Solar Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi

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BY

Atika Benjamin Momanyi

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Dedication

In memoriam Eva Monyenche Atika

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List of Acronyms and Abbreviations

CO_2	:	Carbon Dioxide
€	:	Euro
ERC	:	Energy Regulatory Commission
GDP	:	Gross Domestic Product
GHG	:	Green House Gases
GWh	:	Giga Watt hour
KEBS	:	Kenya Bureau of Standards
kWH	:	Kilowatt hour
KPLC	:	Kenya Power and Lighting Company
NITA	:	National Industrial Training Authority
RET	:	Renewable Energy Technology
PV	:	Photo voltaic
SWH	:	Solar Water Heater
TAM	:	Technology Adoption Model
USD	:	United States Dollar

Abstract

Adoption of Renewable Energy Technologies in urban areas is an important mechanism in addressing Climate Change and reducing Green House Gases (GHG).This study explores the factors affecting adoption of Solar Water Heating (SWH) Systems by household in Nairobi County. This study is based on The Energy (Solar Water Heating) regulations, 2012 and seeks to explore the issues affecting their adoption. The specific objectives were to identify the characteristics of SWH systems; to establish the level of adoption of SWH by household; and to identify the factors that have affected adoption of SWH by households in the County of Nairobi.

The study used triangulation to guide in data collection whereby respondents to the study were purposively sampled and drawn from households and key stakeholders from the Ministry of Energy and Petroleum, Energy Regulation Commission, real estate developers as well as SWH distributors as the key informant interviews. The survey data was collected in Dagoreti North, Ruaraka and Embakasi West constituencies in Nairobi County. The research targeted a sample size of 120, however after denial of access to some sites, the study had a final sample of 58.

The study draws the following key findings. Firstly, SWH systems are categorised into either active or passive systems. SWH systems were also identified by a significant number of household as being easy to use. In terms of adoption, the research established that despite a high level of adoption of SWH by the respondents, the use of hot water was limited to use for bathing mostly. A significant number of households also indicated that they used other water heating systems in their households. In terms of factors affecting adoption of SWH systems the following issues were identified lack of information and awareness; financial and economic factors; institutional factors; technical factors; and social factors.

The study suggests the following key recommendations for policy. Firstly, it is raising awareness to the public on the utility of SWH systems in providing hot water. This will increase that adoption of SWH systems. Secondly, the study recommends that there is need for relevant stakeholders to develop appropriate financial mechanisms to improve adoption among households. The research also recommends the capacity of the Energy Regulation Commission to be enhanced in order to effectively carry out its mandate. The organisations mandated by the Energy (Solar Water Heating) regulations, 2012 should undertake their mandates as prescribed. It is also recommended that an integrated building curriculum to be developed.

Additionally, the study suggests two recommendations for further research. Firstly, this study was based on a small household sample, therefore a more expansive study can be conducted to include households, and other commercial entities such as schools, hospitals, hotels among other users. Secondly, a study on the factors affecting financing of Renewable Energy Technologies (RET) in Kenya can be conducted to identify the various issues and development of requisite policies to address them.

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CHAPTER ONE
INTRODUCTION

1.1 Background

Energy is central to a range of services supporting human development, from modern medical care, transportation, information and communications to lighting, heating, cooking and mechanical power for agriculture (UNDP, 2011). Energy, especially electrical energy plays a significant role in the development of the nation. In the face of climate change, Kenya's energy sector has already been significantly affected over the past few years both by climate change effects and the increased demand for energy.

According to the International Energy Agency (2013) climate change is the change in climate (that is, regional temperature, precipitation, extreme weather, etc.) caused by increases in the greenhouse effect. The Green House effect is the process where Greenhouse Gases (such as water vapour, CO2, methane, etc) in the atmosphere absorb and re-emit heat being radiated from the earth, trapping warmth (IEA, 2013). The impact of climate change has been felt across the globe and in different sectors of the economy ranging from agriculture, energy, health, water availability amongst others. This paper focuses on the energy sector.

AMCEN (2011) indicate that Kenya is considered to be an energy security hotspot. Climate change and variability constitute a considerable energy security risk for Kenya. This risk is exacerbated by the fact the country's … approximately 60 percent of hydro-electric power, is sourced from the Tana River which is located in a drought-prone area, Kenya experiences frequent energy crises… (and despite) Kenya investing in a great degree of energy diversification, it fails to meet its energy needs (AMCEN, 2011.)

This can be illustrated whereby, National Environmental Management Agency (2011), states that Kenya is highly dependent on hydroelectric power and it has traditionally accounted for the preponderance of Kenya's energy and represented 56.8 percent and 50.6 percent of all power generated in 2007 and 2008 respectively. However, because of the acute drought (2008-2009), production plummeted by 35 percent from 3,267.0 GWh in 2008 to 2,160 GWh in 2009 when it constituted only 33.2 percent of the country's energy portfolio and was dislodged by thermal oil power… even though hydro power is considered to be a cleaner source of energy, its reliance on the vagaries of weather has often led to power rationing and rising electricity bills (National Environmental Management Agency, 2011).

In addition to this, the Ministry of Energy (2012) states that Kenya has been affected by the high energy prices – the continued increase in the price of energy in the global market. Insecurity of supply – expressed in the growing discomfort about vulnerability and uncertainty of future energy supplies as well as volatility of their prices. Adverse environmental and health impacts caused by spiraling degradation of the environment… And finally, as a result of the depletion of energy resources such as fuel wood and fossil fuels which are becoming scarce as demand rises (Ministry of Energy, 2012).

These issues have left the country vulnerable in terms of energy sufficiency. It is for this reason that Governments will be required to develop suitable energy policies for their countries. According to Ljung (2007),energy policy needs to be consistent with overarching goals such as promotion of economic growth, social development and poverty alleviation while ensuring sustainable use of natural resources, care for the environment… and good governance (Ljung, 2007.). Governments are undertaking various approaches to ensure that their policies are consistent with environmental demands.

The Kenyan Government's energy policy objective is to ensure affordable, sustainable and reliable supply to meet national and county development needs, while protecting and conserving the environment. The energy policy also specifically seeks to achieve several issues such as to utilize energy as a tool to accelerate economic empowerment for the national… as well as urban and rural development. The promotion of diversification of energy supply sources to ensure security. It also seeks for at least 70 percent of electricity to be generated from clean or renewable resources (Ministry of Energy, 2012).

In order to achieve this, the Kenyan Government through the Ministry of Energy gazetted The Energy (Solar Water Heating) Regulations, 2012. This was done through Legal Notice No. 43 on the 25th of May, 2012. The Government has developed SWH Regulations to promote uptake and guide the incorporation of low temperature SWH systems in industrial, commercial and residential buildings. This has the potential to reduce both energy use and peak demand. The uptake of SWH systems in Kenya is extremely low compared with the enormous potential provided by the abundant availability of the solar energy resource and the demand for low temperature water both for domestic and commercial applications (Ministry of Energy, 2011).

In the face of this new regulation, the paper seeks to investigate the levels of adoption amongst households in the County of Nairobi. The study focused on the urban based households because as the world is becoming more and more urbanised households are becoming a major constituent of energy consumers.

1.2 Problem Statement

As Kenya seeks to achieve Vision 2030, adequate supply of energy will play an integral part in its achievement. The development process requires and will cause an increase in the demand for energy in the country. In the face of climate change, developing countries will need to look to

renewable and alternative energy sources to meet their energy needs. The Kenyan Government has sought to take steps to ensure that there is adequate energy supply by seeking to integrate Renewable Energy Technologies (RET) into the mainstream sectors.

The Energy (Solar Water Heating) Regulations, 2012, is one of these strategies being undertaken to ensure energy sustainability in the country. It seeks to integrate the use of this RET into building premises. The regulation aims for all premises with hot water requirements of a capacity exceeding one hundred liters per day shall install and use solar heating systems. The daily hot water demand for domestic residential houses is calculated at 30 liters per person in the second schedule of the regulation. New buildings are required to comply immediately whilst all existing premises with hot water requirements of a capacity exceeding 100 liters per day are required to install the SWH's within 5 years.

The success of this program is dependent on the adoption of SWH's by households' as the end users of the technology. As the urbanization process continues to take place through increased rural-urban migration, the increase in demand and development of housing will continue to rise in urban areas. This will imply that the energy demand on the national grid will increase significantly. It is for this reason that buildings have been identified as one of the areas that can be targeted to effectively reduce GHG emissions by limiting their energy demand. The SWH Regulations are geared towards reducing the peak demand on the national grid.

This research sought to establish the level of adoption and the issues that have affected adoption of the SWH's among households. These factors included technological, informational, institutional, financial and other factors that may affect adoption. An understanding of these issues is important in developing remedial approaches to ensure the success of the SWH Regulations adoption.

1.3 Research Questions

The main research question for the study was to investigate the factors affecting adoption of Solar Water Heaters among households in Nairobi.

The specific questions for the study were:

1. What are the characteristics of solar water heaters?

2. What is the level of adoption of solar water heaters by households?

3. What are the factors affecting adoption of solar water heaters by households?

1.4 Research Objectives

The overall objective of the study was to investigate the factors affecting adoption of the Solar Water Heaters among households in Nairobi.

The specific research objectives for the study were

I. Identify characteristics of solar water heaters.

II. Establish the level of adoption of solar water heaters by households.

III. Identify factors affecting adoption of solar water heaters by households.

1.5 Justification of the Study

The study seeks to contribute to the existing body of knowledge on policy adoption through investigating the factors that affect adoption of solar water heaters by households. Renewable energy is important to Kenya as it will help reduce some of the negative consequences common to developing countries on their path to development. Examples of these are, large budget and trade deficits, and high cost of fossil fuels have also undermined the ability of developing country governments to meet the needs for basic services such as education, healthcare, and

clean water (World Bank, 2005) which are important Millennium Development Goals. Its importance can be illustrated in two instances in Africa.

The first illustration is drawn from Tunisia, where the government saved nearly €900 million in energy bills (equivalent to 10 percent of primary energy consumption), with an initial investment in clean energy of only €260 million (ANME, 2009). In South Africa, The Ekurhuleni Metropolitan Municipality managed to implement various cost-saving and energy saving measures in three municipal buildings. This resulted in an energy saving of 328,988 kWH in one year, with a payback period of 1.2 years. The co-benefits were GHG emission reduction of 308 tonnes of Carbon dioxide (CO_2) equivalent, 3 tonnes of Sulphur oxide (SOX) and 1 tonne of Nitrous oxide (NOX) (ICLEI, 2009).

In Kenya, the integration of renewable energy will also aid the country in mitigating some of the effects of climate change. AGECC (2010) indicate that currently at the global level, the energy system – supply, transformation, delivery and use – is the dominant contributor to climate change, representing around 60 percent of total current GHG emissions. Integration of SWH systems will help Kenya mitigate some of the effects of climate change.

The research findings can be used by policy makers and analysts to foster the successful adoption of the regulations in achieving the Governments energy policy objectives. The findings will also be useful to other researchers, development practitioners in providing information on how various factors affect adoption of renewable energy technologies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter analyses literature from previous works which have been done regarding the adoption of technology and empirical literature covering experiences in both the developed and developing worlds on the adoption of Renewable Energy Technologies.

2.2 Theoretical Literature

An innovation can be defined as knowledge in the form of an idea, method, or device that differs from current knowledge to an individual or other unit of adoption (Lee, 1995; Rogers, 1983). It does not matter if the idea, practice, or object is objectively new; rather, it is the perception of novelty (Straub, 2009). The SWH regulation can be seen as an innovation, since it seeks to integrate SWH technology into the housing development sector, despite SWH having been in existence for a long time. This is aimed at reducing the GHG emissions that is derived from buildings. Sovacool (2013) states that the built environment – consisting of residential, commercial, and institutional structures – accounts for about one third of primary global energy demand and are the source of 35 percent of global energy-related CO_2 emissions (IEA, 2010).

This will be in line with the growing body of evidence that suggest that improving the energy efficiency of the existing building stock and new construction is a low-cost approach to mitigating GHG emissions. This is because over the long term, buildings are expected to continue to be a significant component of energy use and emissions, driven in large part by the continuing trends of urbanization, population, GDP growth, and the longevity of building stocks (IPCC, 2008).

2.2.1 Rogers' Adoption of Innovation theory

Rogers (1983) defines diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. Communication channels according to Rogers' is the means by which messages get from one individual to another. In its most elementary form, the process involves: an innovation, an individual or other unit of adoption that has knowledge of, or experience with using, the innovation, another individual or other unit that does not yet have knowledge of the innovation, and a communication channel connecting the two units. The communication channel in this study is the SWH regulations.

Time is involved in the diffusion in the innovation-decision process by which an individual passes from first knowledge of an innovation through its adoption or rejection, in the innovativeness of an individual or other unit of adoption – that is, the relative earliness/lateness with which an innovation is adopted – compared with other members of a system and in an innovation's rate of adoption in a system, usually measured as the numbers of members of the system that adopt the innovation in a given time period (Rogers, 1983). In this research, time is the period between when the regulation was gazetted and when the research was conducted

A social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members or units of a social system may be individuals, informal groups, organisation, and or subsystems (Rogers, 1983). In the context of the study the social system is the household.

The rate of adoption is the relative speed with which an innovation is adopted by members of a social system. It is generally measured as the number of individuals who adopt a new idea in a specified period. This theory argues that rate of adoption of innovations is influenced by five issues. These are the perceived attributes of an innovation, the type of innovation-decision, the

communication channels that are used, and the nature of the social system and lastly, the extent of change agents' promotion efforts (Rogers, 1983). This theory has been used in various fields to test the adoption of technologies in various fields of study.

2.2.1.1 Perceived Attributes of Innovations

Innovations bear in themselves several different attributes. Accordingly, the success of an innovation is dependent on these attributes not being an obstacle to its adoption. Rogers (1983) argues that there are several perceived attributes of innovations. The first attribute is the *relative advantage*. Relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes. The degree of relative advantage is often expressed in economic profitability, in status giving, or in other ways. The nature of the innovation largely determines what type of relative advantage is important to adopters.

When individuals/organisations pass through the innovation-decision process, they are motivated to seek information in order to decrease uncertainty about the relative advantage of an innovation. Relative advantage is often the content of the network-message about an innovation. Relative advantage is one of the best predictors of an innovations rate of adoption. This is because in one sense, it indicates the strength of the reward or punishment resulting from adoption of an innovation. There are a number of sub dimensions of relative advantage: the degree of economic profitability, low initial costs, a decrease in discomfort, a savings in time and effort, and immediacy of the reward (Rogers, 1983).

The second attribute is *compatibility*, this is the degree to which an innovation is perceived as consistent with existing values, past experiences, and needs of potential adopters. An idea that is more compatible is less uncertain for the potential adopter. An innovation can be compatible or

incompatible with the socio-cultural values and beliefs, with previously introduced ideas, or with clients' needs for innovations (Rogers, 1983).

The third attribute that influences adoption is *complexity* – the degree to which the results of an innovation is perceived as relatively difficult to understand and use. Any new idea may be classified on the complexity-simplicity continuum. Some innovations are clear in their meaning to potential adopters while others are not (Rogers, 1983).

The fourth attribute is *trialability* – the degree to which an innovation may be experimented with on a limited basis. New ideas that can be tried on the instalment plan will generally be adopted more readily than innovations that are not divisible. An innovation that is triable is less uncertain for the adopter. Some innovations are more difficult to divide for trial than others (Rogers, 1983).

The final attribute according to Rogers, (1983), is *observability*, which is the degree to which results of an innovation are visible to others. The results of some ideas are easily observed and communicated to others, whereas some innovations are difficult to describe to others.

2.2.1.2 Type of Innovation-Decision

The type of innovation decision is also stated to be one of the factors that determine the rate of adoption of an innovation. This is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision. There are three types of innovation-decisions; these are the optional innovation-decision, the collective innovation-decision and the authority innovation-decision (Rogers, 1983).

In relation to our study we shall focus on the authority innovation-decision whereby choices to adopt or reject an innovation made by a relatively few individuals in a system who possess power, status, or technical expertise. The ministry of energy by gazetting the SWH regulation, can be viewed to be have already made the innovation-decision for the households in the county of Nairobi. The question which we will pose for ourselves is whether this will result in the adoption of the SWH system by households.

2.2.1.3 Communication Channels

A communication channel is the means by which messages get from one individual to another. The nature of information-exchange relationships between the pair of individuals determines the conditions under which a source will or will not transmit the innovation to the receiver, and effect the transfer. Communication channels are categorised into two sets, either interpersonal or mass media in nature, or originating from either localite or cosmopolite sources (Rogers, 1983).

