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Marketing Mechanisms for Photovoltaic Technology in Developing Countries

Case Ghana

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Aurinkoenergiateknologian markkinointimekanismeja kehitysmaille – tapaus Ghana

Tiivistelmä

Tämä tutkimus määrittää ja selittää aurinkoenergiajärjestelmien käyttöönoton vaatimuksia Ghanassa. Empiirinen aineisto on koottu haastattelujen, kyselytutkimusten ja kahden yrityksen väliseen yhteistyöhön liittyvän esimerkkitapauksen kautta.

Sähkön tuotannon ja toimituksen epäluotettavuus Ghanassa antoi perusteen toimivien markkinointimekanismien suunnittelulle aurinkoenergian alalla kehitysmaissa. Käsiteltäessä markkinointimekanismeja, tuotteen kokoonpano tarjoaa kuluttajille seuraavat vaihtoehdot: itsenäinen energiayksikkö, varaenergiayksikkö ja hybridijärjestelmät. Jakelun osalta tutkimus rajoittuu myyntiin ja kuluttajan mahdollisuuteen soveltaa tee-se-itse-opasta. Promootio tapahtuu sähköisesti, painetun tekstin ja koulutusmahdollisuuksin työpajojen, seminaarien ja julkisten keskustelujen muodossa. Rahoituksen osalta tutkimuksessa käsitellään seuraavia vaihtoehtoja: yksityishenkilöiden käteistai luottokorttimaksu, hyväntekeväisyystoiminta, rahoituslaitosten ja valtion tarjoamat lainat, luotot ja tuet.

Lisäksi, sähköntuotannon kustannusten tarkastelu – yksittäisten, kotikäyttöisten aurinkoenergiayksiköiden ollessa keskipisteenä – luo valoa tulevaisuudessa mahdollisesti maksuttomiin asennustyyppeihin. Tarkasteltavat Robin Hood- ja Donkey-periaatteet tukevat markkinointimekanismeja, jotka auttavat hallitusta ja lainlaatijoita nykyisen energiakriisin ratkaisussa, sosiaalisesti oikeudenmukaisin ja yleisesti hyväksytyin keinoin.

Edellä mainitut markkinointimekanismit tarjoavat käytännöllisen ratkaisun sovellettavaksi myös muissa kehitysmaissa, joissa on samankaltainen energiakriisi. Alati kasvava perinteisen energian (esim. fossiilinen polttoaine) kysyntä ja sen vahingollinen vaikutus ekosysteemiin tekevät tästä tutkimuksesta katalysaattorin aurinkoenergiajärjestelmien käyttöönottoon kehitysmaissa.

Hybriditutkimusmallissa yhdistyvät hienovaraisesti sekä kuvailevat että kokeelliset tutkimuspiirteet. Tutkimus yhdistää kaupallisen ja teknillisen tutkimuksen menetelmiä esittäessään käytännöllisiä ratkaisuja tutkimuksen kohteena olevaan energiakriisiin.

Asiasanat

markkinointimekanismi, aurinkoenergia, kehitysmaat, Ghana

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Abstract

This study identifies and explains the requirements for the diffusion of photovoltaic systems in Ghana. The empirical data were collected through interviews, surveys and an example case of business collaboration.

The unreliability of electricity production and delivery in Ghana forms a background for proposing viable marketing mechanisms for photovoltaic systems in developing countries. With regard to the marketing mechanisms, the product configuration offers consumer the following options: standalone, backup, and hybrid systems. Regarding distribution, the study limits its options to agent activities and the possibility for end users to apply a do-it-yourself (DIY) manual. The promotional activities include electronic, print, and educational possibilities through workshops, seminars, and public debate. As regards financing, the study discusses the following options: individuals paying cash or credit, philanthropic activities, financial institutions, and the possibility of the government providing green loans, credits and subsidies.

Furthermore, considerations of the levelized cost of electricity generation (LCOE) with key emphasis on individual solar home units helps improve our understanding of the future possibilities of having non-tariff types of installations. The proposed Robin Hood and Donkey principles support the marketing mechanisms, in helping the government and policy makers to solve the current energy crisis through socially equitable and transparent means.

The aforementioned marketing mechanisms also provide a practical solution for replication to other developing countries with a similar energy crisis. The ever-increasing demand for traditional energy (e.g., fossil fuel) and its detrimental effect on the eco-system will position this study as a catalyst in facilitating the adoption of photovoltaic systems in developing countries.

The hybrid research design cautiously blends both descriptive and exploratory features. The study combines both business and engineering research techniques in presenting practical solutions for the energy crisis under investigation.

Keywords

marketing mechanisms, photovoltaic, developing countries, Ghana

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My determination to see an end to the energy crisis in developing countries and especially for my own country – Ghana, fuelled my desire to carry out research into renewable energy markets. Photovoltaic technology and its application have been my passion since I joined the Vaasa Energy Marketing Group (VaasaEMG) under the direction of Dr. Philip Lewis; I developed the desire to re-position myself away from mainstream marketing to energy marketing and other facets of renewable energy business.

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Abbreviations

CEPS	Customs Excise Preventive Service
EC	Energy Commission
ECG	Electricity Corporation Ghana
EF	Energy Foundation
EPA	Environmental Protection Agency
FIT	Feed in Tariff
GIPC	Ghana Investment Promotion Centre
HEP	Hydro Electric Power
IBRD of WB	International Bank for Reconstruction and Development of the World Bank
ISCRET	Innovative Supply Chain for Renewable Energy Technology
KW	Kilowatt
KWh	Kilowatt hour
MoE	Ministry of Energy
NED	Northern Electricity Distribution
PURC	Public Utility Regulatory Commission
SHS	Solar Home Systems
SNEP	Strategic National Energy Plan
UNMDG	United Nation’s Millennium Development Goal
VALCO	Volta Aluminium Company Limited
VRA	Volta River Authority

1 INTRODUCTION

1.1 Background

Changes in climatic conditions have resulted in an unpredictable and unreliable amount of rainfall thus making the dependence on hydroelectric power (HEP) very problematic in Africa. The high volatility of world oil prices significantly worsens the dilemma faced by most of the developing economies in Africa. In Ghana, these problems and many more have created a serious energy crisis resulting in decades of high incidents of unauthorized and frequent power outages as well as regulated load shedding exercises, the rationing of electricity by geographic location, consumption capacity and density lasting between 12–48 hours. This particular phenomenon among other factors has led to high incidences of low productivity, low development and the slow growth of the country's economy (Dovi 2007; Mensah-Biney 2007). Some forms of renewable energy technologies such as photovoltaic and wind energy, due to their structure, portability and accessibility seem to offer promising solutions to energy problems.

Holm (2005: 13) argues that improved access to clean modern energy in developing countries is a necessary requirement for the reduction of poverty, unemployment and the achievement of other economic goals (see also Ndzibah 2006: 11). An increase in the energy capacity of developing economies is of the utmost importance. For instance in Ghana, the Ministry of Energy explained in the *Policy Framework and Guide for Development of Independent Power Producer* that the demand for energy in Ghana has increased in the past 10 years by about 5% per year representing capacity addition requirements of about 50MW–100MW per year (RCEER 2005; MoE-Ghana 2007).

On the other hand, developing economies, like many Africa, have an underdeveloped energy infrastructure. This fact offers an excellent opportunity for creating new sustainable jobs in renewable energy technologies, instead of investing in sunset technologies such as diesel powered generators and analogue metering systems. It is also worth noting that renewable energy solutions can enhance the environment, increase system and infrastructure reliability and provide for greater security (see also Aitken 2010: 33, 35; Holm 2005: 24; Ndzibah 2006: 11).

1.2 Research gap, problem and objectives

There are a vast number of studies on marketing mechanisms in business and in energy markets in both developed and developing countries. However, research on renewable energy business and management practices and activities for such energy technologies in the African region is limited and most examples available are concentrated in a particular part of North and South Africa (Larimo 1989; Austin 1990). Furthermore, although there are numerous business operations that are undertaken in Africa and other developing countries, documented research on energy markets in Africa is limited and highly fragmented; notable among them is the quarterly journal ESI Africa, a leading provider of information relating to the African electricity and energy industry. This means that there is a huge need for research and fulfilling this need requires extensive studies and specific research into different issues at different levels of the growing renewable energy market in the future.

This study aims to provide an empirically grounded view of the marketing mechanisms for the photovoltaic energy systems that are available, or that can be developed, in Ghana. The research problem can be stated as follows: *'What marketing mechanisms are available, or can be developed and implemented, for photovoltaic technologies for developing countries in general and especially for Ghana? And under what conditions could it be done?'* It is crucial that policy makers, investors and other stakeholders in the energy market *(electricity)* be aware of the nature of the present energy crisis, country-specific market structures and regulations to enable them to develop and adopt the right solutions for the market.

In order to address these difficult issues adequately, this study must find:

- *Suitable marketing mechanisms that can be implemented for photovoltaic technology for Ghana, and must*
- *Justify why just those marketing mechanisms are best or recommendable.*

Thus, the detailed objectives of this research are:

1. To review the historical, technical and administrative background of electricity in Ghana.
2. To identify and analyse the different forms of marketing mechanisms suitable for photovoltaic technologies for Ghana.
3. To consider the factors impacting on the implementation of these marketing mechanisms for Ghana.

4. To test a marketing strategy that aims at promoting a decentralized diffusion of photovoltaic energy in Ghana.
5. To develop principles such as the Robin Hood and the Donkey in addressing policy issues.

1.3 Research design

A research process is like a merchant's journey from one town to another. It is obvious that a determined merchant should know *why* he is travelling to the next town and *how* he is going to make the trip. What methods should he use to achieve his objectives and to evaluate whether the journey is worth the effort? The merchant may arrive at a reasoned conclusion concerning the aforementioned questions, by evaluating his possible performance in the market and carefully estimating the profit or loss that would be made.

Hypothesis and preconception

This research trip began with the awareness of the energy crisis in Ghana and of the general need to bridge the gap between the demand and supply of energy in developing countries. Hypothetically, the preconception prior to the research was that the general population of Ghana is aware and thus knowledgeable about the different sources of energy and especially of photovoltaic systems. Unfortunately, the preconception and reality were two worlds apart since the focus group studies and subsequent survey revealed that understanding of photovoltaic systems is usually limited to knowledge of the panels that are generally visible for all to see. Although countless materials on photovoltaic systems are available, the actual curiosity of people in developing economies may not necessarily be sparked by the quest for alternative but sustainable sources of electricity. Thus, the fallacy was to assume that people with an academic degree, no matter on what subject, should be able to understand and know of the components involved in a complete photovoltaic system. This awareness led to the choice of the research topic, which in turn led to a tentative consideration of research problems and questions.

The formulation of the research objectives and questions led to a comprehensive research design. The approach used included both theoretical considerations based on research literature and an empirical study on fieldwork conducted in Ghana. Based on the exploration of journals and books, the key observation was that the ideal parameters for the marketing mechanisms of photovoltaic systems were *product, distribution, promotion and financing*. Furthermore, the carefully socially motivated considerations of research parameters yielded the Robin Hood and the Donkey Principles allowing relevant and serious proposals to be put together for the consideration of policy makers in addressing the energy situation. The collection of data took place using interviews and a survey conducted in Ghana. Once collected, the data needed proper analysis and interpretation and to be decoded into meaningful information (see also Ghauri and Gronhaug 2002).

A researcher needs to choose not only a research theme, questions and objectives, but also theory, data and methods. During the planning process, the latter three were first considered separately and then as being interconnected. The most difficult part of this research was narrowing the number of research questions presented to the focus group and subsequently for the survey. The attendees of the focus group included entrepreneurs, homeowners, a bank official, a public servant, an IT engineer, an architect and a technician.

The theoretical part of this study was much more flexible to realize, as there are countless books and journals concerning the core part of the study. Research seminars, conferences and various workshops as well as guidance from my supervisors along with discussions with my colleagues contributed enormously to the restructuring of the parameters to focus on photovoltaic systems. As a researcher, my association with Atlas Business and Energy Systems and some experts in the renewable energy business helped deepen my understanding of the renewable energy market and especially photovoltaic systems.

Ghauri et al. (2002) say that the research design precedes the research approach in that it helps answer the research problem with a strict consideration of the resources available (*time, money and skills*) thus limiting the danger to the researcher of extensive variations of potential options. According to Ghauri et al. (2002), research design involves the decision of choosing from exploratory, descriptive and causal options. Exploratory research involves the ability to observe, obtain information and theorize based on the information gathered. It frequently relies on secondary research such as reviewing the available literature, in-depth interviews, focus groups and case studies. Furthermore, exploratory research can provide important insight into a given situation but often lacks the flexibility to be used in a generalized way for a sampled population.

Descriptive research usually comes strictly structured, if the researcher knows exactly what he or she is looking for and is determined to get answers based on his or her pre-understanding. In descriptive research, the researcher collects data, for example, by means of personal interviews under the survey parameters. Descriptive research does not necessarily strive for explanations, but is content with mere descriptions of data.

In causal research (most notably conducted in the natural sciences) the researcher considers the relationships between causes and effects. For a causal research design, it is common to try to explain phenomena and this includes determining causal laws and regularities (see also Kumar 2000; Ghauri et al. 2002).

This particular research is hybrid in design, cautiously blending both descriptive and exploratory features. By definition, a hybrid research approach is based on the ability of a piece of research and the researcher to adapt different forms of research methods with the aim of analysing, exploring and narrowing the various gaps brought about by any specific research method. Furthermore, a hybrid research approach seeks to complement the content, weighting and consistency of all the variables used in support of each argument developed as part of the research. A mixed research strategy is not the same as a hybrid research approach. A mixed research strategy aims at using two or more research methods to answer a research problem and its various objectives. On the other hand, the hybrid research approach aims to add value to a mixed research strategy by exploring all the tools and parameters available to explain a phenomenon, without overemphasizing its individual uniqueness, or suggesting that one research approach is better than another. In unique research circumstances, the hybrid research approach makes room for adaptation, carefully considering the principles behind each research parameter and picking only what is necessary to help achieve a desired result.

In this research, discussions of primary and secondary data collection help in the consideration of the options available. The choice between a quantitative and a qualitative approach depends on the action plan available to the researcher. This research tries to employ a combination of the key components found in the various approaches mentioned. For instance, the understanding derived from conducting a preliminary focus group study led to the development of the key parameters for the whole research. After observing the reasons for the energy crisis, I realized what research options were available to me in addressing the problem. The design for the questionnaire for the extensive survey was derived from the results of the focus group studies and the target audience was 12 respondents selected randomly from each of the 10 regions in Ghana, thus resulting in 120 respondents – which is a reasonable enough selection to make the results viable for analysis. The respondents were divided into three groups, with an equal representation of four per group, namely, homeowners, business owners and tenants. In the end, the focus was on households since this category consumed the largest amount of electricity in the country compared to the commercial or industrial usage rate. Since the key segment for this study was the household, vital information about their average electricity demand per year and the requirements for satisfying such demand, whether for backup, standalone or hybrid use (*temporary or continuous usage rate*) became a prerequisite as part of the research process. Furthermore, to address the financing options a brief background of the price of electricity in a comparable context of both grid and renewable energy sources became relevant for drawing the right conclusions and presenting viable proposals for implementation.

Saunders et al. (2003: 99) argue that the use of multi-method approaches and strategies is often beneficial when a researcher aims at building confidence in the objectives under discussion. Furthermore, multi-methods have a key advantage of allowing researchers to triangulate to help identify and narrate the phenomenon under research without any doubts or biases. Some authors use the term 'pluralistic research' for the same approach. Pluralistic research combines the advantages of both qualitative research and quantitative research. It is worth mentioning that with pluralistic research, the qualitative phase often helps develop the quantitative phase (Burns and Bush 2003: 230, 231). It does not matter whether a researcher chooses to use the term 'mixed', 'multi-method', 'pluralistic' or 'hybrid', so long as the objective of using the term is explained in context and in its application to the research in question.

This study avoids the causal research parameters since the study does not include co-variation findings or mainstream theory formulation. Using a hybrid approach helps to bridge the gap between structured and unstructured problems as perceived or documented for investigation.

Kasanen (1991: 317) suggests four research approaches in business science, which involve the use of either descriptive or normative methods in combination with either a theoretical or an empirical method of research. The conceptual research approach involves *conceptualization* with the aim of developing concepts and analysing them mainly through reasoning. The *decision-oriented* approach aims at creating a method with the objective of solving a specific problem using mathematics and logic; the empirical data are applied in the form of an example. The *action-oriented* approach focuses on practical solutions developed in relation to the problems and issues under investigation and sometimes the need to change targets with empirical data usually collected from few cases. (*See also* Arbnor and Bjerke, 2009). This study contributes to the practical benefits of conceptualization by using the Robin Hood and the Donkey Principles in proposing socially important ideas to policy makers. At the same time, the study uses the marketing mechanisms in an action-oriented approach highlighting key issues needed in addressing the diffusion process.

Arbnor et al. (2009: 32–47, 395, 417–426) presented a distinction between actors, analytical and system approaches for scientific research. The *actors approach* assumes that reality is a social construct and aims to create and understand the meaning of reality. The *analytical approach* collaborates with the *positivistic approach* and accepts reality is built on either person-independent (*objective*) or person-dependent (*subjective*) facts. This approach also assumes that reality is independent of the mind and language (*user*). The ability to add new results to previous findings without creating new barriers is a key component in an *analytical approach*. The *system approach* assumes and places reality between hermeneutic and positivistic approaches. The system approach also sees reality as a fact-filled system not in the subjective sense, but rather in the objective sense. This study draws on the system approach in applying a marketing concept to the diffusion of photovoltaic systems (see also Thiam 2011). In using the system approach, this study stresses that although different industries are different in their operations, the principles of applying the marketing mechanisms in solving marketing problems are the same.

So as to consider a practical concept used in engineering science, this study references Reisman's (1988) research strategies such as *ripple, embedding, bridging, transfer of technology, and creative, structuring and empirical validation*. This study borrows the *creative strategy* in the discussion of the research management process. The creative strategy often relates to the transfer of technology. According to Reisman, the creative application strategy uses a known methodology to solve a problem not previously addressed in any specific way. This research tries to find the right marketing mechanisms for photovoltaic technology for developing countries. This task falls under the above description of creative application strategy.

The consciousness of the energy crisis in Ghana serves as the core motivation for undertaking this research. It aims at providing alternative options of power supply and developing constructive mechanisms and suggests tentative principles viable for policy frameworks that seek to bridge the gap between the demand and supply of energy in developing countries and, in this case, Ghana. After further consideration, photovoltaic systems were deemed a feasible alternative power source in Ghana and hence this research looks extensively into areas such as product configurations targeted for standalone, backup or hybrid usage, distribution, promotion and financing of photovoltaic power. Employing a hybrid research method that combines descriptive and exploratory approaches made it possible to analyse and explore the research topic under consideration. The proposal of the Robin Hood and the Donkey Principles are to assist policy makers in making an informed decision concerning alternative power sources.

1.4 Definitions and limitations

In this research the term *marketing mechanisms* encompasses and is limited to *only* marketing parameters such as *product, distribution, promotion and financing*. Furthermore, the term is adapted to the strategic significance of each parameter in relation to the specific nature of photovoltaic technology.

Srinivasan (2005: 38) says that governments, enterprises and investors have over the years recognized the potential role for off-grid/decentralized rural electrification, such as with photovoltaic (PV) solar home systems (SHS), as a complement to any grid extension program. Barriers to such a wide scale implementation and delivery of SHS include:

- High initial technology cost;
- Delivery infrastructure (supplier-dealer chains, service arrangements) which lacks the volume to achieve economies of scale; and
- Lack of credit to system users, a consequence of the high first cost of the system (see also Wamukonya 2007).

This study will also have a theoretical contribution, which includes the creation, development and testing of the so-called Robin Hood and Donkey principles in relation to the diffusion of energy availability, affordability and accessibility (Ndzibah 2011). The Donkey principle (Ndzibah 2011) assumes a strategic billing policy where a government directive makes it the duty of corporate firms, rich communities and urban dwellers to collectively carry some of the cost burden of the usage of electricity by poor rural communities. In a developing economy like Ghana, this is not a new concept as rural electric utilities are subsidized by surcharging the urban communities and firms some extra payments to cover the usage of street lights as well as the rural electrification project (Haanyika 2005; Mulder and Tembe 2008).

The Robin Hood principle (Ndzibah 2011) borrows the essence of the strategy used by a British folklore character by the same name, in taking from the rich and providing resources for the deprived. The concept of *'taking'* in the principle denotes weaning the urban dwellers off the main grid to help allocate the excess capacity to the rural areas. Furthermore, the urban dwellers are then encouraged to adapt to renewable energy systems. Since there are few industrial activities in the rural areas of Ghana and their energy requirements for commercial and domestic use are simple, the benefits of this proposal can be seen to be sound, as the rural communities get the needed opportunity to develop the agro-base sector, creating jobs and mitigating the rural–urban migration influx. The Robin Hood principle also presumably suggests that most urban dwellers are in a better position to afford a photovoltaic system, arguably due to their easier access to credits and loans from financial institutions. The principle is needed to replace the incidental rural photovoltaic projects promoted by NGOs (non-governmental organizations), which are often limited to solar lamps, solar refrigerants for lighting and remote healthcare facilities (see Johansson and Goldemberg 2002). The process of producing renewable energy systems is currently known to be relatively expensive globally compared to conventional sources of energy, but technological breakthroughs are reducing the price gap (see also Bradley Jr. 1997).

Urban citizens are encouraged to adopt the use of photovoltaic systems either as standalone, backup or hybrid systems. Photovoltaic as a *standalone* means the system is used by people who have no access to the national electric grid and so would solely use the photovoltaic system. The use of the photovoltaic system as a *backup* electric unit is recommended for those who have access to the national grid but are ready to use the photovoltaic system instead on a diesel or petrol powered generator in case of a power outage, thus, with the Robin Hood principle, the urbanized centres become socially responsible in reducing pollution in the cities. Finally, the use of photovoltaic system as a *hybrid* unit is recommended for specific households or corporate bodies with enormous energy requirement and thus key appliances could be connected to the grid while the photovoltaic unit powers other systems. The bottom line is that the Robin Hood approach might enable the governments of developing countries to harvest as many megawatts of energy as possible from the urban centres for use in the rural areas, especially in countries undertaking rural electrification programs (see also Mondal et al. 2010; Howells 2005).

The case country, Ghana, is a suitable testing field for this argument. I believe this test would help create a balance in the use of energy in both the rural areas and urban centres, thus accelerating economic growth and development in the whole country. This research aims to fully investigate the principles and implement them in Ghana to help in the diffusion of different forms of renewable energy solutions in the country and later to replicate the key findings applicable to other developing countries.

Renewable energy is any form of energy exploited for human consumption, in which the source of such energy is inexhaustible over time as compared to fossil fuel, which is currently under threat due to the insatiable global consumption patterns (Bradford 2006; Ferrey 2005). Renewable energy systems by popular opinion are more sustainable and environmentally friendly. A *photovoltaic system* harnesses the power of the sun to generate electricity. In this research, the use of the term photovoltaic is preferred above the overly simplified synonym solar, due to its direct explanation in terms of electricity generation (see also FSEC 2002). Due to the on-going dynamic revolution of the photovoltaic industry, the research references will be limited to technology from the year 2000 until the year 2010, thus presenting an enriched timeline regarding how far photovoltaic technology has come in a decade and potential breakthroughs for the future. Notably, the development of photovoltaic technology is limited to countries endowed with technological expertise: these countries include but are not limited to Finland, Sweden, Germany, Spain and the USA (IEA 2001). Companies from these developed countries are needed to start up photovoltaic technology development in Africa. The researcher in this instance only focuses on such systems available in Finland, due to the researchers' dynamic understanding of Finnish technological enterprises as well as their unique way of doing business. Nevertheless, the findings of this research will not only be limited to use in Finland but could be adapted by similar technologically expert countries willing to enter similar fields and industries. The process is further discussed as part of the issues related to technology and marketing and alongside the methods to be used for the empirical part of the research.

The expressions *developing countries and developing economies* are interchangeable in use with the terms *emerging economies and developing nations* especially after the breakdown of the communist economies (except for China and North Korea). Nonetheless, the use of those terms does not suggest that the countries in question experience similar economic development and growth, or that other economies have reached a preferred or final stage of economic development (Cavusgil, Ghauri and Agarwal 2002: 4, 5).

According to Cavusgil et al. (2002: 3), the classical notion of developing countries prior to 2000 included the following features: high risk to foreign business, economically and technologically backward, consumers had poor purchasing power and this provided few opportunities for business.

Notably, all economies are now relatively dynamic for better or worse. In addition, many developing economies are dynamic due to globalization and exposure to other international business as well as the fact they are increasingly becoming technologically competitive, thus offering diverse opportunities as large untapped markets and low cost, high quality sources for investment and business activities.

Cavusgil et al. (2002: 8) presented a realistic view concerning the use of the terms developing and emerging economies. That view holds that as much as emerging economies are developing, it does not mean that all developing economies are emerging. In this study, the references and examples given concerning the marketing mechanisms and photovoltaic systems will be case specific and applicable to most developing countries. For future extensive testing of the proposed Robin

Hood and Donkey principles to be effective, especially when being replicated in other countries, assumptions and the practicality of the premise are mostly from an African context. This research will also present key examples from the African continent unless otherwise stated.

