FACTORS AFFECTING THE ADOPTION OF SOLAR POWER FOR DOMESTIC USAGE IN KAJIADO COUNTY, KENYA

BY

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2014
DECLARATION

This Research Project Report is my own original work and has not been submitted for a degree in any other university.

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DEDICATION

I would like to dedicate this study to my husband, Philip and children Adrian and Alicia. Your love and understanding was my source of strength. May this work inspire you to greater heights of academic achievement.
ACKNOWLEDGEMENT

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But most important, to the almighty God for His grace, providing me with strength and patience to undertake this study.
ABBREVIATIONS

COMESA Common Market for Eastern and Southern Africa
ERC Energy Regulatory Commission
FiT Feed- in Tariff
GDC Geothermal Development Company
GDP Gross Domestic Product
GWH Giga Watt Hour
KETRACO Kenya Electricity Transmission Company
KIHBS Kenya Integrated Household Budget Survey
KNBS Kenya National Bureau of Statistics
LCPP Least Cost Power Plan
LPG Liquefied petroleum gas
MoE Ministry of Energy
MW Mega Watt
PV Photovoltaic
REA Rural Electrification Authority
RET Renewable Energy Technologies
S H S Solar Home Systems
ST Solar Thermal
TWh Tetra Watt hour
UNEP United Nations Environments program
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECLARATION</td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENT</td>
<td>iv</td>
</tr>
<tr>
<td>ABBREVIATIONS</td>
<td>v</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>xi</td>
</tr>
<tr>
<td>CHAPTER ONE: INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Background of the study</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Statement of the Problem</td>
<td>4</td>
</tr>
<tr>
<td>1.3 Purpose of the Study</td>
<td>5</td>
</tr>
<tr>
<td>1.4 Objectives of the Study</td>
<td>5</td>
</tr>
<tr>
<td>1.5 Research Questions</td>
<td>6</td>
</tr>
<tr>
<td>1.6 Research Hypothesis</td>
<td>6</td>
</tr>
<tr>
<td>1.7 Significance of the Study</td>
<td>6</td>
</tr>
<tr>
<td>1.8 Delimitation of the Study</td>
<td>7</td>
</tr>
<tr>
<td>1.9 Limitations of the Study</td>
<td>7</td>
</tr>
<tr>
<td>1.10 Assumptions of the Study</td>
<td>7</td>
</tr>
<tr>
<td>1.11 Definition of Central Terms</td>
<td>8</td>
</tr>
<tr>
<td>1.12 Organization of the Study</td>
<td>8</td>
</tr>
<tr>
<td>CHAPTER TWO: LITERATURE REVIEW</td>
<td>9</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>9</td>
</tr>
<tr>
<td>2.2 Background to solar power systems</td>
<td>9</td>
</tr>
<tr>
<td>2.3 Kenya Energy Situational Analysis</td>
<td>11</td>
</tr>
<tr>
<td>2.4 Overall structure of the energy sector</td>
<td>12</td>
</tr>
<tr>
<td>2.5 Solar Energy and Lighting-Fuel Choice in Kenya</td>
<td>13</td>
</tr>
<tr>
<td>2.6 Level of Knowledge and Awareness of Solar Technology</td>
<td>14</td>
</tr>
<tr>
<td>2.7 Level of Income of Households</td>
<td>15</td>
</tr>
</tbody>
</table>
2.8 Availability of Alternative Sources of Power ............................................................... 18
2.9 Government policy on adoption of solar power........................................................... 20
2.10 Theoretical Framework ............................................................................................. 22
  2.10.1 Innovative Diffusion Theory (IDT) ........................................................................ 22
  2.10.2 Resource Based Theory ...................................................................................... 23
  2.10.3 Theory of Reasoned Action ................................................................................. 24
2.11 Conceptual Framework ............................................................................................. 26
2.12 Summary of Literature Review .................................................................................. 27

CHAPTER THREE: RESEARCH METHODOLOGY ................................................................. 29
3.1 Introduction .................................................................................................................. 29
3.2 Research Design ......................................................................................................... 29
3.3 The Target Population ................................................................................................ 29
3.4 Sample Size and Sampling Procedure ........................................................................ 29
3.5 Data Collection Method ............................................................................................. 30
3.6 Instrument Validity ..................................................................................................... 30
3.7 Instrument Reliability ................................................................................................. 31
3.8 Data Analysis ............................................................................................................. 31
3.9 Ethical Considerations .............................................................................................. 31
3.10 Operationalization of Variables ............................................................................... 32

CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND INTERPRETATION ... 34
4.1 Introduction .................................................................................................................. 34
4.2 Response Rate ............................................................................................................ 34
4.3 Background Information of the Respondents ............................................................ 34
  4.3.1 Gender of the Respondents .................................................................................. 34
  4.3.2 Marital status of the Household Heads ................................................................. 35
  4.3.3 Age of the Household Heads ............................................................................... 35
  4.3.4 Head of the Household ...................................................................................... 36
4.4 Level of Knowledge and Awareness of Solar .............................................................. 37
4.5 Level of income of Households ................................................................................. 38
4.6 Availability of Alternative Sources of Power ............................................................. 38
4.7 Correlation analysis ................................................................................................... 40
4.8 Regression Analysis .................................................................................................. 40
4.9 Test of hypothesis ...................................................................................................... 43
CHAPTER FIVE: SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS............................................................................................................ 44

5.1 Introduction .................................................................................................................... 44
5.2 Summary of the Major Findings .................................................................................... 44
5.3 Discussions ..................................................................................................................... 46
5.4 Conclusions .................................................................................................................... 47
5.5 Recommendations .......................................................................................................... 48
5.6 Areas of Further Researcher ........................................................................................... 49

REFERENCES............................................................................................................................ 50

APPENDICES ............................................................................................................................. 55

APPENDIX 1: LETTER OF TRANSMITAL .......................................................................... 55
APPENDIX 2: QUESTIONNAIRE ............................................................................................. 56
LIST OF FIGURES

Figure 1: Conceptual Framework ................................................................................................. 26
LIST OF TABLES