Rogers (1983) indicates that mass media channels are all those means of transmitting messages that involve mass mediums, such as radio, television, newspapers and so on, which enable a source of one or a few individuals to reach an audience of many. Interpersonal channels involve face to face exchange between two or more individuals. These channels have greater effectiveness in dealing with resistance or apathy on the part of the recipient. Cosmopolite channels are those from outside the social system being investigated; other channels about new ideas reach individuals from sources inside their social system.

2.2.1.4 Nature of Social System

A social system is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The members or units of a social system may be individuals, informal groups, organisations, and/or subsystems. The system has structure, defined as

patterned arrangements of the units in a system, which gives stability and regularity to individual behaviour in a system. The social and communication structure of a system facilitates or impedes the diffusion of innovations in the system (Rogers, 1983).

2.2.1.5 Extent of Change Agents' Promotion Efforts

A change agent is an individual who influences clients innovation decisions in a direction deemed desirable by a change agency. It is argued that the extent of change agents' efforts influences adoption. Evidence suggests that a change agent's success is positively related to the extent of change effort contacting clients. The degree of success is usually measured in terms of rate of adoption of innovations by members of the client system.

This theory is appropriate to the study in that it is primarily descriptive rather than prescriptive, it does not tell how to facilitate adoption but rather why adoption occurs (Straub, 2009). Since the goal of this research is to identify the factors affecting compliance among real estate developers, this theory is appropriate in providing input in the development of a framework and identification of the factors affecting compliance.

2.2.2 Technology Adoption Model

The technology adoption model (TAM) is based on Ajzen and Fishbein's (1980) theory of reasoned action. TAM was proposed by Davis (1989) and it is one of the dominant theories that has been used to explain the process of user acceptance of high-tech products, mainly from intrinsic perception factors rather than extrinsic environmental factors.

Davis (1989) suggests that users' motivation can be explained by three factors; perceived ease of use, perceived usefulness and attitude towards using the system. Davis hypothesizes that the attitude of a user toward a system was a major determinant of whether the user will actually use or reject the system. The attitude of the user, in turn, was considered to be influenced by two

major beliefs: perceived usefulness and perceived ease of use, with perceived ease of use having a direct influence on perceived usefulness (Chuttur, 2009).

The theory can aid in this research by providing an understanding of how innovations are adopted. In the case of the SWH, the theory was adopted in understanding the general perception of the technology by households. This is important to the study as the success of the SWH regulation is dependent on the household's perception of the ease of use and usefulness of the SWH system.

The TAM theory indicates that the perceived usefulness and perceived ease of use have a direct influence on the perceived usefulness of the technology. It is possible to infer that if there is a negative perception towards the technology it will hinder its adoption. The theory is thus important in guiding the study.

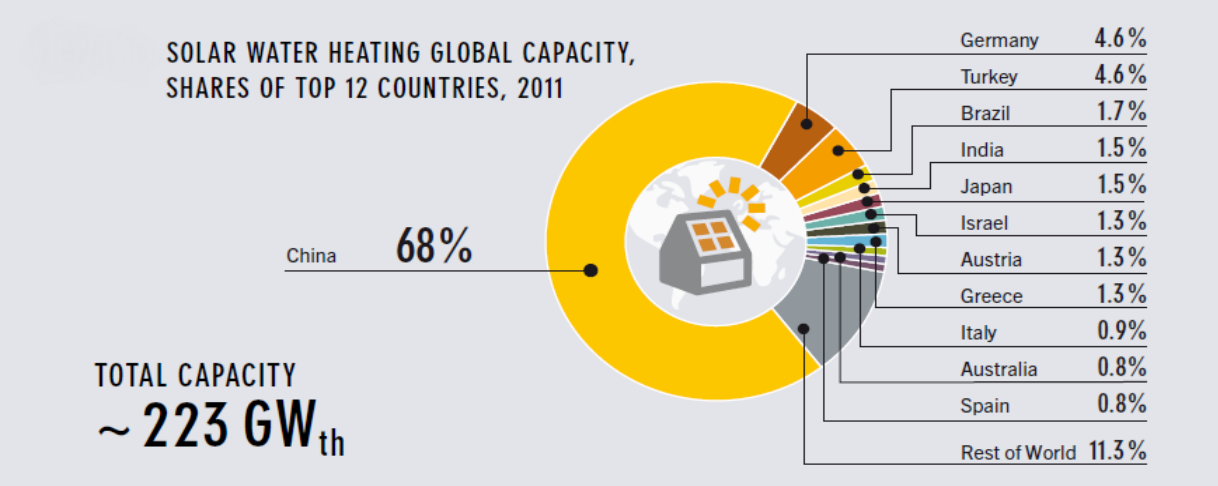
2.3 Empirical Literature

Globally, solar thermal technologies contribute significantly to hot water production in many countries and increasingly to space heating and cooling as well as industrial processes. The vast majority of solar heat capacity (all types) is in China and Europe, together accounting for more than 90 percent of the global market as indicated in Figure. 1, while Figure. 2, indicates the top growing markets. The top countries for total capacity in operation were China, the United States, Germany, Turkey and Brazil with most demand in China driven by local government mandates, especially for residential purposes with a growing share of systems being installed in large apartment buildings (REN 21, 2013).

In the developing and newly industrialised countries in the southern hemisphere, a few countries such as Brazil, India, South Africa and Mexico already have a significant cumulative collector area: respectively 2,300,000 and 1,000,000 m^2 for the first two, and between 250,000 and

260,000 m^2 for the other two. Elsewhere, installed capacity is much lower but numerous markets seem to be emerging in the developing world in response to the growing demand of SWH (Martinot et al., 2002)

Figure 1: Solar water heating global capacity, shares of top countries, 2011



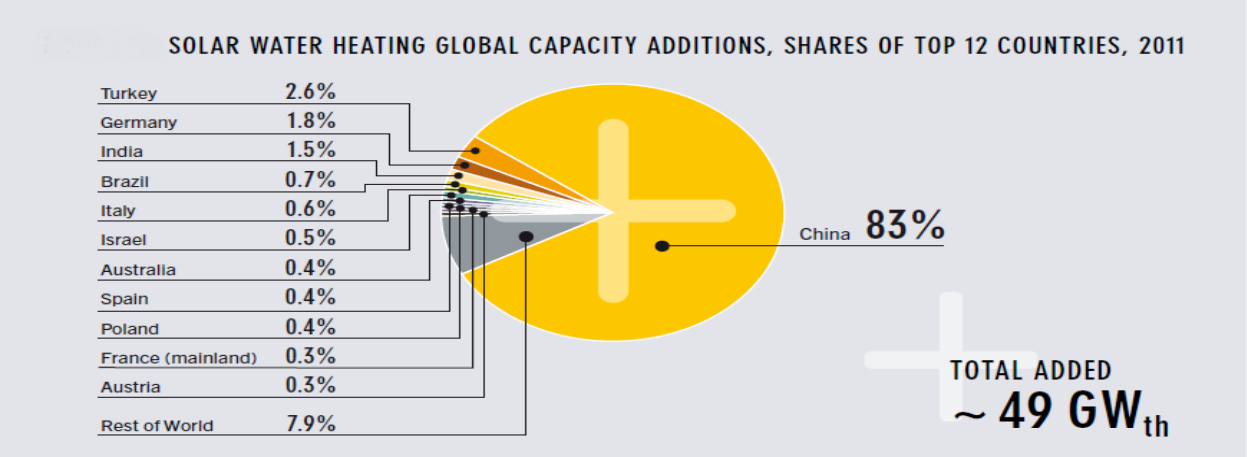
Source: REN 21 (2013)

IRENA (2012) indicates that although the majority of Kenya's electricity is currently generated , by renewable energy i.e. mainly large-scale hydropower and geothermal, many barriers to renewable energy still exist, including: insufficient/inadequate data; lack of adherence to system standards by suppliers exacerbated by poor after-sales service; limited capacity for equipment acquisition/supply; human resources constraints; high resource risks; renewable energy resource distribution relative to existing grid/load centres; climate change impact; high capital costs; challenges in reaching financial closure; lack of appropriate and affordable credit and financing mechanisms; the high cost of resource assessment and feasibility studies; and limited awareness about the opportunities for renewable energy in Kenya (IRENA, 2012).

In several empirical studies conducted in developed and developing countries, several key themes on the barriers have been identified. In the context of this study, we shall categorise the barriers under the key themes identified in Painuly's (2001) work. These thematic areas are

classified as follows, market failure/imperfection factors; economic and financial factors; institutional factors; technical, social, cultural and behavioural factors and other miscellaneous barriers.

Figure 2: Solar water heating global capacity additions, shares of top 12 countries, 2011



Source: REN 21 (2013)

The main barrier cited in many empirical works (UNEP, 2013; Blenkinsopp, et al., 2013; Beck et al., 2004) is the high upfront cost of purchasing and installing the renewable energy technologies. Beck and Martinot (2004), indicate that many argue that renewable energy costs more than other energy sources, resulting in cost-driven decisions and policies to avoid renewable energy. However, in practice, various factors affect the comparison between the RET's and other conventional sources of energy. This can be illustrated, for example where public subsidies lower the cost of competing fuels (Beck and Martinot, 2004).

Beck and Martinot (2004) indicate that organizations such as the World Bank and the International Energy Agency (IEA) put global annual subsidies for fossil fuels in the range of $ 100 billion to $ 200 billion. Although these figures can be very difficult to estimate; for comparison, the world spends some $ 1 trillion annually on purchase of fossil fuels. These subsidies can take many forms: direct budgetary transfers, tax incentives, research and

development spending, liability insurance, leases, land rights-of-way, waste disposal, and guarantees to mitigate project financing or fuel price risks. These subsidies for fossil fuels can significantly lower final energy prices putting renewable energy at a competitive disadvantage if it does not enjoy equally large subsidies (Beck and Martinot, 2004).

Although it is true that the initial capital cost of RET's are often higher on a cost-per-unit basis (i.e., $/kW), it is widely accepted that a true comparison must be made on the basis of total life-cycle costs. Life cycle cost account for initial capital cost, future fuel costs, future operation and maintenance costs, decommissioning costs and equipment lifetime (Beck and Martinot, 2004). Such a comparison makes RET's competitive against conventional energy sources.

However despite the cost of RET's reducing, the cost of solar technologies have dropped substantially over the last 30 years. For example, the cost of high power band solar modules has decreased from about $27,000/kW in 1982 to around $4,000/kW in 2006; the installed cost of a PV system declined from $16,000/kW in 1992 to around $6,000/kW in 2008 (IEA-PVPS, 2007, LAZARD 2009). However this cost is still high in comparison to conventional sources (for example, fossil-fuelled systems) (IfS, 2014).

This can be illustrated for example in South Africa (UNEP, 2013), where it was noted that RET's with high-upfront investment costs, were simply unable to compete with conventional technologies. This is also noted by Attachie et al., (2013) in Ghana, C-Tran (2010) in India, Karekezi (Afrepen, 1990) in sub-Saharan Africa and Katihabwa (Afrepen, 1990) Burundi. Given the scale of some of the housing projects, the cost of SWH can become prohibitive. WEC (2007) noted that the cost of a SWH system could be as low as € (Euro's) 300-400 (Ksh.[1] - 33,000 –

[1]Approximated against euro at 110/-

Ksh. 44,000) in China and India and as high as € 5,000 – 7,000 (Ksh. 550,000 – Ksh. 770,000) in countries in Northern Europe.

It has also been argued that there has been a lack of financing mechanism for the adoption of RET's. Beck and Martinot (2004) state that consumers or project developers may lack access to credit to purchase or invest in renewable energy because of lack of collateral, poor creditworthiness, or distorted capital markets… available loan terms may be short relative to the equipment or investment lifetime. In some countries, power project developers have difficulty obtaining bank financing because of uncertainty as to whether utilities will continue to long-term power purchase agreements to by power (Beck and Martinot, 2004).

Painuly, and Fenham, (2002) in their study on RET's in Egypt, Ghana and Zimbabwe found that there were inadequate financing arrangements for RET's, this is at the local, national and international levels. This was also indicated in the works of Blenkinsopp et al., (2013), Attachie and Amuzuvi (2013), and C-Tran (2010). This is whereby due to the high cost of RET's, adoption is limited further by financial institutions being unwilling to finance this projects. This results in hindering adoption of the technology by users.

AMCEN (2011) indicate that however, developing countries have a number of funding avenues available to them to support their responses to climate change and this number of funding channels is growing. The funds availability was started with the Rio Earth Summit in 1992. The funds are targeted to support development and economic growth in key emitting sectors to sectors affecting vulnerability to climate change (i.e. water, health, energy, forestry and agriculture) (AMCEN, 2011).

AMCEN (2011) state that the Cancun Agreements formalise a collective commitment by developed countries to provide new and additional funding for action on climate change in developing countries both in the short- and longer-term, with developed countries committing to the goal of mobilising jointly United States Dollar (USD) 100 billion per year by 2020. This funding will aim to help developing countries adapt to and address the impacts of climate change and to pursue actions that will bring them towards a low carbon future (AMCEN, 2011).

However, private financing has been successful in increasing adoption of RET's. In India, the Shell Foundation worked with two leading banks in India, viz. Canara Bank and Syndicate Bank, to develop renewable energy financing. This initiative helped the banks put in place an interest rate subsidy, marketing support and vendor qualification process. Using the wide network of their branches, the interest subsidies were made available in over 2,000 branch offices in the two states of Kerala and Karnataka. Within two and a half years, the programs had nearly 16,000 solar home systems, and the subsidies were being phased out. Whereas in 2003 all sales of PV home systems were on a cash and carry basis, by 2006, 50 percent of sales were financed (Usher and Touhami, 2006).

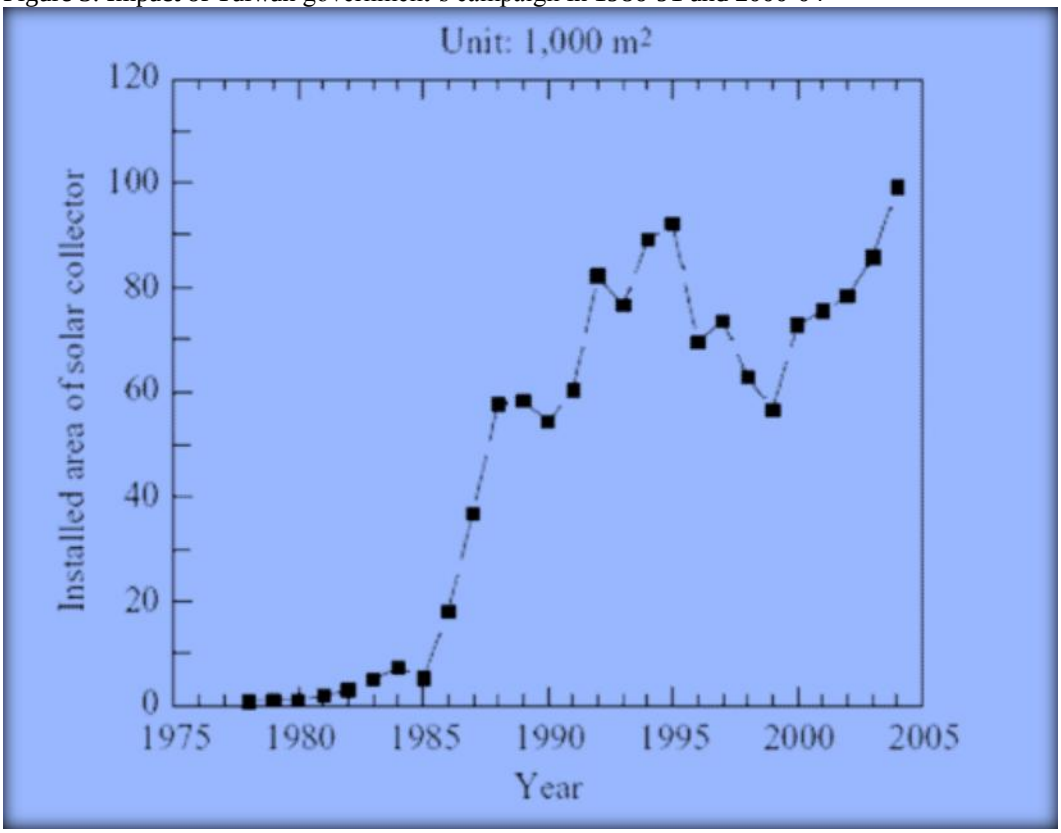
Bangladesh also had a similar programme conducted by the Rural Electrification and Renewable Energy Development Project established microcredit financed facilities that resulted in the installation of over 970,000 solar-home systems between 2003 and May 2011. The project exceeded its expectations and aimed to have 1 million solar home systems by 2012 (Uddin and Taplin, 2008).