Figure 1 (below) presents a summary of what the marketing mechanisms will address. The research identifies the product under research as being limited to photovoltaic systems. Although the focus group study and field survey included findings from both households and small-medium scale enterprises, the emphasis will be on households. The photovoltaic configuration and capacity installed is dependent on the usage rate, namely, *standalone, backup or hybrid* and since household size and usage of electricity varied, all examples used in the research are case specific. The usage rate also depends on the types of appliances an end user is willing and able to use depending on the installation cost and considerations of payment terms.

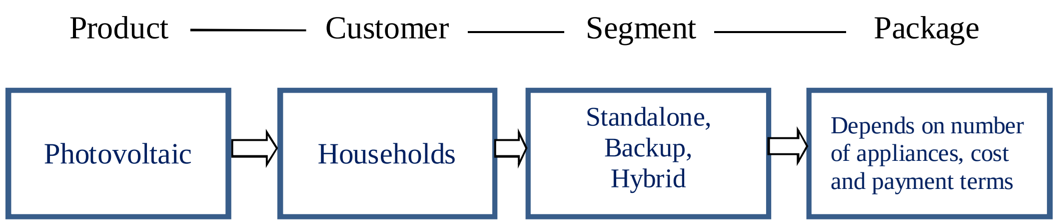


Figure 1. Product, Customer and Segment Configuration

1.5 Structure of the study

First, the research gives a summary of the current energy market situation in Ghana and the role and types of renewable energy in place in this market. The core idea is to review the findings concerning the diffusion of photovoltaic systems in Ghana; the outcome can serve as a benchmark in facilitating the development of reliable energy solutions in developing countries. The research starts with a background review of the energy situation in African countries south of the Sahara, with an emphasis on the energy crisis in Ghana. A summary analysis addressing the research gap, problem and objectives follows.

Because the research theme of this study is broad, it is necessary to address the parameters of the objectives in order to narrow the research to specific areas of interest, it is also necessary to define central research concepts adequately and limit the subject matter and research area respectively. Even though there are varying forms of renewable energy, the aim of this research is to evaluate the potential of just one: *photovoltaic technologies*. To understand the whole framework of photovoltaic systems from a business point of view and how they can sustainably boost the development and growth of developing economies requires a concise understanding of what is involved in the options chosen for research as well as the various components involved in photovoltaic technology. The identification of the core segment *(households)*, usage rate *(backup, standalone and hybrid)*, capacity and system to be installed as well as the comparative cost between conventional electricity system from the national grid and that of photovoltaic systems helps to develop the right marketing mechanisms for the diffusion of renewable energy systems.

Chapter 2 starts with the historical, technical and administrative background information concerning electricity in the case country – Ghana. As part of the background description and analysis, the chapter addresses the types of energy systems in the country including its generating capacity and potential future forecast. The chapter then presents highlights of the renewable energy policy in Ghana and finally the marketing mechanisms of electricity in Ghana.

Chapter 3 presents the technology and marketing related background of the research and this includes a non-technical definition of photovoltaic technology. Furthermore, specific aspects of the marketing mechanisms including the configuration of the product strategy and distribution will be discussed as well as, an in-depth analysis of promotional strategies feasible for adoption and financing options available for photovoltaic technology in developing countries. The chapter ends with a summary framework drawn as a realistic reflection on and connection to the opinions developed.

Chapter 4 discusses principles, affecting factors and actions. These include the target markets variables such as the issues pertaining to available energy systems and energy regulations in practice in developing countries. An analytical discussion of the *Donkey as well as the Robin Hood principles* suggests key policy issues for adoption by the authorities. Chapter 4 will also address the role of government agencies and institutions as impacting factors in a deregulated energy market and, as such, their impact on the marketing mechanisms and the development of the economy, especially since they will be in charge of policymaking and the actual implementation of any feasible proposal. The chapter concludes with a figure providing a conclusive link between theories and aspects of policies feasible for implementation.

Chapter 5 discusses the empirical approach used to reach a viable conclusion. The research process, strategy, design and methods ascertain the accuracy of the principles and assumptions developed. Burns and Bush (2000: 230) have discussed the use of qualitative, quantitative and pluralistic research methods depending on the objectives of the research in order to achieve the desired result. For this research a hybrid research approach will be adapted. A hybrid research approach combines the advantages of both qualitative and quantitative research, and it will be used in phases where the qualitative phase will serve as a foundation preceding the quantitative phase (Burns and Bush, 2000: 230, 231). The chapter will develop and report on a focus group study and field surveys aimed at ascertaining the average wattage capacity per household, small and medium scale enterprises, henceforth referred to as SMEs, and cost involved in installing a standalone, backup or hybrid system. To ascertain the reliability of the study, the chapter will present a summary documentation of a photovoltaic business collaboration between a Finnish photovoltaic technology provider and a Ghanaian business unit and a discussion on how to replicate the key findings related to the product configuration.

Chapter 6 will finalize the whole research by presenting a summary analysis of the theories developed and the results acquired. The theoretical contribution of this study includes a predictive tool useful in measuring population growth, density and energy consumption. The tool aims at helping ascertain or at best approximate the projection of the energy capacity needed at every point in time as the population and consumption of energy increases. Finally, future study suggestions will be given, based on the limitations here discovered which present issues needing conclusive resolution before any further replication of the principles and marketing mechanisms to other developing countries in Africa with similar electricity needs can take place.

2 CASE COUNTRY BACKGROUND

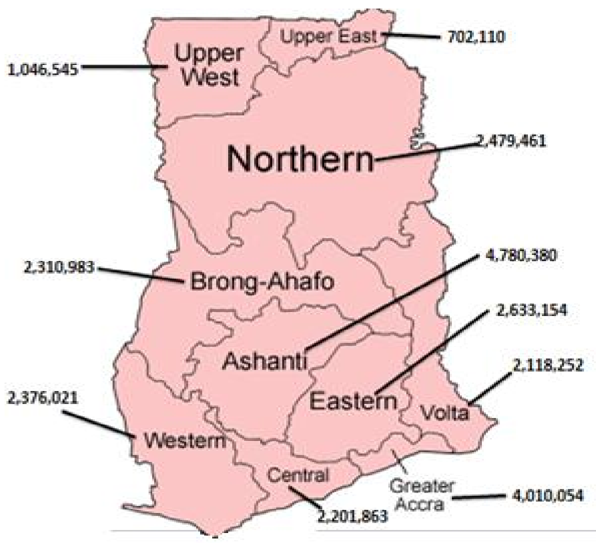
This chapter first discusses the historical, political and technical administrative background issues of the energy systems in Ghana since the country´s independence from Britain. The chapter continues with an overview of the different types of energy systems available in the country, the installed capacity and estimated capacities of future systems yet to become operational. The chapter concludes by discussing the principles of the current renewable energy policy in Ghana.

2.1 Historical, political and technical administration of energy systems in Ghana

Ghana, the case country, previously known as the Gold Coast, was the first African nation to achieve independence from the United Kingdom in 1957. Ghana shares a common border with Côte d' Ivoire to the west, Burkina Faso to the north and Togo to the east. The inhabitants of the country speak some 250 languages and dialects, although English is the official language, which is predominant in government and business affairs in the country. The country has a current population of about 23 million with a rate of population growth of approximately 1.9% (see also Ndzibah 2010).

After Ghana's independence in 1957, the first energy generating system available to country was the hydro power plant at Akosombo, built between 1961 and 1964 and opened in 1965. The total cost of the project was approximately $258 million. The Ghanaian government handled the development of the Akosombo hydroelectric power plant with funding from the International Bank for Reconstruction and Development of the World Bank (IBRD of the WB), the United States with the American Volta Aluminium Company (henceforth VALCO) which played an instrumental role in the whole development and funding process. Although the original purpose of this project was to create a power plant for the aluminium smelting production at Tema, a network of power lines installed through southern Ghana made it possible for an initial output of 20% to be used in serving some 70% of the national demand for electricity. The remaining 80% of the output was for the production activities of VALCO. The initial output was primarily for consumption in Ghana, but a contractual agreement between Ghana and its neighbouring countries, especially Togo and Benin, made it possible for those countries to enjoy some of the electricity supplied by the power plant. In the 1980s, 90s and early 2000s, the installation of additional electricity generating systems augmented the demand for electricity. It is noteworthy that most of them, if not all, are currently underperforming.

It is important to mention that in 1961, a post-independence population census recorded some 6.7 million inhabitants in the country. With this population, the dam´s power production greatly surpassed the actual demand. Unfortunately, despite an upgrade from a 912 MW to a 1,020 MW generating capacity after a retrofit project completed in 2006, demand has consistently outpaced supply. The country´s current population of over 24 million and its electricity requirements, compared to the current total generating capacity, gives a clear indication that the government and its policy-making apparatus have been unable to anticipate adequately the dynamics of electricity demand and supply. This failure has had a detrimental impact on the country´s economy. Since the demand for electricity definitely exceeds the supply capacity, the need for alternative solutions for electricity energy production creates opportunities aimed at accelerating economic development and growth.



Region	Population
Western	2,376,021
Central	2,201,863
Greater Accra	4,010,054
Volta	2,118,252
Eastern	2,633,154
Ashanti	4,780,380
Brong Ahafo	2,310,983
Northern	2,479,461
Upper East	1,046,545
Upper West	702,110
All Regions	24,658,823

Figure 2. A distribution map and table of the population of Ghana in 2012.

The table and figure above represent the current population distribution by region with the table showing the total population to be over 24 million people. The population of Ghana since independence in 1961 has almost quadrupled. The figures do not necessarily call for the quadrupling of the energy supply, nonetheless, it gives an idea of how the demand will obviously outstrip the supply if effective and efficient processes are not put in place to address the energy and electricity supply crisis in the country. Furthermore, the above figure and table present an idea of the potential of photovoltaic systems in supplementing the supply of electricity in the country. Ghana has an average family size (household) of between 5–7, thus with the current population, the country has a potential of between 3.5

to over 4 million households on which the strategic planning process for the diffusion of photovoltaic systems could be based.

2.1.1 Types of energy systems, capacity and future forecast

Ghana's electricity production in 2007 was around 6.7 billion kWh. During the same period, the consumption, exports and imports were approximately 5.7 billion kWh, 2.49 billion kWh and 435 million kWh, respectively, with the main sources of electricity coming from the Akosombo and the Kpong hydro power plants and the Aboadze thermal power plant (Essandoh-Yeddu 2006; Ndzibah 2010). According to a well-informed estimation, some 9.2 million Ghanaians, mostly in rural and some urban communities, lack access to electricity which shows that the energy situation in the country is very difficult (see also Yeboah 2010; Ndzibah 2010). Furthermore, some of those who have access to the grid acquire the electricity supply through unauthorized channels. These specific problems and many more have created a serious energy crisis, resulting in decades of high incidence of unauthorized use, frequent power outages as well as regulated load shedding exercises – the rationing of electricity by geographic location, consumption capacity and density. The consequences of regular power rationing in Ghana have led to many industries, commercial and domestic consumers opting for secondary sources of energy like diesel generators as a standby system, which come with their own problems such as environmental pollution and the high cost of fuel.

The table below presents a summary overview of the current electricity generating systems in Ghana, types of power plants, year installed and operating status of these systems. Furthermore, the table gives information on work in progress systems. The gross capacity produced by the four operating power plants based on documentary evidence from the Energy Commission, is too low to sustain the ever-growing population and industrial operations of the country. The other three power plants scheduled for inclusion in the grid to alleviate the energy crisis are not working. The current statistics collated are limited to grid electricity since information on decentralized and individual generation is either not well documented, very limited, or, at worse, unreliable. The report by the Energy Commission for the 2006–2020 Strategic National Energy Plan on electricity indicates that the current primary energy generation, mostly from the two hydro power plants in the country, was about 7,224 Gigawatt-hour in 2000 but this capacity dropped to some 5,901 Gigawatt-hour in 2003. Since 2003, the generation capacity has been highly sporadic due to droughts caused by climatic changes.

Table 1. Status of the existing main power plant in Ghana.

Location	Type of Power Plant	Year Installed	Gross Capacity (MW)	Net Capacity (MW)	Status
Akosombo	Hydro	1965/1972	1038	1020	Operating
Kpong	Hydro	1982	160	148	Operating
Takoradi T1	Thermal	1997–2000	330	300	Operating
Takoradi T2	Thermal	2000	220(330)	210(320)	Operating
Total (Potential)			1748(1858)	1678(1788)	
Effasu Power Barge	Steam Turbine	NC	125	0	Work in progress
Tema	Gas Thermal	NY	330/900	0	Work in progress
Bui	Hydro	NY	200/400	0	Work in progress
Total (Potential)			655 (1425)		

To address the irregular power supply, both households and industries have resorted to standby generators. In 2006, the total number of installed photovoltaic systems, in mostly remote areas and especially in rural communities, was around 5,000. The installed capacity is mainly used for lighting health care centres, vaccine refrigeration, solar water pumps, telecommunication, battery charging stations and, in some few rural areas, for lighting (Oteng-Adjei 2010; Ghana EC 2009; EC 2006).

Figure 3 (below) depicts the varied solar radiation in Ghana. The topographical outlook helps technicians to configure devices and give realistic information and advice to clients on the potential of the installed capacity or the best configuration of photovoltaic systems capable of taking advantage of the type of solar radiation present and its effects on the installed system. Notably, the northern regions and the northern parts of Brong-Ahafo and Volta Regions receive very high radiation levels with a monthly average of between 4.0 and 6.5kWh/m^2/day. The area experiences one major rainy season between July and September. The Harmattan is prevalent between November and February. Ashanti, parts of the Brong-Ahafo, Eastern, Western and parts of Central and Volta regions have a monthly average radiation level of 3.1–5.8 kWh/m^2/day. The water vapour in the atmosphere causes greater absorption and scattering, producing high levels of diffuse radiation. Greater Accra, and the coastal regions of Central and Volta Regions have monthly average radiation levels ranging from 4.0–6.0 kWh/m^2-day (EC 2009).

According to the analysis by the energy commission, the humidity is low and rainfall is bimodal in these regions. Throughout the country, diffuse radiation constitutes more than 30% of the total solar radiation and this does not augur well for concentrating collectors used in solar thermal power plants. This device uses the direct component of the solar radiation. Direct solar radiation is highest in the small Upper West region as depicted in Fig 3. Nevertheless, flat plate solar collectors and PV modules are not affected by the diffuse fraction and thus may be used effectively anywhere in the country. In conclusion, the potential for using solar thermal energy for hot water production in the commercial/service sector is very high. It could reduce the use of electric water heaters in the sector. The potential for the use of solar energy in agro-industrial and wood processing is also very high (EC 2009).

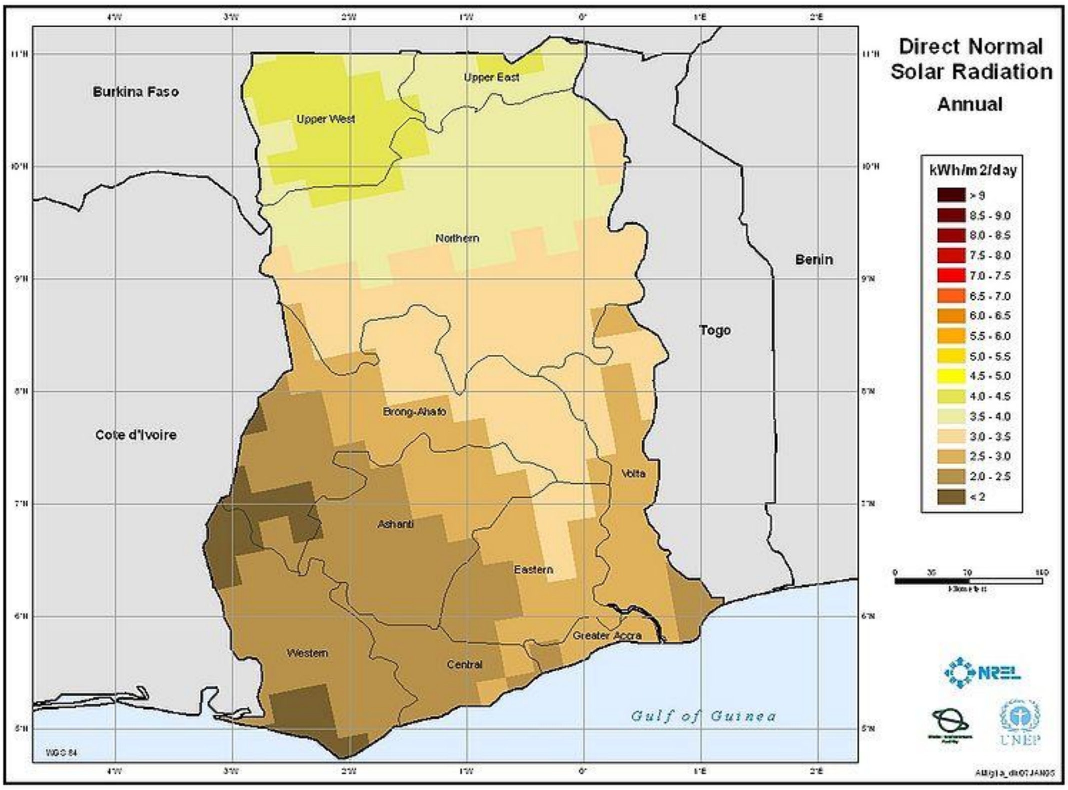


Figure 3. Solar radiation in Ghana.

The outlook for energy generation and supply in Ghana looks gloomy and corrective measures such as increasing the current generating capacity by introducing renewable energy, for example, photovoltaic, wind and biofuel, is the only way to attain reliable, accessible and affordable electricity in the country. The Energy Commission estimates that the net final grid electricity consumption, excluding technical losses from transmission, will grow from 6,900 Gigawatt-hour in 2000 to about 18,000 Gigawatt-hour by 2015. The projected demand, if true, will adversely affect Ghana´s balance of payment since the country imports huge amounts of refined oil due to the non-availability of reliable refinery centres in the country. To assure a secured uninterrupted electricity supply, the government aims to double the current generating capacity by installing some gas and diesel systems by 2020. Table 2 (below) further explains the options projected by the government, the ministries responsible and the energy generating institutions. The three options include the repair and expansion of the already existing capacities: hydro power and thermal systems with the possibility of a wide scale variety of renewables to augment the deficiency. Tables 3 and 4 elaborate on the third option of the electricity expansion plan and include a summary of the cost and job creation opportunities it presents. It is laudable to attempt to incorporate and implement in the overall electricity plan about 10% renewable energy. Nonetheless, the popular tendency is usually to install this capacity in rural sectors.

The recommendation will be for the government to provide incentives through capital subsidies for private investors and the promotion of technological research into renewable energy, and generation based incentives, including feed-in-tariffs. Thus, due action is needed to accelerate the development and utilization of renewable energy and energy efficiency technologies. Such actions will secure and increase future energy security using diversified sources of energy supply. To date, the aforementioned proposals are merely work in progress. The only proposal officially created and being implemented is a permit manual that provides guidelines for the issuing of permits to service providers to conduct business in the renewable energy industry. Nevertheless, the standard board supposed to collaborate with this initiative is still struggling due to inadequate training and a lack of proper measuring tools for renewable energy systems.

Table 2. Electricity Expansion Plan 2013–2015.

ELECTRICITY EXPANSION PLAN- GENERATION MIX BY INSTALLED CAPACITY 2013–2015							
SOURCE	PLANT	Option 1		Option 2		Option 3	
		total	Percent	total	Percent	total	Percent
Hydro power		**1180**	**36.30 %**	**1380**	**42.60 %**	**1380**	**42.60 %**
				-1580	**45.90 %**	**1580**	**45.90 %**
	Akosombo & Kpong	1180		1180		1180	
	Bui hydro 200–400 MW	0		200		200	
				-400		-400	
Thermal		**1175**	**55 %**	**1565**	**48.30 %**	**1565**	**48.30 %**
					45.50 %		**45.50 %**
	Tapco	330		330		330	
	Tico	330		330		330	
	Tema diesel	0		0		0	
	Effasu Barge	125		125		125	
	330MW Tema GT 1	330		330		330	
	330MW Tema GT 2	330		330		330	
	Embedded Gas Gen-sets	0		120		120	
	3rd 330MW Takoradi CCGT	330		0		0	
	4th 330 MW Takoradi CCGT	0		0		0	
Renewables		**294**	**9.10 %**	**294**	**9.1 %**	**294**	**9.1 %**
					8.5 %		**8.5 %**
	Biomass, solar, mini-hydro, etc.	10		10		10	
	Wind	200		200		200	
	Municipal Solid Wastes	80		80		80	
	Landfills	4		4		4	
Nuclear		**0**	**0 %**	**0**	**0 %**	**0**	**0 %**
	Light water reactor-IRIS-335	0	0	0	0	0	0
				3239	**100 %**	**3239**	**100 %**
	Total	**3249**	**100 %**	**-3439**		**-3439**	

Table 3. Electricity Capacity Plan 2005–2015.

Capacity Plan: Option 3: Thermal + Bui Hydro + Nuclear +10% Renewable by installed capacity											
Power Plants	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
a. Akosombo Hydro	1020	1020	1020	1020	1020	1020	1020	1020	1020	1020	1020
b. Kpong Hydro	160	160	160	160	160	160	160	160	160	160	160
c. Tapco_oil CCGT	330	330	0	0	0	0	0	0	0	0	0
c. Tapco_gas CCGT		0	330	330	330	330	330	330	330	330	330
d. Tico_oil SCGT	220	220	0	0	0	0	0	0	0	0	0
d. Tico_gas SCGT/CCGT		0	220	330	330	330	330	330	330	330	330
e. Tema diesel	30	0	0	0	0	0	0	0	0	0	0
f. Wind turbines				50	100	160	160	200	200	200	200
g. Effasu Power gas Barge	125	125	125	125	125	125	125	125	125	125	125
h. Tema 330MW gas thermal				110	220	330	330	330	330	330	330
h. 2nd Tema 330MW gas thermal									110	220	330
i. Embedded Generation - gas turbine											120
j. Bui Hydro at 200 MW							200	200	300	300	300
k. Nuclear light water reactor - IRIS 335											
l. Biomass, solar mini hydro, etc.			1	5	6	6	7	7	7	10	10
m.Municipal solid wastes									20	40	80
n. Landfill power								1	2	4	4
Total	1885	1855	1856	2130	2291	2461	2662	2703	2934	3069	3339
VRA expected Import	100	200	200	0	0	0	0	0	0	0	0

Green: No Installation
Yellow: Standby/Backup/Reserved Installation/Or yet to be connected to the grid

Table 4. Cost and Job Creation Potential.

2013–2015	Option 1	Option 2	Option 3
Cost in US $ billion	1.2–1.4	1.3–1.4	1.3–1.4
Investment	40 %	52 %	52 %
Operation & Maintenance	60 %	48 %	48 %
Job Creation potential			
Construction	5,000	5,000	5,000
Operation & Maintenance	135,000	135,000	135,000
Total	140,000	140,000	140,000

Ghanaian Electricity Infrastructure

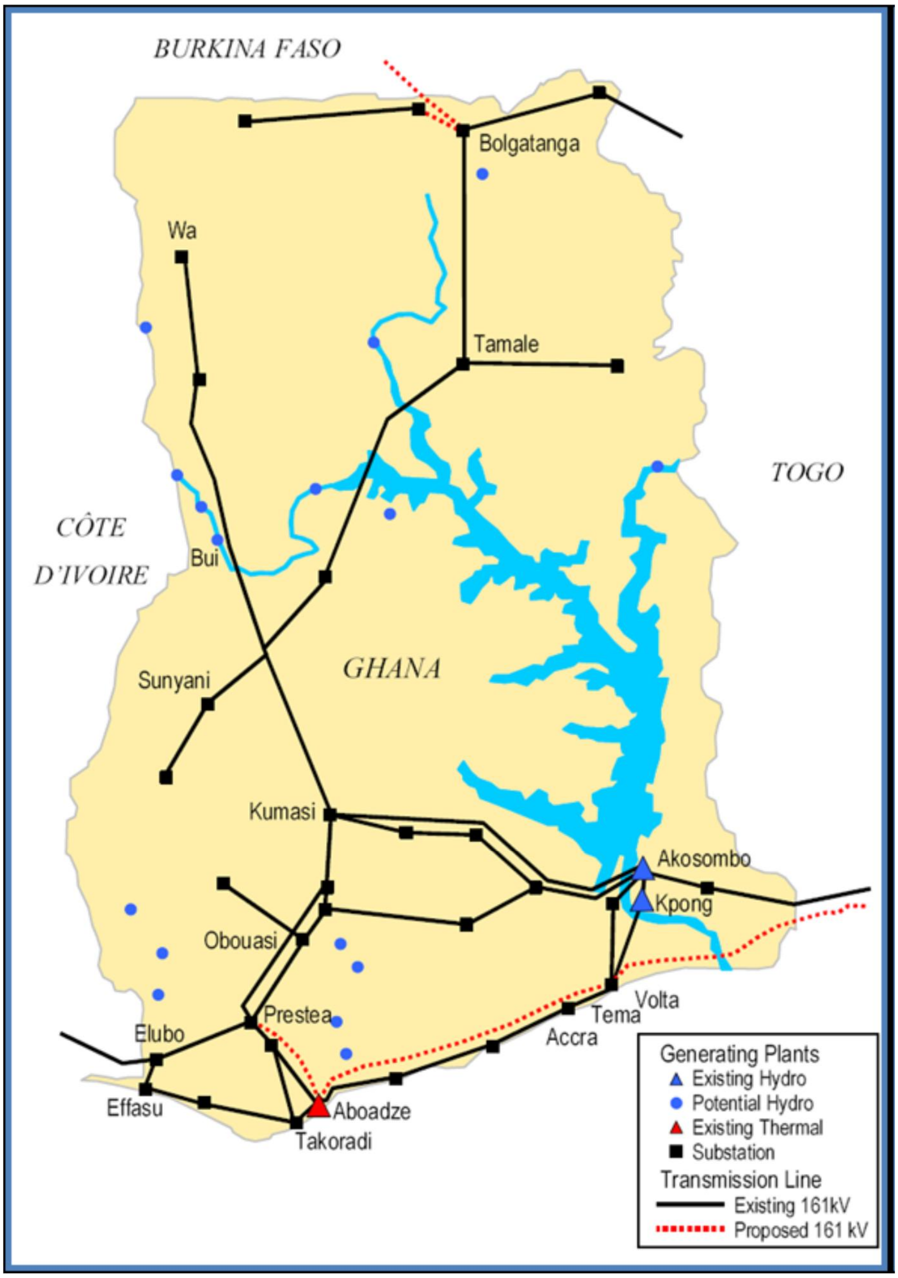


Figure 4. Volta River Authority Transmission Network.