Table 3.1: Sampling Frame ........................................................................................................... 30
Table 3.2: Operationalization of Variables ................................................................................... 32
Table 4.1: Response Rate .............................................................................................................. 34
Table 4.2: Gender of the Household heads (n=300) ................................................................. 35
Table 4.3: Marital status of the Household Heads (n=300) ......................................................... 35
Table 4.4: Age of the Household Heads (n=300) ......................................................................... 36
Table 4.5: Head of the Household (n=300) .................................................................................. 36
Table 4.6: Level of Knowledge and Awareness of Solar Technology ...................................... 37
Table 4.7: Level of income of households .................................................................................... 38
Table 4.8: Availability of alternative sources of power .............................................................. 39
Table 4.9: Pearson’s Correlation .................................................................................................. 40
Table 4.10: Model Summary ........................................................................................................ 41
Table 4.11: Analysis of Variance (ANOVA) ................................................................................ 41
Table 4.12: Coefficients of regression equation ........................................................................... 42
Table 4.13: Hypothesis testing ...................................................................................................... 43
Table 5.1: Summary of findings ................................................................................................... 44
ABSTRACT

Kenya envisions transforming itself into a newly-industrializing, middle-income country by 2030. With only 44% of Kenyans having access to Grid Electricity, solar technology provides the Kenyan government with the opportunity to address energy challenges without the need for expensive power generation projects, transmission and distribution networks. The objective of this study was to establish the factors affecting the adoption of solar power technology for domestic power usage, specifically to assess the extent to which the level of knowledge and awareness of solar technology influences adoption of domestic solar technology, to investigate the extent to which the level of income of households influences adoption of solar technology and finally the extent to which the availability of substitute power source influences adoption of solar technology. A descriptive survey design was undertaken in the study. A stratified random sampling was used to identify a sample and data was collected using questionnaires. A sample of 365 households was studied from a target population of 6733 households. Only 300 household heads responded which represented 82.5% of the targeted population. The findings indicate that the community has not adopted much to solar technology with only 32% using solar in the region. Out of the three variables studied, all agreed to the research hypotheses concluding that there was a significant relationship between the level of knowledge and awareness, level of income of households, availability of substitute power source and the adoption of solar technology. The results indicate that the level knowledge and awareness has a positive effect on adoption of solar technology, level of income of households has a negative effect, while availability of substitute power source does not positively influence the adoption of solar technology. The findings of the study may be of use to the Ministry of Energy, to the government in general and to most Energy Solution Companies including Kenya Power and Lighting Company as Kenya looks to achieve vision 2030.
CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Solar power is electrical power generated through the conversion of sunlight into electricity, either directly using photovoltaic (PV) arrays, or indirectly using concentrated solar power (CSP) systems. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a relatively small beam. Photovoltaic cells and arrays convert light into electric current using the photoelectric effect. Photovoltaic arrays were initially, and still are, used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. They are an important and relatively inexpensive source of electrical energy where grid power is inconvenient, unreasonably expensive to connect, or simply unavailable (Jacobs, 2006). However, as the cost of solar electricity continues to fall, solar power is increasingly being used even in grid-connected situations as a way to feed low-carbon energy into the grid.

According to UNEP, 2011, Global investments in renewable energy in 2010 reached US$211 billion representing a year-on-year increase of 32%. The increase was mainly because of wind-farm development in China and small-scale solar PV installations in Europe. Africa achieved the largest percentage increase in investment in renewable energy among developing regions. Total investment on the continent rose from US$750 million to US$3.6 billion, largely, because of strong performance in Egypt and Kenya (UNEP, 2011).

Australia has been a key player in the global solar power revolution. After World War 2, 'diggers' who had experience in engineering put their knowledge and experience into the solar power industry. From this, Australia was able to lead global research and fund ideas from US inventors that were not necessarily supported in their home countries. Australia's renewable energy industry was particularly productive during the 1970s and 80s. However, in the last ten years, Australia's influence in world solar power technologies has dwindled (Jennings, 2007). Despite this decline, Australian technology and expertise have been adopted far and wide. Much of the technology that is now used by solar industry giants (Japan, Germany, China and the United States) was developed in Australia. By August 2011, more than half a million household PV solar systems were installed across Australia, representing an incredible uptake of solar panels over recent years, 35 times greater than it was in 2007. The year 2012 also saw the
reduction of the feed-in tariffs, which contributed to an increase in national sales of solar power systems (Mwakubo et al, 2007).

Based on conservative analyses, achievement of China’s renewable energy goals or targets (formal and informal) through 2015 and 2020 are dependent on an aggressive and successful expansion of the electricity transmission grid. In particular, the wind power sector faces adverse forces that are likely to slow near-term growth from now into the 2014 period. With 20 GW of new installed capacity added in 2011 and only 16 GW incrementally connected to the grid, the pace of additions to installed capacity has exceeded the rate at which the wind power capacity can be connected to the grid. It is estimated that by the end of 2012, there was an approximate 5 GW overhang of wind power installations awaiting connection to the grid (over and above the estimate of an amount of installed capacity awaiting interconnection at any point in time equal to approximately 75% of total new installations built in any year), and that an overhang is expected to continue into 2014. With regard to solar, China now informally aims for 30–50 GW of solar PV by 2020. China aims to install 30 GW of grid-connected solar power by 2020, compared with less than 1 GW currently installed. To date, China’s modest adoption of solar PV compared with wind power stems from a combination of relatively high costs, the geographic remoteness of resource-rich regions, and a lack of transmission to those areas. With the recent introduction of a feed-in tariff, rooftop and grid-scale solar now have clearer policy support than traditional capital cost subsidies offered, although distributed rooftop is slow to grow (Babiker, 2001). In addition, emphasis on renewable energy is also designed to promote China’s competitiveness as a leading global supplier of clean, low cost renewable energy technologies.

Japan has adopted targets for the deployment of renewable energy through 2020. These targets are sizable both in terms of total installed capacity as well as the anticipated contribution of renewable energy to total electricity generation. An important objective of renewable energy development in Japan is to reduce CO₂ emissions and the reliance on imported energy by decoupling rising fossil energy use from economic growth over the next several decades. This decoupling is expected to have a positive impact on local air and water quality as environmental pollution is estimated to cost over 4% of GDP each year (Karplus, Paltsev, and Reilly, 2010).

There were about 82,200 domestic micro generation and renewable energy systems by 2005 in the UK, with solar thermal water heating (STWH) accounting over 95% of them. Although a
A typical flat plate or evacuated tube STWH system can provide about half of a household’s hot water, they are still rare in Britain compared to other European countries. Even rarer are micro-CHP, ground source heat pumps, wood-pellet stoves and boilers, solar PV and micro-wind (Karplus, Paltsev, and Reilly, 2010).