The existence of various funding avenues indicate that despite the high cost of the RET's, developing countries can access various funding opportunities and develop public and private

financing mechanisms can support the uptake of RET systems. Several financing mechanisms have been used in various contexts to promote the uptake of SWH globally.

Financing mechanisms may include subsidies, which aim to reduce the capital cost at the time of purchase and shorten the payback time, which are the principal barriers of growth of the SWH market. In Taiwan for example, as indicated in Figure 3, there have been two successive government campaigns conducted in 1986-91 and 2000-04 to promote solar collector for heating water had a clearly visible impact on the sale of equipment (Menanteau, 2007).

Figure 3: Impact of Taiwan government's campaign in 1986-91 and 2000-04



Source: Chang et al., 2006

However it has been noted that if subsidies are discontinued prematurely it is quite possible for sales to plummet in a market that is not sufficiently mature. This was experienced in Tunisia among other countries where discontinuation of subsidies resulted in a drop in market sales of

SWH systems (ANER, 2003). This indicates that there is need for subsidies programmes to be well planned and extended over a significant period of time in order to promote RET effectively.

Tax incentives/credits can also be used to provide financial support to promote adoption of SWH. These may range from tax reductions (lower VAT for example) applicable to equipment or installation costs, reduced tax rates on imported equipment where applicable, tax credits, shorter write-off periods etc. In France for example, since the start of 2006 tax incentives/credits have been implemented, SWH have benefited from a tax rebate of 50 percent, which means that households can deduct half of the purchase cost of SWH equipment from their income tax (Menanteau, 2007).

Low-interest loans/third-party financing can also be used as financing mechanisms to promote the adoption of SWH. Providing access to credit is another way of lowering the initial cost barrier as long as interest rates are lower than those generally applicable to consumer loans. In Spain, this has been done where households can obtain low interest loans (6-8 percent instead of 14 – 18 percent) which have greatly facilitated implementation of legislation on solar installations (Menanteau, 2007).

Katihabwa in Afrepen (1994) and WEC (2007) in their study indicate that one of the major constraints is the shortage of qualified manpower on the development of the solar energy systems. Karekezi and Kithyoma (2003) point out that the introduction of unfamiliar technologies such as RET's require the development of technical skills. The importance of technical know-how in the increased utilisation of RETs has been recognised in the region, but in spite of efforts by governments, there is a continuing shortage of qualified personnel (Baguant and Manrakhan, 1994).

Attachie et al., (2013), points out that enough technical manpower has not been developed to support the design, installation and monitoring of systems. Timilsina, et al., (2011), indicate further that lack of integration with typical building materials, designs, codes and standards make widespread application of solar space and water heating applications difficult. This is summed up in a MNRE and REEEP report (2010), the dearth of trained and competent planning engineers and installation technicians creates a significant hurdle in the growth of the SWH systems market. This is especially because solar energy still has to operate and compete on the terms of an energy infrastructure designed around conventional energy technologies (Timilsina, 2011).

Indeed the IPCC (2007) indicates that this lack of awareness of energy-saving opportunities among practicing architects, engineers, interior designers and professionals in the building industry including plumbers and electricians, is a major impediment to the construction of low-energy buildings. This lack of requisite knowledge has significant impact on the adoption of RET's.

It has also been stated that some of the institutions tasked with approving RET projects do not have qualified personnel to undertake the inspection duties. In a study conducted in the United States, Pitt (2008) indicates that system installers frequently faced planners and building inspectors with little or no experience of permitting solar or wind systems. This had an adverse effect during the implementation of the projects.

Institutions that are to guide adoption or compliance, have also been indicated as barriers to the adoption of RET's. This is seen in both developed and developing countries. A UNEP report (2013) indicates that in South Africa, several institutional barriers existed limiting adoption. These barriers included too many agencies being involved in the approval process, which resulted in increased time taken in the approval of licenses.

Bigerna et al., (2015), state that similarly in many European countries, there is a large number of organizations who make a decision on a single market (such as wind power or solar). As a result it becomes difficult to obtain permits and also funding for RET's project. Nelson (2011) also indicates that there seems to be competing regulations from different agencies, and the number of agencies can be large.

Mendonza, et al., (2010) further indicate that in the European Union, a recent study surveying 21 countries found a host of political barriers which created considerable uncertainty (Coenraads et al., 2008). Red tape and unforeseeable bureaucratic delays from local and national authorities were cited by project developers as a significant impediment, with an average renewable energy project involving more than nine separate authorities. Attachie and Amuzuvi (2013) state that in Ghana, the institutions lacked the capacity to effectively carry out steps and procedures that were to ensure effective adoption of RET's.

Another key barrier to adoption of technology is a lack of awareness and understanding of the technologies being introduced. Markets function best when everyone has low-cost access to good information (Beck and Martinot, 2004). However, Bigerna et al., (2015), states that provision of information is subject to what economists call a public goods problem because the production of useful information is valuable to everyone, not just the person who produced it. It is stated that furthermore, those that have the information may have strategic reasons to manipulate its value. Sellers may intentionally give misinformation to make their products seem more attractive; and the cost of acquiring reliable information may be significant, especially when up against well-distributed misinformation for example by oil companies or anti-environmental groups (Bigerna et al., 2015).

Reddy and Painuly (2004) report that lack of information about solar thermal energy systems among actors of the building sector and the general public is a key barrier to adoption of the technology. In Nigeria, Ogunleye and Awogembi (2010) indicate that there was a low awareness of the usefulness, efficiency or reliability of the technologies. There is a lot of fear of the unknown; a lot of industrial entrepreneurs would rather stick to the known conventional modes of power rather than taking the risk of investing in new solar schemes (Ogunleye and Awogembi, 2010). This was also exhibited in the municipalities in India, where there was a general lack of awareness about the changes in the law, about the technology and maintenance thereof (C-Tran, 2010).

Milton (2006) states that, many institutions are ill-equipped to ensure that proper information about SHW systems are available, and therefore, a massive knowledge gap prevails. Attachie (2013) also identified and quotes that Edjekumhene et al., (2001) in a previous study conducted in Ghana, that a vast majority of the Ghanaian population were not aware of the ability of RET's to meet their energy needs. Another study by Blenkinsopp et al., (2013) also identified this barrier in India, where there was a significant lack of knowledge and understanding of technologies being introduced.

In Botswana, Mosimonyane (1995) indicates that in a survey, 57 percent of the respondents had no knowledge of government policies designed to promote the use of RET's. Blenkinsopp et al., (2013) further notes that this is one of the main reasons that a technology is not adopted. If the target group are not aware, their chances of complying with the regulation are minimal.

Various scholars have however indicated that standards and labelling can be used to overcome barriers relating to the lack of information and transforming markets and stimulating adoption of new, more efficient technologies and products. It is stated that since 1990s, 57 countries have

legislated efficiency standards and/or labels, applied to a total of 46 products as of 2004 (IPCC 2007; Wiel and McMahon, 2005). It is stated that this can be used to guarantee a specific level of quality to the consumer who may not have perfect information to make good decisions on the use of SWH systems.

In 2003, for example, European manufacturers developed the Keymark voluntary certification scheme with the support of the association European Solar Thermal Industry Federation (ESTIF). This label is recognised in most European countries and is also one of the basic references used by the Chinese government to develop its own national technical standards of solar thermal equipment. This has resulted in the risk related to poor performance by SWH systems to be no longer borne by the user but the manufacturers and installation contractors, who are thus strongly encouraged to supply high quality equipment (Menanteau, 2007; Wallace 2006).

As indicated earlier in a study conducted in the United States, Pitt (2008) indicates that system installers frequently faced planners and building inspectors with little or no experience of permitting solar or wind systems. IPCC (2007) also indicates that the lack of awareness of energy-saving opportunities among practicing architects, engineers, interior designers and professionals in the building industry including plumbers and electricians, is a major impediment to the construction of low-energy buildings.

The lack of knowledge among key actors in the building profession has been stated to reflect inadequate training at universities and technical schools, where the curricula often mirror the fragmentation seen in the building design profession. This indicates that there is a significant need in most countries to create comprehensive, integrated programmes at universities and other educational establishments to train the future building professional in the design and construction

of low-energy buildings. It is stated further that such programmes are significantly enhanced if they have an outreach component to upgrade skills and knowledge of practicing professional (IPCC, 2007).

Social-cultural factors have also been identified as barriers to the adoption of RET's. Painuly (2001), indicates that one of the most prevalent social-cultural barriers is the lack of consumer acceptance of the product for reasons such aesthetics. This is indicated in Pitt (2008) whereby in some states in the United States of America, some jurisdictions require more planning for RET's beyond electrical and building permit applications.

In some areas the design review process in urban planning evaluates the aesthetics of a proposed RET and typically allows for public comments from neighbours and others who may object to the use as being visually unattractive or incompatible with the look of the surrounding neighbourhood. However in some Californian municipalities, these processes are required despite state law protecting consumer rights to install RET's on their property and prohibits the regulation of solar power based on aesthetic concerns (Pitt, 2008).

Some other barriers to adoption of RET's identified in various empirical works are the rate of flow and supply of water to the buildings (C-Tran, 2010), corruption (Blenkinsopp et al., 2013), limited availability of the RET's in some countries associated with poor supply and after-sale service of the RET's (C-Tran, 2010).

2.4 Conceptual Framework

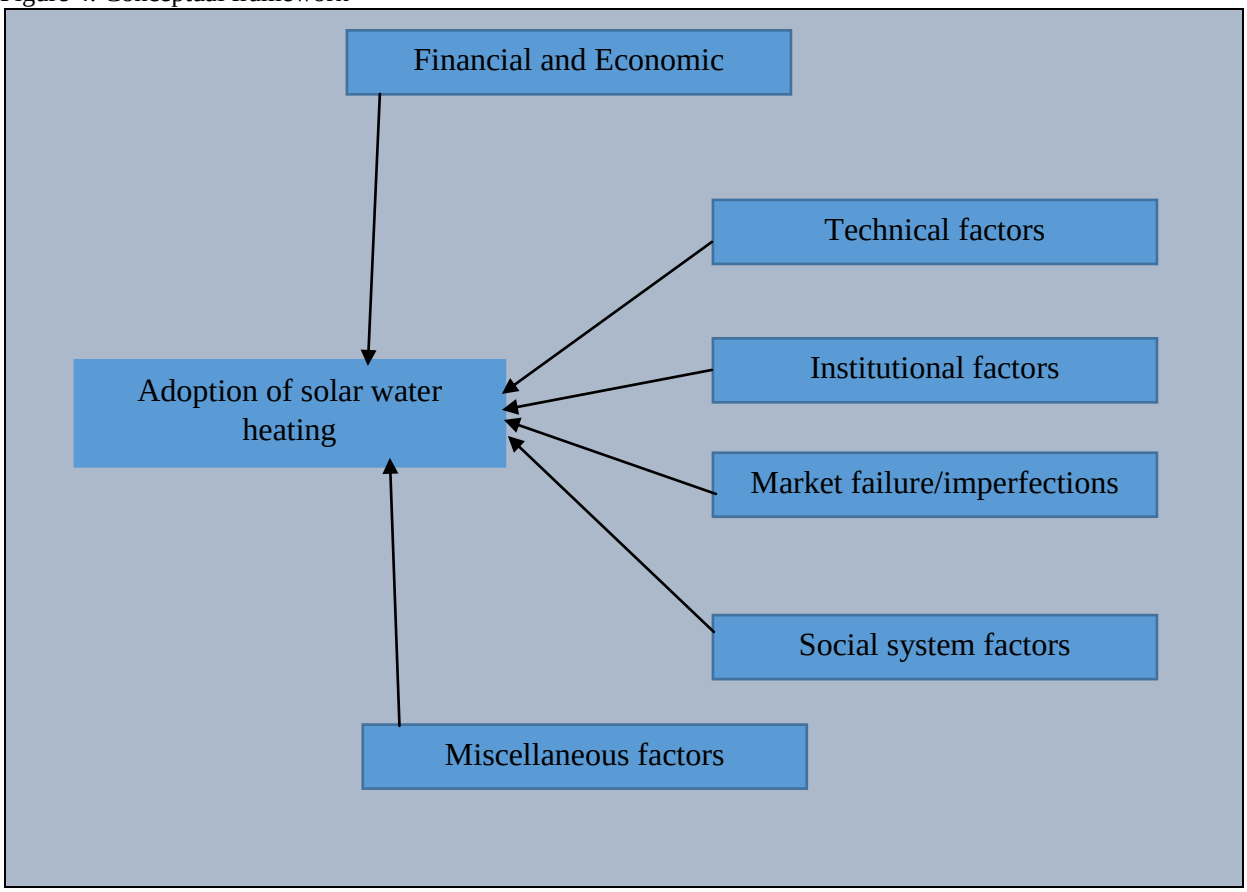
The main purpose of this research is to examine factors affecting adoption of solar water heaters in urban housing. The framework has been structured as follows:

Dependent Variable: the dependent variable in this study is the adoption of solar water heaters.

Independent variables: the independent variables in this study are the factors that affect adoption. These are financial and economic, technical, institutional, market failure/distortion, social system factors and miscellaneous factors.

The conceptual framework in this study is a synthesis of Rogers' (1994) adoption of an innovation theory and Painuly's framework for analysis of barriers to use of RET's. The framework borrows some components from each of the approaches.

Figure 4: Conceptual framework



Adopted from Painuly (2001) and Rogers (1994)

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter covers the mode through which the research was going to be conducted. It consists of a study site, population and sampling procedures, data collection and data analysis. These issues are discussed as follows.

3.2 Research Design

The study adopted a mixed research design. Such a research design allows the researcher to collect and analyse both qualitative and quantitative data. The quantitative data came from the household level interviews while the key informants were the primary source of qualitative data. Data from the two sources were used to complement each other in order to gain a deeper understanding of the factors affecting the use of solar water heating among households in Nairobi

3.3 Study Site

The study was carried out in three different constituencies of Nairobi County, i.e. Dagoretti North, Embakasi East and Ruaraka. The County is also the capital city of Kenya. The county is also the commercial and political capital of the country. Nairobi has a population of 3,138,369 people according to the national census of 2009 (KNBS, 2010). Nairobi occupies an area of about 700 km squared at the south-eastern end of Kenya's agricultural heartland. At 1600 to 1850 m above sea level, it enjoys tolerable temperatures year round (CBS 2001). The city experiences a rapidly increasing population. Nairobi is projected to top 3.8 million by 2015 (UNEP, 2009).

The study site was chosen because as the city grows and continues to experience rural urban migration and the population explosion, the demand for housing will continue to rise. The

importance of adoption of solar water heaters in these developments is important in the achievement of sustainable energy development in the country. This is because buildings have been identified as one of the main sources of GHG.

3.4 Population and Sampling

The unit of analysis in the study was the households in estates that have SWH systems installed. This was in order to provide an overview of the experience of the users in the initial phase of the Energy (Solar Water Heating) Regulations, 2012. The study population consists of the households in the county of Nairobi which were purposively sampled. A purposive sample allows the research to take into account the cases that have the required information with respect to the objectives of the study (Mugenda, 2008).

Households were therefore handpicked in relation to the required characteristics of this study which in this case is centred on estates where SWH have been installed. This technique was used in this research in order to ensure that the data that is collected was from the key players in the housing development field in the city.

The study targeted 120 households in Dagoreti North and Embakasi West Constituencies, and this was informed by the nature of the study, cost, and time considerations. However as a result of denial of access in some locations in the two purposively sampled sites, the research added Ruaraka Constituency into the sample. The final sample size of the study was 58, with 12 respondents from Embakasi West Constituency, 32 from Dagoreti North Constituency and 14 from Ruaraka Constituency. The constituencies were chosen due to the likelihood of them having contrasting socio-economic profiles of the household.

The research study sought to collect data from the household head or spouse to the household head or a senior member in the household in the absence of the household head or the spouse to

the household head. Key informant interviews were conducted with officials from the Ministry of Energy, Energy Regulatory Commission, two real estate housing developers' and three solar water heater distributors. The key informants selected for this study are those who have a key mandate in the Energy (Solar Water Heating) Regulations, 2012 and provided supplementary data to answer the research questions.