The figure above depicts both existing electric generating plants as well as proposed transmission networks in various regions in Ghana. Ghana has a unique energy generating system, which includes hydro and thermal power plants. Nonetheless, among these power plants only two are generating electricity close to full capacity. The others are merely getting by due to varied reasons, thus compounding the gap between the demand and supply of electricity in the country.

2.1.2 Renewable energy regulation – policy in Ghana

In Ghana, according to the report by the Energy Commission, primary energy is comprised of about 90–95% of wood fuel (mostly biomass), 5–10% hydro energy and less than 1% photovoltaic energy. The use of renewable energy by the government, households and industries is very limited and not well documented. The current situation has created a reformation in the energy policy of the country. The government, in consideration of the energy requirements, has formulated a strategic national energy plan for 2006–2020 (henceforth SNEP). The SNEP energy policy framework includes an existing socio-economic and environmental policy, the linkages between the energy sector and other sectors of the economy, international linkages of the sectors and, more importantly, the need for a policy for the import and usage of renewable energy products in the country. This research focuses on renewable energy regulation and its parameters.

The international connection of the energy sector presents the country with attainable milestones; for instance, Ghana needs to improve the living standard of its citizens which includes significant poverty reduction without compromising the environment. Ghana has signed international environmental protocols such as the United Nation´s Millennium Development Goals (*henceforth* UNMDG). The UNMDG, among others, focuses on eradicating extreme poverty and hunger by promoting sustainable energy and environmental policies aimed at sustaining jobs. Furthermore, the UNMDG seeks to protect the interests of future generations and invariably helps increase the standard of living of people living on less than a dollar a day. More so, the UNMDG's objectives include the Clean Development Mechanism under the Kyoto Protocol, which makes it possible for a country to obtain assistance in developing its energy resources. Two of the 10 broad objectives of SNEP, which include the stimulation of economic development with energy acting as a catalyst, are essential in supporting the marketing mechanisms needed to make the proposed policy work. The objectives include increasing future energy security by diversifying sources of energy supply, the enhancement of the private sector's participation in energy infrastructure development and service delivery, and the acceleration of the development and utilization of renewable energy and energy efficiency technologies (Ghana EC 2009; EC 2006).

To achieve the aforementioned objectives the government, through the ministry of energy, intends to put in place measures to encourage public-private sector partnership. The measures include securing private sector investment in collaboration with the public sector for the re-capitalization of the energy supply system by expanding electricity generation capacities, reinforcing and expanding electricity transmission and distribution networks, among others. Furthermore, the government aims to ensure efficiency in the management of the existing energy infrastructure through restructuring public utilities to attract private participation. The government also intends to break up the public sector monopoly on the electricity supply through improved regulatory transparency and an unbundling of the supply systems currently in place. Moreover, the government intends to accelerate the development and utilization of renewable energy and energy efficiency technologies to achieve the target of 10% renewable energy penetration of the national electricity demand by 2020.

The strategies intended for implementation by the government demonstrate its recognition of the advantages of renewable energy resources in complementing the existing conventional or traditional energy mix in the country. The renewable energy for electricity is to come primarily from photovoltaic systems, small and medium sized hydro plants, wind, biomass and municipal solid wastes. Finally, the government will seek to sensitize energy suppliers and users about the environmental issues associated with energy, besides supporting international efforts and cooperation to ensure the sustainable delivery of energy to mitigate climate change. Furthermore, the government aims to strengthen the existing regulatory agencies, namely the Energy Commission (EC) and the Public Utility Regulatory Commission (PURC) to enhance their capabilities. The strategy includes supporting the training of Ghanaians in all fields of energy development, management and an initiation of power sector reforms.

The recommended policy for the commercial and service sector includes government support for energy efficiency and conservation measures in the service sectors, the promotion of pre-paid metres in government buildings and offices and, finally, the setting up of an electricity consumption ceiling for ministries, government departments as well as agencies, including all the security services, as part of efficient usage measures. The implementation measures will include the intensified activity of the Energy Foundation (EF). Furthermore, the measures also include a rule making the use of pre-paid instead of credit metres for electricity mandatory for all ministries, government departments and agencies, the setting up of a committee comprising the PURC, EF, EC and chaired by the Ministry of Energy to determine a ceilings for the ministries, government departments and all other agencies. According to these plans, any governmental entity which defaults will have to pay from its own coffers. Finally, regulation of the electricity consumption by the public tertiary institutions will set a good precedent for other service sectors to emulate.

The recommended policy for the supply sector includes governmental support for the development of alternative energy sources. These sources include renewable energy for power generation and the exploration of various options including decentralized and mini-grid systems for reducing the cost of supplying utility power to rural communities. The implementation measures include the creation of incentives to attract private sector investment including access to concessionary loans, financial instruments, guarantees and grants for infrastructure investment. In addition, the government hopes to create an environment that promotes the entry of multiple players into the generation market by encouraging private and public investors to take advantage of the opening up of the electricity generation market. Finally, the government intends to scout for overseas development assistance to augment the current electricity infrastructure. The government plans to sustain its commitment to achieving the National Electrification Scheme objective of 100% electrification by 2020. Nonetheless, to avoid needless strain on the government's budgetary allocation for subsidies, the role of the government policy should be to create and promote a competitive market environment, which is sustainable from both the economic development and technological innovation point of view (Bojnec and Papler 2011).

2.2 Electricity management in Ghana

The following describes the role of regulatory bodies in the production, distribution, promotion and management of electricity in Ghana. It is worth noting that the current institutional structure of energy regulation as a whole is monopolistic, making the administration and regulatory process bureaucratic in nature. There are six public institutions currently involved in power (electricity) regulation in the country. One of these institutions is the Ministry of Energy, serving as a government mouthpiece and responsible for energy policy formulation. There is also the Energy Commission, the mandate of which is energy policy advice, planning, technical regulation and monitoring. These institutions also include PURC, responsible for electricity tariff regulation, the Volta River Authority (VRA) responsible for electricity generation and transmission. In addition, there are two state owned companies, Electricity Corporation Ghana (ECG) and Northern Electricity Distribution (NED), the primary responsibility of which is the distribution of electricity for the southern and northern sectors respectively. Finally, there is the Energy Foundation the responsibility of which is to promote energy efficiency and conservation.

In Ghana, electricity production and the regulation of its supply is under the oversight of the VRA. The VRA is a state run entity in charge of all the hydro power plants and thermal power generation in the country. These include the Akosombo and Kpong power stations, the Takoradi Thermal Power Station, Tema diesel power station and the Ghana (Osagyefo) Power Barge at Effasu in the Western Region.

Two government-regulated institutions, ECG and NED, handle the current ongoing distribution control of electricity in Ghana. ECG oversees the southern sector, which includes the Greater Accra, Ashanti, Eastern, Western and Volta Regions. NED manages the northern sector, with control over the Brong Ahafo, Northern, Upper East and Upper West Regions. Unfortunately, the new energy reform proposes that there be only one national entity to handle electricity distribution in Ghana. Thus, the new state distribution company will be a merger of the VRA, NED and ECG. This new reform begs the question as to whether the Energy Ministry really intends to deregulate the energy sector. Merging the three government entities could give rise to an unprecedented monopolistic practice difficult to regulate or control. The best option would be for a decentralized institution involving both the public and private sectors to help in a mutual front of policy suggestions and improvements of electricity generation and distribution standards for the country.

Although the Energy Foundation is supposed to be in charge of the promotion of energy efficiency and conservation, its current operation is mediocre at best. One would think that, as part of the foundation´s mandate, it would seek avenues to educate the public on energy efficiency by putting in place well designed plans for public workshops, which on the one hand educate its institutional partners, and on the other hand sensitize the public to responsible energy usage. At best, the EF provides information on the energy capacities of different household appliances. This type of information needs to be supplemented with additional education with an actual orientation on responsible energy usage, thus making it possible for them to achieve aspects of their core mandate.

In Ghana, the financing of electricity usage is usually the responsibility of the end user. In rental apartments, tenants share the accrued utility bill equally, irrespective of how much is consumed by individuals in the building. The aforementioned practice has resulted in needless arguments among tenants, especially against those suspected of having many appliances and who would thus consume higher amounts of electricity than their neighbouring tenants. In such cases tenants opt for a personal metering system to help monitor consumption rates. ECG and NED currently have in place procedures to transfer all households from credit pay to pre-paid systems purposefully to help reduce instances of non-payment and illegal connections. People in urban sectors are by practice also surcharged for the government’s rural electrification program as well as for the implementation of streetlights to specific sectors of the country´s highways and utility roads. Thus, government subsidies mainly exist for rural people because of their relatively low income, among other things.

To conclude, the aforementioned points provide some clarity as to the nature of electricity generation, distribution and management in Ghana. Furthermore, the chapter touches on the growing demand and inadequate supply of electricity in Ghana. Since the current supplied capacity is less than the demand, the issues at stake represent a significant challenge to the government in finding lasting solutions to the frustrating energy crisis. Progress will depend on how much the government, institutions and the public are willing to invest scarce resources to achieve desired the objective of raising the energy generating capacity by efficient and sustainable means to aid in the promotion of economic development and growth.

3 TECHNOLOGY AND MARKETING RELATED FACTORS

This chapter addresses background issues related to photovoltaic technologies and recent studies in marketing mechanisms. The marketing mechanisms discussed here concern key parameters, including product, promotion, distribution and financing options available for the effective diffusion of photovoltaic systems. The critical discussions on marketing mechanisms can help policy makers, implementing authorities and energy entrepreneurs reconsider their strategies for developing countries.

3.1 Photovoltaic technologies

This part of the research helps in our understanding of the basic components involved in a complete photovoltaic system. A brief review of the key systems involving photovoltaic product components will help to focus the discussion on its role in the marketing mechanisms. Renewable energy systems are methods of harnessing energy for human consumption in a way that whereby the source of such energy does not deplete over time (for millions of years). This includes but is not limited to wind, sunlight, bio-fuel (biomass and biogas), tides, and geothermal heat (see also Patel 2004; REN21 2010). For the development of this research, the focus is on standalone, backup and hybrid energy systems wholly owned by end users, a category which could include but is not limited to individual households, small and medium scale enterprises as well as small communities with little or no access to electricity. The research focuses on photovoltaic technology and the marketing mechanisms in consideration of such technology for developing countries including Ghana as a case example. This choice does not in any case limit the findings and conclusions drawn to photovoltaic technology, rather it helps to establish a clear framework for future replication under similar parameters for other renewable energy systems. This part of the research will also focus on some basic background of the technology in question, considering the development of its architecture as well as the uses and benefits of photovoltaic technology in general.

To begin with, photovoltaic technologies are made up of photovoltaic cells – also called solar cells, which convert light into electricity via a semiconductor material such as silicon (see also Howard 2005: 22; Ndzibah 2006; Ndzibah 2010). Since the 1980s, photovoltaic systems have gradually evolved from being used mainly for remote-area power supply to its current use as photovoltaic power stations, which are grid connected. At the end of 2008, the total capacity of PV installation amounted to some 15,200 MW globally, thus meaning photovoltaic production has doubled every two years. To date, photovoltaic producing countries include Japan, China, Germany, Taiwan and the USA, among others. Furthermore, photovoltaic technology, as well as other renewable energy systems, is by popular opinion more sustainable and environmentally friendly. Sunshine as a fuel is abundant, renewable and free. Photovoltaic cells generate electricity without creating emissions, have no moving parts, are highly reliable and require no additional fuel (see also Carts-Powell 2006: 28–31; Ndzibah 2006; Kropp 2009; REN21 2010).

3.1.1 Photovoltaic architecture

The photovoltaic architecture core package includes the design platform modules (panels), charge controllers and inverters. For the sake of efficiency, a 12 or 24-volt DC battery is included as part of the installation package of a complete photovoltaic system. The battery serves as a storage device making the generation of electricity possible at night, when no sunlight is available to power the photovoltaic cells.

Photovoltaic Design Platform is a semiconductor device, normally made from silicon. Crystalline silicon solar cells may be made using mono or polycrystalline and, in some models, ribbon silicon wafers, all with varying output capacity. In recent times, *sliver cells,* a type of innovative micromachining technique that requires less silicon and fewer wafers and is very efficient and adaptable to a wide variety of panels and module architectures and applications, has been in use (Origin 2010). Other innovative technologies in this field include the use of nanocrystals and other non-silicon materials like plastic; the only drawback is the industrial application of these solutions. The cost and performance of these different cells are similar. Thin film photovoltaic cells use much thinner layers (around 0.001mm) of semiconductor deposited on glass or another supporting material and these include amorphous silicon, cadmium telluride and copper indium selenide. There is also the nano-crystalline silicon (microcrystalline silicon) as well as concentrated photovoltaic (CPV) which uses a large area of lenses or mirrors to focus sunlight onto a small area of photovoltaic cells. The idea behind ´high concentrated' photovoltaic modules means one hundred or more times more direct sunlight will be in focus when compared with crystalline silicon panels. The primary advantage of CPV systems is the reduced usage of semiconducting material, which is expensive and limited in supply (see also Duke et al. 2002). Nevertheless, there are serious limitations, that need consideration and these include the cost of focusing, sun tracking and cooling equipments among others (Howard 2005: 23, 24; see also Rentzing 2005: 64; Löfken 2006: 65–69).

Photovoltaic Modules: After the design platform, (mono, poly, ribbon or the other variants) the solar modules are assembled from solar cells. Since each photovoltaic cell produces a low voltage, to obtain a useful working voltage many cells come assembled in series. The cells are connected together to give a voltage suitable for charging a 12 or 24 volt battery. The module thus becomes the standard building block for larger photovoltaic systems. A set of photovoltaic modules connected together to produce a required working voltage and current is called a photovoltaic (or solar) array; the array includes any support structure and interconnections necessary (see Patel 2006; Ndzibah 2006).

Photovoltaic Charge Controller: A charge controller is the heart of the system and it is vital for preventing the photovoltaic modules from overcharging the battery. Charge regulation also prevents excessive water loss and the reduction of battery life. The charge controller normally also stops the load from over-discharging the battery, which is harmful to most battery types. In addition, charge controllers may include features like:

- *LCD screen for displaying battery voltage, state of charge and various currents.*
- *Remote alarm relays to send signals to indicate fault conditions.*
- *Control signals to start up a backup generator, etc.*
- *Software interface for remote communications.*

Designing a suitable charge controller for a particular application requires in-depth knowledge of photovoltaic module behaviour, battery characteristics, and the user's needs.

Photovoltaic Inverter converts DC (*direct current*) to AC (*alternating current*) (D'Errico 2003: 13). Any unit that can convert a 12-volt battery or a direct solar current to 220/230 volt electricity is an inverter. Inverters have a wide range of applications, from small switched power supplies for a computer to large industrial applications to transport bulk power (Tirumala, Imbertson, Mohan, Henze and Bonn 2002: 1009–1100). A standalone photovoltaic system also uses inverters. When an inverter is part of a photovoltaic system, it converts direct current (DC) from the battery to alternating current (AC). The battery unit acts as a storage system (see also Cheng, Cheung and Leung 1997: 279–283; Solar Panel 2006).

3.1.2 Uses, benefits and problems of photovoltaic technology

Many applications and benefits derived from the use of photovoltaic systems include but are not limited to the following, for example:

- *The production of electricity for both commercial and domestic usage with multiple applications like powering electric lamps, television set, DVD players, stereos and a lot of other household and industrial appliances* (see also Klaus 2005: 71).

- *The adaptability of panels in architectural designs, for example, integrated in roofing and some window designs* (IQ Marine 2004).

- *Hi-Tech equipment such that for charging cell phones* (Armstrong 2006: 90).

In Ghana, there are sporadic applications of photovoltaic systems; the table below represents areas that have been well-chosen where solar-PV systems are in practical use. The attention is gradually turning to solar home systems to augment the diffusion process and accommodate the deficiency in electricity supply in the country. It is worth mentioning that out of all the installed capacities, the most popular and functioning categories are the systems for lighting health centres and vaccine refrigeration *(mostly because the refrigerators are the DC type instead of the AC type, thus meaning it uses the solar unit efficiently).* Photovoltaic systems are most popular in rural communities with little or no knowledge about solar units, thus making the provision of proper maintenance for the installed units difficult. Sadly, most of the solar streetlights installed in urban centres have never functioned due to the inadequate feasibility study of the type of system installed. In most cases the battery banks installed were underground, thus during rainfall these batteries were flooded and damaged, rendering them useless and non-operational. Although the current capacity installed is relatively low, with government support, interest will grow which will in turn facilitate the adoption of the systems in resolving the energy crisis in the electricity sector.

Table 5. The application of solar electricity in Ghana. Source: EC-Ghana 2009.

Solar PV System	Installed Capacity	Generation
	Kilowatt	Gigawatt-hour
Rural Solar home systems	450	0.70–0.90
Urban solar home systems	20	0.05–0.06
Systems for schools	15	0.01–0.02
Systems for lighting health centres	6	0.01–0.10
Vaccine Refrigeration	42	0.08–0.09
Solar Water Pumps	120	0.24–0.25
Telecommunication	100	0.10–0.20
Battery Charging stations	10	0.01–.0.02
Grid connected systems solar streetlight	60	0.10–0.12
Solar streetlights	30	0.04–0.06
Total	853	1.34–1.82

Solar energy technologies everywhere have the potential to diversify the energy supply, reduce the dependency on imported fuels, improve the quality of breathable air and even stimulate the economy by creating new jobs (see also Oteng-Adjei, 2010).

It is worth mentioning that the production of photovoltaic cells has its own harmful side effect on the environment. For instance, polysilicon is a key component for developing solar panels. Polysilicon generates a powdery waste called silicon tetrachloride and, although this can be recycled, the manufacturers usually ignore environmental protection to increase their profits. The toxic waste, silicon tetrachloride, is dumped into the ground which endangers the health of humans and wildlife (Cha 2008; Wensel 2008). Notably, there are few problems stemming from photovoltaic technology. To produce a reasonable amount of the panels and the other related components currently requires the use of conventional energy systems but efforts are in place to use renewable energy to manufacture components used in generating other forms of renewable energy. Furthermore, there are still on-going problems concerning the appropriate standardized technology utilized in the manufacturing of solar panels and photovoltaic systems, for example, many proposals have focused on the use of organic materials instead of cadmium telluride due to its high toxicity. Thus, although it is also justified and important to take into consideration any negative environmental issues, the focus of this study is on the positive aspects of photovoltaic technology. Nevertheless, this research focuses on bringing power to the people and bridging the gap between the demand and supply of energy in developing countries.

3.2 Marketing mechanisms for photovoltaic technologies

This section defines the concept of marketing mechanisms in general and then narrows the content of the concept to the specific features under consideration in this research. This section also discusses product strategies including platforms and product configurations relevant for photovoltaic technology.

In general, marketing mechanisms involve the direct and indirect manipulation of marketing elements. In this study, those elements will be limited to *product, distribution, promotion and financing* aimed at achieving a desired objective in any given market (Kotler et al. 2005; Cateora and Graham 1999). The strategic interest regarding the diffusion of photovoltaic technology in developing countries is to use the above-mentioned elements to attain the market requirements as well as convincingly satisfy existing and potential customers' needs. Thus, this section discusses product parameters essential for the adaptation of photovoltaic technology on a large scale for consumers.

This section also discusses strategies, platforms and configurations necessary for developing the framework of photovoltaic technology for developing countries. With regards to the distribution of photovoltaic technology, the focus will be on the segmentation configuration and management of the distribution network. The promotion strategy seeks to consider communication tools and campaigns that would be viable in developing countries. This will include the use of media and the deployment of additional tools in the form of education. The design format for the educational part focuses on the use of seminars and public debates in the media in creating awareness and disseminating the right information to ordinary people to motivate them to adopt photovoltaic systems. Finally, instead of emphasizing market pricing, this study will consider potential financing alternatives for the photovoltaic systems.

3.2.1 The role of the product in the marketing mechanisms

This section discusses central concepts related to marketing. Since the main idea is to develop the right tools in approaching the diffusion of photovoltaic technologies, the selected parameters such as product, distribution, promotion and financing will help managers to design product strategies based on the core value of the individual parameters discussed. A product is any appliance, tool, machine, idea or artistic artefact made by an individual or group. The concept of product also includes the idea of individual variation, differentiation and innovation, as well as tangibility and intangibility issues (Kotler et al. 2005; Holman et al. 2003). Nevertheless, this research emphasizes the composite parts that form the complete electricity generating photovoltaic system consisting of *the panels, charge controller, battery and an inverter*. The consideration of photovoltaic technology from the point of view of marketing focuses on the potential market segments and strategies available in the diffusion process.

Understanding the role of the product in marketing mechanisms includes understanding its different facets such as the product line and strategies involved. According to Kotler et al. (2005: 552), a product line is a group of products closely related to each other because they function in a similar manner and are often sold to the same customer groups, usually marketed through the same types of outlet, or fall within given price ranges. In photovoltaic technology, different products of the same product line usually come from a common platform (see also McGrath 1995: 61; Gabrielsson 2004: 33).

A product strategy includes the decisions surrounding and management of the different dimensions of a product, product platforms, product lines and individual products (Kotler 1991: 68; McGrath 1995: 14). Product strategies are concerned with issues pertaining to the standardization or adaptation of the product (Czinkota and Ronkainen 1990: 263–265) and the decision to innovate, modify or imitate a product (Drummond, Ensor and Ashford, 2008). Product strategies also include the classification of products differentiated by the firm in relation to the needs of the customers and the benefit they intend to derive from the product (Taggart and McDermott 1993: 74). The final justification of product strategy is anchored in specific parameters that include technical factors, the legal environment, and the conditions of use, income, education and the consumer's taste and preference (Taggart and McDermott 1993: 75). Anticipating and solving the aforementioned issues provides an advantage in developing the right product for the right market. Product strategies can also include decisions relating to product positioning and brand strategy (Trott 1998: 91–93).

Based on the aforementioned points, the product strategy of any technology is made up of the *product platforms, product lines and individual products* (see also McGrath 1995: 14; Gabrielsson 2004: 30). The product strategy dimension is a bundle of decisions on the product platform that decides how to develop the right platform for an intended market. Different products with varied attributes come from a product platform. Then, from the platform, there is the product line, which defines the width, length and depth and the positioning of products. Finally, there is the individual product with its categorization and packaging attributes. (Gabrielsson 2004: 29–30).

According to Czinkota et al. (2004: 249), a firm has four basic alternatives when approaching international markets: (1) selling the product as it is in the international market, (2) modifying the product for different countries and region, (3) designing new products for different foreign market, and or (4) incorporating all the differences into one product design and introducing a global product. This research is focused on the product strategy of high technology industries and thus, the explanation of the product strategies given by McGrath (1995: 166–173) provides better consistency to the debate on whether to standardize or adapt the product platform to suit the needs of local, regional, international or global customers and market criteria.

The view presented by Gabrielsson (2004) and Czinkota et al. (2004) describes product strategy alternatives as follows:

1. **Localized product strategy:** In this strategy, a company may decide to develop products for only one country or a limited area. This option is often insufficient, as it does not leverage the often-huge development costs in the high technology area. This localized product strategy is used for adapting to the market requirements.

2. **Modified product strategy**: This is more of a regio-centric strategy in that a company may develop a common product platform applicable across the globe, but allows for product adaptation based on regional or country-specific requirements. Thus, the cost advantages as well as the advantages of research and development investment worldwide make room for a significant competitive advantage.

