
xxxv.	Material savings derived from the product/material/practice						
xxxvi.	Fascination with new product/material/practice						
xxvii.	Impact of product, material or practice on safety						

Q5. Do you know about photovoltaic energy technology (a type of solar technology that is used to generate electricity from sunlight)? (Please tick **one** only)

Yes ☐

No ☐

If you answered "Yes" to the above, please continue on to Part B of the questionnaire; if you answered "No", please continue on to Part C.

PART B: PHOTOVOLTAIC TECHNOLOGY

Q6. From which source did you **first** find out about photovoltaics technology? (Please tick **one** only)

Consultants/fellow building participants ☐

Trade show/building exhibition ☐

Client ☐

World wide web/internet ☐

Sales and supplier representative ☐

Seminar/Conference ☐

University/Research Institute ☐

Journal/Technical publication ☐

Advertisement (television, newspapers, radio etc) ☐

Peers or friends ☐

Manufacturers' brochure ☐

Don't remember ☐

Other (please specify).....

Q7. Please indicate which of the following best describes you. (please tick **one** only)

I have been part of a project in which photovoltaics were adopted ☐

I am currently on a project in which photovoltaics are to be installed ☐

I have been part of a project in which photovoltaics were proposed but not installed ☐

I have never been part of a project in which photovoltaics were adopted ☐

I have been part of a project in which photovoltaics were adopted but later discontinued ☐

NOTE: If you have never been part of a project in which photovoltaics were adopted please skip questions eight (Q8) and nine (Q9)

Q8. Please indicate which of the following building participants had an influence on the decision to adopt photovoltaics. (Where you have been on more than one project involving photovoltaics please give a response based on the most recent)

		Had an influence	Had no influence
i.	Client		
ii.	Project manager		
iii.	Architect		
iv.	Quantity surveyor		
v.	Structural engineer		
vi.	Contractor		
vii.	Lenders, insurers and bankers		
viii.	Electrical engineer		
ix.	Mechanical engineer		

Q9. Please indicate which of the following building participants made the final decision to adopt photovoltaics. (Where you have been on more than one project involving photovoltaics please give a response based on the most recent)

Client □

Project manager □

Architect □

Quantity surveyor □

Structural engineer □

Contractor □

Lenders, insurers and bankers □

Electrical engineer □

Mechanical engineer □

NOTE: The next question (Q10) requires that you provide your perceptions of photovoltaic energy technology based on a set of attributes. If you have not used photovoltaics or experienced them enough to have formed perceptions please proceed to Part C otherwise go on to the next question (Q10).

Q10. Please rate photovoltaics with regard to their performance on the following attributes.

0= don't know or have no opinion 1= Poor 2=Fair 3=Good
4=Very Good 5= Excellent

		5	4	3	2	1	0
i.	Impact of photovoltaics on profitability						
ii.	Certainty of its future performance						
iii.	Labour savings derived from the use of photovoltaics						
iv.	Waste reduction potential of photovoltaics						
v.	Ability to recover the cost of photovoltaics						
vi.	Reduction in build time						
vii.	Compatibility with preferred construction practices						
viii.	Ease of continuing use of photovoltaics						
ix.	Impact of photovoltaics on image/status						
x.	The degree of newness of photovoltaics						
xi.	Initial cost of the photovoltaics						
xii.	Ease in first use of photovoltaics						
xiii.	The risk of failure associated with using photovoltaics						
xiv.	Continuing cost of photovoltaics (Cost-in-use/running cost)						
xv.	Quality compared with alternatives						
xvi.	Compatibility with construction codes and standards						
xvii.	Greenhouse gases/CO2 reduction potential of photovoltaics						
xviii.	Ability to see the photovoltaics in use in other projects						
xix.	Noise reduction potential of photovoltaics						
xx.	Cost savings derived from the use of photovoltaics						
xxi.	Visual/aesthetic impact of photovoltaics						
xxii.	Ability to try the photovoltaics before final adoption						
xxiii.	Knowledge/understanding of photovoltaics						
xxiv.	Material savings derived from the use of photovoltaics						
xxv.	Impact of photovoltaics on safety						

PART C: BACKGROUND INFORMATION FOR CLIENTS

Q11. Please indicate which of the following best describes you? (Please tick **one** only)

Architect ☐

Contractor ☐

Electrical engineer ☐

Building Client ☐

Q12. Please state your profession

.....

.....

Q13. What was your age on your last birthday? (in years)

Below 20 ☐

21 -30 ☐

31 - 40 ☐

41 – 50 ☐

51 - 60 ☐

Over 60 ☐

Q14. What is your highest level of education? (Please tick **one** only)

Senior High School/Senior Secondary School ☐

Diploma ☐

Bachelor degree ☐

Masters Degree ☐

Doctorate ☐

Other ☐

Please specify.....

Q15. Additional /professional qualification

.....

.....

END OF QUESTIONNAIRE

Please take a minute to ensure you have answered each question

Thank you very much for your time and effort

Comments (If you have any comments about this survey please indicate these here)

.....
.....
.....
.....
.....

PART C: BACKGROUND INFORMATION FOR CONSULTANTS

Q11. Please indicate which of the following best describes you? (Please tick **one** only)

Architect ☐

Contractor ☐

Electrical engineer ☐

Building Client ☐

Q12. How many years of experience have you had working in the building industry?

.....

Q13. What is the nature of the jobs you undertake? (Please tick **one** only)

Civil engineering works ☐

Building works ☐

Both civil engineering and building works ☐

Other ☐

Please specify.....

Q14. What was your age on your last birthday? (in years)

Below 20 ☐

21 - 30 ☐

31 - 40 ☐

41 – 50 ☐

51 - 60 ☐

Over 60 ☐

Q15. What is your highest level of education? (Please tick **one** only)

Senior High School/Senior Secondary School □

Diploma □

Bachelor degree □

Masters Degree □

Doctorate □

Other □

Please specify.....

Q16. Additional /professional qualification

.....

.....

Q17. As part of this research some building clients will have to be surveyed. Please provide the names, email and contact addresses of one or two individual clients you work with who could be surveyed. (Optional)

.....

.....

.....

END OF QUESTIONNAIRE

Please take a minute to ensure you have answered each question

Thank you very much for your time and effort

Comments (If you have any comments about this survey please indicate these here)

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.....

INTERVIEW GUIDE- CONSULTANTS

This interview guide is not an exhaustive list of questions for each interview but a guide containing the list of issues that must be tackled in the interview. Where there is the need to ask other questions outside of the guide for further clarifications or to illicit useful information, this is to be done. Some questions may also be skipped where not appropriate or they do not apply.