Bloor and Wood (2006) indicate that key informants were used in this study as they provide important understanding to the researcher… because they have a particularly rich knowledge… through their seniority or through their specialist roles in the setting. The key informants provided timely information on some of the trends in regards to the adoption of solar water heaters in Nairobi.

3.5 Data Collection

Data for the study was collected using different methods in relation to the research questions that have been identified. This process is referred to as triangulation. Triangulation and especially, data triangulation involves using multiple sources of data in an investigation (Hastings, 2010). The data for the first research question was collected through a key informant interview of the SWH distributors. The key informant interviews were conducted through the use of a semi structured interview. According to Bryman (2008), this method is flexible in that it gives the interviewee leeway to provide in-depth information on the subject at hand. It also provides the researcher with a guide in which to conduct the interview and ensure collection of data on all the relevant topics that need to be studied in the research.

The second and third research questions were collected through the use of a structured questionnaire which was to be filled by a senior member of the household (self-completion) as well as key informant interviews. Data was collected on the characteristics of the household,

possible knowledge on SWH, level of adoption and the major factors that have been identified as barriers to the adoption of solar water heaters.

3.6 Data Analysis

The data that was collected fell into either qualitative or quantitative techniques. Analysis of quantitative data was analysed through the statistical package of social sciences. This was undertaken in order to enable analysis of the data through use frequency distribution and cross-tabulations to explore the factors that influence adoption of solar water heaters. The qualitative data was thematically coded. This coding involves the segmentation, categorization, summary and reconstruction of qualitative data that allows for the analysis of qualitative data (Ayres, 2008).

3.7 Limitations of the Study

The study had several challenges and limitations. One of the limitations of the study was the denial of access to some of the study sites. This meant that the targeted number of respondents for the study could not be reached. Another challenge that was experienced was that some respondents complained that the questionnaire was too long. This challenge was overcome by informing the respondents that the data they provided would be key in providing remedies to the possible challenges that they had faced.

CHAPTER FOUR
STUDY FINDINGS

4.1 Introduction

This chapter presents the findings of the study in line with the research objectives. The data presented includes the basic characteristics of the respondents and their households, adoption of SWH systems and factors affecting their use. The survey data was supplemented by data from the key informants. The Key informants were individual's from the Ministry of Energy and Petroleum, Energy Regulatory Commission, real estate developers and SWH distributors. Where appropriate, charts have been used to illustrate the findings of the study.

4.2 Respondents and Households Background Characteristics

This section presents the background characteristics of the respondents and households studied. The basic characteristics that the study sought included the respondent's sex, age and citizenship status. The study also sought data on households from which the respondents were drawn such as the ownership status of their home, the number of residents in the household, the location of the household's residence, years spent in the residence and factors that they considered when selecting their residence.

The study targeted the household head or spouse to the household head or a senior member in the household in the absence of the household head or the spouse to the household head. The distribution of the respondents by sex shows that female respondents accounted for 70.7 percent of the total number. The male respondents accounted for 29.3 percent of the total number of respondents. This was as a result of more female respondents being available in their households when the study was being conducted in contrast to the male members of the households. This result has been indicated in Table 1.

The age bracket of most of the respondents of the study was between the ages of 29-38 years. Respondents in this age category accounted for 41.4 percent of the respondents in Table 1. This is in line with the demographics of urban areas where more young people seek gainful employment and economic opportunities. The age group between the ages of 39-48 years accounted for 31 percent of the total responses. The least represented age group in the study was between 49-58 years accounting for only 6.9 percent of the respondents.

Table 1: Sex, age, and citizenship status of the respondents

Variable	**Indicator**	**Frequency %**
Sex	Male	29.3
	Female	70.7
Age in years	18-28	20.7
	29-38	41.4
	39-48	31
	49-58	6.9
Citizenship	Kenyan	75.9
	Other East African Resident	5.2
	Foreign Resident	13.7
	Foreigner	5.2

The study classified the citizenship of the respondents into four classes. These four classes were:-

- Kenyans - Citizens of the Republic of Kenya
- East African residents - Citizens from the East African region countries
- Foreign Residents - foreigners who have permits to work and reside in Kenya

- Foreigners - those in the country on tourist visas

Kenyan citizens accounted for 75.9 percent of the total respondents of the study. Other East African residents and Foreigners were the least represented groups accounting for an equal 5.2 percent each of the total respondents.

The respondents also provided information on the location of their residences and this indicated in the Table 2. Residents who lived in Dagoreti North Constituency accounted for 58.6 percent of the total. Ruaraka Constituency and Embakasi West Constituency accounted for 24.1 and 17.2 percent of the total number of the respondents respectively.

The households home ownership status was also analyzed. Respondents were to choose between home owner and tenant. Tenants accounted for 63.8 percent of the total respondents and this is illustrated in Table 2. Home owners on the other hand accounted for only 36.2 percent of the total.

Table 2: Location of residence and ownership of other residence in Kenya

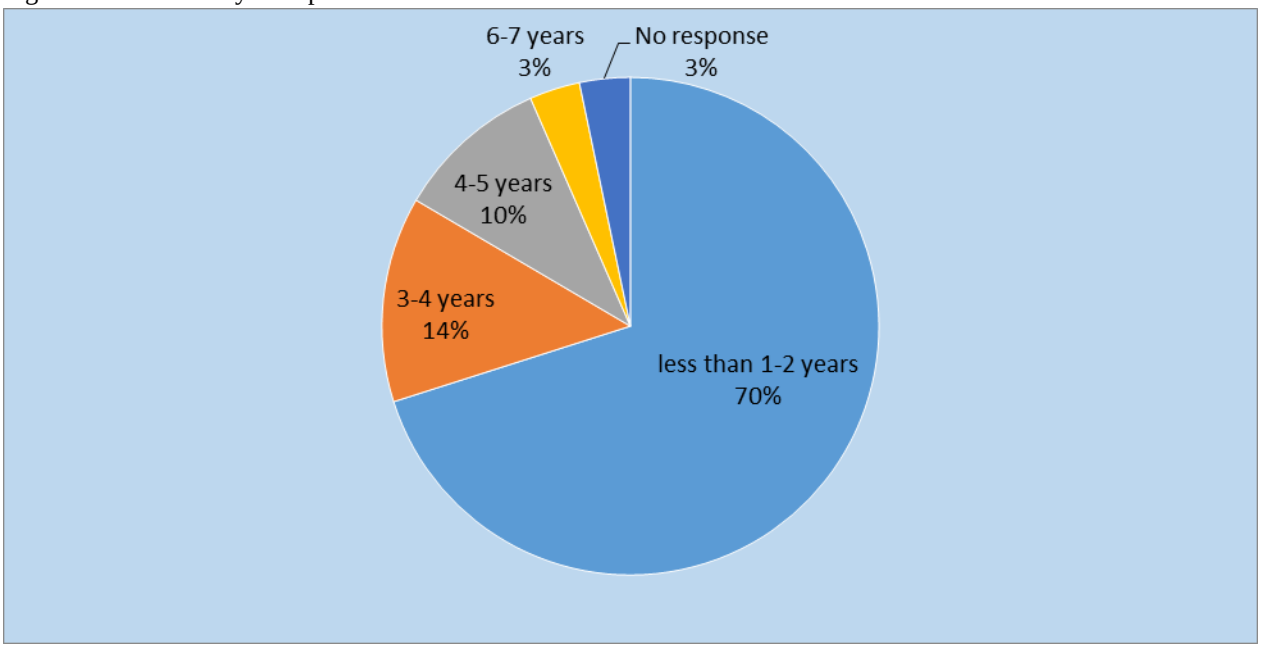
Variable	Indicator	Percentage
Location of Residence	Dagoreti North Constituency	58.6
	Embakasi West Constituency	17.2
	Ruaraka Constituency	24.1
Households Home Ownership Status	Owner	37.2
	Tenant	63.8
Ownership of other residence in Kenya	Yes	39.7
	No	56.9
	No response	3.4

The study also sought to find out whether the respondents owned other residences in the country, 56.9 percent of the respondents stated that they did not have any other residence in the country.

On the other hand 39.7 percent of the respondents stated that they had other residences in various counties in the country. These results indicate that a majority of the respondents did not own the houses that they were occupying and this was indicated by a high proportion of them renting.

The study also investigated on the length of stay in their households by the respondents in their residences as illustrated in Figure 5. Respondents who had lived in their houses for less than one year to two years accounted for 72.4 percent of the total number of residents. In contrast only 3.4 percent of the respondents stated that they had lived in their residences, which had SWH systems for six to seven years. This large margin could be seen to indicate that the availability of households with SWH systems being installed has increased.

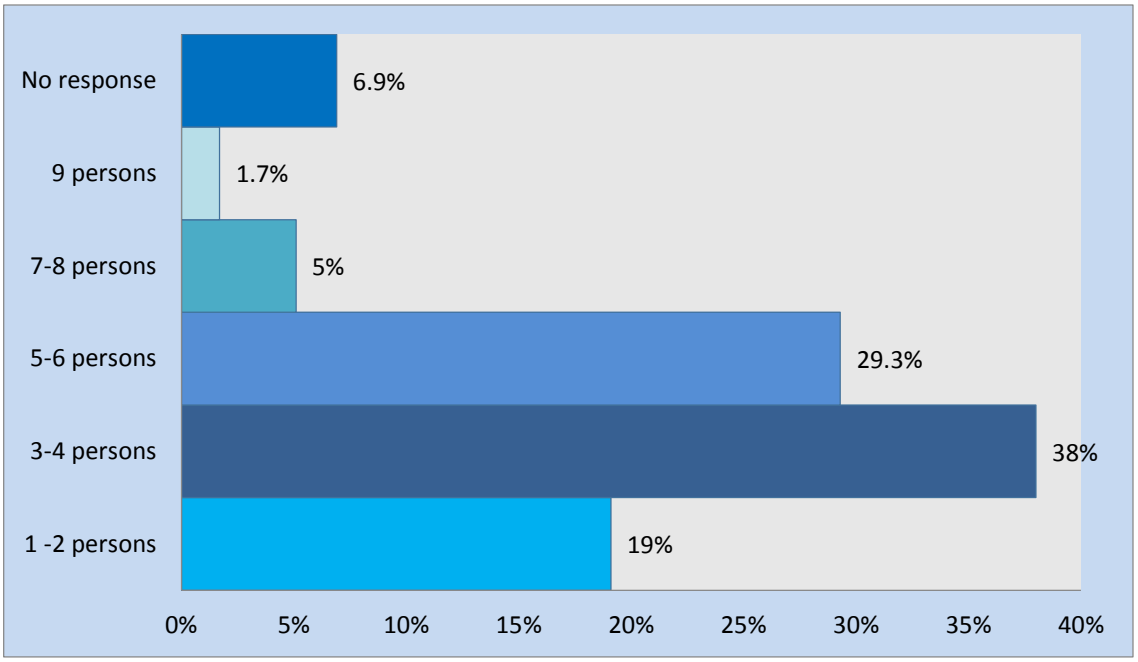
Figure 5: Number of years spent in the residence



The study sought to identify the number of residents each household had as this was seen to have possible impact on the use of the SWH system. The households with 3-4 persons constituted 38 percent of the total number of respondents. This result may be an indicator of smaller household sizes in the area understudy. This can be further illustrated whereby households that constituted 1

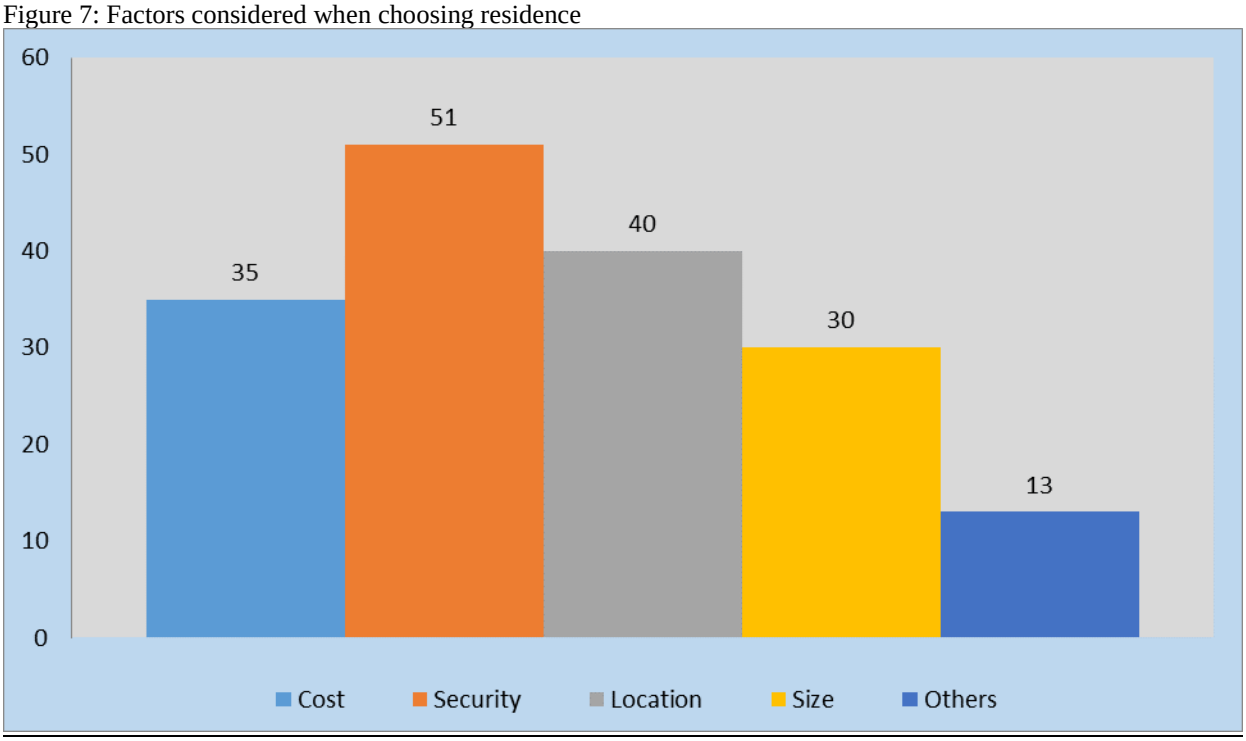
– 4 persons constituted 57.1 percent of the total number of respondents for the study. Households that constituted 7 – 9 persons constituted only 6.7 percent of the total number of respondents.

Figure 6: Number of resident's in household



Respondents were also asked to provide information on the factors they considered when choosing the locations of their residences. The data which is shown in Figure 7 indicates that 51 respondents stated that they considered security to be one of the key features that they considered when selecting their residence. This was followed by location, whereby 40 respondents stated that it was an important factor when selecting their residence. Cost was considered by 35 respondents as an important factor when selecting their residence. Other factors considered included closeness to schools, shopping malls, and workplace and this was pinpointed by 13 respondents.

Figure 7: Factors considered when choosing residence



Note: Figures are in absolute terms

4.3 Characteristics of SWH

The study sought to find out about the basic characteristics of SWH systems. This data was collected from the household level respondents, the key informants and secondary literature especially on the standards specifications for the SWH by the Kenya Bureau of Standards. The key informants from the SWH distributing companies stated that they supplied various SWH systems. They classified the systems as either direct or indirect systems and also stated that the systems could be either flat panel systems or vacuum tube systems.

According to the Kenya Bureau of Standards (KEBS) Solar Heating Systems for Domestic Hot Water - Code of Practice, SWH are classified into two general categories. Systems are classified as either active systems, which use a pump to control water flow or passive systems which use no pump. These systems can either be direct or indirect (Kenya Bureau of Standards, 2009).

Direct systems are whereby the potable water; drinkable water, circulates from the storage tank to the collector and back to the storage tank. Thus, the heat collecting fluid is the same potable water that is in the water heater. In contrast indirect systems, the fluid circulates through the collector may be water or it may be another heat transfer fluid. This heat collecting fluid never comes in contact with the potable water in the storage tank. Instead, it transfers heat to the potable water through a heat exchanger (Kenya Bureau of Standards, 2009).

SWH are thus classified into three distinct categories. The first category is the active direct system which uses differential controlled, photovoltaic controlled and timer-controlled systems. The second category is the active indirect systems which uses either indirect pressurized systems or the drain-back system. Lastly we have the passive direct and indirect systems which uses the thermo-siphon system (direct or indirect), integral collector storage system and the batch system (Kenya Bureau of Standards, 2009). The classification of SWH systems by the Key informants from the SWH companies indicated that the systems that were in the country were in line with the standards set by the KEBS.