3. **Standardized product strategy**: This is an all-embracing global approach where the firm's strategy is to develop a fully standardized product for global markets. This provides the highest advantages in both development and manufacturing. It is technically and economically advantageous if the product requires relatively few or no modifications for different markets. In the case of developing countries, it is risky to choose the standardized product strategy without necessarily understanding the specific needs and usage requirements of the final consumers in the market.

As part of the internationalization phase, a company may choose to enter a market initially by utilizing a localized product strategy to gain as much knowledge and understanding of the market as possible. Furthermore, a company may choose to present a domestic market strategy with little or no adaptation to both the product and management processes (see also Gabrielsson 2005; Andersson 2003). Some companies are prone to using a mixture of the above-mentioned strategies.

Based on the aforementioned discussion, this study adopts a modified product strategy due to the specific energy requirements of developing countries; the conclusion would be a set of strategies that leans towards that specific continent more than just a globalized approach. Furthermore, using a modified product strategy will enable local businesses to control the initial investments and help them to utilize efficient economies of scale (in production) and scope (in geographic coverage).

3.2.2 The functions of distribution in the marketing mechanisms

Distribution encompasses but is not limited to all direct or indirect activities involved in bringing a product to its desired end user or consumer (Kotler et al. 2005; Cateora et al. 1999). An organization may choose to take care of all pre and post-research, and marketing activities, which will include segmenting a market and configuring an offer to the end user. On the other hand, an organization may adopt a strategy where it focuses on its core business and sub-contracts the role of distribution to competent businesses who act as intermediaries with the ability to hold title of the desired products as well as provide crucial post-sales services and other business activities as required (Hunt et al. 2007; Cateora et al. 1999).

Conventional distribution strategies include but are not limited to individual channel decisions, channel motivation such as incentives and channel management which includes the extensive monitoring of channel members to ensure maximum customer satisfaction (Kotler et al. 2005; Cateora et al. 1999). Considering the nature of photovoltaic technology, the direct involvement of the manufacturer or retailer in customer profiling, which involves an actual visit to the customer’s premises or work place to calculate the usage capacity based on the types of appliances in place, is very important.

In considering the distribution parameters for the marketing mechanism, it is worth including a clear segmentation protocol; this will include an understanding of the various segments available and the basis for such segmentation. In order to focus on subject matter that is of direct merit to the research questions and their objectives, issues of segmentation are limited to including only three presumed usage situations, namely, *standalone, backup and hybrid*. A *standalone* photovoltaic system refers to a situation where people have no access to the national electric grid and rely solely on the photovoltaic system. Photovoltaic systems are recommended for use as a *backup* electric unit for those who have access to the national grid but are ready to use the photovoltaic system in case of a power outage. Finally, the use of photovoltaic systems as a *hybrid* unit is recommended for specific households or corporate bodies with enormous energy requirements. In such cases, key appliances could connect to the grid while photovoltaic unit powers other systems (see also Ndzibah 2010). The segmentation of the market into a regional configuration can also help to establish realistic and easy contact with potential buyers. Depending on the physical location of producer, a distribution and service network can help to make product and related services available to end user on time. Furthermore, the involvement of a local agent with good personal knowledge of the sector helps for an effective and efficient customer negotiation, contracting, and transfer of title where applicable. It can also help in arranging financing with notable local financial or banking institutions, servicing of the product at periodic intervals and provision of local inventory for producer (Hutt et al. 2007; Glemarec 2012). For a well functional network, an agency management is necessary to help define the individual territorial activities with each having access to any potential market be it consumer or industrial buyer (Kotler et al. 2005; Czinkota et al. 2007).

The role of distribution also depends on the type of logistics available for effective management of the market. A localized agency service could help bridge this gap, by providing updated information on the transport network in each assigned region and data on the accessibility of the current and potential clients. The localized agents have the potential to easily screen potential customers to ascertain their actual needs, buying interest, funding and timeframe for making the purchase. The localized agency plan promotes customization, installation, post-sale problem recognition and resolution as well as assistance to ensure customer loyalty and growth of the market (Czinkota et al. 2007; Cateora et al. 1999). In principle, the distribution network, when effectively implemented, will help solve the issues of availability and accessibility, leading to affordability of the photovoltaic system.

3.2.3 The contributions of promotion in the marketing mechanisms

Promotion includes the sum of the various tools available for the effective communication and dissemination of information to the public to facilitate a purchasing decision from end customers (Kotler et al., 2005). Since no individual promotional tool is necessarily better than another, the best approach is to use a combination of tools which the firm believes would yield the most-desired results. In this section, I discuss the potential promotional tools appropriate for disseminating information about the availability, affordability and reliability of the photovoltaic systems. To make a justified choice of a specific form of renewable energy systems requires the right information among other things and the challenges involved in disseminating such information are different from promoting a household appliance or any other consumer product. The availability of different promotional tools does not automatically mean that they are viable in any given energy market (see also Kotler et al. 2005; Ndzibah 2010).

Energy markets often lean towards personal selling and public relations rather than mere impersonal advertising. Personal selling presents 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. Public relations in this context aim to develop a mutual understanding of an energy system, the role of capacity builders, systems providers and their distribution interface with the end user, thus enhancing the image of both the business and the systems provided (see also Kotler et al. 2005: 719).

Furthermore, a mix of communication strategy in the marketing of photovoltaic technology tries to identify the right promotional tools to help both households and businesses make informed decisions. While a given individual might consider affordability, another (individual or business) may focus on reliability or availability. All the same, the implementation of the right mix of communication is essential to building trust with the end customer as was shown in the results of the interviews that I conducted. An analysis of promotional strategies feasible for adoption shows that the right media are an important consideration be it electronic or print, educational seminars, debates on issues pertaining to social responsibility on energy usage aimed at sensitizing the public to the reliability, affordability and availability of photovoltaic systems. In developing countries, an important challenge is the lack of proper statistics required for quantifying the level of coverage of usage and accessibility of any specific media in the country. Knowledge of the aforementioned issues would provide a necessary understanding of the choices and frequency of use of any of the promotional tools viable for use in developing countries.

The most popular media in developing countries include electronic: radio, television; and print: local newspaper, billboards, posters, and banners. In recent times, the internet has increased in popularity especially among the youth and the working population (Czinkota et al., 2007). Although all these media are useful, their reach varies greatly and is relative to the type of audience (Cateora et al. 1999). The hope is to use of seminars, workshops and public debates to bridge the gap created by the use of print and electronic media. Seminars and workshops aim to create awareness and to disseminate the right information to ordinary people. Seminars, workshops and public debates can create opportunities for deliberative democracy. Especially when hosted electronically, these avenues can promote phone-in discussions and questions to enrich the process.

3.2.4 Financing options for photovoltaic technology in developing countries

This section discusses various options for financing a photovoltaic system in developing countries. Derrick (1998) reviews financing options such as revolving fund, credit co-operatives and leasing. Sarkar and Singh (2010) propose government grants, subsidies, special funds, credit lines and loan guarantee programs. Furthermore, they emphasize the need for strong public institutions to be in place to plan, implement and monitor these options to enforce the validity and efficiency of the options stipulated. This study further categorizes key actors in the market with regard to financing options worthy of consideration. These include options initiated by individual households or an enterprise (cash and carry or hire purchase), non-governmental organizations, financial institutions and the government. Although each individual option has its advantages and disadvantages, this research tries to focus on the positive aspects of promoting affordable solutions in mitigating the energy crisis in developing countries (see also Kowsari and Zerriffi 2011). Knowledge of these options would serve as part of the educational process in helping consumers evaluate and decide on the best alternative from an informed perspective.

Nonetheless, the financing options would be incomplete without understanding the cost involved in any photovoltaic package adopted by the varied segments in the market. Although this research does not directly discuss issues pertaining to grid-connected installations, an understanding of the levelized cost of electricity opens up future possibilities and options available to the government and the energy institutions. The first part of this subchapter determines the energy price for photovoltaic systems in developing countries based on the levelized cost approach, followed by the different financing options and concludes with a suggestion as to the viable method for the Ghanaian market.

The *general cost approach* involves determining the levelized cost of electricity (LCOE) combined with knowledge of interest rates to help arrive at a realistic cost which will in turn help determine the best option for end users. The LCOE compares the relative cost of energy produced by different energy generating sources, regardless of the project's scale or operating period (Christoph Kost et al. 2012; Agbejule 2012).

LCOE is thus determined by dividing the project’s total cost of operation by the energy generated. The total cost of operation should include all the costs that the project incurs including but not limited to the architectural design, installation, post-sales service, operation as well as any salvage or residual value at the end of the project’s lifetime (Christoph Kost et al. 2012; Agbejule 2012).

Christoph et al. (2012) offer a compelling argument that for all technologies, the project specific location conditions are key in determining the level of the LCOE. An example of this is southern Germany where typical irradiance on a PV installation is 1300 kWh/m2, the assessments for LCOE are between 0.14 and 0.16 euro/kWh for small PV installations and between 0.13 and 0.14 euro/kWh for ground-mounted PV installations. Depending on the structure, size and location of the installation, the LCOE for PV installations reaches 0.10 euro/kWh for ground mounted PV installations with 2000 kWh/m2 year of irradiance. Thus, the LCOE from using PV falls below the end user energy price of 0.253 euro/kWh not only in regions with high irradiance but also in Germany. Although solar irradiance in Ghana varies from the northern and southern part of the country, this research will not measure out every single variation. In the equation below, the r defines the average interest rate of five banks in Ghana in August 2012. A discount rate either includes the effect of inflation (nominal) or excludes inflation (real). Thus the annual production cost for a photovoltaic system is:

APC = Annual capital cost + annual operation cost + miscellaneous

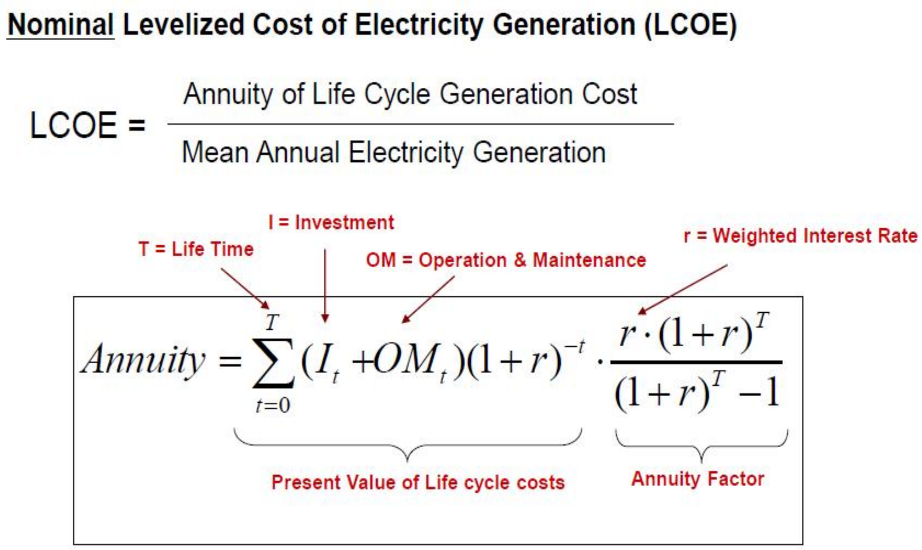


Figure 5. Nominal levelized cost of electricity generation.

The LCOE calculation is applied in two case scenarios to a 100kW photovoltaic system with the first case example focusing on a system which had all its photovoltaic components (panels, inverter, batteries and charge controllers) imported. The second case is of a similar capacity but in this case the panels are assembled in Ghana. The parameters used do not take into consideration the following: subsidies from the government and other philanthropic institutions and the cost of the battery that should be replaced on average twice during the lifetime of the system. Finally, the model does not consider the degradation effect of the solar model. The model uses Accra, the capital city of Ghana, as the context for the varied interest rates available in the banks operational in the region; this helps draw a base line for calculating the different irradiance and costing accurately. The banks interviewed are lettered A, B, C, D and E to ensure confidentiality. The table below gives an overview of the interest rates of the most popular banks in Ghana (in August 2012).

Table 6. Interest rates overview in Ghana.

Name of Bank	Interest Rate in August, 2012
A	**22,5%**
B	**General (24%),** **Consumer Loan (20%)**
C	**22,5%**
D	**12,6%**
E	**23,95%**
Average interest rate	**20.31%**

Although an online tool could possibly project assumed quotients based on the formula applied, the research limits the parameters to Accra, the capital city of Ghana where valid working examples exist. All additional references to solar radiation and other applications are supplementary in nature. The figure below is a copy of an online tool with data representing the solar radiation in Accra. The figure shows the yearly average for solar radiation making it possible to perform a realistic calculation of solar energy generation in the capital city per household, given the parameters of the system installed. The analysis includes estimated losses due to temperature and other losses due to cabling, inverter, and charge controller components installed as part of the total package for a solar home system.

Solar radiation database used: PVGIS-helioclim

Nominal power of the PV system: 100.0 kW (crystalline silicon)
Estimated losses due to temperature: 13.1% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.4%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 27.1%

Fixed system: inclination=0°, orientation=0°				
Month	E_d	E_m	H_d	H_m
Jan	462.00	14300	6.35	197
Feb	471.00	13200	6.51	182
Mar	445.00	13800	6.18	192
Apr	435.00	13100	6.08	182
May	380.00	11800	5.22	162
Jun	319.00	9560	4.35	131
Jul	366.00	11400	5.02	156
Aug	355.00	11000	4.87	151
Sep	359.00	10800	4.91	147
Oct	417.00	12900	5.72	177
Nov	428.00	12900	5.89	177
Dec	439.00	13600	6.01	186
Yearly average	**406**	**12400**	**5.59**	**170**
Total for year		**148000**		**2040**

E_d: Average daily electricity production from the given system (kWh)
E_m: Average monthly electricity production from the given system (kWh)
H_d: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)
H_m: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

Figure 6. Online tool with data representing the solar radiation in Accra.

Table 7. Levelized costing for imported and locally assembled units

Costing	Case 1 – Imported Components	Case 2 – Panels Assemblied in Ghana
Total Investment	2420 €/kW	1636 €/kW
Annuity factor	.2082	.2082
Annual capital cost	503.84 €/kW	340.64 €/kW
O&M (0.1% of investment)	2.42 €/kW	1.636 €/kW
Inflation adjusted annuity factor	10.0145	10.0145
Annual O & M cost	24.232 €/kW	16.38 €/kW
Miscellaneous (0.05% of investment)	1.21 €/kW	0.818 €/kW
Inflation adjusted annuity factor	10.0145	10.0145
Annual Miscellaneous cost	12.116 €/kW	8.188 €/kW
Annual Production cost	540.188 €/kW	365.208 €/kW

Where annuity factor is based on: interest rate of 20.31% for a period of 20 years; O&M (Operation and Maintenance) and inflation adjusted annuity based on: I = 20.31; t = 20 year and rate = 8.1%. The above calculation is based on an exchange rate of 2.5GH: 1€ which it was in January, 2013.

The current supply chain in Ghana requires the importation of all renewable energy equipment. Adapting such equipment to local needs is difficult and there is a lack of training in design, marketing, installation and maintenance. The current approach does not promote country or organizational learning and does not develop and encourage the concept of a renewable energy entrepreneurship environment. A realistic financing option needs an innovative, manageable and cost effective supply chain for renewable energy technology (ISCRET).

An innovative supply chain for renewable energy technology (ISCRET) is how some parts of RET can be locally designed, manufactured, operated, managed and financed. ISCRET can create both value added jobs, promote economic development and increase incomes in developing countries. Furthermore, ISCRET can create a market for cost-effective RET and make viable the matching of RET with needs, resources and competences of local people. Thus linking ISCRET with LCOE can make PV solar competitive in developing countries (Agbejule 2012).

According to Schmidt, the 2012 principles of tariff and price setting are based on full costing with an emphasis on average costing, a fixed nominal tariff payment over 20 years where possible and applicable, and performance oriented payments (per kilowatt-hour produced). Lessons learnt from Germany which is transitioning from government subsidies to the free market generation and operation of renewable energy units with feed-in-tariff applications are useful for an effective IS-CRET in developing economies. For instance, by 2011, Germany had installed one million PV systems and the PV system performance has strongly improved over the last 15 years: the typical performance ratio has increased from 70% to about 85%. Furthermore, more than 3% of the total electricity supplied in 2011 came from photovoltaic systems. It worth mentioning that the energy payback time of PV system is dependent on the geographical location. The assessment was there would be a shorter payback in the south compared to similar systems installed in Northern Europe by a ratio of 1.5 to 2.5 years.

In 2011, the efficiency of inverters and batteries for power generation greater than 100kWp contributed to the retail price in Germany being around 25 €ct/kWp. Moreover, the long-term effect of different subsidy schemes in Germany has decreased PV system prices from around 14,000 €/kWp in 1990 to 2,100 €/kWp by the end of 2011, which is claimed to be a net-price regression of 85% over a period of 21 years with an equivalent compound average price reduction rate of 8.6%. The learning curve indicated that for the past 30 years the module price decreased by about 20% and such a cost reduction resulted from economies of scale and sharp progress in research into photovoltaic systems (Christoph Kost et al. 2012). The figure below presents a rough estimate of the yearly production of PV systems in Germany since 2000. It is clear that in the early stages when technology and other components involved in the complete PV system were expensive, the installation of smaller units with 10kWp was a little over 60% of the total and this has gradually been overtaken by bigger installed capacities in excess of 500 kWp by 2012 (Christoph Kost et al. 2012).

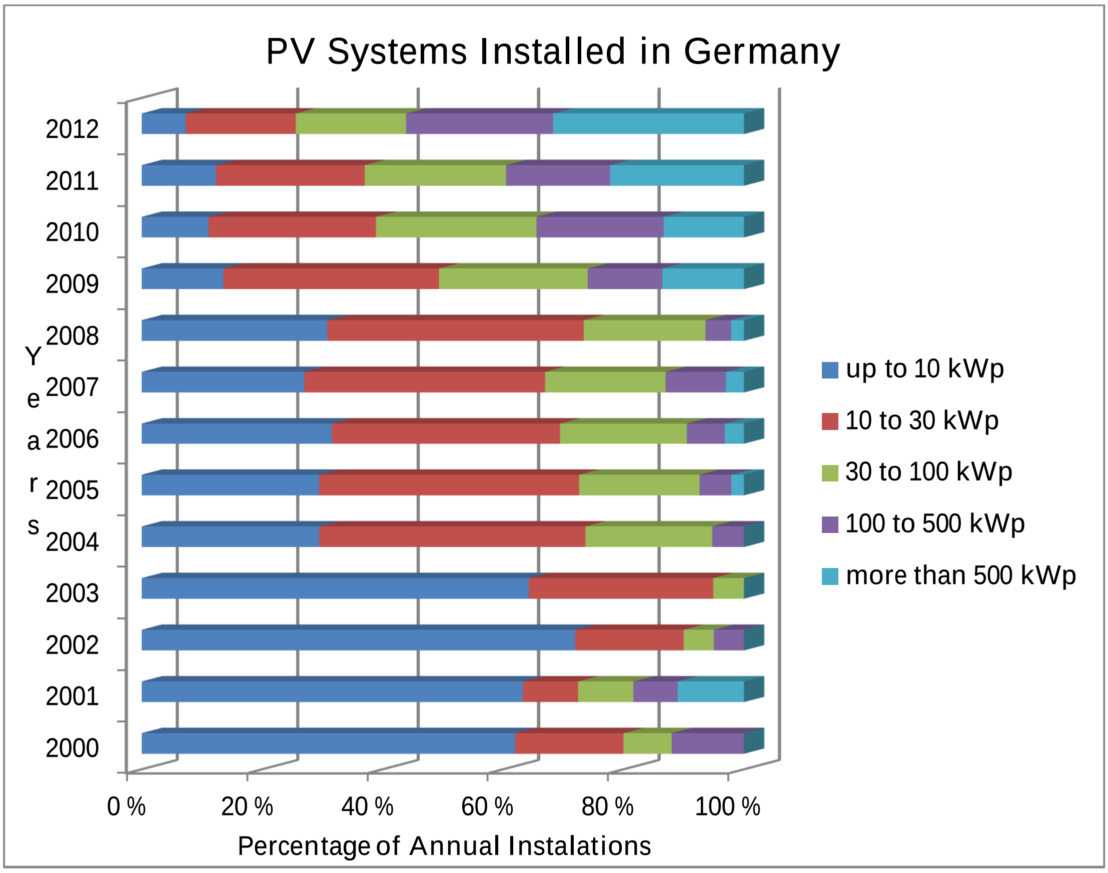


Figure 7. PV Systems Installed Yearly in Germany (share by system size).

The amount of PV energy generated in Germany has also directly influenced the amount of CO2 avoided or saved. In 2011, the production of 10 million tonnes of CO2 was avoided due to 19 TWh of electricity energy generated by PV in Germany. Another important aspect for consideration is the price development. The calculation of the price development in Germany brought into consideration the current electricity costs, costs for rooftop systems and market incentives in Germany (Christoph Kost et al. 2012). Optimistically, the price learning curve will help policy makers and energy administrators to plot similar scenarios for Ghana.

The figure below highlights the changes in cost for small rooftop systems connected to the grid since 1990. Although these estimates are far from the current situation in Ghana, lessons learnt from the dynamic success story in Germany can help the government of Ghana and the energy ministry come up with a lasting solution to the current energy crisis in Ghana. Nonetheless, since engineers in Ghana lack the technical skills to design and manufacture these systems, the initial outlook suggests their heavy reliance on imported components will continue. However, with adequate training and increasing experience over time, experts in

Ghana will be able to come up with solutions suitable for the climate to utilize the abundant solar radiation in the sub region.

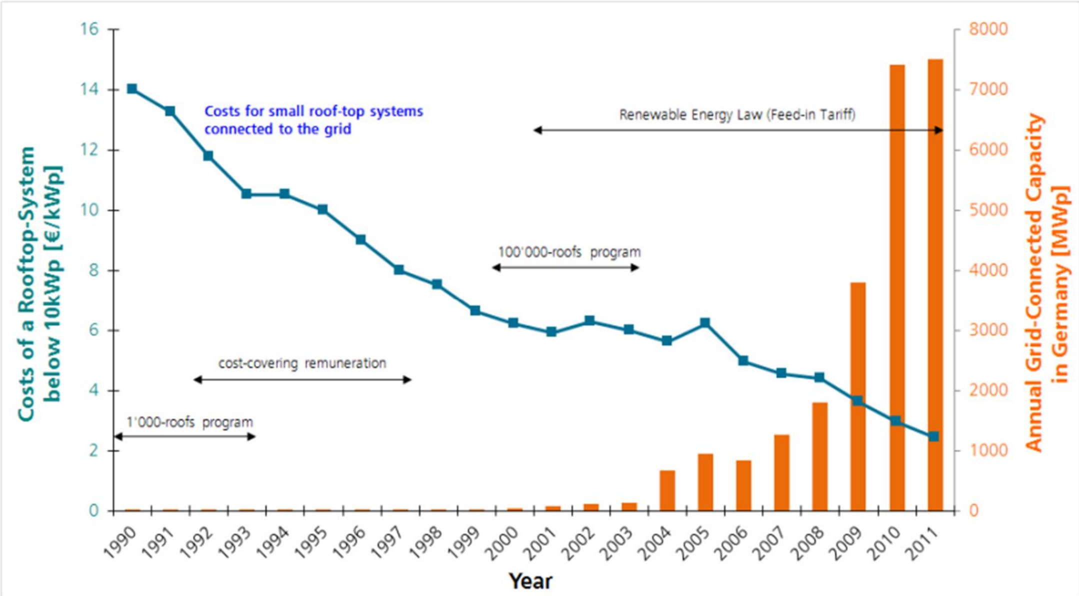


Figure 8. Investment in small rooftop PV systems in relation to market development and subsidy schemes in Germany. (Source: BSW-Solar, Graph: PSE AG 2012 as presented in Fraunhofer Photovoltaic Report 2012).

Furthermore, with regards to the financing options, the following are alternatives for end users: revolving funds, credit cooperatives, leasing, individual financiers, NGOs, financial institutions and government activities.

A *revolving fund* is a form of financing in which a number of willing individuals or organizations contribute to a common fund from which members of the community, especially the poor, borrow to acquire a basic solar or photovoltaic system, and they in return pay interest on the total amount acquired for the system. The interest paid covers the administrative costs of running the funds (see also Derrick 1998). This type of system is inherently inflationary since the interest charged could be higher than an end user would expect, thus increasing the total cost of the whole system.

The option of a *credit co-operative* is usually a common fund created by end users from which stakeholders borrow to cover the cost of a system. This method usually has a high rate of success and a low default rate, since the members are fairly well acquainted with each other (see also Derrick 1998). Although this is very convenient and highly reliable, depositing the collective fund periodically with financing institutions offers short-term high interest rate options, thus guaranteeing a stable co-operative fund.