1. Introduction to the study
2. Level of acceptance
    a. In your opinion has the innovation gained acceptance in the Ghanaian building industry?
3. Knowledge of the technology
    a. When did you first hear about the technology?
    b. Prior to hearing about the actual product did you know about the principle behind the product (this especially applies to the Fast floors)?
    c. Do you have any idea of the history of the product in Ghana? Who first introduced it when it was introduced etc?
4. Adoption decision
    a. Have you ever been on a project where it has been used?
    b. Whose suggestion was it to use the innovation?
    c. Was the decision to use the product an individual or collective decision?
    d. Have you/will you advice a client to use the product?
    e. What are the questions/issues/clarifications that potential adopters have expressed in making a decision about the product?
    f. Have you used the innovation on your own personal project?
5. Factors that influence acceptance/adoption
    a. What do you think has most influenced the acceptance of the product in the Ghanaian building industry?
    b. Which of the communication channels were most influential- mass media or interpersonal channels?
    c. How well does the product fit into our way of doing things in the building industry- construction processes, standards and norms, climate?
    d. What are the challenges of the product?
    e. What advantage do the conventional/similar products have over this new product- i.e. insitu floor or fast floor, metal roof over felt/asphaltic shingles, ordinary portland cement over pozzolana?
    f. If you were to pick one most influential attribute of the product, which will it be?
    g. What, if any, are the indirect, unanticipated or unexpected consequences of using the innovation?
    h. To what extent do you think the change agents'/suppliers' promotional efforts have influenced the acceptance of the innovation?
    i. Are there any other factors or issues that come to mind/you think are relevant?

INTERVIEW GUIDE- SUPPLIERS/CHANGE AGENTS

This interview guide is not an exhaustive list of questions for each interview but a guide containing the list of issues that must be tackled in the interview. Where there is the need to ask other questions outside of the guide for further clarifications or to illicit useful information, this is to be done. Some questions may also be skipped where not appropriate or they do not apply.

1. Introduction to the study
2. Level of acceptance
    a. In your opinion has the innovation gained acceptance in the Ghanaian building industry?
3. Knowledge of the technology
    a. Do you have any idea of the history of the product in Ghana? Who first introduced it when it was introduced etc?
4. Adoption decision
    a. Which people normally patronise the innovation?
    b. Have you used the innovation on your own personal project?
5. Can you briefly describe you marketing activities?
    a. who do you normally talk to about your products,
    b. which avenues do you use to promote the product
    c. What questions and clarifications do you normally have from your audience and users of your product?
6. Factors that influence acceptance/adoption
    a. What do you think has most influenced the acceptance of the product in the Ghanaian building industry?
    b. Which of the communication channels were most influential- mass media or interpersonal channels?
    c. How well does the product fit into our way of doing things in the building industry- construction processes, standards and norms, climate?
    d. What are the challenges of the product?
    e. What advantage do the conventional/similar products have over this new product- i.e. insitu floor or fast floor, metal roof over felt/asphaltic shingles, ordinary portland cement over pozzolana?
    f. If you were to pick one most influential attribute of the product, which will it be?
    g. What, if any, are the indirect, unanticipated or unexpected consequences of using the innovation?
    h. To what extent do you think your promotional efforts have influenced the acceptance of the innovation?
    i. Are there any other factors or issues that come to mind/you think are relevant?

INTERVIEW GUIDE- ADOPTERS

This interview guide is not an exhaustive list of questions for each interview but a guide containing the list of issues that must be tackled in the interview. Where there is the need to ask other questions outside of the guide for further clarifications or to illicit useful information, this is to be done. Some questions may also be skipped where not appropriate or they do not apply.

1. Introduction to the study
2. Personal information including the project information
3. Level of acceptance
    a. In your opinion has the innovation gained acceptance in the Ghanaian building industry?
4. Knowledge of the technology
    a. When/from whom did you first hear about the technology?
5. Adoption decision
    a. Whose suggestion was it to use the innovation?
    b. Was the decision to use the product an individual or collective decision?
    c. Have you/will you advice a colleague/friend to use the product?
    d. Given the chance will you choose the product if you had to make your choice over again?
6. Factors that influence acceptance/adoption
    a. What was it about the product that most influenced your decision to use it?
    b. Which of the communication channels were most influential- mass media or interpersonal channels?
    c. Did you have any challenges when installing/using the product?
    d. Do you have any challenges with the product now?
    e. What advantage do you think the conventional/similar products have over this new product- i.e. insitu floor or fast floor, metal roof over felt/asphaltic shingles, ordinary portland cement over pozzolana?
    f. If you were to pick one most influential attribute of the product, which will it be?
    g. What, if any, are the indirect, unanticipated or unexpected consequences of using the innovation?
    h. To what extent do you think the change agents'/suppliers' promotional efforts influenced your acceptance of the innovation?
    i. Are there any other factors or issues that come to mind/you think are relevant?

APPENDIX TWO
QUESTIONNAIRE ASSESSMENT FORM

QUESTIONNAIRE ASSESSMENT FORM

REVIEWER'S NAME:

INSTRUCTIONS

1. Please use the following criteria to review the questions.
2. For each criterion, please list (if any) affected question numbers and write briefly remedial suggestions.

1. Questionnaire instructions: Look for problems with any introductions, instructions, or explanations from the respondent's point of view.
1a. **Conflicting or inaccurate introductions**, instructions, or explanations
1b. **Complicated introductions**, instructions, or explanations

2. Clarity: Identify problems related to communicating the intent or meaning of the question to the respondent.
2a. **Wording**: Question is lengthy, awkward, ungrammatical, or contains complicated syntax.
2b. **Technical term(s)** are undefined, unclear or complex.
2c. **Vague**: There are multiple ways of interpreting the question or to decide what is to be included or excluded.

3. Assumptions: Determine if there are problems with assumptions made or underlying logic.
3a. **Inappropriate assumptions** are made about the respondent or about his/her situation.
3b. **Assumes constant behaviour** or experience for situations that vary.
3c. **Double barrelled**: Contains more than one implicit question.

4. Knowledge/Memory: Check whether respondents are likely to not know or have trouble remembering information.
4a**. Knowledge may not exist**: Respondent is unlikely to know the answer to a factual question.
4b. **Attitude may not exist**: Respondent is unlikely to have formed the attitude being asked about.
4c. **Recall failure**: Respondent may not remember the information asked for.

5. **Sensitivity/Bias**: Assess questions for sensitive nature or wording, and bias.
5a. **Sensitivity**: The question asks about a topic that is embarrassing, very private, or that can lead to individual respondent being identified.
5b. **Desirability response** is implied by the question.