India’s installed solar power capacity of 15.2 MW at the end of June 2010 was based entirely on PV technology with approximately 20% of the capacity being used for off-grid applications. Currently, more attention is being paid to large-scale solar PV projects. In Phase 1 of Jawaharlal Nehru National Solar Mission (JNNSM), India aims to install 500 MW of grid-connected solar PV power. New PV projects are also being registered under state programs such as in Punjab, Gujarat, West Bengal, Rajasthan, and Karnataka, though many of these are being migrated to JNNSM. The creation of special economic zones that provide land, water, and power as well as financial incentives has spurred growth in the domestic manufacturing sector. International companies from all over the world are now lining up to get a share of India’s solar market, which is estimated will be valued at USD 70 billion through the end of JNNSM in 2022.

Egypt has a high solar availability. The total capacity of installed photovoltaic systems is about 4.5 MWp. These are used in remote areas for water pumping, desalination, lighting of rural clinics, powering telecommunications, rural village electrification, etc. Egypt has seen investment in renewable energy rise by US$800 million to just over US$1.3 billion as a result of just two deals, a 100MW solar thermal project in Kom Ombo and a 220MW onshore wind farm in the Gulf of El Zeit (Babiker, Reilly, 2001).

Kenya has vast renewable energy resources such as solar, wind, biomass, bio-fuel, geothermal and hydropower although their exploitation has been limited (apart from hydropower). Expansion of the renewable energy sector is being catalyzed by the growing demand for and cost of electricity, increasing global oil and gas prices and environmental pressure. In Kenya, biomass accounts for over 70% of total consumption, mainly through charcoal and firewood used in cooking and lighting. The other sources are petroleum and electricity, which account for about 22% and 9% respectively (Mwakubo et al., 2007). Currently, the Kenyan energy sector is characterized by the heavy reliance on unsustainable biomass use, frequent power outages, low access to modern energy, over reliance on hydroelectricity and high dependence on oil imports. Renewable energy is, therefore, an important and timely means to meet the challenges of
growing demand and addressing the related environmental concerns.

Kenya’s Least Cost Power Plan (LCPP) aims to identify new generation sources to enable the national electricity supply to respond to demand, taking into account the 15% margin required to ensure its security. In the light of frequent droughts and the increase in oil prices, there is an emphasis on developing alternative energy resources especially geothermal, solar, wind and coal. Since power projects take time to construct, there will be measures to fast-track implementation of the power projects in the master plan, to ensure adequate energy supply to meet the demand over the MTP period (Ministry of Finance, 2011a).

As evidenced by good government policy and energy planning that aim to ensure a sustainable energy mix, Kenya’s move towards renewable energy has been broad-based. Investment has grown from virtually zero to more than US$1.3 billion (including funding for wind, geothermal and small hydro). Geothermal power generation was the highlight, with the local electricity-generating company, KenGen, securing debt finance for additional units at its Olkaria project (UNEP, 2011). With the new financing arrangement, the company is expected to add 280MW of power to the grid in the next three years. In all this it can be seen that at the household level the adoption of solar technology is still relatively low. There has been little government initiative in promoting the adoption of solar power for domestic use, essentially leaving the householder on his/her own.

1.2 Statement of the Problem
Approximately one fifth of the world’s final energy production is consumed by electrical appliances, including lighting (World Bank 2010). Lighting alone accounts for 19% of global electricity demand (IEA 2006). In developing countries, lighting is generally thought to rank among the top three uses of energy, with cooking and entertainment (mainly television) and space heating being of even greater significance (World Bank 2010 and IEA 2006). While cooking fuel choices have been examined in a number of empirical studies, lighting fuel choices have received less attention. In addition, the adoption of renewable energy sources is typically not placed in the context of a specific fuel choice. Yet only in this specific context can adoption of renewable fuel switching be adequately understood.

In Kenya, solar household systems seem to mainly be used to a significant extent for lighting (Jacobs 2006). Most of the Rural Population use kerosene for lighting and charcoal or firewood
for cooking. These are known to have caused many health problems because of the smoke emitted and also due to burns caused by the open flames. There exists a big risk of house fires and suffocation from use of these traditional fuels. Less than 44% of the general population and 5% of the rural population in Kenya have access to electricity (World Bank, 2010). Demand is growing fast for electricity from both on- and off-grid consumers. Evidence of this includes frequent blackouts due to insufficient supply and the growing popularity of off-grid solutions such as diesel-powered generators and small-scale hydro generation units found both in Kisii and the Mount Kenya highlands that are largely illegal and poorly regulated energy wise.

Adoption of Solar Technology would provide one solution to this evident energy gap but this tends to be neglected in most developing countries. In fact, representative data on Solar Energy use in Kenya at household level is virtually non-existent. There has also been no evident comprehensive research on the factors that influence adoption of solar energy. This study therefore sought to find out the factors affecting the adoption of solar power for domestic usage, a case study of Kitengela within Kajiado County.

1.3 Purpose of the Study
The purpose of the study was to investigate the factors affecting adoption of solar power for domestic usage.

1.4 Objectives of the Study
The study was aimed at achieving the following objectives:-
1. To assess the extent to which the level of knowledge and awareness of solar technology influences the adoption of solar power for domestic usage.
2. To investigate the extent to which the level of income of households influences the adoption of solar power for domestic usage.
3. To determine the extent to which the availability of alternative sources of power influences the adoption of solar power for domestic usage.
1.5 Research Questions
This study was guided by the following research questions:

1. To what extent does the level of knowledge and awareness of solar technology influence the adoption of solar power for domestic usage?
2. To what extent does the level of income of households influence the adoption of solar power for domestic usage?
3. To what extent does the availability of alternative sources of power influence the adoption of solar power for domestic usage?

1.6 Research Hypothesis
The research hypotheses of this study were as follows:

1. Level of Knowledge and Awareness of the Solar Technology
   \[ H_0: \] There is no significant relationship between level of knowledge and awareness and the adoption of solar power for domestic use in Kitengela area.
   \[ H_1: \] There is a significant relationship between level of knowledge and awareness and the adoption of solar power for domestic use in Kitengela area.