Leasing involves the contractual obligation of a monthly fee for the use of a photovoltaic system made available by a utility service provider. The payment could be regulated based on the systems generating capacity or by a metering system based on the household or business' electricity consumption (see also Derrick 1998). Defaulting on the payment usually results in the payment of a penalty as well as the removal of the system from the user's facility. It is worth mentioning that this form of action could end up defacing the facility, or worse, causing damage to the photovoltaic unit. Thus, advocates for the leasing system usually prefer the pre-payment metering methods.

This study further expands the financing options by identifying four key areas for consideration due to their uniqueness, namely: individual, NGO, financial institutions and government.

The individual

An individual or business as a financier could opt for a simple cash and carry system or negotiate payment by instalment (high purchase) (see also Ndzibah 2010). In this option, the negotiation of credit terms and payment plan is done between the business owner and the client. The business owner could offer a bundled payment package that includes an extensive post-sales service. The business owner has the sole responsibility of performing a background check on each client to avoid instances of non-payment.

NGO option

An NGO, charity or even an individual philanthropist could sponsor communities with a real need after they have thoroughly investigated the level of poverty and determined whether the need for such help in building energy capacity for productive use is real. The investigation conducted by an NGO, the community or a third party research institution helps to reduce patronage tendencies plaguing SHS activities, especially in rural communities in developing countries.

Financial institution

The banking sector could promote the financing of photovoltaic systems as part of their corporate social responsibility activities. Additionally, financial institutions could act as mediators between the end user and the sales agent, thus using their facility as a unit for the transfer and management of credit. An arrangement of a loan package with a realistic interest rate may also be possible in Ghana for end users willing to purchase a photovoltaic system (See also Liming 2008; Ndzibah 2010). All loans given for the purchase of any form of renewable energy system can be termed a 'green loan', with interest rates relatively lower than the existing market rate (Ndzibah 2010).

Government

The government can play an important role in the promotion of renewable energy systems as well as grant subsidies to the manufacturers and public through the reduction of import tariffs and other taxes such as value added tax on any renewable energy system imported or assembled in developing countries (see also Gutermuth 1998; Liming 2008; Ndzibah 2010). Furthermore, the importance of institutional choices and structures also depends on the types of boundaries and definitions of a potential and attainable set of economic decisions as well as the constitutional frameworks in place (see McIver 2006: 13).

Bojnec and Papler (2012), researching competitive solar electricity, discovered that the success of Slovenia's rapid increase in solar electricity production was because of the heavily subsidized economic conditions, particularly in terms of the guaranteed high price. Nevertheless, Bojnec and Papler (2012) pointed to the budgetary burden and budgetary limitations, which always pose a threat to the implementation of subsidized installed PV systems in developing economies, as opposed to the ease of implementation in developed economies such as Germany. Furthermore, the paper on competitive solar electricity appraised the investments in different sizes of solar electricity power stations to determine the revenue costs, the ratio of profit to all the project's assets, net present value and internal rate of returns. To avoid needless strain on the government's budgetary allocation for subsidies, the role of government policy should be to create and promote a competitive market environment, which is both sustainable, from both an economic and technologically innovative point of view (Bojnec and Papler 2012). Moreover, since Ghana does not manufacture the actual components needed for a photovoltaic system, the future for a viable, sustainable and cost effective investment will be in the promotion of locally assembled photovoltaic systems. This is especially important for boosting the technical expertise needed for large-scale grid related installations.

The aforementioned discussion should be collaborative in nature. In Ghana, the most successful options will come from the combination of efforts by financial institutions and the government. Financial institutions, on the one hand, already have in place regulations and monitoring processes regarding existing customers which makes deliberate oversight on the non-payment of loans effectively impossible. By promoting a product portfolio on a green loan, the banks will not only uphold their resourcefulness and support for their existing customers, but also enable them to make new customers. The banks will thus enhance the cash flow of businesses in the photovoltaic market and at the same time help to attract new customers. The government can do more to help the process by reducing or removing all forms of tariffs to provide an inexpensive diffusion process for the photovoltaic system. Furthermore, the government can relieve some cost burdens by means of incentive packages for all who voluntarily adopt the use of photovoltaic systems either as a backup or as a standalone unit.

4 PRINCIPLES, IMPACTING FACTORS AND ACTIONS

This chapter combines the theory and practice of marketing photovoltaic technology. I start by providing a general overview of the current energy situation in developing countries and the type of segments available in these markets. I will then introduce the Robin Hood and the Donkey principles with the intention of helping policy makers consider alternative solutions and approaches to the current energy crisis that plagues the majority of developing countries. The chapter also discusses impacting factors of the energy crisis, including the inadequate supply of electricity which hampers, in many ways, the economic development and growth of developing countries. The impacting factors further demonstrate the reality of the importance of the Robin Hood and the Donkey principles, thus emphasizing the actions needed to address the energy crisis. Finally, the discussion of the architectural input of photovoltaic systems and the marketing mechanisms framework helps bridge the central points presented in Chapter 3.

4.1 Energy market situation in developing countries

Most developing countries have to make difficult decisions to maintain their current energy capacities and will also have to do so in the future. There is also a need to solve the persistent shortage of electricity to households and businesses in these countries. Developing nations have underdeveloped and unreliable energy infrastructures, which curtails economic development and growth. If challenges brought about by sunset technologies (*technologies that have reached the end of their life cycle in some developed countries*) can be avoided, then this will help promote an enhanced local environment, increased system capacity and an improvement in the reliability and security of the social infrastructure (see also Aitken 2003: 33, 35; Holm 2005: 24; and Ndzibah 2006).

Developing countries are plagued with institutional inefficiencies including factors such as corruption, bureaucratic politics and a low level of technological expertise. For example, in West Africa alone, out of the region's 234 million potential consumers, approximately one in three have access to electricity (see Ndzibah 2006). Considering the current capacity of about 10,000 megawatts and the expected growth of 5% per annum for the next 20 years, the region needs to increase its generating capacity by approximately 17,000 megawatts by 2023 to help keep up with the demand (Plunkett 2004; Ndzibah 2006). The majority of the countries in Africa have small power utilities with an installed capacity of less than 1,000MW. Furthermore, levels of electrification are low, averaging less than

30%. More so, in the West African sub-region, higher electricity consumption is concentrated in countries like Nigeria (54%), Ghana (23%), Cote d' Ivoire (8%) and Senegal (32%) for which the industrial, residential and tertiary sectors account for 41%, 41% and 16% respectively. The consumption of electricity in the agricultural sector in most of these countries is at best marginal. Furthermore, apart from Ghana and Nigeria, electricity tariffs in the region are high. Since significant amounts of capital will be required to finance hydro and thermal power plants, the advantages of the idea of giving power to the people in the form of a renewable energy system are obvious (see also Ndzibah 2006).

This research continues to emphasize the need for households and SMEs to adopt portable renewable sources of energy, including photovoltaic ones, to help bridge the gap between the demand and supply of electricity. The table below presents an overview of the electricity rate in 13 African countries. The table further highlights the percentage of the population with and without electricity as well as the supply and consumption rate of electricity in these countries. Apart from Benin, Namibia, Togo and Zimbabwe, the electricity supply for the countries listed is reasonably higher than the consumption. A careful look at the population without electricity arguably demonstrates the dire nature of the energy situation in developing countries. The International Energy Agency (2001) reports that by 2015 about 34% of sub-Saharan Africa will have electrification and this projection will increase to about 51% by 2030. However, the total electrification rate for developing countries around the same period will be 72% and 78% respectively (see Barry 2011). All estimates provided in this table are from 2007 (CIA 2011).

The only country with a very high electrification rate is Mauritius. Mauritius is an example of ´the best practice´ because, since independence in 1968, the country has developed from a low-income, agro-based economy to a middle-income diversified economy. The willingness of the government to embark on multi-sector reforms since 2006 has attracted substantial investment from both local and foreign investors. Furthermore, the reforms brought about changes and economic diversity thus accelerating the rate of economic growth and reduction in the unemployment rate in the country. With a current population estimated in 2011 to be about 1.3 million with a nominal per capita income at approximately $8,655, the country´s electrification rate has remained at a level where the total electricity consumption is less than the supply. Recently, the country has added information and communication technology, property development, renewable energy and education to its diversified economy. The renewable energy sources in Mauritius include biomass, hydro, solar and wind energy. Although Mauritius is an exceptional case, nonetheless, having a higher electrification rate does not automatically lead to thriving economic development and growth (*for extensive data, see*

Barry 2011). Despite currently known and possible future restraints, localized plans based on sound institutional frameworks will help in advancing some changes in developing countries (Ndzibah 2006). Even if the accessibility, affordability and reliability of renewable energy are a priority in developing countries, it will take a lot of time to stabilize the economic development of these countries (Ndzibah, 2010). To tackle these problems, among others, the following sub-chapter introduces two socio-economic (and ethical) principles for adequately addressing the present problematic distribution and billing system of electricity in Ghana.

Table 8. Electrification rate, demand and supply in 13 African Countries.

Country	Electrification rate	Population without Electricity (Million)	Population with Electricity (Million)	Electricity supply	Electricity consumption
Benin	24,8%	4,9	1,6	124 million kWh	597 million kWh
Cameroun	40,7%	9,3	6,4	5.601 billion kWh	4.801 billion kWh
Côte d'Ivoire	50,7%	8,1	8,3	5.275 billion kWh	3.231 billion kWh
Gabon	47,9%	0,7	0,6	1.774 billion kWh	1.446 billion kWh
Ghana	48,5%	10,5	9,9	6.746 billion kWh	5.702 billion kWh
Mauritius	100,0%	0	1,2	2.321 billion kWh	2.158 billion kWh
Nigeria	44,9%	66,6	54,3	21.92 billion kWh	19.21 billion kWh
Senegal	31,4%	6,8	3,1	1.88 billion kWh	1.384 billion kWh
South Africa	67,1%	14,7	30	240.3 billion kWh	215.1 billion kWh
Sudan	31,0%	22,7	10,2	4.341 billion kWh	3.438 billion kWh
Togo	17,0%	4	0,8	230 million kWh	640 million kWh
Zambia	18,4%	8,7	2	9.752 billion kWh	8.838 billion kWh
Zimbabwe	40,9%	7,6	5,3	8.89 billion kWh	10.89 billion kWh

4.2 The Robin Hood and the Donkey principles

The following sub-chapter introduces the Robin Hood and the Donkey principles with the intent of helping policy makers consider and implement a new and socially advantageous approach for handling issues pertaining to the distribution and billing of the use of electricity. In most developing countries, urban communities have access to most of the country´s basic amenities and infrastructure such as roads, good drinking water, affordable housing, and modern health care unlike rural communities. On the other hand, most of the rural communities have to make do with an underdeveloped agro-based industry. The agro-based industry in developing countries lacks proper incentives to help add value to the produce. Inadequate infrastructure including storage facilities and a lack of appropriate transport network exposes these rural communities to opportunist intermediaries who offer to take their produce at less than the realistic market price. Consequently, rural economic development often stalls since they do not receive enough compensation for their hard work resulting in their inability to save any of their earnings – thus the typical cyclical nature of poverty.

The Robin Hood principle

If expressed in a straightforward way, the Robin Hood principle recommends taking from the rich and giving to the poor. Although here the principle does not advocate community robberies or other crimes, it borrows the essence of its strategy from the British folklore character, in providing resources for the deprived and in this sense an equitable supply of electricity. Thus the Robin Hood principle has a social and political aim and it can help policy makers resolve, in a just manner, electricity distribution issues for both urban and rural sectors of the Ghanaian economy (see also Ndzibah 2011). The concept of ‘‘*taking from the rich*’’ refers to the following procedures:

- Weaning the urban communities off some percentage of the electricity generated from the main grid. The procurement of about 20% of the usage capacity, which is estimated as being the excess household energy requirements, for use in the rural communities. Policy makers can thus recommend that households in the urban communities obtain the same percentage or more from the use of the photovoltaic system. This will not come about by mere dreaming or suggestions, thus the government needs to have a clear plan on how to provide subsidies, especially to end users, as part of an investment incentive.

  Energy subsidies usually help keep prices for consumers below regulated market levels as well as above market levels for producers. More importantly, the motive for government subsidies in this context is to promote the generation by households and commercial entities of electricity from renewable energy sources to augment the deficit of the electricity supply. The subsidy can be in the form of direct cash transfers to consumers (*easily abused without a proper monitoring system in place*) or producers. The subsidy could also be in the form of tax exemptions, price controls and trade restrictions. There are four main arguments for energy subsidies, including the security of supply, especially for independent power producers. The other arguments are that they bring environmental improvements by reducing pollution, including emissions; there are economic benefits in that they alleviate poverty and they increase access to energy in developing countries thanks to reduced prices used to stimulate the economic sectors of the populations and there are social benefits including the creation and maintenance of employment (adapted from: EEA, 2004).

Nonetheless, there are some relevant arguments against energy subsidies and these include the effects of such subsidies on sustainable development, especially as they may lead to higher levels of consumption and waste, as well as create heavy burdens on government finances. Furthermore, some negative aspects of subsidies are their ability to impede the expansion of distribution networks and the development of more environmentally friendly energy technologies (Bojnec and Papler 2012; EEA 2004).

- Allocating the excess capacity of electricity generated for consumption by people in rural areas, thus helping them gain access to affordable electricity.

- Encouraging, by means of reduced tariffs and other related taxes, urban communities to adapt and acquire, for example, a photovoltaic system. A bundled package deal for both renewable energy businesses and end consumers would achieve a great response. For renewable energy businesses, the abolishing of import tariffs and a significant reduction in any related customs and clearing charges would help maintain a standardized market price for renewable energy related products. On the other hand, any form of incentive to end users in the form of a tax rebate or a government approved bank guarantee with a realistic interest rate as discussed in the financing options (*green loan)* would be of benefit.

- Initiating a Feed-in-Tariff system (FITs). This will benefit the urban communities benefit by feeding into the grid any excess of their generating renewable energy capacity. FITs is a policy designed to fast-track investment in renewable energy technologies. This includes the offering of long-term contracts to renewable energy producers based on the cost of the generation of said technology. The goal of FITs is to serve as a temporal cushion for producers from the high investment cost of a given renewable energy system. Nonetheless, the mechanism allows the price to go down over time since its objective is to encourage technological cost reduction. This system makes more sense and is highly applicable if the government approves it by creating adequate incentive packages in the form of subsidies for its implementation. In 2010, FIT policies were in use in over 50 countries. A typical FITs requires three key provisions such as guaranteed grid access, long-term contracts for electricity produced usually framed between 15–25 years and purchase prices based on the cost of generation usually pegged above the market retail price with a gradual price regression as a percentage of the adopters' increases, to help the retail price. Currently, there is no feed-in-tariff in Ghana. The government is currently experimenting with a net metering system with the installed photovoltaic capacities at the Energy Ministry and Energy Commission. Information about the actual direction that the government of Ghana will take is currently unclear and unknown to say the least. In this research, the omission of a comparative analysis of FITs is merely to avoid unrealistic speculations (Couture et al. 2010; Ghana EC 2009; RCEER 2005).

Although FITs is operational in more than 50 countries, research into FIT is difficult to find and, typically, extensive research is required to find adequate information (SFIT 2013; REN 21 2007). Popular among the FITs is the policy in Germany. The policy has gone through major restructuring over the years and, in its new form, has proved to be the world's most effective policy framework at accelerating the deployment of renewable energy technologies. According to Jacobsson, (2006) Germany's new FIT made a number of important changes to its previous policy including the following:

- First, the purchase price is based on the cost of generating electricity from different renewable energy sources. This led to different prices for wind power, solar power, biomass and biogas sources, and geothermal energy, as well as different prices for projects of different sizes, to account for economies of scale;

- purchase guarantees were extended for a period of 20 years;
- utilities are now allowed to participate; and finally,
- the rates offered by the government are designed to decline annually based on expected cost reductions, in a mechanism known as ‘tariff degression’.

The success of photovoltaic systems in Germany, driven by the FIT policy, has resulted in a drop in peak electricity prices by up to 40%, with savings between 520 million and 840 million euro for consumers (Parkinson, 2012). Nonetheless, energy utilities, seeing a major reduction in their profit margins, reacted by lobbying the German government against the FIT policy. If government is to give grant arbitrarily, against the wishes of big corporate firms and producers of energy, the energy deficit in developing countries will never be resolved and thus economic development and growth will be stalled.

For the sake of practicality, the following example better explains the FIT:

Assume you install a 5kW solar PV plant in your house and the unit produces say 25kWh of electricity every day. In a month your unit will produce some 750kWh of electricity. If the FIT policy allows a local power company (utility service) to pay you for the energy, you produce to the grid – this is feed-in-tariff. Assume the FIT is 50 cents per kWh, then the FIT gained is as follows:

(Energy Produced X FIT/kWh) = Cash

In principle, the basic idea of FITs is to earn money to pay for the installation and to profit from investing in a clean and renewable energy source, which supports the energy grid, stabilizes peak energy demands, and offsets CO_2 and other pollutants.

The ultimate goal of the Robin Hood principle is to allow rural communities to increase their energy capacity, build competences and thus facilitate a smooth economic development and growth. Applying the Robin Hood principle to energy policy can provide rural communities with the needed opportunity to develop the agro-base sector, creating jobs and mitigating the rural – urban migration influx. The Robin Hood principle entails the assumption that most people in urban communities are in a better position to afford renewable energy systems, arguably due to their easier access to credits and loans from financial institutions (Ndzibah 2010; Ndzibah 2011). This does not mean that the portion of poor people in the urban communities is as high as that of the rural communities. Rather, the aforementioned statement focuses on the credit opportunities which are more available to the urban communities than their rural counterparts.

The Donkey principle

Donkeys have the potential of easily carrying a load of 20 to 30% of their own body weight; therefore Donkeys are used in farming and transportation. Donkeys also have the tendency to resist any form of force or intimidation if, for whatever reason, they consider submitting to a demand to be dangerous to them (see also Ndzibah 2011). In this study, the Donkey principle is the norm that exhorts the state, in collaboration with the electricity producers, to ensure a practical, fair and transparent billing system for electricity usage. Thus, the Donkey principle concerns the billing policy for electricity use. According to the principle, the government should make it possible by taxing corporate firms and urban communities to carry some of the cost burden of the electricity used by the poor rural communities. The same policy suggests that the extra cost paid by the urban citizens, some of whom are relatively poor, cover rural electrification projects as well as the setting up of streetlights at strategic locations across the country. For years the levies or surcharges have been collected, but in reality the proposed beneficiaries and assumed projects are so few or in some cases non-existent and hence their frustration and scepticism towards the actual uses of their contributions.

The Donkey principle is about the extra load in terms of levies or taxes put in place and the transparency of how the usage of the amount collected. In a Donkey-like way, people in the urban communities will supposedly resist and find a way to avoid paying any extra charge, if for some reason they perceive such a payment as a ploy from the government to extract more money from them for purposes they do not clearly understand. Since the core idea is to promote social fairness, a degree of accountability to the public would make the process acceptable. Conversely, everything concerning rural electrification and other related projects are usually activities initiated under secrecy.

Giving power to the people in essence should include some measure of openness and this usually aims at building trust. To promote accountability, the Donkey principle recommends a clear-cut system, where an institution is set up to monitor and report on all the money accumulated from this strategic billing and to give a clear framework and timeline as to how the money is disbursed for the projects that it is collected for.

The effectiveness of the Robin Hood and the Donkey principles depends on not only the government and its legislative arm but also the public administration and business life of the populace. Changes in the public´s attitude, taste and preference will help resolve this impasse in an ethically balanced way for the benefit of all. A collaborative effort by all stakeholders in promoting and educating the public on how they could monitor the whole implementation process will reassure the public and thus gain their unflinching support for the rural electrification project and other actions taken by the government to help restore an equitable electricity supply in the country.

4.3 Factors impacting on marketing mechanisms and economic development

Next, I will identify and analyse the central factors that influence the marketing mechanisms and their appropriate use in the energy market of developing countries. These factors include potential barriers related to specific aspects of the product, distribution, promotion and financing of photovoltaic systems. Furthermore, a discussion of social and corporate responsibility with regards to energy usage will help to identify the need for changes in attitude and understanding of photovoltaic systems, especially in developing countries. A country's infrastructure plays a key role in its success through its contribution to its development and the facilitation of the free flow of general economic activities.

Impacting factors on product

Since developing countries do not manufacture renewable energy systems, the question of whether to standardize or to make a product multifunctional enough to meet the varied needs of the end user becomes an issue. Taggart et al. (1993: 74, 75) claim that to justify standardization or adaptation an evaluation of the following aspects is required:

- **Technical factors:** A product must be technically consistent with its destination country in terms of determining factors such as voltage of electricity, units of measurement as well as, in some cases, the presence of viable skills, capital or raw materials. Of developing countries´ potential with regard to technical issues is a constituent component of the empirical part of this study (see also Ndzibah 2006).

- **Legal environment:** This includes the product standards in terms of safety, efficiency or pollution control, for which host-country governments may set strict policies. In the energy market, the regulations are much more flexible especially for the implementation of renewable energy systems. An understanding of the legal environment will help policy makers in addressing energy issues with critical considerations. This is especially important for the adoption of renewable energy systems and for mitigating the energy crisis in developing countries (Ndzibah 2006).

- **Use Conditions:** The variations in the use of a product are different from country to country. With regards to photovoltaic systems, the use conditions are the same (i.e., they generate electricity) but the usage capacity can vary between domestic, commercial and industrial levels due to the different energy requirements of the appliances as well as the intensity of their use. Furthermore, understanding the different usage categories in terms of the categories of domestic, commercial and industrial besides the categories concerning the intensity of usage capacity, namely, *standalone, backup and hybrid,* helps identify the types of product package to be developed for use (see also Ndzibah 2006).

- **Income:** The personal income of potential customers may be a determining factor. A low income is not necessarily a hindrance to energy usage because of different credit schemes provided by financial institutions. The credit schemes promote the accessibility of electricity to even the relatively poor in societies of developing nations. Nonetheless, the credit schemes or financing need a viable structure and should be different in terms of the interest rate associated with them. The issue is discussed in this study in more detail under the financing options (see also Ndzibah 2006; Ndzibah 2010).

- **Education**: Due to the complex nature of a photovoltaic system, the assumption is that only educated people will easily understand and be able to handle such complex systems. Regarding the installation and possible periodic services of photovoltaic system, the issue of literacy is not necessarily an impediment to owning the system. As part of the promotional strategies for photovoltaic systems, a conscious effort in the form of public debate, seminars and the effective use of the media will help to educate the public (see also Ndzibah 2006).

- **Consumer tastes and preference:** Cultural and other societal factors influence a consumer’s aspirations. Nevertheless, in the case of electricity consumption, the question of taste and preference is not a main issue in the West African region, where approximately one out of three has access to electricity (Ndzibah 2006; Pineau 2007). Thus, the focus on consumers in this context is their ability to gain access to the best generating capacity at an affordable price.

Furthermore, barriers to products include understanding the right combination of packages offered to the end users. In dealing with this particular issue, it is important to consider the specific needs of the end user. Instead of basing installation parameters on word of mouth, proper profiling and sizing of the potential end users' premises should be carried out by sales and technical personnel to ascertain for what purposes the system is to be used in order to supply the right capacity for the benefit of the end user (see also Stapleton 2008). Renewable energy systems generate limited output. Therefore, to avoid incidences of failed systems it is important that the sales and technical personnel in this industry proactively give the right and relevant information to their clients.

Factors impacting on distribution

Factors affecting the distribution of photovoltaic systems are limited to the accessibility of those systems by end users. Accessibility includes information regarding the locations of specific vendors or agency services as well as the grand total cost of delivering a system so it is in place for the end user. The basis for this as an influencing factor is the reliability of the country´s infrastructure, including road networks and accessibility to specific locations in all the regions of a given country. Due to the fragility of photovoltaic systems, the packaging of the components is crucial to helping prevent any form of damage on the way to their final destination. Developing countries have bad road networks with many communities being barely accessible, which adds to the cost of any form of business activity. Since the transportation of photovoltaic systems cannot be done in a public van, service providers, technical team and sales persons have to map up the regions well in advance and respond to calls and inquiries promptly.

Vendor services in specific localities could increase the ease of access to the systems. However, these vendor services have their own limitations in terms of the training period, inventory management, post-sales services, and payment schemes, especially in cases of hire purchase or similar schemes.

Apart from vendor services, hired agents on commission payment terms, allowed to act as sales persons, with flexible working schedules, could add value to the supply chain and distribution management (Czinkota et al. 2007). It is worth noting that sales agents require similar training to, if not more than a vendor service, to help present products in a realistic way and to avoid instances of misrepresentation.

Another option relevant for efficient distribution will be for detailed documented "*systematically do it yourself*'' (DIY) material to be included in the packaging so that the end users can undertake the installation and possible maintenance of the systems themselves. Nevertheless, unlike light bulbs, easy to fix or replace when they burn out, it is not advisable for any individual to arbitrarily adopt the DIY option especially in developing countries where there is a serious lack of knowledge and expertise about such energy systems.

The aforementioned points are merely a fraction of the whole supply chain and distribution management. Since these occur usually at the end section of the supply chain process, proper accounts should be in place from the supplier of materials for the system through to the profiling and subsequent installation by the technician to help promote a just in time system. All the aforementioned could also be hampered by the order cycle time of any given component that forms part of the whole system, for instance, delays in the shipment of individual cells, batteries or inverters could adversely affect the efficient distribution of the complete system to the end user.