The key informants stated that the cost of the SWH systems was high in comparison to other water heating systems. It was stated that the price of SWH systems ranged from 95,000/- Ksh. for a 150 liter capacity system and 170,000/- Ksh. for a 300 liter capacity system. This cost was independent of the cost of installation which varied form 15,000/- Ksh. and 35,000/- Ksh among the SWH distributors sampled.

According to the respondents the SWH systems were easy to use. A total of 89.7 percent of the respondents stated that the system was easy to use which could be a pointer to a technology that is not complicated to use. One respondent stated that “all you have to do is turn the tap on.” However 8.6 percent stating that it wasn’t easy to use as indicated in Table 3. In terms of its

usefulness a majority of the respondents that is, 62.1 percent stated it was very useful while 5.2 percent stated that the system was not useful.

Table 3: Usefulness and ease of use of SHW systems

	Usefulness of SWH systems			
	Very Useful	Useful	Moderately useful	Not useful
Frequency %	62.1	25.9	6.9	5.2
	Ease of use of SWH system			
	Yes	No	No response	
Frequency %	89.7	8.6	1.7	

4.4 SWH Adoption

In order to identify the adoption of the SWH systems the study sought to identify the household's use of various energy sources in their daily activities. This ranged from electricity, Liquid Petroleum Gas (LPG), firewood, charcoal and RET's. Electricity was seen to be the major energy source used by the respondents in their daily lives and is indicated in the Table 4. The findings show that 50 percent of the respondents used electricity as an energy source in their daily routines very highly. This was followed by 22.4 percent of the respondents stating that they used it highly and 19 percent stating that they used the system moderately. Only 3.4 percent of the respondents stated that they used the system slightly.

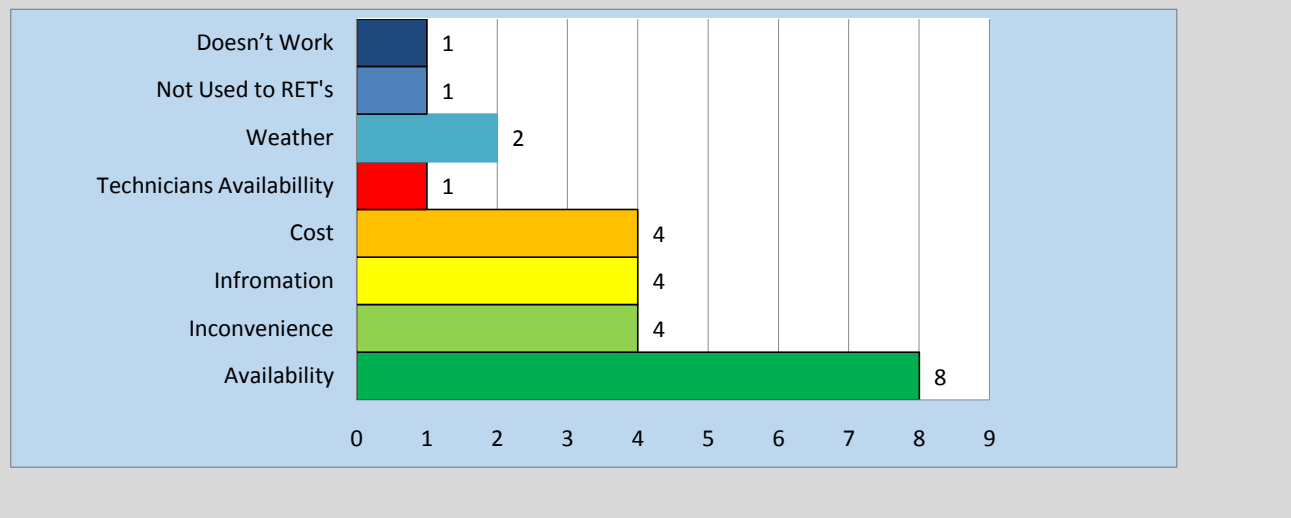
In contrast, only 17.2 percent of the respondents stated that they used RET's very highly and a similar percentage stated that they used the technology highly as can be seen in Table 4. A total of 15.5 percent of respondents stated that they did not use RET's. The respondents gave various factors which they stated had affected their use of RET systems. In the Table 4 respondents indicated that the major factor that affected their use was the availability of RET's. Information,

cost and inconvenience were cited as the major factors that affected the use of the RET's by the respondents.

Table 4: Energy source use by percentage

Variable	Don't Use	Slightly	Moderately	Highly	Very Highly	No Response	Total
Electricity	-	3.4	19	22.4	50	5.2	100
LP Gas	5.2	5.1	22.4	24.1	24.1	19	100
Firewood	72.4	8.6	-	-	-	19	100
Charcoal	39.7	29.3	13.8	-	-	17.2	100
RET's	15.5	22.4	12.1	17.2	17.2	15.5	100

Figure 8: Factor affecting use of RET's



Note: Figures in absolute terms

The study also sought to identify the hot water needs of the households for various activities as indicated in the Table 5. The activity that households used hot water for mostly was bathing with 56.9 percent and 19 percent of the respondents stating they used it very highly or highly respectively. Cooking was the second activity which household stated they used hot water for very highly or highly with 22.4 percent and 8.6 percent of the respondents respectively.

The activity that respondents stated they used hot water for least was cleaning the house, with 44.8 percent stating they used hot water for this activity very slightly only. Drinking and laundry were also activities where the hot water need according to respondents was low, with 39.7 percent and 36.2 percent of respondents stating this.

Table 5: Hot Water needs use in households

	Very Slightly %	Slightly %	Moderately %	Highly %	Very Highly %	No Response %	Total
Cooking	15.5	12.1	10.3	8.6	22.4	31.0	100
Laundry	36.2	6.9	8.6	8.6	1.7	37.9	100
Cleaning the House	44.8	3.4	6.9	3.4	1.7	39.7	100
Drinking	39.7	6.9	10.3	5.2	10.3	27.6	100
Bathing	6.9	1.7	8.6	19	56.9	6.9	100

The study sought to find out the level of adoption of SWH by investigating the activities that households used their SWH systems for, the results are indicated in the Table 6. The respondents stated that the activity which they used the SWH system mostly for was for bathing, with 96.6 percent of the respondents indicating this. In contrast respondents did not use the SWH system for the other activities despite in Table 5 indicating some degree of use of hot water. The other activities that the respondents stated they used the SWH system to provide hot water for was washing dishes and their pets.

The significantly low use of the SWH system by the respondents may indicate that the system is incompatible with the needs of the users. Rodgers (1983) states that compatibility is the degree to which an innovation is perceived to be consistent with the existing values, past experiences and needs of potential adopters. An idea can be compatible or incompatible with the socio-cultural

values and beliefs, with previously introduced ideas, or with clients' needs for innovation. The low percentage of use for other needs other than bathing indicates that the SWH system may be incompatible with the needs of the respondents.

Table 6: Use of SWH to meet hot water needs

	Use %	Don't Use %
Cooking	6.9	93.1
Laundry	12.1	87.9
Cleaning House	13.8	86.2
Drinking	1.7	98.3
Bathing	96.6	3.4
Other	10.3	89.7

In the analysis, the usefulness of the SWH system as indicated in Table 3, 5.2 percent of the respondents stated that they did not find the SWH system to be useful. However 94.8 percent of the respondents stated that they found the SWH system to be useful in varying degrees. They stated that the system was either very useful, useful and moderately useful.

With regards to ease of use, 89.7 percent of the respondents stated that the SWH system was easy to use. However 5.6 percent of the respondents stated that they did not find the systems easy to use. According to Davis (1986) TAM, users' perceived ease of use of a system was one of the major determinants of whether they would use or reject a system. Using this analysis, it is possible to state that the high number of respondents who stated that the system was easy to use would indicate that there is potential for significant adoption of the SWH systems.

A cross tabulation of the usefulness of SWH and SWH ease of use of SWH in Table 7 indicates that the respondents who found the system easy to use, considered the system to be very useful or useful. The respondents who found the system difficult to use also considered the system to be useful, moderately useful and not useful.

Table 7: Cross tabulation of usefulness of SWH and ease of use of SWH

Usefulness of SWH	**SWH Ease of Use of SWH**			**Total**
	Yes	**No**	**No Response**	**Yes**
Very Useful	36	0	0	36
Useful	13	2	0	15
Moderately Useful	2	2	0	4
Not Useful	1	1	1	3
Total	52	5	1	58

With regards to use of other water heating systems as indicated in Figure 9, 63.8 percent of the respondents stated that they used other water heating systems in their houses. The respondents stated that the water heating systems that they had in their households were instant hot water shower systems and kettles or alternatively they used electricity and gas to heat their water. Only 36.2 percent of the respondents stated that they did not use other water heating systems in their households. It is possible to asses from this data that SWH systems may be considered by household's to be not effective in meeting their hot water needs.

A cross tabulation of ease of use of SWH and use of other water heater on Table 8 indicates that despite respondents finding the system easy to use, a majority of the respondents stated used other water heating systems. Indeed 37 respondents stated that they had other water heating systems in their households. Of these, 31 respondents had stated that they found the system easy to use whilst only 21 respondents stated did not have other water heating system.

Figure 9: Use of other water heating systems

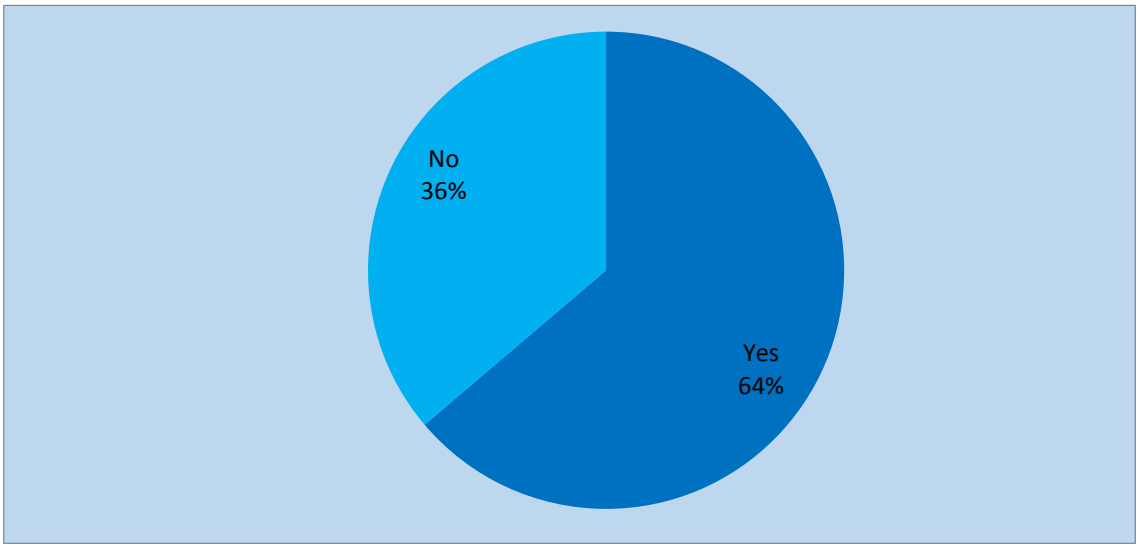


Table 8: Cross tabulation of SWH ease of use and use of other water heaters

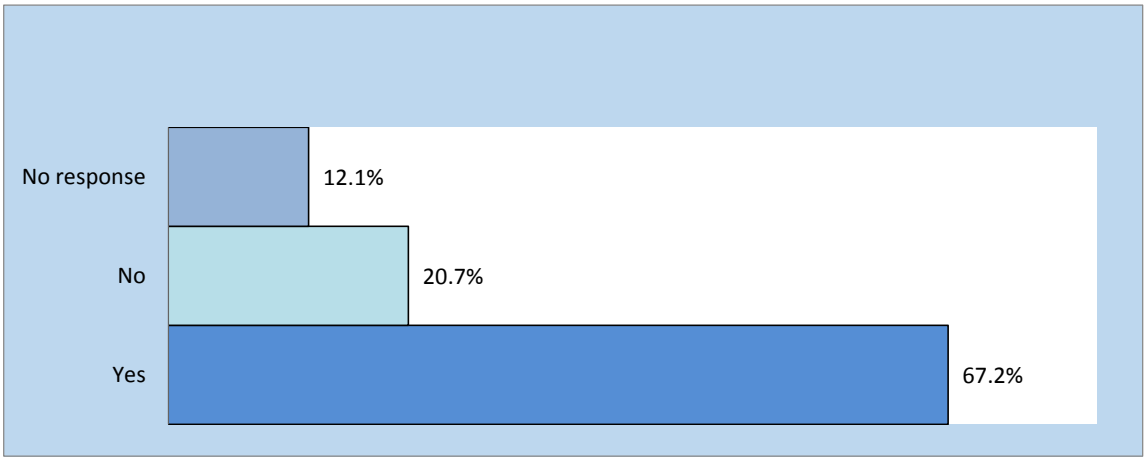
		Other Water Heater		**Total**
		Yes	No	Yes
SWH Ease of Use	Yes	31	21	52
	No	5	0	5
	No Response	1	0	1
	Total	37	21	58

The use of other water heating systems in the households sampled may indicate that SWH may lack the relative advantage that Rodgers (1983) identified. Rodgers (1983) states that relative advantage is the degree to which an innovation is perceived as being better than the idea it supersedes. This indicates that the SWH system may not have a significant relative advantage over the current water heating systems.

The study sought to investigate whether the use of SWH had led to a reduction of the respondent's electricity bill. A total of 67.2 percent of the respondents stated that the use of the SWH system had led to a reduction of their electricity bills as indicated in Figure 10. Only 20.7 percent of the respondents however stated that there was no reduction in their electricity bills despite the use of SWH.

Respondents were asked to approximate the savings on their electricity bills that they may have gained from using SWH system and this was estimated to range from at least 10 percent to as high as 80 percent. This indicated that the use of SWH systems had significantly led to reduction of the electricity use of some of the households studied which is in line with the government's goal of reducing the electricity demand on the national grid.

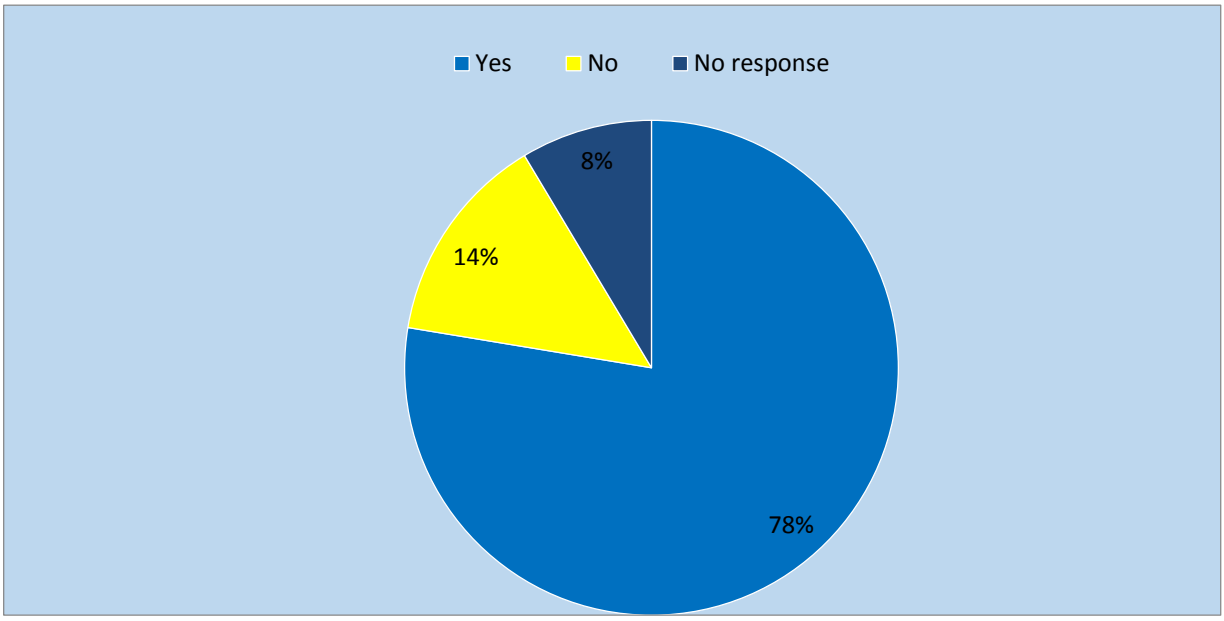
Figure 10: SWH and reduction of electricity bill



A significant number of respondents, 77.6 percent stated that they used other energy efficiency products in their household's as illustrated in Figure 11. However, 13.8 percent stated that they did not have any other energy efficiency products in their houses. The significantly high proportion of users who used energy efficient products indicated that there was awareness on the need to reduce energy use by the respondents. This may have also played a role in the reduction of the household's electricity bills as illustrated in Figure 10.