6. **Response Categories:** Assess the adequacy of the range of responses to be recorded.
6a. **Mismatch** between the question and response categories.
6b. **Technical term(s)** are undefined, unclear, or complex.
6c. **Vague** response categories are subject to multiple interpretations.
6d. **Overlapping** response categories.

6e. **Missing** eligible responses in response categories.
6f. **Illogical** order of response categories.

7. **Other problems**: Look for problems not identified in the above criteria.
7. **Other problems** not previously identified.

APPENDIX THREE
QUESTIONNAIRE CODING

Q1. How often do you refer to the following sources or channels for information on new products, materials and practices?

i. Consultants/other building participants	CON1
ii. Trade shows/ building exhibitions/science shows	TRA1
iii. Clients	CLI1
iv. World wide web/ internet	WWW1
v. Sales and supplier representatives	SSR1
vi. Seminars and conferences	SEM1
vii. Universities and research institutes	UNI1
viii. Journal and technical publications	JOU1
ix. Advertisements (television, newspapers, radio etc)	ADVERT1
x. Observing other building works	OBS1
xi. Peer-information i.e. friends	PEER1
xii. Manufacturers' brochures	MAN1

Q2. Please rate the reliability of information that is provided by the following information sources or channels on new building and construction products, materials and practices.

i. Consultants/other building participants	CON2
ii. Trade shows/ building exhibitions/science shows	TRA2
iii. Clients	CLI2
iv. World wide web/ internet	WWW2
v. Sales and supplier representatives	SSR2
vi. Seminars and conferences	SEM2
vii. Universities and research institutes	UNI2
viii. Journal and technical publications	JOU2
ix. Advertisements (television, newspapers, radio etc)	ADVERT2
x. Observing other building works	OBS2
xi. Peer-information i.e. friends	PEER2
xii. Manufacturers' brochures	MAN2

Q3. Please indicate the level of influence the following building participants have on the decision to adopt a new product, material or practice on a building project

i. Client	CLI3
ii. Project manger	PM3
iii. Architect	ARC3
iv. Quantity surveyor	QS3
v. Structural engineer	SE3

vi. Contractor	CONT3
vii. Lenders, insurers and bankers	LEND3
viii. Electrical engineer	EE3
ix. Mechanical engineer	ME3

Q4. Please rate the importance of the following factors to your decision to use a new product, material or practice.

i. Impact of product, material or practice on profitability	PROFIT4
ii. Certainty of its future performance	FUTPERF4
iii. Labour savings derived from the product/material/practice	LABSAV4
iv. Prior experiences with similar product/material/practice	EXP4
v. Waste reduction potential of the product/material/practice	WASTE4
vi. Ability to recover the cost of the product/material	ABREC4
vii. Influence of opinion leaders e.g. political leaders	OPLEAD4
viii. Constraints on project time	CONTIME4
ix. Reduction in build time	REDTIME4
x. Compatibility with preferred construction practices	COMPCP4
xi. Acceptance of other building participants	BPATACC4
xii. Difficulty/ease of continuing use of the product/material	CONTUSE4
xiii. Consumers' preference for the product or material	CONPREF4
xiv. Manufacturers' technical support	MANSUP4
xv. Source and proximity of the source of the product/material	PROX4
xvi. Impact of product, material or practice on image/status	STAT4
xvii. The degree of newness of the product /material	NEW4
xviii. Initial cost of the product/material	INICOST4
xix. Acceptance of lenders, bankers and insurers	LENACC4
xx. Difficulty/ease of first use of the product/material	FIRSTUSE4
xxi. The risk of failure associated with using the product/material or practice	FAIL4
xxii. Acceptance of building inspectors	INSACC4
xxiii. Continuing cost of the product/material (Cost-in-use/running cost)	CONTCOST4
xxiv. Quality compared with alternatives	QUAL4
xxv. Acceptance of clients	CLIACC4
xxvi. Constraints on project cost	COSTCON4
xxvii. Compatibility with construction codes and standards	COMSTAN4
xxviii. Greenhouse gases/CO2 reduction potential of the product/material/practice	GRNHSE4
xxix. Ability to see the product/material in use in other projects	ABSEE4
xxx. Noise reduction potential of the product/material/practice	NORED4
xxxi. Cost savings derived from the product/material/practice	COSTSAV4

xxxii. Visual/aesthetic impact of the product/material	VISIM4
xxxiii. Ability to try the product/material	ABTRY4
xxxiv. Knowledge/understanding of the product/material/practice	KNOW4
xxxv. Material savings derived from the product/material/practice	MATSAV4
xxxvi. Fascination with new product/material/practice	FASC4
xxxvii. Impact of product, material or practice on safety	SAFEIM4

Q5. Do you know about photovoltaic energy technology (a type of solar technology that is used to generate electricity from sunlight)?	KNOW5
Yes	1
No	0

Q6. From which source did you first find out about photovoltaic technology?	KNOW6
Consultants/other building participants	1
Trade shows/ building exhibitions/science shows	2
Clients	3
World wide web/ internet	4
Sales and supplier representatives	5
Seminars and conferences	6
Universities and research institutes	7
Journal and technical publications	8
Advertisements (television, newspapers, radio etc)	9
Observing other building works	10
Peer-information i.e. friends	11
Manufacturers' brochures	

Q7. Please indicate which of the following best describes you.	ADOPCHA
I have been part of a project in which photovoltaics were adopted	1
I am currently on a project in which photovoltaics are to be installed	2
I have been part of a project in which photovoltaics were proposed but not installed	3
I have never been part of a project in which photovoltaics were adopted	4
I have been part of a project in which photovoltaics were adopted but later discontinued	5

Q8. Please indicate which of the following building participants had an influence on the decision to adopt photovoltaics.

i. Client	CLI1
ii. Project manger	PM8
iii. Architect	ARC8
iv. Quantity surveyor	QS8
v. Structural engineer	SE8
vi. Contractor	CONT8
vii. Lenders, insurers and bankers	LEND8
viii. Electrical engineer	EE8
ix. Mechanical engineer	ME8
Had no influence	0
Had an influence	1

Q9. Please indicate which of the following building participants made the final decision to adopt photovoltaics.