Factors impacting on promotion

This includes the dissemination of the right information to the public and, for that matter, the end user. The right choice of media is crucial and the medium of communication to stakeholders should be simple and accessible. The observation is that sales and technical experts, as part of their promotion campaign, exaggerate the amount of electricity generated by any particular photovoltaic system and promise too much to customers without considering their actual needs and usage rate (see Stapleton 2008).

Sales and technical personnel should explain the features and requirements of photovoltaic systems even before the customer makes the decision to purchase a system. Promotion in this format would avoid unwarranted complaints from end users arising from them not complying with information made available to them as well as any abuse to the system. Furthermore, the lack of a public forum prevents the proper diffusion of photovoltaic systems in developing countries. Organizing a public forum as a promotional tool is not the task and responsibility of the service provider or firm selling the system alone. The government could intervene by incorporating such discussions, seminars and debates into the educational program for it to be accessible to the public. This is possible with structured programs on a weekly basis on selected media, where invited experts present sound evaluations and applications of photovoltaic systems. The incorporation of similar discussions in the annual teachers' educational workshops held in the country would also be beneficial. Government policies and regulatory frameworks should be accessible to the public and this should be well defined, documented and monitored to ensure the quality and success of the framework. For example, the government could use simple flyers, brochures and magazines discussing the requirements for and benefits of photovoltaic systems.

The necessary requirements for the proper diffusion of renewable energy education are lacking in developing countries. The education curriculum does not even contain modules that educate the youth from the primary to the tertiary level of their academic life cycle. The reinforcement of education on renewable energy systems by the governments of developing countries is necessary to augment the knowledge base of renewable energy systems. This can be possible by incorporating free seminars and workshops into the educational policy to educate the masses to make them conscious of renewable energy systems and their related benefits. Organizing such workshops needs planning, for example, members of parliament could take the initiative in implementing such programs in their respective regions by visiting them on a monthly basis with experts and an annual national energy week which includes a question and answer session could supplement all other efforts. Furthermore, the educational program might include the compulsory study of renewable energy systems and related sustainability programs. In some developing countries, efforts have been limited to the tertiary level of education and particularly to technology and engineering faculties. Furthermore, contemporary professionals in such fields have been educated abroad. Currently, the right structure and programs in the school curricula targeting all disciplines are required to avoid limiting such intelligence and awareness to an insignificant few and to enable students to understand the basis of photovoltaic systems and the responsible use of electricity (see also Garg and Kandpal 1992; 1995). From the formulation of the syllabus to the deployment of the program, careful analysis is needed, as are planning, implementation and control mechanisms for a successful teacher and student interface implementation. Finally, key parameters for promotion should include but not be limited to the following:

- **Mentality**: This eases the fears of the public concerning the perceived danger and potential applications of photovoltaic units. This can also address the public' knowledge before and after the introduction of photovoltaic systems.

- **Environment**: This helps the public understand the need to protect the environment by adopting renewable energy systems.

- **Economics**: This covers the cost benefits of photovoltaic systems as well as all renewable energy systems. The economics element includes the calculations of ecological savings from the suppliers' point of view since all solar agents and businesses have well documented client lists as well as the total capacity installed over any given period. These agents even have documentation of individuals who import the components and yet require local experts and technicians to install the system. Thus, the statistics of total emission savings CO_2 (in tonnes) can be easily monitored based on the total capacity sold per annum or as required.

- **Independence**: highlights the long-term benefits of the use of photovoltaic systems since the end user becomes the owner of the electricity produced at the end of the payback period especially for end users who acquired the systems through any of the alternative financing options other than cash payments.

Factors impacting on financing

The high initial costs are one of the main reasons for the slow diffusion of photovoltaic systems. Affordability is an economic precondition, that relates to the customers' willingness and ability to pay for a product such as a photovoltaic system (see also Bradford 2006; Ndzibah 2010). The higher the purchasing power of consumers, the more likely they will be to take an opportunity offered to them concerning appropriate, reliable and flexible financing of the energy system (see also Glemarec 2012).

The lack of a renewable energy policy and its education in many developing countries also makes it difficult for financial institutions to formulate the right business strategy to promote and help finance renewable energy systems. The lack of a viable credit system has compounded the on-going problems affecting the financing of renewable energy systems. The sensitization of financial institutions to including green loans as part of their loan services credibly increases the adoption of credit facilities and the acceptance of the initial high costs.

Furthermore, in some developing countries import duties and value added tax on renewable energy components frustrate renewable energy businesses' attempts to implement a proper and affordable pricing strategy for the systems and related components. These obstacles can be, at least in principle, relatively easily removed by legislative changes.

4.4 Summary of the principles, impacting factors and actions

The overview presented above of the impacting factors related to the implementation of photovoltaic technology has identified and analysed the different forms of marketing mechanisms suitable for developing countries. Furthermore, these impacting factors usually slow down any economic development and growth. Therefore, addressing such factors will help to resolve the problems at stake and to a wider extent help to increase the energy capacity in developing countries in Africa and globally. The figure below illustrates the different aspects of the marketing mechanisms and their connecting variables.

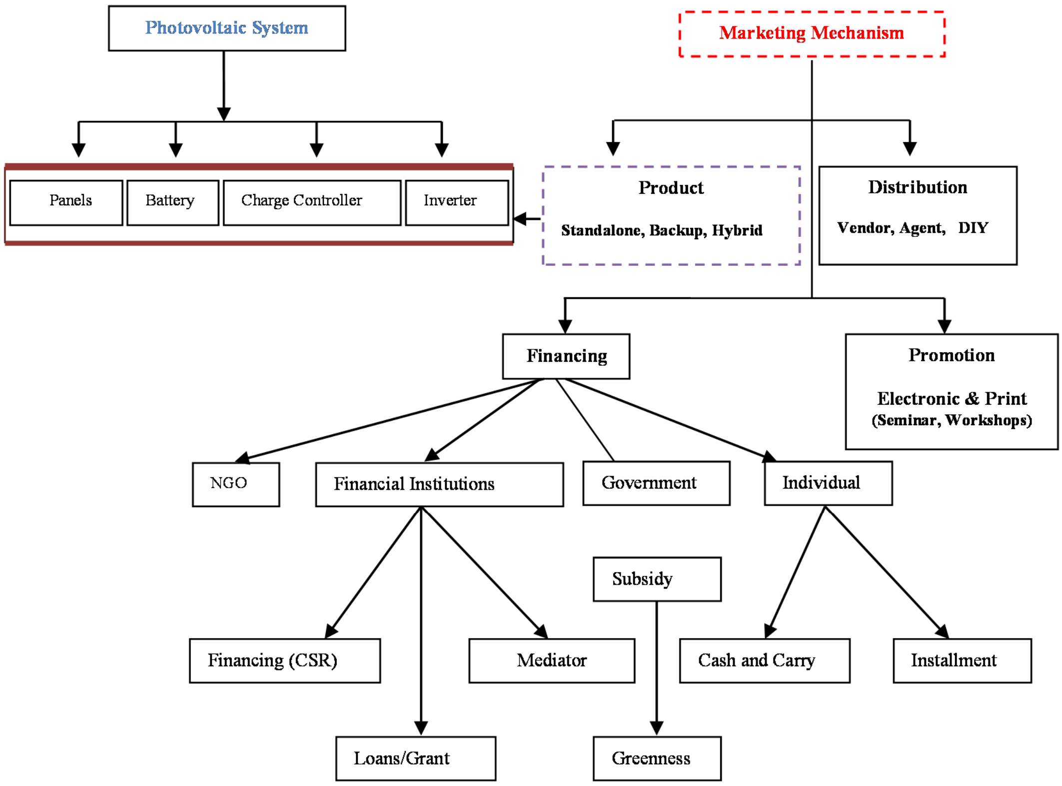


Figure 9. Summary of framework.

The focus on marketing mechanisms includes discussions of the product, distribution, promotion and financing options for a proper diffusion of the photovoltaic systems. The product configuration includes different consumer options: *standalone, backup and hybrid system. Standalone* units are for those without access to the electric grid systems. *Backup* electric units are for those who have access to the national grid but are ready to use the photovoltaic system in case of a power outage instead of a diesel or petrol powered generator. Hybrid units are recommended for households or corporate bodies with high-energy requirements to connect key appliances to the grid while the photovoltaic unit powers other systems. The photovoltaic system, the main product under discussion, includes photovoltaic panels, battery banks, a charge controller and an inverter.

Regarding distribution, the key area for discussion in this study is limited to vendor and agent activities as well as the possibility of end users applying a *DIY* manual. The promotional activities include electronic and print, not forgetting a thorough discussion of the educational possibilities in the diffusion process through seminars and workshops.

Finally, the financing option concerns various actors, such as NGOs and financial instructions in their use of their financial apparatus as a corporate social responsibility tool, the creation of flexible loan and credit systems as well as acting as mediators between the service provider and end users. Furthermore, as regards financing, this study discusses the role of the government in providing subsidies and promoting greenness. Finally, financing also includes a client's option either to pay cash or in instalments (credit).

5 EMPIRICAL STUDY

This chapter discusses the approach used to collect and analyse the empirical data that are the basis of the key claims and conclusions of this study. The chapter concludes by presenting the reliability and validity of the study by discussing a documentary based on business collaboration and a replication of the design parameters of a photovoltaic energy solution.

The main research question of this study is, *'what marketing mechanisms are available, or can be developed and implemented for renewable energy technologies in developing countries?'* The following main objectives present a breakdown of the questions in helping to identify and analyse the different forms of marketing mechanisms suitable for photovoltaic technologies in developing countries and to explore key factors that influence the implementation of these marketing mechanisms. Another objective is to evaluate the current marketing mechanisms used in Ghana, especially for photovoltaic technology, and to test a new marketing strategy that aims at promoting a decentralized diffusion of photovoltaic energy in Ghana. As a central ingredient for energy policy consideration, the discussions on the Robin Hood and the Donkey Principles create a social and political framework in support of the marketing mechanisms.

5.1 Data collection

In what follows, I address the method and approach for collecting the data necessary for understanding the type of marketing mechanisms suitable for developing countries with special reference to Ghana. This section includes the definitions and presentation of qualitative and quantitative research approaches for this study. Then the different phases of the study and a reconstruction of the fieldwork with a description of the procedures used in achieving the key goals and objectives of the research will be presented.

This study uses primary and secondary data. The primary data start with the investigation of the energy crisis, collecting and keeping records of the findings on the energy crisis and suggestions for alternative solutions to the phenomenon. The secondary data consist of existing data collected by other researchers and recognized as valid and it has a direct or an indirect linkage with the research conducted. Although primary data are preferred in studies where new theories, proposals and models are developed and proven empirically, there is no justifiable merit or evidence that bans the use of both primary and secondary simultaneously under the same premise or conditions. A researcher may choose to use secondary data to obtain an in-depth background and understanding of similar phenomena or parameters under investigation.

The data for this research came from two sources: focus group studies and a countrywide survey *(eight out of ten regions)* based on the restructured results from the focus group studies. The focus group studies are the starting point for the findings, analysis and conclusions of the study conducted in Ghana. The focus group studies offered a basis for further questions and a view of the selected population's opinion about photovoltaic systems and its usage. The approach used was exploratory in nature in the sense that the specific set of questions asked yielded results in both educating the participants and accessing realistic information for further studies.

To ascertain the clarity and reliability of the focus group questionnaire, the researcher allowed some selected African students at the Vaasa University of Applied Science to provide answers to a preliminary sketch of the intended questions. The feedback given by these students helped to readjust the questions to the final desired setting. The core part of the questions aimed to ascertain the type of information available to the respondents about renewable energy with photovoltaic systems as the core choice for discussion. The goal of the focus group studies was to help design a proposal for the right marketing mechanism to help diffuse renewable energy systems for people living in developing countries. The attendees of the focus group included entrepreneurs, homeowners, a bank official, a public servant, an IT engineer, an architect and a technician. The researcher led the primary focus group discussion in Accra, the capital city of Ghana. For validity and reliability, the researcher trained and authorized an entrepreneur to experiment with the questions used by conducting a similar focus group session in another region of the country, Takoradi, the western regional capital of Ghana. The focus group session lasted for two hours although the intended duration was for one hour. A reason for the extension was the in-depth questions and feedback from the attendees. The interviewer allowed the interviewees to express themselves freely on the core points discussed, thus reducing any form of preconceived ideas or bias in reasoning. The entire focus group session was video recorded and some key issues were documented. The use of a video recorder helped in producing an accurate textual transliteration of the discussions.

Different scholars use different definitions in explaining the same research methods used to arrive at the results for specific phenomenon. For example, Burns and Bush (2000: 230) argue that the use of qualitative, quantitative and pluralistic research depends on the desired result, in other words, the objective, of the research. In summary, qualitative research in social sciences consists of observing the phenomenon under study and asking open-ended questions of it, usually with a small number of respondents. Quantitative research often involves a structured questionnaire and a large sample. Qualitative research is more holistic with a mixture of explorative and intuitive approaches where the key asset is the researcher´s skills and experience and these are highly important in arriving at an acceptable analysis of the data acquired. On the other hand, the quantitative research approach requires that the researcher have the ability to step back, critically analyse a given situation, recognize and avoid biases and to keep analytical distance from the subject under investigation (see also Ghauri et al., 2002).

Since the case country is Ghana, the objectives of this research are:

1. To identify the current marketing mechanisms used in Ghana on issues relating to photovoltaic technology.

2. To test a marketing strategy that aims at promoting a decentralized diffusion of photovoltaic energy in Ghana.

Chapters 2.1 and 2.2 answer the first question, while Chapters 5.3 and 5.4 answer the second question. According to Ghauri et al. (2002), the case study method is most useful when answering ´how' and ´why´ questions and these are essential for building the research framework and solutions (see Yin, 1994). This study aims to ascertain the right marketing mechanisms for photovoltaic systems for developing countries, thus the explanatory 'why' questions are necessary.

The research problem of this study is as follows: *What marketing mechanisms are available or can be developed and implemented for photovoltaic technologies in developing countries in general and especially for Ghana and under what conditions could this be done?* Chapter 2 discussed the historical background of the case country Ghana with details concerning its energy systems, capacity, future forecast, renewable energy policy and marketing mechanisms for electricity. From this point on, as part of the research process and method, this study uses the focus group discussion and a survey to address the current energy crisis and the potential of photovoltaic technology.

A focus group study is a situation involving a group of people sampled from a larger population, interviewed in an open session usually for market research. A focus group discussion differs from an in-depth interview in that interaction is not limited to being between the interviewer and the interviewees, but can include discussions between the interviewees as well, thus it could almost be described as critical brainstorming. The main advantage of using a focus group session is that it is cheaper to execute, quick and flexible. Moreover, it provides rich and in-depth data expressed in the interviewees' own words, which is usually difficult to access using, for example, a survey (see also Ghauri et al. 2002: 89, 109). In a focus group session, the number of participants in the group should be relatively reasonable, such as 8–10, to help the moderator keep a proper perspective of the whole session. Nevertheless, there can be some disadvantages to this form of approach, such as unskilled moderators and the potential non-representation of the target population as well as the possible presence of dominant groups or individuals which can distort the objectives and results of the issue under discussion.

This study tried to avoid or limit the disadvantages typical to a focus group session. In addition, the study seeks a deeper understanding of the underlying issues of electricity and the possible solutions available to Ghana. The topics of the questionnaire used in the focus group study aim to unearth a general overview of the problems related to the current electricity situation in Ghana. The summarized objectives are:

- *The depth of the current problem;*
- *The cost of the current electricity service;*
- *The real applications of electricity both in industry and at the residential level; and*
- *The need for an alternative solution as well as its marketing and deployment.*

Next, I present the questions posed to the focus group participants and a summary of the answers to each question.

How do you use electricity at work and home?
It was clear that most Ghanaians rely on electricity for both domestic and industrial activities. For all equipment: industrial – 11hrs, telecommunication – 24hrs, public services – 8hrs, entrepreneur – 8hrs, lighting – 11hrs, fridge/freezers – 24hrs per day.

How many hours do you use electricity per day at work or at home?
Entrepreneur – 10hrs, hospitals – 24hrs, lighting – 5hrs, fridge/freezers – 24hrs, TV – 6hrs, radio – 5hr; industrial – 11hrs, telecommunication – 24hrs, public service – 10hrs, the number of hours varied depending on the services rendered. Telecommunication, Industrial and Health service providers need energy 24hrs a day to power the equipment in use. The situation gets worse if there are frequent power outages and generators are in use. The cost of running generators is expensive.

What appliances does electricity power at work or home?
Industries: *Telecommunication companies and health providers are high consumers of energy. They use high-powered equipment – servers, telephone transceivers, hospital equipment, industrial machines, lighting, PCs, printers, photocopiers, heavy-duty equipment for industrial workers etc.*
Home usage: *Domestic consumption is not high depending on the equipment in use – air conditioners, lighting, fridge/freezers, hot water, ironing, charging of phones, TV/radio, microwaves, electric fans.*

How much do you pay for electricity on average?
Telecommunication/industrial organizations: the cost of running equipment for these industries is very high. Compounding the situation is the frequent power outages requiring fuel to be purchased, making the generators run at a very high cost. In Ghana, the current per diem minimum income in February 2010 is 3.11 Ghana cedis (approximately €1.33 based on the June, 2012 currency exchange of €1 to 2.34 GHS). The current minimum income is 17% increment from the previous level of 2.65 GHS (€ 1.13). The household income of urban dwellers in Ghana varied heavily based on their academic qualification and the nature of their work. Meanwhile, an extrapolation of the lowest to the highest income levels based on the minimum wage is considered. The monthly income level for urban dwellers ranged from as low as 50 euro to about 1,500 euro per month. The figures below shows how much people pay on the average for electricity.

- *House/home owners = GHS 60 [€25 per month, being 1.6% of the household income assume we consider the homeowner category as those earning an average of €1500 per month. Nevertheless, if we are to assume that this category realistically earns € 500 per month, then they would be using 5% of their income for electricity every month]*
- *Tenants = GHS20 - 50 (€8.55 – 21.37)*
- *Semi-detached apartments (with air conditioner unit)= GHS100 (€42.74)*

How reliable is the electricity? Would you want an alternative energy solution?
Low-level of reliability, frequent outages and fluctuations resulting in damaged equipment and appliances. It was clear that industries, homeowners, entrepreneurs and everyone else would appreciate an alternative energy source such as a photovoltaic system.

Why have you not used any alternative reliable sources of energy?
Facts indicate that there are no known alternatives easily available on the Ghanaian market; people are ignorant of the reliable alternatives. Furthermore, there is inadequate incentive to invest in alternatives. A follow up survey indicated that

there were some secondary sources of energy including candles, torchlights; generators etc. (see also Ndzibah, 2011)

How would you like to finance the purchase of solar-PV solution?
Most people would like to make payment in instalments or supported by a loan.

What do you know about solar energy?
Most Ghanaians have little or no knowledge about solar energy.

What is involved in the generating of solar energy? (A question by respondents)
This is the generation of electricity using a combination of solar-PV panels, batteries, charge controllers and inverters. The solar panels charge the batteries which stores power for use. The charge controller helps avoid instances of the battery overcharging or overly discharging, while the inverter transforms a 12 VDC (VDC – volt direct current).

Results from the focus group sessions in Accra and Takoradi revealed that many consider photovoltaic energy as the best alternative due to the degree of awareness created during the interviewing session. The interviewees in the focus group sessions and respondents to the survey suggested a joint effort to provide education, organized by the government, related energy institutions and experts in renewable energy, for the public through seminars and workshops in the regions. However, the problems identified were the availability, accessibility, and affordability of the energy system. For those who claimed that they could afford, it was a matter of the "availability'' and "accessibility" of the solar products on the market. This raises the need for further studies to ascertain the right segments for the diffusion of photovoltaic solutions. The findings pointed out that photovoltaic solution would be of great help for both industries and domestic usage. As regards financing options, the main problem lies in having a viable economic framework from which financial institutions could design a realistic payback time. The existing financial structures identified in Ghana include individual and corporate loan systems for investments, such as cars, housing and start-up businesses. This system makes the financing of alternative photovoltaic solutions possible. For the moment, the research pointed out that photovoltaic solutions as an alternative source of energy are not yet the only viable option due to a lack of adequate knowledge and information about their availability, accessibility and affordability. A further observation is that the public barely understands the actual components that make up a complete photovoltaic system. The study further establishes the public's perception of solar panels as monstrous and bulky, making potential customers wonder if their properties would not be defaced.

In conclusion, it is evident that photovoltaic systems would be a preferred choice in Ghana and developing countries in general, compared to using diesel generators and other fossil fuels. Moreover, the implementation of photovoltaic technology would require a well-developed marketing strategy and the joint efforts of various actors. These actors include marketers, investors, educators, the government and the general public and for that matter the individual developing countries' policies overall.

Making the photovoltaic solution accessible will involve creating a viable business model, which includes an efficient network of sales and distribution programs. This would require that every regional capital have at least one sales point for the dissemination of relevant information on the systems and sales of complete systems or components. The financiers need to combine their efforts with the manufacturers, service providers and the end-users and to help draft effective plans for the training, diffusion, servicing and maintenance as well as the financing of the program. A comprehensive training program is necessary. In this sense, the manufacturers and the government need to make a joint effort to recruit and educate students on renewable energy courses to help them become competent enough to handle the diffusion and implementation of renewable energy in Ghanaian communities.

The role of the government in this program would include emphasizing education about photovoltaic systems and renewable energy as a whole. More focus on "green" issues within its educational programs and the responsible use of energy in state-owned institutions would be an added advantage. The energy ministry´s use of photovoltaic systems to power most of its essential appliances is a commendable example to the public. Various forms of education are needed to make the diffusion process possible, including seminars, workshops, posters, televised demonstrations, radio and phone-in programs, and classroom lectures, among others. Energy users, on the other hand, must consider the various options presented by the photovoltaic solution identified in this study. This involves matching the right energy requirements against the specific segments. To be successful in this effort, heavy users of electricity may consider a hybrid unit, recommended for households or corporate bodies with enormous energy requirements, connecting key appliances to the grid while the photovoltaic unit powers other systems. Furthermore, light users should consider the standalone or back-up systems as a recommended solution for those without access to the electric grid and those who would prefer to use photovoltaic instead of diesel generators.

Further research into areas of conservation and the "smart" usage of energy is an area for future studies. The term "smart" usage denotes the conservation and even distribution of energy to specific appliances as and when needed. For example, a photovoltaic system does not have to power all the appliances of a household or business at once but only as and when an appliance is needed or in use. Besides, there is normally no point in listening to the radio and watching television simultaneously and so doing so would be a waste of energy and a lack of responsible use of electricity.

In summary, this study collected data from both primary and secondary sources and this allowed for a thorough consideration of other published materials on photovoltaic power sources as well as a fresh investigation into issues not specific to the current energy crisis in Ghana. A focus group approach that aims at identifying the depth of the energy crisis, the cost of electricity, the use of electricity and the need for alternate solution in Ghana served as the basis for designing a nationwide survey. The participants selected for the focus group included a diverse range of people from different working and social backgrounds. The focus group was very insightful in that it helped identify that the majority of Ghanaians have limited knowledge about photovoltaic systems and the size, convenience, availability, and accessibility of these systems. Moreover, it revealed that most Ghanaians would like to buy these systems in instalments rather than on a cash basis and this requires special financing options from financial institutions. Furthermore, the focus group identified that stringent efforts from various stakeholders such as marketers, investors, educators and the government would be necessary to create awareness of the availability of photovoltaic systems as alternative power sources in Ghana.

5.2 Analysis of the data collected

According to Yin (1994: 102, 103), the analysis of the data depends on the researcher's own style of rigorous thinking, the sufficient presentation of evidence and the careful consideration of alternative interpretations. Burns et al. (2000: 488–89) argue that having gathered the data, the problem confronting a researcher is usually how to reduce the amount of data collected to a meaningful limit. A descriptive data analysis is a common means of data reduction. In fact, the reduction of data begins at the very early stages of the research when the focus is decided upon. The process of data reduction includes the explanation of the interviews, the documents as well as the summarization and incorporation of information derived from them (see also Miles and Huberman 1994: 10–12; Ndzibah 2006). The use of a few computer programs such as SPSS 16.0 (SPSS Inc. 2009) and Microsoft Excel (Microsoft Office Enterprise, 2010) helped in the analysis of the statistical data of this study. The tools helped in describing the probable mind-set, attitude and justification of the responses given by all the various categories of sample groups used in the survey. The extrapolation of each theme and their supplementary questions formed part of the core discussion of the research (see also Saunders et al. 2003: 394–408; Ndzibah 2006).

Pre-survey assumptions

The following discussion describes all the variables which are assumed as having a significant impact on the marketing mechanisms for photovoltaic technology and presents the general diffusion process of these systems for developing countries. The technology and marketing related factors present a concrete platform for the development of the preliminary questionnaire. The questions serve as the underlining principles for discussion during the focus group session. The objective of the questions used was to ascertain the relevance of the questions vis-à-vis the actual research questions and its significance in addressing the diffusion process of renewable energy systems in developing countries. The major issues at stake include the usage application *(rate, systems and duration)*, affordability *(cost, financing options)*, and accessibility *(number of households and businesses which have the energy systems compared to those who are yet to be connected to the grid)*. Finally, the survey tries to ascertain the reliability of the current energy system.