2. Level of level of income of households
   \[ H_0: \] There is no significant relationship between level of income of households and the adoption of solar power for domestic use in Kitengela area.
   \[ H_1: \] There is a significant relationship between level of income of households and the adoption of solar power for domestic use in Kitengela area.

3. The availability of alternative sources of power
   \[ H_0: \] There is no significant relationship between availability of alternative sources of power and the adoption of solar power for domestic use in Kitengela area.
   \[ H_1: \] There is a significant relationship between availability of alternative sources of power and the adoption of solar power for domestic use in Kitengela area.

1.7 Significance of the Study
It is hoped that this study will be useful in providing insight into the factors that influence the adoption of solar power for household use in Kenya and especially in the sub-arid areas where sunshine is abundant.

There has been no evident comprehensive research on the factors that influence adoption of solar
energy and it is hoped that the study results will provide representative data on Solar Energy use in Kenya at household level.

The study findings will be of importance to:

1. Policy makers in formulation of policies by relevant Energy Authority (ERC) regarding energy usage and planning.
2. Planning and investment decision making by government implementing agencies (KenGen, REA, KPLC) on solar technology options and alternatives to delivering energy services.
3. Planning and investment decision making by energy solution investors and other energy sector stakeholders as in a bid to bridge the existing energy gap.
4. Useful reference material on the same for readers and other researchers on similar topics.

1.8 Delimitation of the Study
The study covered only rural households in Kitengela. The study targeted a sample of 365 households drawn from a population of 6,733 households in Kitengela. Data was collected from household heads as respondents using open and close ended questionnaires.

1.9 Limitations of the Study
The constraints that the researcher encountered included inadequate finances and time to extensively collect data from each household and respondents. This was particularly difficult after the wave of insecurity across various areas of the country and deaths by alcohol. This forced the researcher to look for alternative funding source to enhance the budget. The other challenge was unwillingness of respondents to answer the questionnaire due to lack of trust on how the research findings will be utilized which led to lost time and a less than expected response rate of 82%. Geographical distance between the households and their sparse distribution did not become a challenge as the researcher was able to get bike readers at affordable rates.

1.10 Assumptions of the Study
The researcher made the assumption that the respondents provided correct and valid information during the study. The other assumption was that the selected sample was not be biased and was representative of the population.
1.11 Definition of Central Terms

**Availability of Solar**
This refers to availability of solar panels, batteries, bulbs and other gadgets used to generate solar energy for domestic use by households.

**Availability of Substitutes**
This refers to availability of other sources of energy used by households such as electricity, biogas, bio fuel, kerosene, gas and others.

**Education Level**
This refers to the number of heads with formal education per household and also the highest education level achieved by household head.

**Income Level**
This refers to the regular income received by the household and from other sources including assets and shares held by the household.

**Solar Technology**
This refers to source of energy from the sun that is converted for lighting, heating, pumping water and also for running other household appliances.

1.12 Organization of the Study

Chapter One has presented the background information of the study, statement of the problem, purpose of the study, objectives of the study, research questions, Research Hypothesis, significance of the study, delimitation of the study, limitations of the study, assumptions of the study and definition of Central terms.

Chapter presents Literature review associated with the study objectives.

Chapter three highlights the research methodology and procedures used in data collection and methods for data analysis.

The results and findings of the study are presented in chapter four while chapter five gives the summary of findings, conclusions and recommendations.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction
This study focused on factors influencing adoption of solar energy namely: Knowledge and awareness of solar technology; Level of income of households; and Availability of alternative Power Sources.

2.2 Background to solar power systems
The literature concerning the adoption of domestic solar power systems is limited and typically paints a pessimistic picture of the potential for solar power systems. According to a report of ETSU (Flaherty et al 2001), it is a mature technology that is being pushed by policy but has failed to be adopted as it is too expensive and while solar power systems are attractive at a national or policy level as a means of reducing carbon emissions, they remain unattractive to individual householders (Timilsina 2000). Research has already suggested that to be attractive in simple financial terms, solar technologies would need to cost approximately £1000 at 2003 UK prices (BRECSU 2001). Solar energy is not being implemented at the rate that it could or should be in the United States for reasons mainly due to efficiency and cost. United States is dependent on environmentally degrading energy sources owned and operated by corporate conglomerates. Changing the way they use energy would be changing the way multinationals do business, and it may be that their non-renewable resources such as coal and natural gas must be depleted till they look for alternative sources such as solar.

PV systems are seen as an affordable technology at a commercial level, but are incompatible with personal priorities and unfortunately, ‘compatibility’ is a basic criterion of a consumers ‘willingness to pay’ for the technology (Berger 2001). ST technology is seen as a mature and proven technology and barriers to widespread individual householders (Timilsina 2000). Research has already suggested that to be attractive in simple financial terms, solar technologies would need to cost approximately £1000 at 2003 UK prices (BRECSU 2001).

The single largest trend in international solar policy circles over the past decade has been to shift solar dissemination strategies from heavily subsidized donor projects to private market-based approaches that seek to achieve—or at least move toward—‘full cost recovery’ (Martinot et al
Solar photovoltaic technology emerged as an important tool for rural electrification at a time when neo-liberal policies dominated mainstream development thinking. In the late 1980s and 1990s, a period that some have called the age of ‘‘market triumphalism’’ (Peet & Watts, 1993), mainstream development policies emphasized economic liberalization, privatization, and market-based approaches to service provision (Kapur, Lewis, & Webb, 1997). In the energy sector, donor financing for state-owned electricity infrastructure was reduced, while efforts to support liberalization, reforms, and private sector participation expanded.

In this context, public support for grid-based rural electrification was sharply curtailed in many countries (Karekezi, Kimani, Mutiga, & Amenya, 2004). Thus, market-based solar electrification grew at a time when publicly financed rural electrification schemes were in decline. Solar PV, a small-scale technology that can be used to provide decentralized electrical service to individual homes or businesses, is particularly compatible with market-based distribution. PV systems are seen as an affordable technology at a commercial level, but are incompatible with personal priorities and unfortunately, ‘compatibility’ is a basic criterion of a consumers ‘willingness to pay’ for the technology (Berger 2001). ST technology is seen as a mature and proven technology and barriers to widespread Kaplan (1999) showed that the adoption of renewable energy systems often requires extensive research and deliberation by the householder, and therefore, marketing activities that increase familiarity such as offering small-scale PV goods such as radios, calculators and lamps are beneficial. This concurs with other recommendations (e.g. Aggarwal 1998, Bolinger et al. 2001) to develop greater awareness through customer education programmes, marketing material, and information about processes involved, including disruption that may occur during installation or operation.