	FINDEC
Client	1
Project manger	2
Architect	3
Quantity surveyor	4
Structural engineer	5
Contractor	6
Lenders, insurers and bankers	7
Electrical engineer	8
Mechanical engineer	9

Q10. Please rate photovoltaics with regard to their performance on the following attributes.

i. Impact of photovoltaics on profitability	PROFIT
ii. Certainty of its future performance	FUTPERF
iii. Labour savings derived from the use of photovoltaics	LABSAV
iv. Waste reduction potential of photovoltaics	WASTE
v. Ability to recover the cost of photovoltaics	COSTREC
vi. Reduction in build time	REDTIME
vii. Compatibility with preferred construction practices	COMPCP
viii. Ease of continuing use of photovoltaics	CONTUSE
ix. Impact of photovoltaics on image/status	STAT
x. The degree of newness of photovoltaics	NEW

xi. Initial cost of the photovoltaics	INICOST
xii. Ease in first use of photovoltaics	FIRSTUSE
xiii. The risk of failure associated with using photovoltaics	FAIL
xiv. Continuing cost of photovoltaics (Cost-in-use/running cost)	CONTCOST
xv. Quality compared with alternatives	QUAL
xvi. Compatibility with construction codes and standards	COMPSTAN
xvii. Greenhouse gases/CO2 reduction potential of photovoltaics	GRNHSE
xviii. Ability to see the photovoltaics in use in other projects	ABSEE
xix. Noise reduction potential of photovoltaics	NORED
xx. Cost savings derived from the use of photovoltaics	COSTSAV
xxi. Visual/aesthetic impact of photovoltaics	VISIM
xxii. Ability to try the photovoltaics before final adoption	ABTRY
xxiii. Knowledge/understanding of photovoltaics	KNOW10
xxiv. Material savings derived from the use of photovoltaics	MATSAV
xxv. Impact of photovoltaics on safety	SAFEIM

Q11. Please indicate which of the following best describes you?	BLDGPAT
Architect	1
Contractor	2
Electrical engineer	3
Building Client	4

Q12. Please state your profession

Q13/Q14. What was your age on your last birthday?	AGE
Below 20	1
21 - 30	2
31 - 40	3
41 – 50	4
51 - 60	5
Over 60	6

Q12. How many years of experience have you had working in the building industry? YREXP12

Q13. What is the nature of the jobs you undertake?	JOB13
Civil engineering works	1
Building works	2
Both civil engineering and building works	3
Other	4

Q14/Q15 What is your highest level of education	LEVEDU
Senior High School/Senior Secondary School	1
Diploma	2
Bachelor degree	3
Masters Degree	4
Doctorate	5

APPENDIX FOUR
MISSING VALUE ANALYSIS

Table A4- -1 Distribution of Missing Data (Number of missing cases per variable)

VARIABLES	RESPONSES		MISSING DATA 99	
	NO.	%	NO.	%
CON1	138	99	2	1
TRA1	139	99	1	1
CLI1	136	97	4	3
WWW1	138	99	2	1
SSR1	138	99	2	1
SEM1	137	98	3	2
UNI1	137	98	3	2
JOU1	137	98	3	2
ADVERT1	136	97	4	3
OBS1	138	99	2	1
PEER1	138	99	2	1
MAN1	137	98	3	2
CON2	138	99	2	1
TRA2	138	99	2	1
CLI2	137	98	3	2
WWW2	136	97	4	3
SSR2	138	99	2	1
SEM2	137	98	3	2
UNI2	136	97	4	3
JOU2	138	99	2	1
ADVERT2	138	99	2	1
OBS2	137	98	3	2
PEER2	138	99	2	1
MAN2	138	99	2	1
CLI3	138	99	2	1
PM3	137	98	3	2
ARC3	138	99	2	1
QS3	138	99	2	1
SE3	138	99	2	1
CONT3	138	99	2	1
LEND3	138	99	2	1
EE3	138	99	2	1
ME3	138	99	2	1
PROFIT4	138	99	2	1
FUTPERF4	138	99	2	1
LABSAV4	136	97	4	3

VARIABLES	RESPONSES		MISSING DATA 99	
	NO.	%	NO.	%
EXP4	138	99	2	1
WASTE4	138	99	2	1
ABREC4	137	98	3	2
OPLEAD4	138	99	2	1
CONTIME4	137	98	3	2
REDTIME4	138	99	2	1
COMPCP4	138	99	2	1
BPATACC4	137	98	3	2
CONTUSE4	137	98	3	2
CONPREF4	136	97	4	3
MANSUP4	136	97	4	3
PROX4	138	99	2	1
STAT4	136	97	4	3
NEW4	138	99	2	1
INICOST4	138	99	2	1
LENACC4	137	98	3	2
FIRSTUSE4	135	96	5	4
FAIL4	138	99	2	1
INSACC4	137	98	3	2
CONTCOST4	137	98	3	2
QUAL4	137	98	3	2
CLIACC4	137	98	3	2
COSTCON4	136	97	4	3
COMSTAN4	137	98	3	2
GRNHSE4	138	99	2	1
ABSEE4	137	98	3	2
NORED4	138	99	2	1
COSTSAV4	137	98	3	2
VISIM4	137	98	3	2
ABTRY4	138	99	2	1
KNOW4	138	99	2	1
MATSAV4	135	96	5	4
FASC4	137	98	3	2
SAFEIM4	138	99	2	1
KNOW5	138	99	2	1
KNOW6	135	96	5	4
ADOPCHA	135	96	5	4

VARIABLES	RESPONSES		MISSING DATA 99	
	NO.	%	NO.	%
CLI8	129	92	11	8
PM8	123	88	17	12
ARC8	126	90	14	10
QS8	122	87	18	13
SE8	121	86	19	14
CONT8	122	87	18	13
LEND8	120	86	20	14
EE8	127	91	13	9
ME8	122	87	18	13
FINDEC	127	91	13	9
PROFIT	134	96	6	4
FUTPERF	135	96	5	4
LABSAV	136	97	4	3
WASTE	136	97	4	3
ABREC	136	97	4	3
REDTIME	136	97	4	3
COMPCP	136	97	4	3
CONTUSE	136	97	4	3
STAT	135	96	5	4
INICOST	136	97	4	3
FIRSTUSE	136	97	4	3
FAIL	136	97	4	3
CONTCOST	136	97	4	3
QUAL	136	97	4	3
COMPSTAN	136	97	4	3
GRNHSE	134	96	6	4
ABSEE	135	96	5	4
NORED	136	97	4	3
COSTSAV	136	97	4	3
VISIM	135	96	5	4
ABTRY	133	95	7	5
MATSAV	136	97	4	3
SAFEIM	136	97	4	3
BLDGPAT	137	98	3	2
YREXP12	134	96	6	4
JOB13	132	94	8	6
AGE	134	96	6	4
LEVEDU	134	96	6	4
TOTAL	15050		490	

Table A4- -2 Distribution of Missing Data (Number of missing variables per case)