The table below presents the specific themes and a related set of questions for which the researcher wanted to find answers. From critical observations, the themes and related questions formed an adequate premise for the research. Furthermore, the classification of the questions as independent or dependent variables enabled the researcher to avoid overly simplifying the results. The results for these variables aim to facilitate the proper diffusion of photovoltaic systems and the related factors which have an impact on the economies under research. All currency notations are in Euro with a standard exchange rate of approximately GHS 2.34 as it was in June 2012, unless otherwise stated. The parameters of the survey questionnaire include all the questions under each theme. For this research, the formulation of the distinction between the explanations of the eight main themes was made possible by the focus group sessions. Nonetheless, there has been an extensive application of the key issues discussed. For the Ghanaian economy and the background of the respondents, it was necessary to make the questions practical and simple to avoid ambiguity of any kind.

Table 9. Preliminary survey questions

	Theme	Key Parameter(s)
1	Diffusion Barriers	High cost of installation
2	Growth of Solar Business	Level of income
3	Driving force for adopting photovoltaic unit	Solving energy problems and high electricity cost
4	Brand Name	Cost and durability
5	Area of Use	Lighting etc.
6	Knowledge about Renewable Energy	Yes/No
7	Business Type	Service
8	Billing	GHC 11- GHC 100

The eight themes served as a guide for the researcher so as to avoid bias and directly influence the answering of the questions under investigation. The focus group session at the end of the discussions revealed other relevant issues that would be viable for critical investigation. Some of the individual questions that were included in the focus group studies served to support the analysis of the results. Nevertheless, at the end of the survey it was obvious that some of the respondents lacked a basic understanding of the product configuration of a photovoltaic system. This led to some response errors or responses irrelevant to the whole analysis, thus they were omitted from the final analysis. A typical example was in the case of post-sales service and maintenance. It became obvious that if the respondent had a reasonable knowledge of photovoltaic systems, *they would have known that in nowadays most photovoltaic systems are maintenance free in nature and thus its relevance in the diffusion process should be positive, not negative*. Moreover, in real cases of maintenance, a few minutes' worth of training was all one needs to ensure the proper running of the system. Nevertheless, the respondent represented the potential attitude of prospective households and their receptivity to photovoltaic systems. All or most of the controversial input presented here are merely cautionary tales for the reader.

Post survey analysis

To analyse the data collected, there was an assessment of all the responses to ascertain the associations of the responses given and their relationship with the research parameters. A critical evaluation of the pre-survey and the final questions for the fieldwork helped us arrive at a rational conclusion as to where attention is needed and what issues would be relevant for future research. The analysis and input process of the data collected starts with the preparation of an SPSS code-book, which includes the definition and labelling of each variable and the assigning of numbers to each of the responses (Pallant 2001). The process continues with the assigning of unique ordered names to each question in the questionnaire such as taxes, income, bill, etc. Finally, each response receives an assigned code and is then entered into SPSS. (For instance, 1 = Least significant, 2 = Quite significant, 3 = Significant, 4 = More significant and 5 = Most significant).

The next step is the preparation of the data file. This includes checking and modifying, where necessary, the options that SPSS uses to display the data and its output. Furthermore, the researcher has to set up the structure of the data file by defining the variables (Pallant 2001). In this instance, the SPSS program should have as part of its input the ordered names of the questions and coding instructions such as values, type (e.g., numeric), width, labels, and measures (either scale, nominal or ordinal) etc.

Having input all the needed data from the respondents, the next step is to analyse the data. There are countless approaches available for data analysis but this research uses two factors, namely *frequency* and *descriptive analysis*. Frequency in statistics is the number of times an event occurs in a given situation or a period. For example, in a survey carried out to discover a group of children´s favourite flavour of candy, assume 10 children out of the group pick the strawberry flavour. This gives the strawberry flavour a frequency of 10. In this study, frequency analysis is used to determine the area of use, i.e., whether they are rural or urban respondents, thus helping to decide on key strategies in the implementation of policy decisions and the diffusion process of the marketing mechanism.

For this research, the idea of using descriptive analysis is to provide simple quantitative summaries about the sample population surveyed. A descriptive analysis aims to summarize a data set rather than using the data to learn about the population or phenomenon in question. This approach aims at augmenting the results attained from the focus group studies. The data of the frequencies for each theme answered and their subsequent descriptive analysis helps to present a tentative suggestion as to how to implement the Robin Hood and Donkey principle for people in rural areas and urban centres. Furthermore, the descriptive analysis of the survey intends to minimize any form of distortion or exaggerations which other methods of statistical analysis could easily have produced. Thus, at a glance, anyone can draw the same conclusions concerning the key parameters relevant for a successful diffusion process of the photovoltaic systems. Despite any resultant limitations, a descriptive analysis provides a summary that may support comparisons across the themes in the survey. Thus, a descriptive analysis seeks to achieve the same possible interpretation and results, and it is hoped that any reader would arrive at the same results without overemphasizing any irrelevant details.

This part of the research presents the frequency and descriptive analysis as generated from the SPSS program and includes interpretations as perceived necessary by researcher. In the interpretation, the focus is on the responses, the frequencies of which range from significant to most significant since that will give an idea as to the level of understanding, interest and perception of the key parameters under investigation. Furthermore, comparing the key responses from the rural areas to those from the urban centres helps the researcher focus on which of the marketing mechanisms needs more emphasis. The table below gives an overview of the target respondents for the survey; these include tenants, homeowners and business owners. The table also gives information about the number of respondents for each target group.

Table 10. Respondent Type

		Frequency	Percent
Valid	Tenants	38	40,4
	Home Owners	27	28,7
	Business Owners	29	30,9
	Total	94	100

With regards to the respondents' knowledge of renewable energy sources, Table 4 below shows that 40.7% of the respondents had some knowledge of renewable energy sources while 52.7% had difficulties understanding the concept of renewable energy and sources of such energy until a definition and examples were given. This became a crucial part of the investigation in that it allowed the researcher to ascertain the accuracy of the responses given as well as helping to determine the understanding of the population as whole of photovoltaic systems. This information is also vital in decision-making as it helps address the level of education needed, the category on which to focus in the marketing mechanisms as well as the type of promotions required in the diffusion process.

Table 11. Knowledge of renewable energy sources.

		Frequency	Percent	Valid Percent
Valid	Yes	37	39.4	40.7
	No	48	51.1	52.7
	Can´t Say	6	6.4	6.6
	Total	91	96.8	100.0
Missing	System	3	3.2	
Total		94	100.0	

From among the diffusion barriers, the key component worth emphasizing was the high cost of installation. Photovoltaic systems are usually relatively expensive. In Ghana, the cheapest, basic photovoltaic unit currently sells for €214 (214 euro based on exchange rate of 2.34 GHS to a euro) which represents more than two months' salary of a minimum wage earner in the country. Furthermore, considering the minimum an average tenant spends on electricity is about €8.55, it will take approximately 2.1 years for such an individual to pay back a simple photovoltaic unit that only provides power to 2–5 lead lamps and charges a phone. With this said, it is up to the technical sales person to convince the potential user of the need to adopt the system without malice or ambiguity. It is worth mentioning that the motive is to sell a solution, not just a product. Since the average response from the 90 people surveyed was 4.30 out of 5, it is fair to conclude that the majority considered the high cost of installation to be a significant or the most significant barrier to diffusion. It became obvious that the financing options, a key parameter in the marketing mechanisms, needed sound revision to help tailor financing packages suitable to the benefits of the populace. Furthermore, the implementation of the Robin Hood and the Donkey Principle are favourable since their collective benefit seems to outweigh any misconception that may otherwise have been presented. Moreover, a high payback period will have a positive impact on the diffusion process as opposed to a short payback period. A high payback period is based on how fast a consumer could pay back an investment in a photovoltaic system. The respondents' opinion was that high taxes could indirectly make the cost of the system expensive, thus the government, by removing tariffs and even giving some incentives in the form of purchasing subsidies for photovoltaic systems, will evidently make it easier for people to adopt the system. Finally, most respondents reasoned that lack of knowledge about photovoltaic systems should not be an excuse in the diffusion process. Some respondents believe that as long as the system works, everything should be fine. A critical observation of the responses given by some respondents also hints at their frustration about the current energy situation in the country and for that matter their willingness to try anything, which is accessible, affordable and reliable.

Table 12. Diffusion barriers.

	N	Mean	
	Statistic	Statistic	Std. Deviation
High cost of installation	90	4,3	0,108
High payback period	87	3,69	0,122
High taxes	89	3,42	0,141
Lack of knowledge about solar	89	3,1	0,161
Valid N (list-wise)	82		

For the dynamic growth of the photovoltaic business, respondents, by popular choice, suggested that the level of income and the type of promotional campaign have a direct impact on the sustainability of the photovoltaic business. Reasons include the opinion that the higher the household's disposable income the more likely they are to spend on the photovoltaic systems, especially for leisure activities or entertainment, since they would have access to appliances of which the sole purpose is to improve the quality of life through music, television, video, internet access, etc. For promotional campaigns, some respondent suggested the use of the electronic medium and especially television to inform the population about the uses and benefits of the photovoltaic systems. When it came to answering the questions about the relevance of research technology, most of the respondents were evasive and suggested that experts know best. Finally, respondents understood the issues around incentives, which in practical terms is the giving of loans to businesses to develop renewable energy activities and the giving of incentives to end users as a form of motivation to buy the systems. The respondents agreed that the incentives should come from the government.

Table 13. Growth of photovoltaic business.

	N	Minimum	Maximum	Mean	
	Statistic	Statistic	Statistic	Statistic	Std. Deviation
Level of income	91	1	5	3,58	0,14
Promotional campaign	92	1	5	3,53	0,141
Research Technology	90	1	5	2,88	0,138
Incentives (Loan)	89	1	5	2,8	0,138
Valid N (list-wise)	89				

The most critical driving force for adopting photovoltaic systems is, according to the respondents, the need to solve the current energy problem as well as to reduce the high cost of electricity. Notably, the supply of electricity is highly irregular and currently works insufficiently for the population both in rural areas and urban centres. Answers relating to the availability of photovoltaic products were at best ambiguous, since most of the respondents assumed the systems would be imported rather than locally produced and possibly assembled. It worth mentioning that the 2.67 statistical mean derived from the question pertaining to social prestige indicates that most of the respondents do not consider the owning of a photovoltaic system that important in terms of social reputation. The respondents believe that adopting photovoltaic systems can be a way to improve their quality of life, add value to business activities and, for one respondent, to gain their much needed freedom from the unreliable electricity generated from the national grid. Some emphatically stated that electricity is a required necessity and not an option despite its related cost.

Table 14. Driving force for adopting a photovoltaic unit.

	N	Mean	
	Statistic	Statistic	Std. Deviation
Solving the energy problem	92	4,23	0,108
High Electricity Cost	91	4,13	0,131
Availability of Photovoltaic Products	91	3,02	0,139
Social Prestige	89	2,67	0,128
Valid N (list-wise)	86		

The question of the average monthly electricity bill was included to help extrapolate on the desired and varied payback time based on current consumption and the financing of electricity by the majority in the country. Roughly half of the respondents were paying between GHC 25 – GHC 100 (equivalent to €10.7 - €42.7) on average per month. The proportion of monthly income spent on electricity is around 21.4% for those earning around €50. On the other hand, those using air conditioning could pay about €42 or more and this represents about 2.8 percent of their monthly income if they earn about €1500. The aforementioned amount compared to Western standards is a lot; nonetheless, these people often suffer from an interrupted supply of electricity.

Table 15. Average Monthly Electricity Bill.

		Income Status	Frequency	Percent	Valid Percent
Valid	GHC 1- GHC10	Very Poor	18	19,1	20,2
	GHC11-GHC50	Poor	29	30,9	32,6
	GHC 51-GHC100	Lower – Middle	27	28,7	30,3
	GHC101-GHC300	Upper – Middle	15	16,0	16,9
	Total		89	94,7	100,0
Missing	System		5	5,3	
Total			94	100,0	

The use of frequency analysis in this specific instance helps identify differences in the use of electricity between urban and rural regions. At first glance, it is easy to draw the wrong conclusion as to why there are many more responses from the rural sector than from the urban centre. A simple explanation is that most the people in the urban centres, due to their access to some form of electricity supply, underestimate the energy situation in the country.

From the figure below, it is obvious that the issue of lighting was an absolute priority for both the urban and rural regions. At the same time the majority of business owners were sceptical as to the reliability of using a photovoltaic system at the work place since they believe that it would not be enough to use the system just for lighting but rather for productive activities to generate revenue. Moreover, some of the business owners were concerned with the high cost of installing the system primarily for businesses, but they did not rule out the possibility of such an option. Nevertheless, the initial idea was to promote the use of photovoltaic energy in households, so this segment is an option for future research.

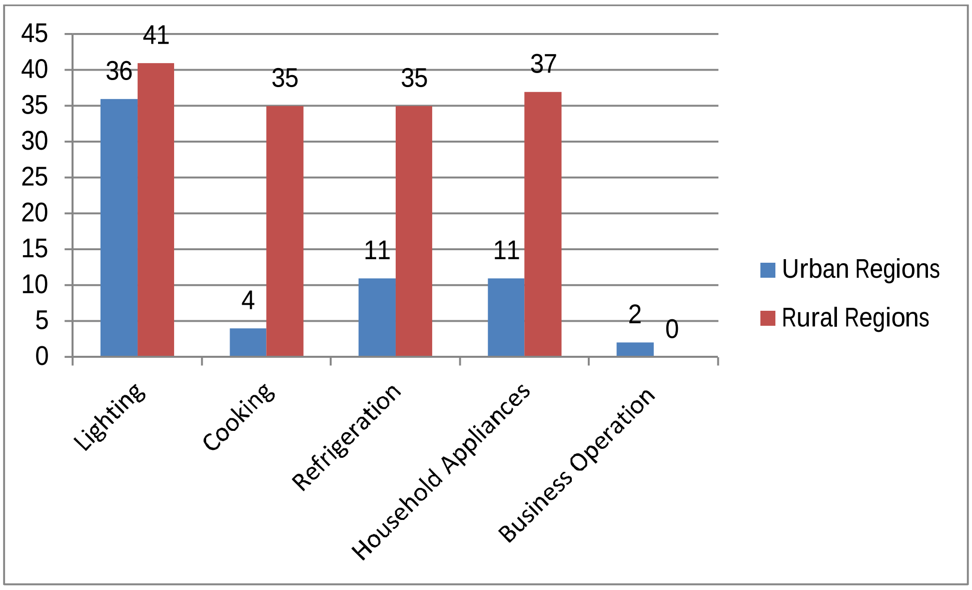


Figure 10. Area of use.

The outcome of the focus group studies immensely dictated the design of the survey questions. The clustering of various potential questions into themes under which various parameters that may influence the main theme fall brings clarity to the importance of the marketing mechanisms. For instance, the cost of installation, the level of taxes, the payback period and knowledge of photovoltaic systems influence or act as factors which have an impact on the key theme: the diffusion barrier. Other major themes developed include the growth of solar business, the driving force behind solar business, the brand name of solar products, and the area of use of solar systems among others. The descriptive analysis tool in SPSS is used to analyse the data to ascertain the associations of the responses and their relationship with the research parameters. Descriptive analysis was utilized and captured at a glance the quantitative summaries of the population surveyed. It is worth mentioning that this analysis does not in any way try to establish causality between the different variables.

The analysis carried out in SPSS depicts that the respondents consist of people from diverse backgrounds and use electricity for different purposes. They are tenants, home owners and business owners with the majority being tenants and the rest being home owners and business owners. Only a little over 40% of the respondents stated that they have some knowledge of solar systems and this signifies that comprehensive education and aggressive marketing need to be put in place to create awareness of solar systems. Other key analyses are as follows.

Firstly, the high cost of installing photovoltaic systems constitutes the most pressing obstacle to the diffusion of photovoltaic systems in Ghana. On average, it would take a medium income earning tenant in Ghana four years to pay back a basic solar system, valued at, and in comparison with respect to, the average electricity bill per month. The aforementioned payback estimate takes into consideration the initial cost of connecting to the national grid and an average monthly electricity bill for medium income earners.

To understand this better, let us assume an average to medium income earner uses the following as described in the table below:

Table 16. Calculation for a basic photovoltaic unit.

Appliances	Quantity (A)	Voltage Capacity in watts (B)	Hours in use per day (C)	Total Wh/kWh (a x b x c)
Television	1	80	5	400 wh
Lamps	6	20	5	600 wh
Radio	1	20	2	40 wh
Laptop	1	40	5	200 wh
			Total	1240 wh or 1.24 kWh

Thus, the daily power requirement is 1240wh or 1.24kWh. The second step is to define what a sufficient number of batteries required to run the appliances is. A typical 200 Ah battery can store approximately 2.4kWh of energy but as a recommendation, the battery should not lose more than 80% of its energy during its normal operation. This means that the power needed from the battery would be 1.92kWh. With this battery capacity, you can manage your daily energy requirements. The tricky part is keeping the battery at its optimum capacity on a daily basis by defining the correct size of the panel for an efficient uninterrupted output. The energy output should always be more than 30% of the required consumption and this should include losses from wiring and distance from the panel, batteries, charge controller and the inverter. A 100-watt panel can generate about 655wh, so to be on the safe side and to allow for efficient charge and discharge cycles, two panels of 100 watts are required to supply enough energy on a daily basis. Finally, a pure sine wave inverter with a capacity of 1.5kW is required especially if all the appliances indicated in the table are to operate simultaneously. The total price is estimated to be 5000 GHC *(current exchange rate of 2.6 GHC to 1€ gives us an estimate of €1923)*. This price point is relatively expensive and for a lower middle-income earner it would take approximately 4 years to pay this back by factoring a monthly utility bill of €40 into this equation for the acquisition of a solar unit. This calls for a feasible and flexible financing package that would reduce the financial burdens on potential customers. Furthermore, the sample population is of the view that high taxes would indirectly increase the prices of photovoltaic systems (Agbejule 2012).

Secondly, the level of income and the type of promotional campaign employed have a direct bearing on the sustainability of solar business in Ghana. The reason is that the higher the income of the household, the higher the probability that they would possess a variety of equipment and hence be driven to obtain an alternative source of power. The respondents propose electronic media as the most effective advertising tool in creating awareness of solar systems.

Thirdly, the driving force or motivational factor in selecting photovoltaic as an alternative energy source is the high cost of electricity provided by the government and the unreliable nature of this source of energy. The respondents, however, were a little sceptical as to the availability of photovoltaic systems in the country. They preferred the importation of photovoltaic systems into the country over the local assemblage of the system.

Fourthly, the average monthly bill of the respondents showed the amount spent on electricity to be around 10–42 euro a month and this varies with respect to the gadgets used in the house. This amount is comparatively very high for people in developing countries, coupled with the unannounced power outages, and thus its reliability is questioned.

Additionally, the clustering of the data into urban and rural areas helps us to obtain a general idea of the demand for electricity in these two distinct areas to help design specific marketing mechanisms that would suit each area. The results show that rural areas have a vast demand for electricity in such areas as cooking, refrigeration and household appliances. However, in lighting, the difference is not much; whilst for business operations; urban areas require more electricity than rural areas.

5.3 Reliability and validity of the research process

This part of the study discusses the justifications of the reliability of the data as well as the validity of the whole research. The term ‘reliability’ in a scientific study denotes the ability to duplicate or replicate the results of the research and the capability to draw the same results as the original study with all things being equal (Yin 1994: 33.)

In the study at hand, to avoid interviewer bias and other research errors, both the focus group questionnaire and the subsequent survey questionnaire were all typed written for suitable referencing. Moreover, a local representative was responsible for the final selection based on his or her own discretion as to what the requirements suggest. The consideration of the validity issue can be from a constructive (internal) perspective or from a realist (external) perspective (Yin 1994: 33). The term ‘*constructive validity*’ refers to the building up of correct operational measures for the concept under study. In the case of this study, the procedures applied were multiple sources of evidence, clarifications in the interviews, feedback from the interviewees, and a reconstruction and interpretation of the responses of the interviewees which were used to reflect key terminologies used in research.

The *multiple sources of evidence* from Ghana came from different sources such as interviews, personal observations and experience of the phenomenon under research (energy crisis) as well as documentation from the energy ministry and its affiliate bodies including the energy commission, the media and public opinion of the phenomenon. All the individuals who made up the focus group session were sent a summary analysis of the subject under investigation to help familiarize themselves with the intended requirements and an honest opinion about the phenomenon. In addition to this, there was a brief explanation of all the main themes of the questions, thus clarifying the content and context for the session. The session started with a formal introduction and a background appraisal of each member. A thorough description and illustration of photovoltaic systems, its components and uses made the session dynamic. Furthermore, the initiation of a brainstorm session after the main pre-survey questions helped widen the understanding of the phenomenon under research. The objective of the brainstorm session was to help widen the scope of questions under each theme and to include valuable details, an element which at that time was considered important by researcher. The exact responses were video recorded and then later transcribed for further analysis.

External validity is the extent to which the findings can be generalized (Yin 1994: 33; Mitchell and Jolley 2001). According to Brewer (2000), inferences about cause-effect relationships based on a specific scientific study often possess external validity if they may be generalized from the unique settings, procedure and participants to other populations and conditions (see also In Reis and Judd 2000). To achieve an accurate result, this study presents a discussion of energy systems including the energy capacity and future forecast in Ghana as well as energy regulation and proposed policies in Ghana, thus demonstrating the economic implications of the results.

5.3.1 Documentary: business collaboration on photovoltaic energy in Ghana

In the following section, I report in documentary format a careful observation of a photovoltaic assembling system set up in Ghana. The aim is to justify a *weak market test* of the marketing mechanisms described in this study by adopting the constructive approach. According to Kasanen et al. (1991), constructive research involves managerial problem solving through the construction of models, diagrams, plans, organizations and so forth. Furthermore, for the constructive approach to work, six phases are necessary, however, this study focuses on *finding a practically relevant problem that also has research potential, obtaining a general and comprehensive understanding of the topic, and demonstrating that the solution works*. The current energy crisis in Ghana is relevant enough to warrant a reasonable research. Kasanen et al. (1991) proposed *obtaining a general and comprehensive understanding of the topic*. In view of this, this study discusses technology and marketing related factors from which come *solution ideas* related to marketing mechanisms. To *demonstrate that the solution works,* Atlas Business and Energy Systems, (henceforth ABES) a Ghanaian energy company, decided to apply highlights of the technology and marketing related factors discussed in this study.

The information presented includes a key roadmap and challenges faced by the business collaborators, ABES and Opam Solar, a Finnish photovoltaic systems developer. In addition, there are hints of how to use the key findings presented in this research to restructure and evaluate adjustments needed to implement marketing mechanisms which would help the business achieve its primary objective of providing alternative energy in the form of photovoltaic systems. ABES is a leading renewable energy solutions provider currently focusing on the provision of solar systems for both industrial and domestic clients in Ghana. This private company is wholly Ghanaian owned and is duly registered under Ghanaian law as a Limited Liability Company (LLC).

Ironically, Ghana has lots of renewable energy resources – abundant sunshine, wind, forest residue and water resources needed to meet energy needs. As an example, the dominant energy resource in terms of endowment and consumption in Ghana is biomass. Biomass resources cover about 20.8 million hectares of the 23.8 million hectares land mass of Ghana and is the source of the supply of about 60% of the total energy used in the country. The land is rich for the cultivation of crops and plants, convertible into a wide range of solid and liquid biofuels (Oteng-Adjei 2010). In 2008, the National Renewable Energy Laboratory (NREL) reported solar potential to be in excess of 706 Megawatt hours per year, making it a realistic alternative source of electric energy viable for adequate consideration by the government and renewable energy businesses in Ghana. For many on the continent, the technologies required for tapping these resources are beyond their reach. The renewable energy industry in Ghana is underdeveloped and the use of renewable energy technologies remains very low.

ABES sought to find an innovative way to solve this problem. The company hoped to cut down the cost of renewable energy systems by developing them locally, with local labour and as many local resources as possible. The search for a technology partner resulted in a partnership with a Finnish firm OPAM which had then began manufacturing small solar units for cottages after diversifying its core operation of manufacturing clinical equipment.

Original business idea

The original idea of the collaboration between ABES and OPAM was to assemble and sell solar panels to real estate companies and other major clients. A target of producing and selling 50pcs of 50W solar panels per month was set so that companies would maintain a consistent cash flow. The company was to concentrate on assembling PV modules and charge controllers. The quality of the products was guaranteed, since OPAM had a lot of experience in that field and monitors all the process. The monitoring process aims to meet the quality standards set by the Ghana Standards Board (GSB).

Modification of the initial business idea

After careful analysis of the market, the local team decided to come out with packaged solutions that would suit different market segments to broaden the market base. A marketing team also sought innovative energy solutions for client needs that suited various market segments. This means energy efficient devices had to be imported which are better suited for solar systems. One of the first tasks is the design of rural lighting kits that come with LED lighting technology. Marketing is working hand in hand with Green Water Systems to push this model in rural communities. The package is still undergoing some fine-tuning so that it can include certain essentials such as phone charging outlets.