Utility companies could further incentivize the systems by providing generous prices for energy produced by householders (commonly known as a buy-back) thus reducing the time for a householder to recover the cost of the technology and installation (Bolinger et al. (2001). Specifically, householders need information such as descriptions of the technology, methods of operation, and their overall performance with regard to energy savings and environmental benefits (Lai 1991; Berger 2001).
Caird et al’s (2008) investigation into the adoption of energy efficiency and renewable energy technologies confirmed much of what has been documented in that the barriers to adoption of renewable technologies are mostly financial, as well as some practical issues regarding installation and general levels of knowledge. However, it is not clear that even if the costs were reduced and information made more available that adoption levels would increase. Neither is it clear that if an increase in adoption were to occur that it would lead to reductions in carbon emissions due to the effect known as the ‘Rebound’ effect (Caird et al 2008).

The rebound effect describes the phenomenon where individuals divert their spending onto equally carbon rich activities as soon as they have saved money on another; for example by spending money that has been saved as a result of energy saving in one area, on energy intensive appliances that might be perceived as improving their quality of life, for example a larger more energy intensive television (Herring 2006). Despite the criticisms of domestic level solar power technologies, some householders are adopting the technology (BERR 2008). The literature does indicate areas of research that could be pursued if a more rounded view of the adoption of solar power systems is to be gained. Hence, a broader review of the literature concerning the adoption of innovations was undertaken and is introduced in the following section.

2.3 Kenya Energy Situational Analysis

According to Kenya National Bureau of Statistics, in 2007, the country’s population stood at 35.5 million people distributed in 6.860 million households with an average size of 5.1 persons per Household. About 75 % of the households are found in rural areas average household size of 5.5 persons while some 25% households are in urban areas but with a smaller household size at 4.0. For most of this population firewood remains the predominant fuel for cooking with 68.3% households using 80% of the rural households use firewood compared with 10% urban residents. Charcoal, derived from primary biomass is the second most popular cooking fuel used by 13.3% of the households. Kerosene paraffin is ranked third predominant cooking fuel and the most common in urban areas with 44.6% reporting using it (Nairobi and Mombasa reporting 63.5% and 53.6% respectively).

Kerosene is on the other hand the most popular lighting fuel with over 75% reporting using it. This translates to 86.4% of the rural areas using kerosene for lighting. Electricity is the second
most popular energy for lighting at 15.6% where 51% of the urban households connected and 4% of the rural households. It is noteworthy that 1.6% of the households are using solar photovoltaic for lighting.

According to the Kenya SWERA report, the national efforts towards meeting millennium development goals and poverty eradication are focused on increasing access to services in a holistic and pragmatic manner. The UNDP supported regional strategy for scaling access to modern energy services which is based on High Impact, Low Cost, Scalable (HILCS) interventions that are target: to address the cooking and heating practices by 50% of those who at present use traditional biomass for cooking; increase access to reliable electricity for all urban and peri-urban poor, increase access to modern energy services such as lighting and communication technology and increase access to mechanical power within the community for all heating and productive uses.

2.4 Overall structure of the energy sector

The MoE coordinates the overall policy and provides guidance on investment and development of the energy sub-sectors covering electricity, petroleum and renewable energy. The country’s energy policy is guided by the 2004 Sessional Paper No. 4 on Energy and by the resulting Energy Act 2006. In August 2010, Kenya promulgated a new constitution that further promotes sustainability and the independence of the energy sector to secure supply and protect the environment. The energy policy and Act are currently under review to incorporate the aspirations of the constitution and the Energy Policy, 2014 and Energy Act, 2014 were expected to be effective by June 2014.

The Energy Act 2006 brought the regulations affecting all the energy sub-sectors under one umbrella body, the Energy Regulatory Commission (ERC). The ERC is a single-sector regulator with responsibility for economic and technical regulation of the electric power, renewable energy, and downstream petroleum sub-sectors, including tariff-setting and review, licensing, enforcement, dispute settlement and approval of power purchase and network service contracts (Republic of Kenya, 2006a). The Act also recognizes other institutions such as the Rural Electrification Authority (REA) to oversee the implementation of the rural electrification programme (previously the role of the MoE) and the energy tribunal, and also created other key institutions such as the Geothermal Development Company (GDC) to oversee geothermal
exploitation, and the Kenya Electricity Transmission Company (KETRACO) to carry out electricity transmission in addition to the existing institutions in power generation, supply and distribution. The new constitution provides for some regulatory functions to go to constituency governments in electricity and gas networks. Nevertheless, national laws and policies supersede constituency laws to avoid duplication.

2.5 Solar Energy and Lighting—Fuel Choice in Kenya
To investigate lighting-fuel choices and, afterwards, specifically discuss the use of SHSs in Kenya we used data from the Kenyan Integrated Household Budget Survey (KIHBS) 2005/2006 provided by the Kenya National Bureau of Statistics (KNBS). The sample consisted of 13,430 households — with 10 households randomly drawn from each of the 1,343 clusters — stratified into 136 strata, according to Kenya’s 69 districts. The clusters are drawn from a pool of 1,800 clusters with a probability, proportional to their size, based on data from the 1999 Population and Housing Census. Item non response is virtually nonexistent (less than 1 percent). The KIHBS dataset contains a unique set of information for our purposes, since it includes very detailed questions about households energy consumption and, furthermore, specifically asks for details on households’ ownership and use of SHSs. By far the most important energy source that Kenyan households purchase is paraffin/kerosene (hereafter referred to simply as kerosene). More than 80 percent of all Kenyan households have some expenditure for this type of energy source). And (non-zero) median expenditure amounts to 160 Kenyan shillings (KES) per household.