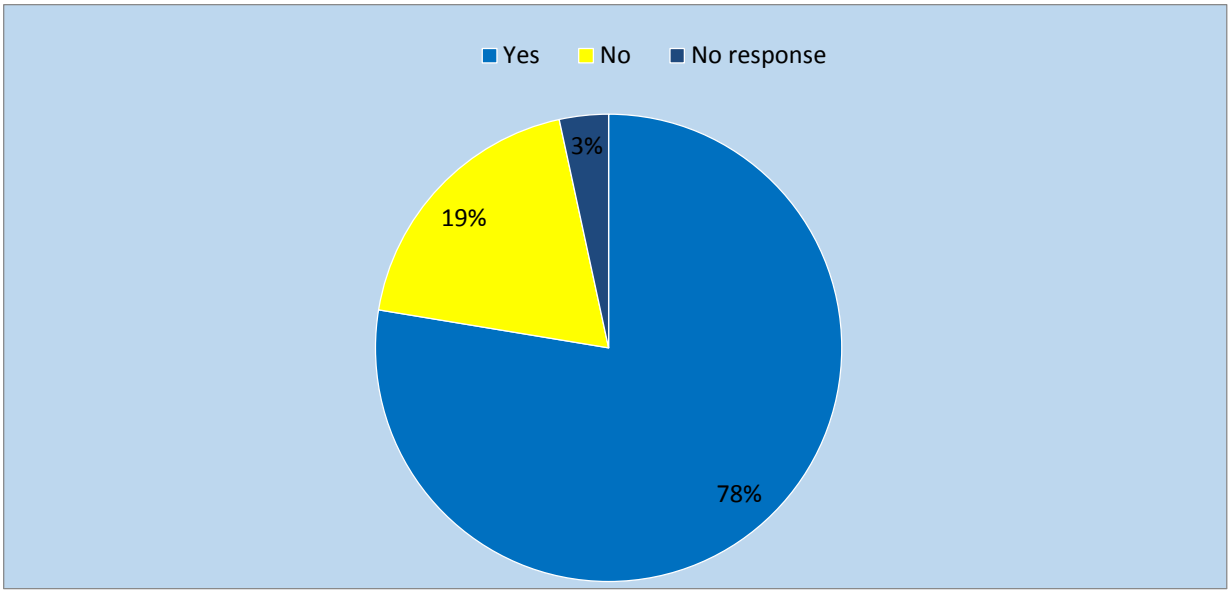
According to Davis (1985) attitudes of users to use or reject the use of a system were determined by perceived usefulness and perceived ease of use. A total of 77.6 percent of the respondents stated that they were satisfied with their SWH, however 19.6 percent of the respondents stated that they were not satisfied with their SWH systems.

Figure 11: Use of other energy efficient products



The study sought to inquire the level of satisfaction of the SWH system by the respondents. A total of 78 percent of the respondents stated that they were satisfied with their SWH system. However a total of 19 percent of the respondents to the study stated that they were not satisfied with their SWH system. This is illustrated in Figure 12.

Figure 12: Satisfaction with SWH System



4.5 Factors Affecting SWH Adoption

The study identified various factors that have affected household's adoption of SWH systems in the County of Nairobi. The analysis of the factors was guided by the conceptual framework developed from Painuly's (2001) framework for identifying factors affecting adoption of renewable energy technologies and Rogers' theory of diffusion. The factors identified were the lack of information/awareness, financial and economic factors, technical factors, institutional factors and social system factors.

4.5.1 Lack of Information and Awareness

The study sought to identify the factors that affected adoption of SWH in households. Awareness levels on the benefits, government SWH policies, and environmental conservation awareness were explored as illustrated in Table 9. It was stated by 58.6 percent of the respondents that one of the factors that had affected the use of the SWH system significantly among the respondent's households was the awareness of benefits of the system. Similarly, 43.1 percent of the respondents stated that environmental conservation awareness had significantly guided their use of the SWH system.

It was noted that awareness of government SWH policy was stated by 32.8 percent of the respondents as not having affected their use of SWH systems at all. This could be attributed to the lack of information by the public on the use of SWH systems and their benefits to the people. In the literature reviewed it had been stated that a key barrier to adoption of technology was a lack of awareness and understanding of the technologies being introduced. The high level of awareness among the respondents indicated that this had a significant impact on the use of the SWH system.

Table 9: Information and awareness effect on use of SWH system

Variables	Significantly	Insignificantly	Not Sure	Not at all	No response
	Data in %				
Awareness of benefits of SWH	58.6	3.4	8.6	15.5	13.8
Awareness of Government SWH policy	17.2	6.9	29.3	32.8	13.8
Lack of information and awareness	24.1	17.2	15.5	27.6	15.5
Environmental conservation awareness	43.1	5.2	10.3	22.4	19

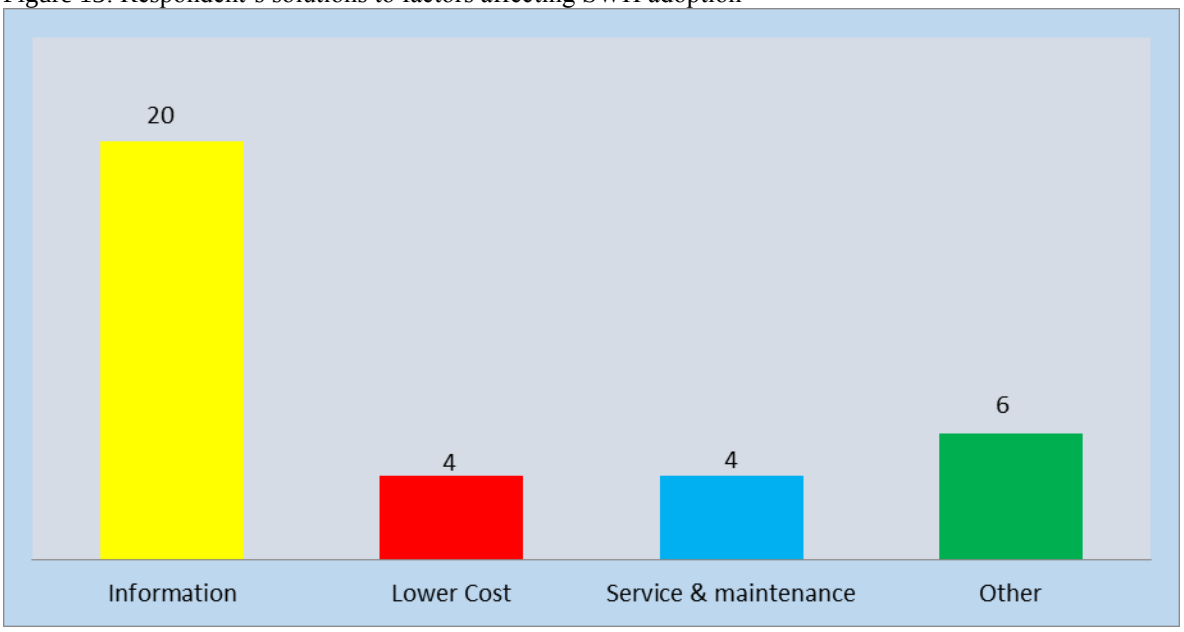
This can be illustrated whereby only 17.2 percent of respondents stated that awareness of Government SWH policy had a significant effect on their use of SWH by households. According to Blenkinsopp et al., (2013) the lack of awareness had significant implications on the adoption of SWH systems in the daily use by household's. This is because if the target group is not aware of the regulations and importance of the policy the user's lack of compliance will affect the adoption of the technology.

Moreover, key informants identified lack of information and awareness as the major factor affecting adoption of SWH. It was stated that this had affected the adoption of SWH by households since there was limited availability of information on the use and benefits of the technologies to the general public. One key informant stated that "people believe that SWH systems are foreign, expensive and they don't work." It was suggested by another key informant that there was need for the government agencies and the private sector needed to collaborate in disseminating information on the use of SWH to the public.

According to Painuly's (2001) framework for identification of barriers penetration of RET's the lack/low level of awareness, inadequate information on product, technology, costs, benefits and potential of the RET's needed to be addressed. The presence of this barrier also indicates the need for agencies involved to be equipped to provide more information to the public.

Respondents to the questionnaire were asked on what possible solutions they would provide to address use of RET's and as indicated in Figure 13, 20 respondents stated that dissemination of information on the use of SWH would provide users with important information to increase effectiveness and use.

Figure 13: Respondent's solutions to factors affecting SWH adoption



Note: Figures in absolute terms

4.5.2 Financial and Economic Factors

The key informants stated that several financial and economic factors played a role in affecting adoption of SWH by households. They stated that the cost of the SWH systems was a major factor preventing households from adopting solar water heaters. A Key informant from one of the SWH distribution companies stated that, "the prices of SWH systems range from as low as Ksh 95,000/- for a 150 liter capacity system and as high as Ksh. 170,000/- for a 300 liter capacity domestic SWH system." This cost is independent of the cost of installation which vary from Ksh, 15,000/- and Ksh, 35,000/- among the SWH distributors sampled.

With regard to the financial cost of the SWH systems, a key informant stated, "the SWH system prices are affected by the international market. The developed countries are also integrating SWH systems into their buildings and this has increased the demand for the products. Due to our low income per capita, the target market cannot afford the system."

It was indicated by several of the key informants that there was a need for the country to develop credit facilities for potential SWH system consumers, in which households can be allowed to purchase the equipment and pay for it in affordable installments. It was suggested that a majority of household's would be unable to afford the system considering the prices of alternative water heating systems, this was illustrated whereby one informant stated that "you can get an instant hot water shower system for around Ksh. 1,500/- to Ksh. 10,000/- which is significantly lower than the cost of a SWH system."

Furthermore, as illustrated in Table 10, 31 percent of the respondents stated that prices of alternative water heating systems had affected their use of the SWH system significantly. Several key informants stated that access to credit for the SWH systems would enable the uptake of the systems to increase and make the SWH regulations successful. Some respondents suggested that lowering of the price would have a significant impact on the adoption of SWH systems.

Table 10: Economic and financial factors

Variables	Significantly	Insignificantly	Not Sure	Not at all	No response
Prices of alternative water heating technologies	31	5.2	25.9	20.7	17.2
Savings on energy cost	53.4	5.2	13.8	13.8	13.8

The respondents to the study stated that savings on energy costs had played a significant role in their use of SWH system. 53.4percent of the respondents stated that this was a significant factor

determined their use of their SWH system. In contrast, only 13.8 percent of respondents stated that savings on energy costs had not affected their use at all of the SWH system.

With regard to the tax exemptions that the Government of Kenya (GoK) is currently providing for solar energy systems, it was indicated by a key informant that the Kenya Revenue Authority (KRA) was reviewing the tax exemptions offered to solar energy systems. This was because there was an argument that the benefits of the tax exemption were not trickling down to the consumers as intended by the exemptions.

The key informant also stated by that "there needs to be clarity on what the tax exemption for renewable solar energy systems covered. The exemption has been made to seem to cater to only to Solar PV and not to SWH. Even the components of Solar PV systems are not covered" The respondent indicated that when one of his SWH system components broke down, he had to import and there was no exemption on the components.

4.5.3 Technical Factors

The key informants stated that there were several technical factors that had affected the implementation of the SWH regulations. The first factor that was stated to hinder the adoption of SWH was the quality of the products that were in the market. It was noted that since the regulation was gazetted there was a proliferation of substandard systems in the market. The key informants from SWH distributors stated that they had noted this especially when they went for service and maintenance of SWH. One of the key informants from the SWH system stated "the substandard systems are affecting our business. Once customers are deceived into buying counterfeit systems and it doesn't work. They inform others that the system doesn't work and this creates a negative perception of the system."

It was also stated that there was a widespread plumbing culture in the country where most houses used a single line system; this is whereby all the water needs of a household are serviced by a single plumbing line. This had affected households from installing SWH systems since it requires an independent line for hot water to work effectively. One of the informants stated that "there is little use of a SWH system in a single line system. There is no use flashing your toilet with hot water." This had affected the possibility of the use of SWH in various houses in the county.

The key informants from the SWH distribution companies also stated that roofing design was a significant factor that affected the adoption of SWH by households. This was especially where the structure of the roof could not handle the weight of a standard SWH system, and additionally there was a minimum angle in which the system could be installed on. It was stated that there was a need for roofs to be able to bear the weight of the structures. A key informant stated that "there is need for the considerations of the SWH system to be considered during the construction phase of the building rather than as an afterthought."

Other factors that were found to affect the use of SWH were the waste of water and low water pressures experienced in parts of the city. The systems were stated to waste a lot of water as individuals waited for the water to warm up before they could access the hot water in the system. Several respondents stated that they estimated the amount of time for water to heat up ranged from at least three to ten minutes. This resulted in a lot of waste of water. Several respondents as reported insulation of water pipes from the SWH system to reduce this wastage of water.

Low pressure was also found to affect the SWH systems by not ensuring there is enough water to be heated. This affected the availability of water to the households. A key informant stated, "in some areas where there is low pressure, the users of the SWH system have to purchase water

pumps in order to effectively use the systems." This implies that some households have to bear further costs on pumps to ensure that the systems work properly.

The informants stated that to counter some of the challenges, certain changes would require to be undertaken. This may include the enforcement of quality standards by the Kenya Bureau of Standards (KEBS). This it was stated would ensure that the quality of products that come into the country are of the requisite standard.

Informants also stated that there was need for the re-modification or implementation of appropriate design of the roofs. It was stated that especially in the houses under construction the engineers and architects would require to consult with the companies that supplied the SWH systems. This would arrest the issue in which the SWH systems could not be installed due to inappropriate roofing designs.

It was also stated by the informants that there was a need for plumbers to be certified. This was because a good plumbing system was necessary for the SWH system to work appropriately. Certifying plumbers it was suggested would increase the quality of work done and this would not hinder the application of the SWH system by households.

A key informant indicated that the ERC was currently engaging the National Industrial Training Authority (NITA) to develop a curriculum for SWH installers. NITA is a state corporation that is mandated to promote the highest standards in the quality and efficiency of industrial training in Kenya and ensure adequate supply of properly trained manpower at all levels in the industry (NITA, 2015). This, it was stated would increase the skill set of the technical individuals who are required to undertake the task of installation of SWH and Solar PVC systems. The key informant

indicated that the ERC was at the date of the interview had registered 50 SWH installers and 200 Solar PVC installers only.

Respondents stated that several technical factors had affected their use of SWH systems as indicated in Table 11. The technical factor that was cited respondents as being the main factor that affected the use of the SWH system was product reliability with 32.8 percent of the respondents stating that this had affected the use significantly with only 19 percent stating that this had not affected their use at all. The number of residents in a household was also cited as being significant with 27.6 percent of respondents stating this.

Table 11: Technical factors affecting adoption of SWH systems

Variable	Significantly	Insignificantly	Not Sure	Not at all	No response
	Data in %				
Corrosion	12.1	10	25.9	32.8	19
Difficulties with self – maintenance	12.1	19	15.5	41.4	12.1
Malfunctions	17.2	19	25.9	25.9	12.1
Number of Residents in Household	27.6	15.5	15.5	29.3	12.1
Overheating	15.5	22.4	12.1	39.7	10.3
Poor Installation	10.3	12.1	17.2	43.1	17.2
Product Reliability	32.8	15.5	15.5	19	17.2
System undersized for needs	15.5	10.3	19.0	41.4	13.8
Under heating	15.5	34.5	13.8	22.4	13.8
Rate and flow of water	29.3	15.5	10.3	31	13.8

Among the factors that had not affected the use of the system were poor installation which 43.1 percent of respondents stated had not affected their use of the SWH system. Difficulties with self-maintenance were also indicated by 41.4 percent of respondents as not having affected their use of the SWH system significantly. However several respondents as indicated in Figure 13 stated that consistent service and maintenance of the SWH systems would be address some of the

factors that had been identified affecting use of SWH systems by households. Overheating and corrosion were also cited as not having had affected the use of the SWH systems significantly.