NUMBER OF MISSING VARIABLES	PERCENTAGE OF MISSING VARIABLES PER CASE	NUMBER OF CASES
0	0%	83
1	0.9%	24
2	1.8%	10
3	2.7%	2
4	3.6%	1
5	4.5%	2
6	5.4%	2
7	6.3%	2
8	7.2%	3
9	8.1%	2
10	9.0%	1
11	9.9%	3
20	18.0%	1
34	30.6%	1
41	36.9%	1
109	98.2%	1
111	100%	1
TOTAL		140

Table A4-3 Distribution of Missing Data (After Case deletions)

Variable	N	Missing	
		Count	Percent
YREXP12	129	3	2.3
CON1	132	0	.0
TRA1	132	0	.0
CLI1	131	1	.8
WWW1	132	0	.0
SSR1	132	0	.0
SEM1	131	1	.8
UNI1	132	0	.0
JOU1	132	0	.0
ADVERT1	130	2	1.5
OBS1	132	0	.0
PEER1	132	0	.0
MAN1	131	1	.8
CON2	132	0	.0
TRA2	132	0	.0
CLI2	131	1	.8
WWW2	131	1	.8
SSR2	132	0	.0
SEM2	132	0	.0
UNI2	130	2	1.5
JOU2	132	0	.0
ADVERT2	132	0	.0
OBS2	131	1	.8
PEER2	132	0	.0
MAN2	132	0	.0
CLI3	132	0	.0
PM3	132	0	.0
ARC3	132	0	.0
QS3	132	0	.0
SE3	132	0	.0

Variable	N	Missing	
		Count	Percent
CONT3	132	0	.0
LEND3	132	0	.0
EE3	132	0	.0
ME3	132	0	.0
PROFIT4	132	0	.0
FUTPERF4	132	0	.0
LABSAV4	131	1	.8
EXP4	132	0	.0
WASTE4	132	0	.0
ABREC4	132	0	.0
OPLEAD4	132	0	.0
CONTIME4	132	0	.0
REDTIME4	132	0	.0
COMPCP4	132	0	.0
BPATACC4	131	1	.8
CONTUSE4	132	0	.0
CONPREF4	131	1	.8
MANSUP4	130	2	1.5
PROX4	132	0	.0
STAT4	132	0	.0
NEW4	132	0	.0
INICOST4	132	0	.0
LENACC4	131	1	.8
FIRSTUSE4	130	2	1.5
FAIL4	132	0	.0
INSACC4	131	1	.8
CONTCOST4	131	1	.8
QUAL4	132	0	.0
CLIACC4	131	1	.8
COSTCON4	131	1	.8
COMSTAN4	131	1	.8

Variable	N	Missing	
		Count	Percent
GRNHSE4	132	0	.0
ABSEE4	132	0	.0
NORED4	132	0	.0
COSTSAV4	131	1	.8
VISIM4	131	1	.8
ABTRY4	132	0	.0
KNOW4	132	0	.0
MATSAV4	131	1	.8
FASC4	131	1	.8
SAFEIM4	132	0	.0
KNOW5	132	0	.0
KNOW6	130	2	1.5
ADOCHA	132	0	.0
CLI8	127	5	3.8
PM8	121	11	8.3
ARC8	124	8	6.1
QS8	120	12	9.1
SE8	119	13	9.8
CONT8	120	12	9.1
LEND8	118	14	10.6
EE8	125	7	5.3
ME8	120	12	9.1
FINDEC	125	7	5.3
PROFIT	130	2	1.5
FUTPERF	131	1	.8
LABSAV	132	0	.0
WASTE	132	0	.0
COSTREC	132	0	.0
REDTIME	132	0	.0
COMPCP	132	0	.0
CONTUSE	132	0	.0

Variable	N	Missing	
		Count	Percent
STAT	131	1	.8
INICOST	132	0	.0
FIRSTUSE	132	0	.0
FAIL	132	0	.0
CONTCOST	132	0	.0
QUAL	132	0	.0
COMPSTAN	132	0	.0
GRNHSE	130	2	1.5
ABSEE	132	0	.0
NORED	132	0	.0
COSTSAV	132	0	.0
VISIM	131	1	.8
ABTRY	129	3	2.3
MATSAV	132	0	.0
SAFEIM	132	0	.0
BLDGPAT	132	0	.0
JOB13	127	5	3.8
AGE	130	2	1.5
LEVEDU	129	3	2.3
TOTAL	**14499**	**153**	**1.04**

APPENDIX FIVE
RELIABILITY ANALYSIS

Table A5-1 Colour Code

Colour	Construct
Black	Compatibility
Blue	Contextual Factors
Brown	Observability
Green	Complexity
Grey	Trialability
Red	Relative Advantage

Table A5-2 Inter-item Correlation for Adoption-Decision Factors

	PROFIT4	FUTPERF4	LABSAV4	EXP4	WASTE4	ABREC4	OPLEAD4	CONTIME4	REDTIME4	COMPCP4
PROFIT4	1.000	.223	.509	-.188	.236	.354	.196	.315	.396	.103
FUTPERF4	.223	1.000	.271	.124	.230	.190	.153	.237	.276	.342
LABSAV4	.509	.271	1.000	.151	.485	.494	.146	.384	.495	.156
EXP4	-.188	.124	.151	1.000	.210	.049	.190	.138	.127	.245
WASTE4	.236	.230	.485	.210	1.000	.466	.137	.385	.532	.142
ABREC4	.354	.190	.494	.049	.466	1.000	.141	.315	.331	.166
OPLEAD4	.196	.153	.146	.190	.137	.141	1.000	.369	.377	.258
CONTIME4	.315	.237	.384	.138	.385	.315	.369	1.000	.708	.349
REDTIME4	.396	.276	.495	.127	.532	.331	.377	.708	1.000	.351
COMPCP4	.103	.342	.156	.245	.142	.166	.258	.349	.351	1.000
BPATACC4	.353	.293	.405	.116	.207	.264	.336	.466	.501	.450
CONTUSE4	.026	.352	.286	.423	.414	.304	.180	.307	.349	.524
CONPREF4	.320	.265	.347	.205	.378	.352	.270	.326	.460	.302
MANSUP4	-.003	.168	.182	.178	.340	.251	.121	.111	.152	.207
PROX4	.029	.192	.314	.193	.456	.342	.233	.312	.384	.166
STAT4	.047	.178	.107	.072	.160	.042	.214	.232	.311	.355
NEW4	.190	-.025	.141	.030	.122	.245	.303	.123	.226	.156
INICOST4	.262	.217	.349	.016	.204	.354	.216	.297	.312	.134
LENACC4	.288	.179	.352	.189	.190	.392	.496	.295	.334	.224
FIRSTUSE4	.129	.340	.296	.238	.353	.298	.240	.392	.365	.498
FAIL4	.018	.331	.197	.285	.338	.198	.074	.286	.201	.406
INSACC4	.102	.097	.159	.064	.404	.373	.118	.160	.155	.174
CONTCOST4	-.014	.215	.200	.239	.294	.357	.116	.220	.174	.140
QUAL4	-.123	.235	.011	.269	.154	.144	-.001	.147	.086	.305
CLIACC4	.260	.272	.286	.035	.282	.329	.307	.313	.309	.305
COSTCON4	.279	.207	.350	.083	.406	.412	.214	.510	.456	.255
COMSTAN4	.123	.188	.324	.114	.418	.430	.175	.285	.239	.319
GRNHSE4	.246	.203	.354	.102	.620	.448	.117	.326	.381	.130
ABSEE4	.025	.232	.055	.341	.266	.231	.157	.004	.049	.182
NORED4	.229	.077	.249	.036	.427	.447	.033	.091	.237	.143
COSTSAV4	.396	.078	.366	-.088	.426	.418	.046	.176	.335	.150
VISIM4	.202	.324	.277	.088	.246	.217	.133	.230	.271	.248