Traditional fuels, more specifically firewood and charcoal, also account for a considerable portion of household fuel expenditure. Approximately 15 percent of Kenyan households have non-zero expenditure for firewood, and 36 percent for charcoal. With non-zero median expenditures even higher than those for kerosene (KES 200 and KES 250, respectively), these traditional sources are generally still used to a significant extent. Modern fuels are used by a smaller part of the population, 6 percent in the case of gas/LPG and 12 percent in the case of electricity. If households use these sources, their expenditure for them is much higher than for traditional or transitional fuels, with KES 780 for gas/LPG and KES 350 for electricity. Of course, these much higher costs reflect much greater energy consumption.
2.6 Level of Knowledge and Awareness of Solar Technology

The adoption of innovations describes a point in time when the adopter of an innovation decides to use the innovation in question. Rogers (2006) theories that the process of adoption commences with an individual driven by precedent conditions such as a felt need to adopt an innovative product or service. The individual will pass along an innovation decision process at a pace that is influenced by their own level of innovativeness and by the perceived characteristics of the innovation. The decision making process is aided by communication channels; either mass-media communications or by local channels such as word-of-mouth.

A more thorough quantitative analysis of the Kenyan SHSs market was carried out by Jacobs (2006), who describes various aspects of the Kenyan SHSs market and presents analyses based on two cross-sectional surveys among rural Kenyan households which were conducted in 2000 and 2001. Jacobs finds that the benefits of solar electrification are captured, primarily by the rural middle class, that solar plays only a modest role in supporting productive activities and education, and that solar electrification is more related to general market forces than to poverty alleviation and sustainable development. Based on the 2000 survey, Jacobs further finds that most SHSs are owned by households in the first three wealth deciles. He characterizes these households as belonging to the rural middle class, with annual household incomes well above USD 2,000 (in current USD). In the paper the further argues that the data suggests a trend towards a deepening of access beyond the middle class, with smaller systems becoming affordable for lower-income households as well.

Rebane and Barham (2011) analyze the determinants of SHSs awareness and adoption in Nicaragua. They identify the determinants of four measures of SHSs knowledge. This is followed by an investigation of factors that predict SHSs adoption conditional upon sufficient awareness about SHSs. They used survey data from 158 households in rural Nicaragua, 40 of which had adopted SHSs. Knowledge is predicted most strongly by the presence of other installed SHSs, being male, being young and having a high-quality residence (as a proxy for wealth). Income, having learned about SHSs from a business or NGO and not living in the Caribbean lowlands (where SHSs were very rare at the time the survey was carried out) are all positive determinants of SHSs adoption, while living near a dealer reduces the likelihood of
adoption. The authors presume that the latter is due to the proximity of dealers to urban areas, which would suggest that the households near a dealer might have higher expectations of grid extension in the near future. Rebane and Barham (ibid.) argue that knowledge about SHSs is important in the adoption process, that the presence of other SHSs is a very important educational tool, and that women should be included in education about SHSs.

The model of adoption that Caird et al. (2008) propose is more directly related to the context of energy efficiency than any of the models discussed in this review and it draws on many elements common to the Diffusion of innovations model, for example the element of communication. The results of research by Caird et al (2008) into the use and adoption of renewable energy systems by householders extends the categorization of adopters depending on their level of engagement with the technology and motivation to reduce energy use. The model they propose presents the consumer as an agent influenced by various sources such as the socio-economic context, consumer variables, communication sources, and product and system properties. Within the two models proposed by Rogers (2006) and Caird et al (2008), there are common factors that inform the decision making process, namely the innovation attributes, and the categorization of adopters.

It is worth noting that while the studies on cooking-fuel choice mostly draw on national household surveys, the SHSs adoption literature cited above typically uses smaller surveys, often tailored to one specific research question (e.g. Jacobs 2006; Komatsu et al. 2011). By using the KIHBS household budget survey we thus try to achieve convergence between household budget survey we thus try to achieve convergence between both strands of literature.

2.7 Level of Income of Households
One important element of our conceptual framework is the energy-ladder hypothesis. This hypothesis assumes that a household’s fuel (or energy source) choice depends crucially on the household’s income level. As income rises, households move first from using traditional fuels, such as wood, to transitional fuels, like kerosene, and then to modern fuels, such as electricity from the grid (Leach 1992). Modern fuels are generally perceived to be superior to traditional or transitional fuels in efficiency, comfort and ease of use (Farsi et al. 2007). The concept can thus be seen as a stylized extension of the economic theory of the consumer: as income rises,
consumers not only demand a larger amount of the good but also change their consumption pattern in favor of higher quality goods (Hosier and Dowd 1987).

The stark differences observed in energy-use patterns between poor and rich countries (e.g. Leach 1992) as well as between households with differing income levels within many (developing) countries motivated the energy-ladder hypothesis, which has since served as the basis for many empirical applications in the literature (e.g. Heltberg 2004; Gebreegziabher et al. 2011). Indeed, the empirical literature has confirmed that income is one of the main demand-side factors determining household fuel choice. This can be partly explained by the fact that modern fuels often involve a relatively large upfront investment in equipment, which hinders credit-constrained poorer households from using it. In addition, the adoption of modern fuels may require knowledge and a certain level of education as demand-side factors. On the supply side, there is often a lack of access to markets for modern fuels and the required equipment may not be supplied. All these factors together may explain why so many poor households are prevented from climbing up the energy ladder.

For this household activity the majority of households use firewood, charcoal, kerosene or electricity, with the specific mix varying depending on the setting (Heltberg, 2004; Hosier and Dowd 1987; Farsi et al., 2007; Njong, and Johannes 2011). Each household faces a number of mutually exclusive options for cooking fuels and chooses the fuel that maximizes its utility. So-called fuel stacking – that is, a household’s combining of different fuels for one purpose (in this case cooking) – is an aspect that is often discussed in the literature (Acker and Kammen, 1996). In this case, a single option can be a combination of different fuels. Fuel stacking is therefore addressed in some cases by using typical fuel combinations as choices (Heltberg, 2004) and ignored in other cases by considering only the main fuel used by the household (Farsi et al. 2007).

The literature on cooking-fuel choice often stem from national household surveys and typically do not include a time dimension. The studies therefore investigate a kind of “cross-sectional energy ladder,” as they do not discuss economic development over time, but rather variations in cross-sectional data – that is, between rich and poor households. In the following, we review
some evidence on the determinants of fuel choices for cooking fuels in developing-country contexts. Heltberg (2004), for example, investigates fuel switching in urban areas for eight developing countries. He finds a strong link between electrification and the uptake of modern cooking fuels. Other factors that are associated with an increased likelihood of choosing modern fuels are consumption expenditure and education, as well as, in some specifications, the size of the household. In a similar investigation in Guatemala, Heltberg (2004) confirms the relevance of income for fuel choice. He also emphasizes the importance of non-income factors, such as the cost of firewood (as firewood is a widely used cooking fuel in Guatemala).