Plans are now underway to make available highly efficient DC appliances such as fridges, TVs, fans, air conditioners, etc., to make the cost of powering them with solar energy reasonable. Efforts are also underway to make frequency convertors a major part of ABES' operations and to venture into other renewable energy projects such as wind and biomass.

Market

The firm now has identified these main market segments and is concentrating its efforts on the following issues:

1. Off-grid PV plants, mainly designed for industrial power consumers
2. Stand-alone Off-grid PV plants designed for private urban households, especially those living in neighbourhoods with no access to grid power.
3. Solar back-up systems (for customers in on-grid regions)
4. Solar home systems for private households in rural areas
5. Real estate developers, NGOs, Government tenders

Industrial power consumers (IPC) demand relatively large PV plants (greater than 10 KW). The IPC group consists of the industry and service sector. Their intention is to bring down the cost of electricity and for the PV plant to replace a share of the power supply from the grid. In case of a power cut during daytime, the PV system provides power to cover the company's own power demand as well as act as a back-up system, instead of a diesel generator. Even here, the economic attractiveness of the PV plant depends on the feed-in price. The challenge now is how to get the prices of a storage system a bit lower so as to make these packages attractive to corporate bodies. Furthermore, the implementation of a renewable energy law expected this year would make on-grid systems attractive because of the feed-in-tariff scheme.

The second group is demanding smaller PV plants designed to meet individual power demand (less than 5 KW). The idea of urban households investing in solar technologies aims to improve the security of the power supply and cut down the cost of bills. The economic viability of the PV plant depends very much on the prices currently paid for grid electricity. Currently rural households receive a subsidy (for each KWh) equal to the power price for residential customers. Currently, there is no law on feed in tariffs, thus individuals or businesses cannot benefit from such an option.

The political framework

The development of the market depends very much on policy decisions. Abolishing subsidies on power prices for residential customers especially for conventional energy and diverting such subsidies to renewable energy would be beneficial for their implementation. Furthermore, introducing *feed in tariffs* (FIT) higher than the power prices for all renewable energy systems could help develop the market. Thus, ABES is very much waiting for the new *Renewable Energy* (RE) bill to come into force, expected anytime in 2012. With that, ABES will be able to build capacity for on-grid installations. The RE bill is a framework, setting the main rules for FITs for the duration of 10 years, with its purchase obligations, etc.

Observations from first year operations

The company caught the attention of the media and the public with its launch and the ABES enhanced the industry's interest with their entry. Nevertheless, the initial planning was weak and the expected delivery has been slow. Technology partners have contributed too little so far. The management and marketing team lack practical experience in the field. For example, the marketing officer did not have a firm grip on the system's design; neither did the technical staff have the competence to suggest solutions for greater demand. It was obvious that the training needed to go beyond just the assembling of the panels. The production team failed to come up with innovative solutions and creativity is lacking. Cash flow challenges led to low staff motivation, low budgeting for marketing activities and inadequate diversity of product offers. More so, the lack of credit facilities for end users makes diffusion problematic, thus frustrating the efforts of the marketing team. Moreover, the initial efforts yielded no dividend as the goods remained at the port for two weeks after arrival. The root cause of the delay was the difficulty in getting the exemptions for the components, although there were clear indications that the imported systems were entitled to some exemptions.

According to the customs rules, which the officials appeared never ready to compromise, solar energy systems exact a customs rate and taxes of between 10% and 25% if they are brought in as separate components. Complete solar systems, however, entered for free, with customs duties and taxes waived. Customs charges increased the cost of the production process and do not make local assembling competitive after all. The anticipated low prices to be charged to end users could not therefore be implemented. This was also likely to result in reduced margins and throw overboard the projected sales estimates. Visits to the customs excise preventive service (CEPS), Ghana Investment Promotion Centre (GIPC) yielded no results. All the agencies blamed government policy which is slow to change. The renewable energy business is currently plagued with unclear registration and legal procedures. Relevant agencies for registration include the Ghana Standards Board (GSB), the Environmental Protection Agency (EPA), and the Energy Commission (EC) among others.

The utilization of a *weak market test*, with a real solar company is part of a constructive research approach that aims to obtain a general and comprehensive understanding of the topic under consideration. ABES, Ghana, in conjunction with Opam Solar, Finland, assembled and sold solar systems in Ghana. ABES segmented its market into industrial power consumers, private urban households, private rural households, solar back-up systems consumers and real estate developers, NGOs, and government tenders. The energy capacity of each individual segment varies, thus a feasible initial research was done so as to determine the core target group as well as design effective marketing mechanisms that would suit all and sundry.

Despite the effective publicity used in launching the company, the company encountered some operational barriers such as weak initial planning, lack of innovativeness on the part of the production team, inadequate knowledge about photovoltaic systems on the part of the marketing team, inability to meet the projected cash flows which then resulted in financial constraints, staff dissatisfaction and the low diversification of products. Moreover, fiscal and customs duties and other charges drained the finances of the company considering that those charges cumulatively amounted to more than 30% of the total cost of every package ordered by clients.

5.3.2 Replication design parameters of photovoltaic energy solutions

This section addresses the question of how countries with similar economies and energy problems to Ghana can replicate the key principles and parameters developed. The term *replicate* as used in this study denotes the ability to reproduce a phenomenon or to duplicate an action. For the replication design parameters to work there is the need to consider what these key parameters are and to ascertain whether they form a core basis for dealing with the issues at stake: solutions to the electricity demand. This study started by identifying the problem of energy sufficiency. Additionally, to help measure the effectiveness and efficiency of the parameters in place, the research investigated the current infrastructure and actions in place to alleviate the problem.

To replicate the phenomenon, we have to assume that photovoltaic systems are the same everywhere in terms of product configuration. Furthermore, the distribution and promotion methods discussed in this research centre on principles which are easy to understand and apply, and are thus viable for replication. Therefore, the only differences that merit replacement or adaptation for the replication to be effective and complete are the types of financing institution and practices available in any given country with similar electricity conditions and requirements. To avoid a wholesale replication, a successful benchmark is needed of how the individual, households, businesses, etc., understand and use the financial institutions in their day-to-day activities. It is worth checking the types of distribution framework available in such countries. A benchmark format of each country´s specific distribution, promotion and financial issues vis-à-vis the financing parameters discussed in this research will help in adapting the realized parameters to any given developing country.

Measurement of the key promotional practices in a given country will include the type of media popularly accessible to the public. Furthermore, there is a need to attain a realistic sample population which actively uses the chosen media as well as the percentage of such a population which takes active action to make purchasing decisions or even understands what to do to be part of the adoption cycle. It is worth considering the content and context of the information disseminated through the chosen media to help ascertain how much of such information really educates the public on the responsible use of electricity and alternatives, along with the adoption cycle. The same premise goes for the distribution network available, especially in dealing with energy related issues.

Replicating the marketing mechanism thus investigated will assist other developing countries faced with a similar energy crisis in adopting renewable energy systems. Furthermore, solving the challenges presented by replication issues discussed in this study will help such economies be able to come up with similar energy systems. Those systems and the required support will benefit the individual end user and help solve the issues pertaining to the availability, affordability and reliability of photovoltaic systems and other related renewable energy systems.

To achieve the overall objective of the replication and application of the principles investigated requires the development of tools for monitoring, evaluating and forecasting energy markets demand and supply. This includes monitoring the prices of different independent power producers (IPP) and informing the end users of common trends of low and peak times for cost savings. In addition, the implementation of realistic policies and regulations will provide customers with the option to switch suppliers based on informed decisions on current market prices.

Nevertheless, these tools can help consumers who have adapted their electricity requirements with renewable energy systems like photovoltaic technology. They are then able to utilize the information to use their photovoltaic systems during the grid's expensive peak times and allow the system to recharge during the lean times when the grid load and cost is less. Besides, the replication process creates a platform for advising policy makers on strategic economic regulations, the re-structuring of the energy infrastructure, power distribution systems, generation and transmission as well as the implementation of policies. The implementation aspects include the creation of public forums and education structures responsible for deploying expertise in different forms of renewable energy technology – photovoltaic, wind, biomass, etc. It is worth emphasizing that all the aforementioned points are case specific and are dependent on each individual country´s economy and institutions in charge of electricity generation and distribution.

The flexibility of duplicating the marketing mechanisms for photovoltaic systems in other countries with similar economic situations, climatic conditions, energy needs and political structures to Ghana would, to a larger extent, bridge the huge gap between the demand and supply of energy in most developing economies. This study has considered in detail the energy crisis in Ghana, the current parameters in place to deal with the crisis and has developed an action plan to improve the situation. It was noted that the product configurations for photovoltaic systems are more or less the same in every country while the promotion and distribution mechanisms discussed in this study are straight forward and easy to adapt to any country that shares some common socio-economic traits with Ghana. However, the financing options may differ from country to country and that might require the localization of financing options in each respective country. To achieve the goals of replication would, therefore, require the monitoring, evaluation and forecasting of energy demand and supply at every point in time.

6 SUMMARY AND CONCLUSION

This chapter presents a summary of the theoretical and empirical objectives, followed by the main findings and contributions. Furthermore, the study raises pertinent issues for future investigation.

6.1 Theoretical and empirical objectives

The research started by presenting a preliminary overview of the energy situation in Ghana with a primary emphasis on the country's electricity sector. This led to the identification of the key research gap, namely, the problem of the inadequate documentation of the renewable energy business in Ghana. The research focused on the issue of what marketing mechanisms could be developed and implemented for photovoltaic technology in developing countries, using Ghana as an example. This research focused therefore on Ghana, making it possible to identify and address key policies and other factors such as country specific market structures and regulations viable for an effective diffusion process of photovoltaic systems. In order to address these difficult issues adequately, the research raised and dealt with the following objectives:

(i) Identifying and analysing the different forms of marketing mechanism suitable for photovoltaic technologies.

(ii) Exploring factors central to the implementation of these marketing mechanisms for developing countries.

(iii) Identifying marketing mechanisms currently used in Ghana for issues relating to photovoltaic technology.

(iv) Testing a marketing strategy that aims to promote a decentralized diffusion of photovoltaic energy in Ghana.

(v) Developing conceptual tools called the Robin Hood and the Donkey Principles to help sensitize policy makers and the public to issues pertaining to photovoltaic technology.

The research continued by defining the keywords. Chapter 2 first gave an overview of the energy market situation in developing countries followed by the background of the electricity supply and regulatory systems in Ghana. A discussion of the energy systems in Ghana mainly focused on the types of electricity generation systems, hydroelectric and thermal power. The research highlighted the generating capacities of the electricity systems as well as the future forecast proposed to help bridge the gap between the demand and supply of electricity in the country. The study continued with a critical discussion of the renewable energy policy proposed by the Ghana Energy Commission, focusing on areas concerning photovoltaic systems. Chapter 2 concluded by briefly discussing the issue of the marketing of electricity in Ghana. The listing of institutions responsible for electricity generation and distribution as well as the service providers was discussed in the same context.

To help understand some key research points the investigation provided background information pertaining to the components that constitute a photovoltaic system, namely, *panel arrays, charge controllers, batteries, and inverters.* Chapter 3 included a discussion of some of the primary uses and benefits of photovoltaic technology. The same chapter focused on marketing mechanisms for photovoltaic technology. The marketing mechanisms in question include four key parameters: *product, distribution, promotion and the financing* of photovoltaic systems. The discussion of the marketing mechanisms was in conjunction with the uses of photovoltaic systems for electricity generation. The research uses a business approach suitable to marketing mechanisms to appeal to the renewable energy industry and all potential end users. For example, instead of focusing on selling strategies, the role of promotion, in the study, emphasized the educational tools needed to help the diffusion of photovoltaic systems. Additionally, the discussion of financing focused on the financing options for photovoltaic systems in developing countries with specific recommendations given with respect to the general economics and purchasing power of the people in Ghana.

Chapter 4 directed attention to some of the key impacting factors concerning the marketing mechanisms under consideration. The research defined and explained the Robin Hood and the Donkey Principles aimed at creating public awareness and helping policy makers understand the key options available in addressing the energy crisis, especially for resolving the gap in electricity demand and supply. In addition, the research presented a framework that combined the background of photovoltaic systems with the key issues discussed under the rubric of each marketing mechanism, namely, *product, distribution, promotion and financing*. For instance, when discussing *product* as part of the marketing mechanisms, the research differentiated between the use of the product into various options, namely, *standalone, backup and hybrid,* in order to help address issues of the availability of the photovoltaic systems to both household end users and small-medium scale enterprises. Moreover, to explain the role of *distribution*, the research discussed, for instance, vendor activities, agents and the ability of an end user to acquire and install the complete photovoltaic system. The *financing* of a photovoltaic system is extensive in that it consists of four key options: the activities of *NGOs, financial institutions, individuals and the government*. Each of the options had specific sub-options that served as alternative approach to the financing issues. For *financial institutions*, the approach included the need for the corporate body to adopt photovoltaic systems as part of their corporate social responsibility policy, thus deploying such systems in their areas of operation. Financial institutions also had the option to act as mediators between end users and photovoltaic business entities or service providers. To conclude, the financial institutions could opt to give loans or specified grants to those who need them to acquire a photovoltaic system. For the individual, the options are either cash or instalment payments. Finally, with regard to the government, it is important and necessary to subsidize photovoltaic systems as well as other renewable energy systems and to promote green energy usage through education and other incentive initiatives.

Chapter 5 reported on the empirical part of this study and its results. The chapter presented methods and techniques for collecting data on the subject and these included the use of a focus group discussion and a survey, to help ascertain the validity of the key questions raised in this research. Besides, the research method helped answer, and at the same time unearth, key issues concerning the electricity crisis and the role of photovoltaic energy in addressing the problem. As part of reliability and validity, the research presented documentary evidence of photovoltaic business collaboration between a Finnish company and a Ghanaian partner. The research concluded with a discussion on the replication of the marketing mechanism for other developing countries with a similar electricity crisis. It is worth noting that the focus for replication was restricted to only the product configuration to avoid blunt generalizations of the marketing mechanisms. Besides, it is a big challenge to correctly determine the types of economic infrastructure and policies in each developing country thus making it unreasonable to replicate parameters such as *distribution, promotion and finance*. However, marketing mechanisms can serve as a benchmark for similar phenomena to help deduce the right approach for a specific related situation in another given country.

6.2 Findings and contributions

The arguments made in this research were intended to address the issue of the demand and supply of electricity in Ghana. Furthermore, the research presented an opportunity for businesses in the renewable energy sector to restructure their approach to their business. This was done by carefully evaluating the promotional tools and financing options available which were discussed vis-à-vis their suitability for a diffusion process. The research questioned key assumptions in the marketing mechanisms and established new arguments to develop clear strategies for businesses, policy makers and the government.

The current energy crisis in Ghana causes frequent power outages. This fact can be mitigated by the introduction of the Robin Hood and the Donkey Principles as key contributions for critical examination that can help solve the problem with a socially equitable and transparent means. This Robin Hood Principle denotes taking from the rich and giving to the poor through legal means. This proposed model is recommended by this study as a way to help policy makers resolve energy distribution issues for both urban and rural sectors of the Ghanaian economy. The principle assumes that the diffusion of photovoltaic systems is available and affordable to urban sectors and firms. Furthermore, the principle proposes the development of a system and a strategy, which will eventually reduce the urban centres' over-reliance on the national grid. The principle suggests helping urban communities, which have a steady income, access to credits and loans, to adapt and adopt decentralized photovoltaic systems. This research recommended three options, *standalone* (the use of renewable energy systems as the only source of electricity), *backup* (the use of renewable energy systems in case of a power outage), or *hybrid* (the use of renewable energy systems for specific household or corporate systems, e.g., lights while the national grid takes care of specific energy intensive systems).

The Donkey Principle, on the other hand, assumes a strategic billing policy where a government directive makes it a legal duty for corporate firms, rich communities and urban dwellers to carry some of the cost burden of the usage of energy (electricity) by poor rural communities. In Ghana, this is not a new concept; there are subsidies for rural electric utilities which are paid for by surcharging the urban communities and firms some extra payments or taxes to cover the usage of streetlights as well as the rural electrification project. The research presents various electricity needs which it has identified and analysed as well as key segments of consumers in Ghana. It also revealed the varied usage activities of both households (*watching television, lighting, refrigeration and cooking among others*) and small-medium scale enterprises (*depending on the type of business, the use of electricity could vary from office appliances such as computers and printers to highly sophisticated equipment like giant photocopying machines*) .

The research presented a strong argument that due to the possibility of incurring additional costs in management decisions, marketing activities and the wholesale importation of energy products, it would be preferable if firms develop their activities by adapting their production processes to pay attention to the needs of the locals. This might help to create local expertise pools that are equipped to service, for example, photovoltaic systems. The research results also help emerging firms in the renewable energy markets, especially for developing countries, avoid costly investments and experiments. Moreover, the research discovered that promotion (*specifically on seminars and workshops*) and financing were of great importance. Therefore, the research recommends options such as *revolving funds, credit cooperative and leasing*.

The research discovered that the cost of consuming electricity supplied by conventional sources was relatively cheaper but disappointingly unreliable in Ghana. In addition, the study uncovered the existence of unfair monopolies and the use of fiscal protection of traditional electricity generating technologies making it difficult for investors to enter into independent power production and thereby utilizing their scarce resources in solving some of the energy crisis in the Ghana. Furthermore, the research discovered that customs regulations on renewable energy were non-existent or highly misunderstood by customs personnel thus making it difficult for importers of renewable energy products to receive a fair tariff rate. The research discovered that electrification policies in Ghana lack the dynamism to take into account the social and environmental benefits of renewable energy.

The research further discovered a lack of flexibility on the part of policy makers and especially the government in approving and promoting the use of renewable energy systems to help alleviate the chronic electricity crisis in the country.

In conclusion, it is evident that photovoltaic systems are a preferable choice. For this choice to become a reality, well-developed marketing strategies and the joint efforts of various actors are required. These actors include investors, marketers, policy makers, the government and all potential end users. Making the photovoltaic systems accessible will involve creating a viable business model, which would include an efficient network of sales and distribution programs. For this to work efficiently, every region in Ghana will need a sales point for receiving and servicing orders and purchases.

A comprehensive training program is necessary, therefore, the manufacturers and the government should join their efforts to recruit and educate students with renewable energy courses to help them become competent enough to handle the diffusion and implementation of renewable energy within communities in Ghana.

The role of the government within this program would be to place more importance on education about photovoltaic systems. More focus on environmental issues within its educational programs and the responsible use of energy would be an added advantage. Various forms of education should be introduced, including seminars, workshops, posters, televised demonstrations, radio and phone-in programs, and classroom lectures, among others. Most government structures and facilities could follow the example of the energy ministry in using photovoltaic systems, thus demonstrating its positive environmental impact to the public. The cooperation between the Finnish company, Opam, and its Ghanaian counterpart, ABES, is a laudable venture in putting theory into practice. The collaboration further solves the issue of the availability of the photovoltaic systems since prospective customers could obtain the system without the hassle of ordering it from abroad as well as worrying about post-sales issues.

6.3 Future research suggestions

This study tried to provide a solution-oriented insight into the energy crisis in Ghana and the study used varied statistics specifically from some African countries to help address this situation more generally, as it is a phenomenon in most developing countries. The study further used four key marketing parameters to address the need for a structured strategic approach in the business management of photovoltaic energy systems.

For a careful back-to-back analysis of the research, a future breakdown of the marketing mechanisms into individual research papers will help make for simplified reading and an appraisal of how to approach the energy crisis in Ghana and other developing countries.

Future research suggestions for scientific papers could include the following:

1. *Product strategies for photovoltaic systems in developing countries:* this will involve discussions pertaining to the different components involved in a photovoltaic package (*panel arrays, charge controllers, battery arrays and inverters*). Furthermore, the discussion of product configuration will focus on the varied uses on the part of the end users, thus making a technical calculation possible, for a better understanding of how to deploy the systems as either *a backup, standalone or a hybrid.*

2. *Promotion of photovoltaic systems in developing countries:* this will involve both the use of promotion as a marketing tool for photovoltaic systems and the use of promotion in the context of education.

3. *Distribution strategies for photovoltaic systems in Ghana:* a discussion on this topic might help develop an in-depth view of the role of vendors, agents as well as how to carry out the whole installation.

4. *Financing options for promoting photovoltaic systems in Ghana:* this study will focus on presenting an overview of the financing options for photovoltaic purchasing in Ghana. Since the photovoltaic system is relatively expensive and out of reach of the majority of the population, it would be important to explore in detail different financing options, including, *revolving funds*, *credit cooperative*, *leasing* and *green loans*. This study might recommend various roles for the *individual end user, government, non-governmental organizations (NGO) and financial institutions* in implementing the recommended financing options.

5. Finally, another area of interest for future research is the issues relating to *the Robin Hood and the Donkey Principles* and their possible relationship with different marketing mechanisms.

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APPENDICES

Research Questionnaire

Dear receiver,

I am writing to ask for your participation in an important and timely study that is designed to develop a ***better understanding of the marketing mechanisms for photovoltaic systems in Ghana.*** This study intends to collect unbiased data that can significantly help reach a meaningful conclusion on a better way to carry out the diffusion process. The conclusions derived could be used by policy makers, investors, energy companies and marketing firms in making critical decisions concerning controlling the existing energy crisis in Ghana. Furthermore, your contribution will serve as a foundation for the replication of the ideas and the development of lasting solutions to the energy crisis in developing countries.

You are requested to answer this questionnaire anonymously. It would also be appreciated if you provide your email and contact information to be used in making available to you the findings of this study.

This study aims to investigate marketing mechanisms for photovoltaic systems in Ghana. The following questionnaire measures your perceptions of specific variables included among which are some impacting factors in connection with the growth and diffusion of photovoltaic systems in Ghana.

Please answer all the questions according to the instructions given. The completion of the questionnaire should not take more than 20min of your time. All responses will be treated in the strictest confidence and only summarized results will be published. Your time and cooperation is very much appreciated.

Many thanks in anticipation of your cooperation. I look forward to receiving a quick response from you.

Yours Sincerely,

Emmanuel Ndzibah (PhD Candidate)
Vaasa University
Faculty of Technology
Dept. of Industrial Management
Vaasa, Finland

Email: endzi@uwasa.fi

Please tick as indicated: ☒

A. Diffusion Barriers

Please indicate the extent to which the following are significant barriers to obtaining a solar product.

Table 1. Diffusion Barriers

		<Least Significant **Please tick only one**				Most Significant>
		1	**2**	**3**	**4**	**5**
a.	High Cost of Installation	☐	☐	☐	☐	☐
b.	High payback period	☐	☐	☐	☐	☐
c.	Lack of knowledge about solar	☐	☐	☐	☐	☐
d.	High taxes	☐	☐	☐	☐	☐

B. Growth of Solar Business

Please indicate the extent to which the following have a significant impact in explaining the growth of solar business in Ghana.

Table 2. Diffusion Barriers

		<Least Significant **Please tick only one**				Most Significant>
		1	**2**	**3**	**4**	**5**
a.	Level Of Income	☐	☐	☐	☐	☐
b.	Incentives (Loans)	☐	☐	☐	☐	☐
c.	Research And Technology	☐	☐	☐	☐	☐
d.	Promotional Campaign	☐	☐	☐	☐	☐

C. Driving force for the adoption of photovoltaic systems

Please indicate the extent to which the following are important forces driving the diffusion of solar business in Ghana

Table 3. Diffusion Barriers

		<Least Significant — Most Significant> Please tick only one				
		1	**2**	**3**	**4**	**5**
1.	Solving the Energy Problem	☐	☐	☐	☐	☐
2.	Social Prestige	☐	☐	☐	☐	☐
3.	High Electricity Cost	☐	☐	☐	☐	☐
4.	Availability Of Solar Products In The Market	☐	☐	☐	☐	☐

Table 4. Diffusion Barriers

D. Kindly indicate which of the following applies to you – Respondents (please tick only one)		
a.	Tenants	☐
b.	Home Owners	☐
c.	Business Owners	☐

E. Please indicate the likely area for the use of solar energy		
a.	Lighting	☐
b.	Cooking	☐
c.	Refrigeration	☐
d.	Household Appliances	☐
e.	Business Operations	☐

F. Do you have any knowledge about renewable energy sources? (please tick only one)		
a.	Yes	☐
b.	No	☐
c.	Can't say	☐

G. What is your average monthly electricity bill (please tick only one)		
a.	GHC 1 – GHC 10	☐
b.	GHC 11 – GHC 100	☐
c.	GHC 101 – GHC 200	☐
d.	GHC 201 – GHC300	☐
e.	GHC 301 – GHC 400	☐

There will be no references to individuals or companies and only aggregated responses will be reported.

This questionnaire can be return to the postal address provided below:

Emmanuel Ndzibah (PhD Candidate)
University of Vaasa
PO Box 700, FI-65101 Vaasa - Finland
Industrial Management
Faculty of Technology
Email: endzi@uwasa.fi

12. Your name :(Optional)....................

Email address...