	PROFIT4	FUTPERF4	LABSAV4	EXP4	WASTE4	ABREC4	OPLEAD4	CONTIME4	REDTIME4	COMPCP4
ABTRY4	.185	.268	.321	.196	.465	.270	.327	.257	.399	.207
KNOW4	-.039	.166	-.002	.024	.198	.116	.074	.083	.075	.202
MATSAV4	.420	.122	.502	.035	.581	.410	.144	.354	.585	.123
FASC4	.280	.258	.254	.137	.131	.223	.349	.345	.357	.339
SAFEIM4	.175	.217	.346	.100	.467	.432	.196	.384	.427	.258

	BPATACC4	CONTUSE4	CONPREF4	MANSUP4	PROX4	STAT4	NEW4	INICOST4	LENACC4
PROFIT4	.353	.026	.320	-.003	.029	.047	.190	.262	.288
FUTPERF4	.293	.352	.265	.168	.192	.178	-.025	.217	.179
LABSAV4	.405	.286	.347	.182	.314	.107	.141	.349	.352
EXP4	.116	.423	.205	.178	.193	.072	.030	.016	.189
WASTE4	.207	.414	.378	.340	.456	.160	.122	.204	.190
ABREC4	.264	.304	.352	.251	.342	.042	.245	.354	.392
OPLEAD4	.336	.180	.270	.121	.233	.214	.303	.216	.496
CONTIME4	.466	.307	.326	.111	.312	.232	.123	.297	.295
REDTIME4	.501	.349	.460	.152	.384	.311	.226	.312	.334
COMPCP4	.450	.524	.302	.207	.166	.355	.156	.134	.224
BPATACC4	1.000	.233	.429	.061	.315	.319	.345	.180	.432
CONTUSE4	.233	1.000	.527	.411	.289	.175	-.047	.128	.176
CONPREF4	.429	.527	1.000	.322	.315	.276	.243	.220	.252
MANSUP4	.061	.411	.322	1.000	.288	.227	-.006	.096	.189
PROX4	.315	.289	.315	.288	1.000	.216	.262	.443	.180
STAT4	.319	.175	.276	.227	.216	1.000	.293	.116	.169

	BPATACC4	CONTUSE4	CONPREF4	MANSUP4	PROX4	STAT4	NEW4	INICOST4	LENACC4
NEW4	.345	-.047	.243	-.006	.262	.293	1.000	.264	.193
INICOST4	.180	.128	.220	.096	.443	.116	.264	1.000	.190
LENACC4	.432	.176	.252	.189	.180	.169	.193	.190	1.000
FIRSTUSE4	.315	.485	.362	.220	.391	.107	.145	.440	.316
FAIL4	.115	.451	.270	.335	.257	.154	-.050	.228	.216
INSACC4	.125	.249	.279	.362	.288	.129	.082	.176	.267
CONTCOST4	.048	.391	.216	.406	.222	.016	-.161	.320	.202
QUAL4	-.046	.412	.181	.305	.153	.036	-.181	.150	.111
CLIACC4	.282	.220	.434	.184	.370	.225	.107	.280	.241
COSTCON4	.382	.302	.442	.291	.361	.057	.153	.478	.219
COMSTAN4	.244	.333	.211	.358	.280	.083	.121	.275	.332
GRNHSE4	.137	.286	.246	.513	.291	.231	-.014	.222	.319
ABSEE4	.041	.289	.150	.453	.301	.108	.174	.128	.218
NORED4	.192	.112	.276	.385	.285	.223	.145	.235	.127
COSTSAV4	.250	.219	.415	.290	.269	.027	.085	.431	.224
VISIM4	.227	.219	.375	.087	.207	.286	.063	.379	.144
ABTRY4	.254	.300	.370	.311	.368	.154	.091	.073	.402
KNOW4	.196	.213	.110	.302	.101	.244	.142	-.052	-.009
MATSAV4	.315	.214	.310	.169	.294	.188	.172	.275	.240
FASC4	.459	.177	.304	.089	.207	.435	.375	.338	.301
SAFEIM4	.285	.315	.289	.295	.439	.139	.129	.381	.265

	FIRSTUSE4	FAIL4	INSACC4	CONTCOST4	QUAL4	CLIACC4	COSTCON4	COMSTAN4	GRNHSE4
PROFIT4	.129	.018	.102	-.014	-.123	.260	.279	.123	.246
FUTPERF4	.340	.331	.097	.215	.235	.272	.207	.188	.203
LABSAV4	.296	.197	.159	.200	.011	.286	.350	.324	.354
EXP4	.238	.285	.064	.239	.269	.035	.083	.114	.102
WASTE4	.353	.338	.404	.294	.154	.282	.406	.418	.620
ABREC4	.298	.198	.373	.357	.144	.329	.412	.430	.448
OPLEAD4	.240	.074	.118	.116	-.001	.307	.214	.175	.117
CONTIME4	.392	.286	.160	.220	.147	.313	.510	.285	.326
REDTIME4	.365	.201	.155	.174	.086	.309	.456	.239	.381
COMPCP4	.498	.406	.174	.140	.305	.305	.255	.319	.130
BPATACC4	.315	.115	.125	.048	-.046	.282	.382	.244	.137
CONTUSE4	.485	.451	.249	.391	.412	.220	.302	.333	.286
CONPREF4	.362	.270	.279	.216	.181	.434	.442	.211	.246
MANSUP4	.220	.335	.362	.406	.305	.184	.291	.358	.513
PROX4	.391	.257	.288	.222	.153	.370	.361	.280	.291
STAT4	.107	.154	.129	.016	.036	.225	.057	.083	.231
NEW4	.145	-.050	.082	-.161	-.181	.107	.153	.121	-.014
INICOST4	.440	.228	.176	.320	.150	.280	.478	.275	.222
LENACC4	.316	.216	.267	.202	.111	.241	.219	.332	.319
FIRSTUSE4	1.000	.595	.375	.363	.399	.467	.498	.413	.246
FAIL4	.595	1.000	.330	.437	.444	.277	.307	.286	.264
INSACC4	.375	.330	1.000	.326	.288	.220	.294	.498	.468
CONTCOST4	.363	.437	.326	1.000	.478	.238	.413	.346	.348
QUAL4	.399	.444	.288	.478	1.000	.140	.080	.274	.154
CLIACC4	.467	.277	.220	.238	.140	1.000	.446	.455	.254