The study shows the widespread prevalence of fuel stacking for cooking purposes in Guatemala and therefore explicitly incorporates two-fuel options into the empirical analysis (for example, joint wood-liquefied petroleum gas (LPG) use). Farsi et al. (2007) take a slightly different approach and also find that income is one of the main factors that prevent households from using modern and cleaner fuels in an application for India based on a household expenditure survey. Additionally, they find that the education level and gender of the household head as well as LPG prices impact fuel choice. In contrast to Heltberg (2004, 2005) the authors use the fuel that provides the highest share of total useful cooking energy as the dependent variable and order the fuels in terms of efficiency, comfort and ease of use, strictly in line with the energy ladder.

Gebreegziabher et al. (2011) assess the determinants of the adoption of electric mitad cooking appliances for baking bread, among other energy uses, in Northern Ethiopia and the effects of this adoption on urban energy transition. The authors' analyze the factors that explain urban households’ choice of fuel among five options: wood, charcoal, dung, kerosene and electricity. Based on survey data the paper finds that the likelihood of the electric mitad adoption increases with household expenditure, age of household head and family size. Furthermore, fuel choices more generally are found to be determined by the prices of substitutes, household expenditure, age and education of household head, and family size, with the probability of using transitional and modern fuels (such as kerosene and electricity) positively correlated with the price of wood and charcoal, household expenditure, the age and education of the household head.
All of the studies presented above find income or household expenditure to be a key determinant of cooking-fuel choice, in line with the energy-ladder hypothesis. Most authors additionally stress the importance of non-income factors, which vary slightly from case to case but typically include both socioeconomic demand-side factors and supply-side factors, such as fuel prices or electrification rates. While some of these factors are specific to cooking (for example, gender of household head), most are likely to affect lighting-fuel choices as well (for example, education).

The above literature on the determinants of cooking-fuel choices is closely linked to empirical studies that analyze SHS adoption. The factors that are of special relevance to SHS up-take should also be included in our lighting-fuel choice analysis, in addition to the more general fuel-choice determinants.

### 2.8 Availability of Alternative Sources of Power

According to KNBS (2011), Kenya’s installed electric power capacity was 1,412.2MW as at 31 December 2010. The effective installed capacity was not enough to meet demand, so the government contracted for 60MW of emergency power. This was needed in order to meet the growing demand and reduce load-shedding, particularly during peak periods. Hydropower is the main source, accounting for 51.55% of total installed capacity. Petrol thermal, geothermal, cogeneration and wind account for 33.2%, 13.38%, 1.84% and 0.36% respectively. Renewable energy accounts for about 67.1%, which means that power generation in Kenya is now largely ‘green’. Although installed capacity in hydropower has not seen much growth in the last decade, there have been increased initiatives in geothermal exploitation, sustaining the level of clean electricity in the national grid.

The solar market in Kenya is among the largest and its usage per capita is the highest among developing countries. Cumulative solar sales in Kenya (since the mid-1980s) are in excess of 200,000 systems, and annual sales growth has regularly topped 15% over the past decade (Jacobs, 2006). Much of this activity is related to the sale of household solar systems, which account for an estimated 75% of solar equipment sales in the country (KEREA, 2009). Compared to countries such as Germany, the existing solar PV market in Kenya remains small. This market is, however, relatively well established compared to other countries in East Africa,
such as Tanzania and Uganda. In 2006, the total installed base was about 250,000 units or 5 MW. New installations have averaged about 25,000–30,000 units p.a (KEREA, 2009).

Further growth in the solar sub-sector is likely to be held back by market failures and other barriers. Most demand for PV systems is driven by the rural non-electrified private sector, with cash sales being the usual method of transaction. Changes in Kenya’s power sector since the adoption of the Sessional Paper No. 4, 2004 on a blueprint for the country’s energy policy have led to new interest in renewable energy. Recent policies have focused on geothermal, hydropower and co-generation technologies with much less emphasis on PV technology, although the government is currently implementing an electrification scheme for remote schools using solar energy (Ngigi, 2006).

In addition to its energy policy, interest in renewable energy in Kenya has risen due to renewed initiatives in rural electrification and environmental concerns about global warming and air quality. The previous focus on renewable energy responded to two main orientations. Large-scale renewables, such as large hydropower and geothermal projects, were developed in order to improve the security of supply through diversification and reduced exposure to external shocks such as high oil prices. Recently, there has been growing interest in new renewable energy technologies (RET) such as wind, small hydro, and PV energy. These technologies have been developed to expand access to modern energy services, especially in rural and marginalized areas such as rural Kitengela area which is arid.

Although Kenya is well endowed with renewable energy resources, only geothermal, wind and co-generation (generation from bagasse) have been seriously exploited and connected to the national electricity grid (KNBS, 2011). Solar energy is relatively well developed and has enormous potential due to the country’s proximity to the equator. Kenya is the third largest market for domestic solar systems after India and China. In fact, Kenya and China are the fastest growing markets, with annual growth rates of 10%–12% in recent years, with private dealers providing most solar systems (Arora et al., 2010) although the government has also taken measures to increase uptake of these technologies. The initial markets received donor seed money in the 1980s (Mwakubo et al., 2007), which allowed PV system components to become
accepted and available. The government has recently intensified measures to increase the uptake of renewable energy by championing initiatives to adopt these technologies. Some of these initiatives include the fitting of the Ministry of Energy (MoE) offices (Nyayo House), the Office of the President (Harambee House), the Office of the Prime Minister and the Ministry of Finance (Treasury) with solar PV and natural lighting. Funds for this were factored in the National Budget 2011/2012, demonstrating government commitment to these initiatives (Ministry of Finance, 2011b).