4.5.4 Institutional Factors

Institutional factors affecting the adoption of SWH systems also identified. These are factors which are affected by institutions which are mandated to carry out various tasks in relation to the SWH regulations. Several institutional challenges were identified by the key informants. The main institutional challenge that was stated was the capacity of the ERC. It was stated by one of the informants that "ERC does not have the capacity to effectively ensure that SWH regulations are fully adhered to. You can look at the number of houses that have been built over the past few years since the regulations were gazetted that don't have SWH. They are many buildings without the SWH system and ERC cannot cope as they have other tasks which they also undertake."

A possible solution to the issues addressed was that the human capacity of the ERC needed to be raised. This would ensure that they could monitor and adequately enforce the regulations as prescribed by the SWH regulations. Rogers (1983) states that evidence suggest that the extent of a change agent's efforts influences adoption rates of innovations.

The Kenya Power and Lighting Company (KPLC) which has a key role in the enforcement of the regulation were stated to have a conflict of interest. On one hand it is stated that the organisation is a business and its core mandate is to its stakeholders. On the other hand, the organisation is also tasked in the regulation not to connect buildings without SWH systems to the national grid. A key informant stated "KPLC is a business, it is difficult to mandate it to enforce the regulations which go against its own interests."

It was also stated that there was need to have discussions with the KPLC to determine the best way forward in which it could undertake its mandate with regard to the SWH regulations. This would be important in ensuring that the organization fulfilled its obligations to the regulations as well as conducting its mandate of supplying power to Kenyans.

Key informants stated that the KEBS needed to enforce the requisite standards for SWH. It was stated that the quality of some of the SWH systems that had been imported into the country did not meet the required standards. SWH system distributors stated that they had stopped servicing systems that they did not install. This was because some of the systems despite repair still continued functioning poorly. This had resulted in households who had installed the systems claiming the distributors were extorting them.

Further, the respondents stated that there was need for information and awareness levels should be raised among the public. These institutions also face the additional charge of ensuring that the public becomes well informed about the use of the SWH system.

One Key informant stated that "there is too much government bureaucracy, when seeking certification for activities. I am unwilling to take myself to government agencies to conduct an application for the clean development mechanism" This was in response to an enquiry on whether their housing developments had applied for certification for consideration in Clean Development Mechanism projects. The respondent stated that there was need for simpler mechanisms of working with government agencies to be developed.

4.5.5 Social System Factors

It was stated that there were some estates where the regulations barred individuals from installing any unsightly things on their roofs. One distributor stated, "I can tell you, there is an estate in Embakasi where the estate regulations prevent installation of SWH systems." This, it was stated

was not limited to one area but also in other parts of Nairobi where distributors and their clients had been denied the right to install the SWH systems.

Key informants stated that there was a need for the importance of the SWH regulations to be disseminated to resident associations in order to ensure that the SWH systems were integrated into households. Integration of residence associations in awareness drives would be important in changing some of the statutes that have been set for residents in certain areas. This can be linked with the market failure factor of information awareness where it was seen there is need to raise awareness to the general public.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of study findings, conclusions and recommendations. The first section presents summary of findings based on the three key research objectives. The second section presents conclusions drawn from the study findings. Lastly, the chapter concludes with presentation of recommendations for policy and areas for further research.

5.2 Summary

The study was conducted as an exploratory research to investigate the factors that have affected the adoption of SWH among households in Nairobi County. The study was guided by three key research objectives: identify characteristics of SWH; establish the level of adoption of SWH by households; and identification of factors that affecting adoption by households in the County of Nairobi.

The justification of the study was based on the need to contribute to the existing body of knowledge on policy adoption by investigating the factors that had affected the adoption of The Energy (Solar Water Heating) regulations, 2012. This is in line with the country's development goal of integrating renewable energy and significantly reduce the cost of energy as well as mitigate some of the effects of climate change.

The study was guided by theoretical literature from Rodgers adoption of innovation and Azjen and Fishbein's (1980) technology adoption model. The study also reviewed empirical literature on studies that had been conducted across the third world countries on adoption of various RET's in order to provide a relative context. The issues that were identified in the empirical literature

were divided into themes according to Painuly's (2001) barriers to renewable energy penetration's framework for analysis.

The research developed a conceptual framework that was used to examine the factors that had affected the adoption of SWH. The major thematic areas that were in the conceptual framework were information and awareness factors, financial and economic factors, technical factors, institutional factors, and social system factors.

The study was undertaken in Nairobi County in three different constituencies i.e. Dagoreti North Constituency, Embakasi West Constituency and Ruaraka Constituency. The study sites were chosen purposively based on the existence of projects that had installed SWH systems in their housing development projects.

The study aimed to study a sample of 120 households. However following denial of access by some residential associations through their estate officials, the study's response rate was limited to only 58 respondents. The data can therefore only be used to indicate the possible trends and challenges that are affecting the adoption of SWH by households.

Data was collected from key informants as well as households. Key informant interviews were conducted with key stakeholders from the Ministry of Energy and Petroleum, Energy Regulation Commission, Real Estates Developers as well as SWH distributors to collect qualitative data. This was based on the various roles in which they undertake in relation to The Energy (Solar Water Heating) regulations, 2012. Data from households was collected through a survey questionnaire, which sought to establish their experience using the SWH system.

The first objective sought to identify the characteristics of SWH. It was established that SWH systems can be classified into two main categories that is active systems which use pumps to

control water flow and passive systems which use no pumps. These systems can be further divided into either direct or indirect. In direct systems the potable water is the heat collecting fluid, indirect systems on the other hand use other agents to act as the heat transfer fluid.

A significant number of household respondents (62 percent), stated that the SWH systems were useful to them. In contrast only 5.2 percent of the respondents stated that the system was not useful. In terms of the ease of use of the SWH system, 89.7 percent of the respondents stated that the system was easy to use with 8.6 percent of the respondents stating that they did not find the system easy to use.

The study sought to establish the level of adoption of use of SWH among households in Nairobi. It was observed that households had varied uses for hot water in their households. This ranged from use of hot water in cooking, laundry, cleaning the house, drinking and bathing. However bathing was the activity that households used their SWH for mostly. This was despite respondents indicating that they found the SWH systems to be useful. It was also observed that despite the respondents finding the systems to be easy to use, a significant number of respondents (64 percent), indicated that they used other water heating systems in their households.

The study revealed that there were several factors that were affecting adoption of SWH by households in Nairobi. Lack of information and awareness was cited as a major factor affecting adoption of SWH. It was stated by both key informants and survey respondents that there was need for this to be addressed. There was also a need for information on the benefits of SWH to be publicized to the residents of the County of Nairobi and across the country. The government was also tasked with informing the public on the benefits of informing the public on the SWH regulations adequately.

Financial and economic factors were also identified and it was stated that they presented a key challenge. This was based on the high cost of the systems as compared to conventional water heating systems and this affected the commercial viability of the SWH systems. The systems were also stated to be affected by the high international prices that were being experienced due to increased demand of the SWH systems globally.

The study also found out that there was limited access to credit for consumers to purchase and install SWH systems. As a result there is need for stakeholders involved to explore means through which consumers can access financial credit in order to promote installation of SWH systems. Subsidies, tax incentives, low-interest loans, third party financing mechanisms could also be explored to promote the installation of SWH systems.

There is also need for clarification on the tax exemption currently afforded to solar energy systems by the KRA. This is as a result of confusion on what the exemption covers exactly. Clarification of this matter will enable households to enjoy the full benefit of cost reduction of the SWH systems.

Several technical factors were also identified by respondents and key informants that hindered the use and installation of SWH. It was indicated that due to the lack of standards and codes and certification, the product quality of SWH systems was wanting and this greatly affected their acceptability. This was because some of the SWH systems that were installed in households were stated to be of poor quality.

It was also established that there was a need to increase the technical manpower in the solar energy sector in the country. The ERC stated that it was taking steps currently towards developing a curriculum with NITA for the SWH and PVC sectors. The shortfall of technical

manpower was indicated whereby only 50 SWH installers and 200 PVC installers had been certified by the ERC. It was also recommended that there was need for certification of plumbers due to the fact that poor workmanship had an impact on the functionality of the SWH systems. Roofing design was also identified as a technical factor affecting adoption of SWH.

The research also identified several institutional factors that affected adoption of SWH. Conflict of interest was identified where the major electricity supplier, KPLC did not carry out its mandate of not installing new developments to the grid when they failed to comply with the SWH regulations. It was also established that the ERC lacked the manpower to properly enforce the SWH regulations. These factors had a significant impact on the adoption of SWH technologies by households.

Finally, the study identified social system factors that had affected the adoption of SWH. It was indicated that in some estates households were denied to install SWH systems because they were considered to be not be aesthetically suitable for their areas. This raised the need of raising awareness of the Government SWH regulations in the public in order to address this.

5.3 Conclusion

This study aimed at exploring the factors that had affected the adoption of SWH among households in Nairobi County. It was based on the Energy (Solar Water Heating) Regulations, 2012. The regulations are aimed at reducing the peak demand from households which is especially used in the heating of water.

From the findings of this study, a number of conclusions can be drawn. Firstly, it can be noted that the SWH system was stated by most of the respondents to be a simple technology given that it was easy to use and quite useful. However, despite this, there is an urgent need to promote awareness among the benefits on the purpose and importance of using a SWH system. This is

because it was found that the level of awareness on the importance of SWH systems was low among households.

Secondly, it can be concluded that there is need for the organisations mandated by the Energy (Solar water Heating) Regulations, 2012 to conduct their respective roles. This is especially as it was noted that there is a conflict of interest between Kenya Power's role in enforcing its mandate and conducting its core business as the country's electricity distribution company. This had adversely affected the need for all new buildings to have integrated SWH systems in their houses.

Thirdly, in order for Kenya to achieve the intended goal of gazetting the regulations there is an urgent need for resolution of the financial perspective in terms of access to credit and clarification on the tax exemption status of solar energy systems components. This will address some of the key challenges identified in this study.

It is also noted that there is need for harmonisation of the building standards curriculum. This was especially after several respondents and key informants indicated that in some instances the SWH systems were affected by poor plumbing or poor roof design. This had a significant impact on the use of the SWH system among households.

It can be concluded that in order for Kenya to achieve its objectives of reducing the peak load on the national grid, there is an urgent need for the issues identified above to be addressed. SWH systems can have a significant role in reducing the energy costs of the users. Ensuring sufficient adoption of the technology by users will contribute to the realization of Kenya's development goals such as Vision 2030.

5.4 Recommendations

The study provides several recommendations for policy and areas for further research.

5.4.1 Policy

(1) Appropriate measures should be undertaken to educate the public on the use of SWH. Raising awareness to the public on use of renewable energy technologies such as SWH will be of significant benefit to the country in reducing the peak demand on the electricity grid.

(2) There is need for the relevant authorities to meet with players in the financial market to enable households to access credit for the SWH systems. Tackling this issue will enable more household's to take up the system and this will not only reduce the demand on the national grid but also reduce the households long term energy costs.

(3) There is need for clarification on the solar energy systems covered by the tax exemption afforded to SWH systems. This will enable SWH distributors to reduce the cost of the SWH systems, resulting in an increase in the installation of SWH systems.

(4) There is need for the human capacity of the ERC to be enhanced. This will enable the organisation to be able to conduct timely and consistent analysis on integration of SWH systems into housing and other developments as prescribed by the SWH regulations.

(5) There is need for the development or adoption of a base standard for SWH systems in the country. This will ensure that SWH distributors and manufacturers to develop systems that meet the bare minimum required. This will enable consumers who don't have clear information to still enjoy reliable and effective systems.

(6) There is need for the institutions that are tasked with enforcing the SWH regulations to undertake their mandate. This is because the conflict of interest is likely to result in the SHW regulations not being fully integrated to housing developments in the country and this will be against the goals of reducing the cost and use of energy.

(7) There is need for the development of an integrated building curriculum in the country to be developed. This will be in order to ensure that during construction, structural, electrical and plumbing systems installed are compatible with each other and do not act as deterrents to installation and the use of SWH and other RET systems.

5.4.2 Research

(1) There is need to conduct a more expansive study on SWH use among households as well as commercial entities such as schools, hospitals, hotels among other users. This will enable more critical literature to be developed on the subject area of factors affecting adoption of SWH and provide better insight on the measures that should be undertaken to solve the issues that will be identified.

(2) There is need to conduct more research on factors affecting financing of RET's in Kenya. Identification of these factors will be important in enabling the development of possible mechanisms to promote the uptake of RET's.

REFERENCES

Advisory Group on Energy and Climate Change., (2010). *Energy for a Sustainable Future.* New York: UN.

African Energy Policy Research Network., (1990). *African Energy: Issues in Planning and Practice.* London; New Jersey: Zed Books ltd.

Agence National pour la Maitrise de l'Energie., (2009) In UNEP. (2011). *Toward a green economy; Pathways to Sustainable Development and Poverty eradication*. www.unep.org/greeneconomy

Ajzen, I., and Fishbein, M., (1980). Understanding attitudes and predicting social behaviour. Englewood Cliffs, NJ: Prentice-Hall

AMCEN, (2011). *Addressing Climate change Challenges in Africa; A Practical Guide towards Sustainable Development.* Unep.org/roa – Accessed 20th April 2013

Attachie, J., and Amuzuvi, C. K, (2013). Renewable Energy Technologies in Ghana: Opportunities and Threats. *Research Journal of Applied Sciences, Engineering and Technology Vol. 6, No. 5* , 776-782.

Ayres, L., (2008). Thematic Coding and Analysis, in M. L. Given, *The SAGE Encyclopedia of Qualitative Research Methods* (pp. 868-869). Thousand Oaks, CA: SAGE Publications.

Baguant. J and Manrakhan.J, (1994). *Issues in energy for the African Region: Higher Education Training with Particular reference to Mauritius.* University of Mauritius. In Karekezi S., and Kithyoma, W., 2004, *Improving Access of Modern Energy Use in Rural Africa.* Nairobi, African Beck, F and Martinot (2004). Renewable Energy Policies and Barriers. In: *Encyclopedia of energy, Volume 5*. Elsevier Inc. pp 365-383

Bigerna, S., Bollino, CA, and Micheli, S., (2015). *The Sustainability of Renewable Energy in Europe.* Heidelberg, Springer.

Blenkinsopp, T., Coles, S. R., Sa, A. S., and Kirwan, K. (2013). The Challenges and Opportunities of Using Low Carbon Technologies to Deliver Sustainable Energy Demands. *International Journal of Chemical and Environmental Engineering Vol. 4, No 4* , 244-248.

Bloor, M., and Wood, F. (2006). Key Informants. In M. Bloor, and F. Wood, *Keywords in Qualitative Methods* (pp. 110-112). London: SAGE Publications.

Bryman, A., (2008). *Social Research Methods 3rd edition.* Oxford, Oxford University Press.

Burningham, K, Barnett, J and Thrush, D., (2006). *The Limitations of the NIMBY Concept for Understanding Public Engagement with Renewable Energy Technologies: A Literature Review.* Manchester, University of Manchester.

Central Bureau of Statistics, (2001), viewed in UNEP.net 1st November 2013

Chang, K., Lee T S., Lin W M., Chung K M., (2006). *Solar Water Heaters in Taiwan.* Renewable Energy 31, 1299-1308. In Menanteau, P, (2007). *Policy Measures to Support Solar Water Heating: Information, incentives and regulations.* World Energy Council and ADEME

Chuttur, M. (2009). Overview of the Technology Acceptance Model: Origins, Developments and Future Directions. Sprouts: Working papers on information systems 9 (37), 1-21.

Climate change. http://www.iea.org/topics/climatechange/ International Energy Agency. Viewed 5th June 2013

Coenraads, R., Reece, G., Voogt, M., Ragwitz, M., Resch, G., Faber, T., Haas, R., C-Tran., (2010). *Building Sector Policies and regulations for Promotion of Solar Water Heating System: submitted to Ministry of renewable Energy - Government of India.* Bhubaneswar: C-Tran.

Davis, F., (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13 (3), pp 319-340.

Edjekumhene, I and Brew-Hammond, A., (2001). *Barriers to the Use of Renewable Energy technologies for Sustainable Development in Ghana.* In Attachie, J., and Amuzuvi, C. K, (2013). Renewable Energy Technologies in Ghana: Opportunities and Threats. *Research Journal of Applied Sciences, Engineering and Technology Vol. 6, No. 5* , 776-782.