	FIRSTUSE4	FAIL4	INSACC4	CONTCOST4	QUAL4	CLIACC4	COSTCON4	COMSTAN4	GRNHSE4
COSTCON4	.498	.307	.294	.413	.080	.446	1.000	.414	.354
COMSTAN4	.413	.286	.498	.346	.274	.455	.414	1.000	.546
GRNHSE4	.246	.264	.468	.348	.154	.254	.354	.546	1.000
ABSEE4	.155	.280	.184	.204	.193	.110	.154	.177	.232
NORED4	.175	.092	.307	.157	.157	.212	.301	.311	.522
COSTSAV4	.419	.173	.361	.289	.158	.321	.537	.308	.365
VISIM4	.377	.289	.120	.100	.311	.376	.186	.356	.203
ABTRY4	.355	.328	.327	.133	.129	.364	.316	.414	.353
KNOW4	.100	.156	.292	.150	.190	.006	.165	.229	.096
MATSAV4	.245	.076	.253	.266	.138	.247	.410	.367	.389
FASC4	.367	.152	.141	.189	.083	.267	.325	.244	.250
SAFEIM4	.408	.260	.410	.251	.410	.319	.317	.511	.482

	ABSEE4	NORED4	COSTSAV4	VISIM4	ABTRY4	KNOW4	MATSAV4	FASC4	SAFEIM4
PROFIT4	.025	.229	.396	.202	.185	-.039	.420	.280	.175
FUTPERF4	.232	.077	.078	.324	.268	.166	.122	.258	.217
LABSAV4	.055	.249	.366	.277	.321	-.002	.502	.254	.346
EXP4	.341	.036	-.088	.088	.196	.024	.035	.137	.100
WASTE4	.266	.427	.426	.246	.465	.198	.581	.131	.467
ABREC4	.231	.447	.418	.217	.270	.116	.410	.223	.432
OPLEAD4	.157	.033	.046	.133	.327	.074	.144	.349	.196
CONTIME4	.004	.091	.176	.230	.257	.083	.354	.345	.384
REDTIME4	.049	.237	.335	.271	.399	.075	.585	.357	.427
COMPCP4	.182	.143	.150	.248	.207	.202	.123	.339	.258
BPATACC4	.041	.192	.250	.227	.254	.196	.315	.459	.285

	ABSEE4	NORED4	COSTSAV4	VISIM4	ABTRY4	KNOW4	MATSAV4	FASC4	SAFEIM4
CONTUSE4	.289	.112	.219	.219	.300	.213	.214	.177	.315
CONPREF4	.150	.276	.415	.375	.370	.110	.310	.304	.289
MANSUP4	.453	.385	.290	.087	.311	.302	.169	.089	.295
PROX4	.301	.285	.269	.207	.368	.101	.294	.207	.439
STAT4	.108	.223	.027	.286	.154	.244	.188	.435	.139
NEW4	.174	.145	.085	.063	.091	.142	.172	.375	.129
INICOST4	.128	.235	.431	.379	.073	-.052	.275	.338	.381
LENACC4	.218	.127	.224	.144	.402	-.009	.240	.301	.265
FIRSTUSE4	.155	.175	.419	.377	.355	.100	.245	.367	.408
FAIL4	.280	.092	.173	.289	.328	.156	.076	.152	.260
INSACC4	.184	.307	.361	.120	.327	.292	.253	.141	.410
CONTCOST4	.204	.157	.289	.100	.133	.150	.266	.189	.251
QUAL4	.193	.157	.158	.311	.129	.190	.138	.083	.410
CLIACC4	.110	.212	.321	.376	.364	.006	.247	.267	.319
COSTCON4	.154	.301	.537	.186	.316	.165	.410	.325	.317
COMSTAN4	.177	.311	.308	.356	.414	.229	.367	.244	.511
GRNHSE4	.232	.522	.365	.203	.353	.096	.389	.250	.482
ABSEE4	1.000	.308	.186	.038	.379	.186	.136	.105	.203
NORED4	.308	1.000	.472	.260	.395	.220	.468	.186	.491
COSTSAV4	.186	.472	1.000	.385	.336	.113	.547	.261	.460
VISIM4	.038	.260	.385	1.000	.377	.074	.321	.263	.421
ABTRY4	.379	.395	.336	.377	1.000	.300	.416	.194	.457
KNOW4	.186	.220	.113	.074	.300	1.000	.241	.116	.264
MATSAV4	.136	.468	.547	.321	.416	.241	1.000	.322	.554
FASC4	.105	.186	.261	.263	.194	.116	.322	1.000	.330
SAFEIM4	.203	.491	.460	.421	.457	.264	.554	.330	1.000

Table A5-3 Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PROFIT4	134.10	395.887	.359	.589	.926
FUTPERF4	133.36	401.394	.402	.431	.925
LABSAV4	134.23	391.135	.549	.603	.924
EXP4	133.75	405.384	.243	.452	.926
WASTE4	134.25	387.200	.629	.716	.923
ABREC4	134.26	388.383	.584	.613	.923
OPLEAD4	135.86	393.674	.386	.515	.926
CONTIME4	134.42	389.544	.551	.675	.923
REDTIME4	134.16	387.948	.636	.749	.923
COMPCP4	133.97	397.170	.473	.611	.924
BPATACC4	134.69	389.137	.514	.656	.924
CONTUSE4	134.08	390.208	.525	.700	.924
CONPREF4	134.19	388.991	.589	.663	.923
MANSUP4	133.81	398.227	.450	.593	.925
PROX4	134.17	390.364	.531	.563	.924
STAT4	134.34	400.055	.337	.593	.926
NEW4	134.92	402.327	.256	.552	.927
INICOST4	134.19	393.714	.467	.655	.924
LENACC4	135.39	386.189	.479	.622	.925
FIRSTUSE4	134.58	385.289	.628	.705	.923
FAIL4	133.86	394.734	.465	.594	.924
INSACC4	134.60	388.019	.471	.522	.925
CONTCOST4	133.83	397.886	.429	.608	.925
QUAL4	133.49	404.919	.321	.605	.926
CLIACC4	133.78	391.284	.522	.575	.924
COSTCON4	133.97	389.589	.611	.686	.923
COMSTAN4	133.90	387.665	.589	.684	.923
GRNHSE4	134.42	384.177	.572	.738	.923
ABSEE4	134.25	401.725	.340	.530	.926

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
COSTSAV4	133.76	394.712	.550	.695	.924
VISIM4	133.96	395.015	.454	.616	.925
ABTRY4	134.31	390.696	.576	.667	.923
KNOW4	133.75	405.627	.257	.454	.926
MATSAV4	134.19	388.842	.582	.711	.923
FASC4	135.40	389.609	.490	.538	.924
SAFEIM4	133.81	389.247	.646	.671	.923

Table A5-4 Inter-item Correlation for Perceived Attributes

	PROFIT	FUTPERF	LABSAV	WASTE	COSTREC	REDTIME	COMPCP	CONTUSE	STAT	INICOST
PROFIT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FUTPERF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
LABSAV	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
WASTE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
COSTREC	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
REDTIME	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
COMPCP	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CONTUSE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
STAT	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
INICOST	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FIRSTUSE	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
FAIL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CONTCOST	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
QUAL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
COMPSTAN	.982	.980	.981	.982	.982	.981	.983	.982	.981	.981
GRNHSE	.982	.981	.981	.982	.982	.981	.983	.982	.981	.981
ABSEE	.982	.980	.981	.982	.982	.981	.983	.982	.981	.981
NORED	.982	.980	.981	.982	.982	.981	.982	.982	.981	.981
COSTSAV	.982	.981	.981	.982	.982	.981	.983	.982	.981	.981
VISIM	.982	.981	.981	.982	.982	.981	.983	.982	.981	.981
ABTRY	.982	.980	.981	.982	.982	.981	.983	.982	.981	.981
MATSAV	.982	.980	.981	.982	.982	.981	.983	.982	.981	.981
SAFEIM	.982	.980	.981	.983	.982	.981	.983	.982	.981	.981

	FIRSTUSE	FAIL	CONTCOST	QUAL	COMPSTAN	GRNHSE	ABSEE	NORED	COSTSAV	VISIM
PROFIT	1.000	1.000	1.000	1.000	.982	.982	.982	.982	.982	.982
FUTPERF	1.000	1.000	1.000	1.000	.980	.981	.980	.980	.981	.981
LABSAV	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
WASTE	1.000	1.000	1.000	1.000	.982	.982	.982	.982	.982	.982
COSTREC	1.000	1.000	1.000	1.000	.982	.982	.982	.982	.982	.982
REDTIME	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
COMPCP	1.000	1.000	1.000	1.000	.983	.983	.983	.982	.983	.983
CONTUSE	1.000	1.000	1.000	1.000	.982	.982	.982	.982	.982	.982
STAT	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
INICOST	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
FIRSTUSE	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
FAIL	1.000	1.000	1.000	1.000	.981	.981	.981	.981	.981	.981
CONTCOST	1.000	1.000	1.000	1.000	.982	.982	.982	.982	.982	.982
QUAL	1.000	1.000	1.000	1.000	.980	.980	.980	.980	.980	.980
COMPSTAN	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
GRNHSE	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
ABSEE	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
NORED	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
COSTSAV	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
VISIM	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
ABTRY	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
MATSAV	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000
SAFEIM	.981	.981	.982	.980	1.000	1.000	1.000	1.000	1.000	1.000

	ABTRY	MATSAV	SAFEIM
PROFIT	.982	.982	.982
FUTPERF	.980	.980	.980
LABSAV	.981	.981	.981
WASTE	.982	.982	.983
COSTREC	.982	.982	.982
REDTIME	.981	.981	.981
COMPCP	.983	.983	.983
CONTUSE	.982	.982	.982
STAT	.981	.981	.981
INICOST	.981	.981	.981
FIRSTUSE	.981	.981	.981
FAIL	.981	.981	.981
CONTCOST	.982	.982	.982
QUAL	.980	.980	.980
COMPSTAN	1.000	1.000	1.000
GRNHSE	1.000	1.000	1.000
ABSEE	1.000	1.000	1.000
NORED	1.000	1.000	1.000
COSTSAV	1.000	1.000	1.000
VISIM	1.000	1.000	1.000
ABTRY	1.000	1.000	1.000
MATSAV	1.000	1.000	1.000
SAFEIM	1.000	1.000	1.000

Table A5-5 Item-Total Statistics for Perceived Attributes

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PROFIT	1462.38	937205.126	.997	1.000	1.000
FUTPERF	1462.29	937535.384	.996	1.000	1.000
LABSAV	1462.56	936763.313	.997	1.000	1.000
WASTE	1462.27	937507.329	.997	1.000	1.000
COSTREC	1462.24	937609.071	.997	1.000	1.000
REDTIME	1462.54	936813.895	.997	1.000	1.000
COMPCP	1462.39	937170.627	.997	1.000	1.000
CONTUSE	1462.27	937518.651	.997	1.000	1.000
STAT	1462.34	937368.289	.997	1.000	1.000
INICOST	1462.65	936507.085	.997	1.000	1.000
FIRSTUSE	1462.45	937077.798	.997	1.000	1.000
FAIL	1462.52	936877.397	.997	1.000	1.000
CONTCOST	1462.13	937928.725	.997	1.000	1.000
QUAL	1462.20	937781.355	.996	1.000	1.000
COMPSTAN	1461.50	938506.494	.992	1.000	1.000
GRNHSE	1461.22	939319.219	.992	1.000	1.000
ABSEE	1461.51	938482.913	.992	1.000	1.000
NORED	1461.30	939094.452	.992	1.000	1.000
COSTSAV	1461.46	938642.234	.992	1.000	1.000
VISIM	1461.58	938304.956	.992	1.000	1.000
ABTRY	1461.74	937827.869	.992	1.000	1.000
MATSAV	1461.80	937672.548	.992	1.000	1.000
SAFEIM	1461.58	938298.553	.992	1.000	1.000