I.C.L.E.I- Local Governments for Sustainability, (2009). *Sustainable Urban Energy Planning: A handbook for cities and towns in developing countries.* UNON, Publishing Services Section, Nairobi.

IEA-PVPS, (2007). *Trends in Photovoltaic Applications: Survey Report of Selected IEA"s between 1992 and 2006.* IEA Photovoltaic Power Systems Programme in Timilsina, G R, Kurddelashvili, L and Narbel, P A, (2011). *A Review of Solar Energy: Markets, Economics and Policies.* Washington D.C, World Bank

Institute for Sustainability, (2014). *Renewable Energy Toolkit*. Institute for Sustainability, London

Intergovernmental Panel on Climate Change, (2007). *Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge, Cambridge University Press.

Intergovernmental Panel on Climate Change. (2008). *Climate Change 2007: Synthesis report.* Geneva IPCC. In Sovacool, K. B., (2013). Energy Policy and Climate Change. In: *The handbook of Global Climate Change and Environmental Policy.* Chichester: Wiley-Blackwell, pp. 446-467.

International Energy Agency, (2010). *World Energy Outlook* 2010. Paris: OECD

International Energy Agency, (2011). *Renewable Energy Technologies: Solar Energy Perspectives.* Paris, International Energy Agency.

IRENA, (2012). *IRENA Handbook on Renewable Energy Nationally Appropriate Mitigation Actions (NAMAs) for Policy Makers and Project Developers. Irena.org* Viewed on 13th May 2013

Jay, A., (2005). *Not In My Backyard: How to run a protest campaign and save the neighbourhood.* White Ladder Press Ltd. In Burningham, K, Barnett, J and Thrush, D., (2006). *The Limitations of the NIMBY Concept for Understanding Public Engagement with Renewable Energy Technologies: A Literature Review.* Manchester, University of Manchester.

Karekezi,S., and Kithyoma, W., (2003). *Renewable Energy in Africa: Prospects and Limits. In: Republic of Senegal and United Nations Workshop for African Energy Experts on Operationalizing the NEPADS Energy Inititative, Dakar, Senegal,* 2-4 June 2003. Viewed in www.un.org/esa/sustdev/sdissues/energy/op/nepadkarekezi on 13th September, 2013

Kenya National Bureau of Statistics. (2010). *Kenya: 2009 Population and Housing Census Brochure. knbs.or.ke* Viewed on 1st November, 2013.

Konstantinaviciute, I., Krivosik, J. and Chadim, T., (2008). *Renewable energy Country Profiles: Final Version.* Utrecht, Netherlands: EU Commission, In Mendonza, M, Jacobs, D and Sovacool, B, (2010). *Powering the Green Economy: The Feed in Tariff Handbook.* London, Earthscan.

Kurian, T. G., (2011). *The Encycopedia of Political Science Set.* Washington, D.C: CQ Press.

LAZARD, (2009). *Levelized Cost of energy Analysis – Version 3.0.* New York: Lazard. In Timilsina, G R, Kurddelashvili, L and Narbel, P A, (2011). *A Review of Solar Energy: Markets, Economics and Policies.* Washington D.C, World Bank

Lee, J. R. O. D. P. M. and. T. H., (1995). Planning for Dominance: A strategic perspective on the emergence of a dominant design. *Research and Development Management Vol. 25 No1,* pp. 3-15.

Ljung, P., (2007). *Energy Sector Reform: Strategies for growth, equity and sustainability.* Stockholm, SIDA

Menanteau, P., (2007). *Policy Measures to Support Solar Water Heating: Information, incentives and regulations.* World Energy Council and ADEME

Mendonza, M, Jacobs, D and Sovacool, B., (2010). *Powering the Green Economy: The Feed in Tariff Handbook.* London, Earthscan.

Milton, S. (2006)., Sustainable Development and Solar Water Heating Systems: An analysis of barriers to technology diffusion and recommendations for policy interventions. *International development, Environment and Sustainability (IDEAS).* Viewed on http://fletcher.tufts.edu/ierp/ideas/default.html, 29th August 2013.

Ministry of Energy, (2011). *Scaling-Up Renewable Energy Program (SREP) Investment Plan for Kenya - Draft,* Nairobi, Government Printer

Mosimanyane T, Zhou P.P, Kigathi D.L., (1995). *Renewable Energy Technologies in Botswana – The Case of Wind Energy for Water Pumping.* SEI/AFREPEN/FWD. In Karekezi,S., and Kithyoma, W. (2003). *Renewable Energy in Africa: Prospects and Limits. In: Republic of Senegal and United Nations Workshop for African Energy Experts on Operationalizing the NEPADS Energy Inititative, Dakar, Senegal,* 2-4 June 2003. Viewed in www.un.org/esa/sustdev/sdissues/energy/op/nepadkarekezi on 13th September, 2013

National Environmental Management Authority, (2011). *Kenya State of the Environment and Outlook 2010; Summary for Decision Makers- supporting delivery of vision 2030.* Progress Press Co. Malta

National Renewable Energy Agency (ANER), (2003). *Etude Stratergique pour le development des energies Renouvelables en Tunisie, Bilan des realisations, Rapport fina alcor – Axene pir L'ANER.* In Menanteau, P, (2007). *Policy Measures to Support Solar Water Heating: Information, incentives and regulations.* World Energy Council and ADEME

Nelson, V., (2011). *Introduction to Renewable Energy.* Florida, CRC Press.

Ogunleye, I.O and Awogbemi, O., (2010). Constraints to the use of solar photovoltaic as a sustainable energy source in Nigeria. *American Journal of Scientific and Industrial Research,* 2(1), pp.11-16.

Painuly, P., and Fenham, V., (2002). *Implementaion of Renewable Energy Technologies - Opportunities and Barriers.* Roskilde: Centre for Energy and Environment, Riso National Laboratory.

Painuly, P.J, (2001). Barriers to Renewable Energy Penetration; a framework for analysis. *Renewable Energy Vol. 24 No1,* pp. 73-89.

Parker, C, (2000). *Volume 8, Issue 77 of OECD working papers: Reducing the risk of policy failure: challenges for regulatory compliance: final version.* OECD.

Pitt, D, (2008). Taking The Red Tape Out of Green Power; How to Overcome Permitting Obstacles to Small-Scale Distributed Renewable Energy. New York, GRACE

Reddy, S, and Painuly. (2004). Diffusion of Renewable Energy Technologies – Barriers and Stakeholders' Perspectives. *Renewable Energy,* 29, pp. 1431-1447.

REN21, (2005). *Energy for Development; the Potential Role of Renewable Energy in Meeting MDG's.* Worldwatch Institute

REN21, (2013). *Renewables 2013 Global Status Report.* Paris: REN 21 Secretariat

Renewable Energy Policy Network (AFREPREN).

Rogers, M. E., (1983). *Diffusion of Innovations.* 3rd ed. New York, London: Free Press.

Sovacool, K. B., (2013). Energy Policy and Climate Change. In: *The handbook of Global Climate Change and Environmental Policy.* Chichester: Wiley-Blackwell, pp. 446-467.

Straub, T. E., (2009). Understanding Technology Adoption: Theory and Direction for Informal Learning. *Review of Educational Research*, 79(2), pp. 625 - 649.

Timilsina, G R, Kurddelashvili, L and Narbel, P A., (2011). *A Review of Solar Energy: Markets, Economics and Policies.* Washington D.C, World Bank

Uddin, N and Taplin, R., (2008). *Toward Sustainable Energy Development in Bangladesh.* The Journal of Energy and Development, 17 (3), 292-315. In Timilsina, G R, Kurddelashvili, L and Narbel, P A, (2011). *A Review of Solar Energy: Markets, Economics and Policies.* Washington D.C, World Bank

United Nations Development Programme, (2011). *Human Development Report 2011 Sustainability and equity: A Better Future for All.* New York, Palgrave Macmillan.

United Nations Environmental Programme, (2009). *Kenya: Atlas of Our Changing Environment*. Malta, Progress Press Co.

United Nations Environmental Programme, (2011). *Toward a green economy; Pathways to Sustainable Development and Poverty eradication*. www.unep.org/greeneconomy

United Nations Environmental Programme, (2013). *Assessing the Effectiveness of Policies to Support Renewable Energy*. *www.unep.org*

Usher, E and Touhami, M., (2006). *Engaging the Banks. Financing Small-Scale Renewables in the Developing World.* In Timilsina, G R, Kurddelashvili, L and Narbel, P A, (2011). *A Review of Solar Energy: Markets, Economics and Policies.* Washington D.C, World Bank

Wallace, W and Wang, Z., (2006). *Solar Energy in China: Development Trends for Solar Water Heaters ad Photovoltaics' in the Urban Environment.* In Menanteau, P, (2007). *Policy Measures to Support Solar Water Heating: Information, incentives and regulations.* World Energy Council and ADEME

World Bank, (2005). *World Bank Group Progress on Renewable Energy and Energy Efficiency: 1990 – 2004.* Washington D.C The World Bank Group, Energy and Mining Sector Board in REN21, 2005.

World Energy Council - ADEME. (2007). *Policy Measures to Support Solar Water Heating: information, incentives and regulations.*

APPENDIXES

Research Instruments

Questionnaire

Solar Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi.

My name is Benjamin Atika. I am a Postgraduate student at the University of Nairobi, at the institute of development studies. I am conducting an academic study for my Masters in development Studies entitled "*Solar Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi."* I would like to assure you that the information collected will be used for research purposes only.

I am grateful for your time in responding to this questionnaire

Background Information

1.1 What is your Sex?

Male ☐

Female ☐

1.2 How old are you?

18 – 28 ☐

29 – 38 ☐

39 – 48 ☐

49 – 58 ☐

58 - Older ☐

1.3 Which of the following best describes your status?

Kenyan Citizen ☐

East African Resident ☐

Foreign Resident ☐

Foreigner ☐

1.4 Which of the following best describes your status?

Home Owner ☐

Tenant ☐

Other ☐

If other, specify ……..

1.5 How long have you resided in your house?

…… Years

1.6 What is your current occupation?

……..

1.7 How many people stay in the residence?

……..

1.8

a) What is the location of your current home?

……

b) Do you have any other residence in the country?

Yes ☐

No ☐

If yes, kindly specify the locations

(County)……

……

1.9 What factors do you consider when selecting your residence?

Cost ☐

Security ☐

Location ☐

Size ☐

Other ☐

If other, specify …….

Solar Water Heating Adoption

Mark where appropriate (/)

(0) Don't use (1) Very Slightly (2) Slightly (3) Moderately (4) Highly (5) Very Highly

2.1

a) How often do you use the following energy sources in your daily routine?

Electricity	(0) (1) (2) (3) (4) (5)
LPG	(0) (1) (2) (3) (4) (5)
Firewood	(0) (1) (2) (3) (4) (5)
Charcoal	(0) (1) (2) (3) (4) (5)
Renewable Energy Technologies	(0) (1) (2) (3) (4) (5)

b) What factors have prevented your use of renewable energy technologies, if any

……
……
…….

2.2

a) What activities do you use hot water for mainly in your household?

Cooking	(1) (2) (3) (4) (5)
Washing Clothes	(1) (2) (3) (4) (5)
Cleaning the house	(1) (2) (3) (4) (5)
Drinking	(1) (2) (3) (4) (5)
Bathing	(1) (2) (3) (4) (5)

Other, elaborate if possible

……

……

……

b) Of these activities above which ones do you use the solar water heating system for?

Cooking ☐

Washing Clothes ☐

Cleaning the house ☐

Drinking ☐

Bathing ☐

Other ☐

2.3 How useful do you find the SWH system in providing hot water for your household?

Very useful ☐

Useful ☐

Moderately Useful ☐

Not Useful ☐

2.4 Do you consider the system to be easy to use?

Yes ☐

No ☐

If no explain your answer

……

……

……

2.5 Do you have any other water heating system in your house?

Yes ☐

No ☐

If yes, can you state which other systems for water heating you have in your house.

……

……

……

2.6 Has the SWH system resulted in a significant reduction of your energy bills?

Yes

No

If yes, by what degree (%) would you say it has reduced?

……

2.7 Do you use any energy efficient products in your house?

Yes ☐

No ☐

2.8 Are you satisfied with your SWH system?

Yes ☐

No ☐

Factors Affecting Solar Water Heater Adoption

To what extent have the following issues affected your use of the SWH system?

(Tick in the spaces provided where appropriate)

(1) Significantly (2) Insignificantly (3) Not Sure (4) Not at all

	Questions	1	2	3	4
3.1	Number of residents in the household?				
3.2	Awareness on benefits of Solar Water Heating?				
3.3	Awareness on Government SWH policy?				
3.4	Malfunctions?				
3.5	Product reliability?				
3.6	Poor Installation?				
3.7	Prices of alternative water heating technologies?				
3.8	Lack of information and awareness?				
3.9	Rate of Flow and supply of water?				
3.10	Environmental conservation awareness?				
3.11	Savings on energy cost?				
3.12	Corrosion?				
3.13	Difficulties with self-maintenance?				
3.14	System Undersized for needs?				
3.15	Overheating?				
3.16	Under heating?				

3.9 What possible solutions can you suggest to ensure that some of the challenges you have stated can be addressed?

……

……

……

……

3.10 Is there anything that you would wish to add to this questionnaire on the issue of Solar Water Heaters?

……

……

……

Thank You for taking your time out to fill this questionnaire. Your Response has been highly appreciated.

Key Informant Guide Solar Water Heater Distributors

My name is Benjamin Atika. I am a Postgraduate student at the University of Nairobi, at the institute of development studies. I am conducting an academic study for my Masters in development Studies entitled "*Solar Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi."* I would like to assure you that the information collected will be used for research purposes only

I am grateful for your time in responding to this interview.

Questions

Background information

Name of organisation _____

Position held in the organisation _____

Nature of your organisations work _____

1. What type of solar water heaters do you supply?
2. Of the SWH supplied what is the capacity of these devices?
3. What is the cost of SWH (without installation and with Installation)?
4. Do you undertake the installation? If yes, are your installers certified?
5. What are the challenges that you face in undertaking installation? How can these challenges be addressed?
6. Since the gazette notice on SWH, has the demand of SWH increased? Explain your response
7. Are users installing the appropriate SWH for their facilities?
8. Are there any other observations that you may want to add in relation to this interview?

Key Informant Guide: Real Estate Developers

My name is Benjamin Atika. I am a Postgraduate student at the University of Nairobi, at the institute of development studies. I am conducting an academic study for my Masters in development Studies entitled "Solar *Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi."* I would like to assure you that the information collected will be used for research purposes only

I am grateful for your time in responding to this interview.

Background information

Name of organisation ……..

Position held in the organisation ……...

What is the status of your company i.e. Local/International ……

Questions

1. Which type of housing developments do you undertake?
2. What has been your experience with SWH?
3. What factors do you consider when installing SWH in housing estates that you develop?
4. Have the housing units you have developed been inspected by ERC staff?
5. What challenges did you face when installing SWH systems in your housing developments?
    - Financial and economic
    - Technical
    - Institutional
    - Market Failure/Imperfection
    - Social System factors
    - Others (prompts)

6. Are there any other observations that you may want to add in relation to this interview?

Key Informant Guide: Ministry of Energy and Energy Regulatory Commission

My name is Benjamin Atika. I am a Postgraduate student at the University of Nairobi, at the institute of development studies. I am conducting an academic study for my Masters in development Studies entitled "Solar *Water Heating in Urban Housing: A Study of Factors Affecting Adoption among Households in Nairobi."* I would like to assure you that the information collected will be used for research purposes only

I am grateful for your time in responding to this interview.

Questions

Background information

Name of organisation ……..

Position held in the organisation ……..

Nature of your organisations work

……

……

……

1. What is the potential for SWH in Housing Developments in Kenya?
2. What steps have been taken in the promotion of SWH among housing developers?
3. What challenges have you faced in promoting SWH?
4. (ERC) Your role in ensuring success of SWH regulations involves registering installers. How many installers have been certified/registered?

5. (ERC) How many Housing developers have sought approval for their SWH projects?

6. What do you consider to be the greatest barrier to adoption of SWH? Why do you think so?

7. What are the major factors that have affected SWH penetration in the country?

    - Financial and economic
    - Technical
    - Institutional
    - Market Failure/Imperfection
    - Social System factors
    - Others (prompts)

8. What are the possible solutions to these challenges identified above?

    - Financial and economic
    - Technical
    - Institutional
    - Market Failure/Imperfection
    - Social System factors
    - Others (prompts)

9. Are there any other observations that you may want to add in relation to this interview?