2.9 Government policy on adoption of solar power
Various policy interventions and strategies have been used to improve access, ensure security of supply of affordable energy and achieve efficiency and conservation. These have been implemented by individual countries or unions such as the European Union or even within economic blocks. The energy policy in Kenya has evolved through sessional papers, regulations and Acts of Parliament. The focus in the past has been on the electricity and petroleum sub-sectors. The Sessional Paper No. 10 of 1965 dwelt on the Electric Power Act (CAP 314) that was used to regulate the sector. This was followed by the Sessional Paper No. 1 of 1986, which however, did not focus much on the power sector. The Sessional paper called for the establishment of the Department of Price and Monopoly Control (DPMC) within the Ministry of Finance, under new legislation, to monitor action in restraint of trade and to enforce pricing in the various sectors. This also included the petroleum sub-sector (Karekezi and Ranja, 1997).

In 1981, the National Oil Corporation of Kenya Limited (NOCK) was established by the government and incorporated under the Companies Act (Cap 486). The company's main objective then was to coordinate oil exploration (upstream) activities. In 1988 the company was mandated on behalf of the government to supply 30% of the country's crude oil requirements that would in turn be sold to oil marketing companies for refining and onward sale to consumers. The Petroleum Act (Cap 116) for a long time was used to guide operations in the sector (Ngigi, 2006). In addition to this legislation there was the Petroleum Exploration and Production Act that was enacted in 1984. It gave NOCK the mandate to oversee oil exploration activities in the country. In 1994, there was further implementation of policies to liberalize most of prices and sectors in the country such as removal of exchange rate controls; interest rates decontrol and price decontrol that included petroleum products among other goods in the consumer basket. It
was during this period that the oil industry was deregulated and NOCK lost its mandate to supply the 30% of the country’s crude oil requirement. The company therefore had to formulate new survival strategies that saw its entry into downstream operations.

The energy sector witnessed further developments in policy which saw the unbundling of the Kenya Power and Lighting Company into three entities with the enactment of the Electric Power Act No. 11 of 1997. These were the Kenya Power and Lighting Company that was to carry out transmission and distribution functions, the KenGen to carry out the generation function and the Electricity Regulatory Board (ERB) to regulate the power sector in 1998. The Act aimed at facilitating private sector participation in the provisions of electricity services. The Act also allowed Independent Power Producers (IPPs) to enter into Power Purchase Agreements (PPAs) with KPLC to add more power into the grid.

In 2004, the Ministry of Energy in consultation with stakeholders in the sector developed the Sessional Paper No. 4 of 2004. This policy has a number of broad objectives including ensuring adequate, quality, cost effective and affordable supply of energy to meet development needs, while protecting and conserving the environment. The specific objectives of the energy policy are to: provide sustainable quality energy services for development; utilize energy as a tool to accelerate economic empowerment for urban and rural development; improve access to affordable energy services; provide an enabling environment for the provision of energy services; enhance security of supply; promote development of indigenous energy resources; and promote energy efficiency and conservation as well as prudent environmental, health and safety practices (Moreira and Wamukonya, 2002). ERC is mandated by the Energy Act, 2006 to carry out the following functions: regulate the electrical energy, petroleum and related products, renewable energy and other forms of energy; protect the interests of consumer, investor and other stakeholder interests; maintain a list of accredited energy auditors as may be prescribed; monitor, ensure implementation of, and the observance of the principles of fair competition in the energy sector, in coordination with other statutory authorities; Provide such information and statistics to the Minister as he may from time to time require; and Collect and maintain energy data; prepare indicative national energy plan; and Perform any other function that is incidental or consequential to its functions under the Energy Act or any other written law. Other institutions
created with the enactment of the Act were the Rural Electrification Authority (REA) and the Energy Tribunal. Recently, the government has created two other key institutions in the sector. These are the Geothermal Development Company (GDC) and Kenya Electricity Transmission Company (KETRACO).

The future of the energy sector in Kenya is bright. In the electricity sector, green electricity is going to be the energy of the future. Government efforts to increase power generation are in geothermal and wind sources of electricity. GDC has embarked on an ambitious programme to increase the number of wells in Olkaria and other potential areas while in wind, KPLC has already signed a PPA with Lake Turkana Power Company to supply 300MW of electricity. In petroleum; there have been increased activities in exploration of hydrocarbons in Northern and Coastal regions in the country. The government has also intensified search for coal deposits in Kitui. Lastly, future government policy in energy is leaning towards improvement of the working modalities with Public Private Partnerships (PPPs). All these initiatives are aimed at ensuring security of energy in the country in order to meet increased energy demand as envisaged in vision 2030.

2.10 Theoretical Framework
The study was guided by several theories that relates to adoption of domestic solar technology.

2.10.1 Innovative Diffusion Theory (IDT)
The theory of diffusion of innovation by Rogers (1995) provides perceptions that individuals may have of adopting an innovation such as solar technology. The theory explains, predicts, and accounts for the factors which influence adoption of an innovation. This is in line with the studied variables. According to Rogers (2006) individuals technology adoption behavior such as solar technology is determined by his or her perceptions regarding relative advantage, compatibility, complexity and observability of an innovation. These constructs have relationship with the studied variables. This relates to attitude towards use of solar technology.

Adoption of a new idea, behavior, or product (i.e., "innovation") does not happen simultaneously in a social system; rather it is a process whereby some people are more apt to adopt the innovation than others. Researchers have found that people who adopt an innovation early have
different characteristics than people who adopt an innovation later. When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. The stages by which a person adopts an innovation, and whereby diffusion is accomplished, include awareness of the need for an innovation, decision to adopt (or reject) the innovation, initial use of the innovation to test it, and continued use of the innovation. There are five main factors that influence adoption of an innovation, and each of these factors is at play to a different extent in the five adopter categories.

1. Relative Advantage - The degree to which an innovation is seen as better than the idea, program, or product it replaces.
2. Compatibility - How consistent the innovation is with the values, experiences, and needs of the potential adopters.
3. Complexity - How difficult the innovation is to understand and/or use.
4. Triability - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.
5. Observability - The extent to which the innovation provides tangible results.

2.10.2 Resource Based Theory

The resource based theory states that the basis for competitive advantage of a firm lies primarily in the application of the bundle of valuable resources at the firm’s disposal (Wernerfelt, 1984), including technology such as solar technology. According to Manoney and Pandian (1992) firm’s ability to reach competitive advantage when different resources are employed and these resources cannot be imitated by competitors. This relates to access to solar technology resources, tools and funds. From this theory when households have enough resources of funds and access to solar tools they can easily adopt solar technology in their homes.

The resource based view has been a common interest for management researchers and numerous writings could be found for same. A resource-based view of a firm explains its ability to deliver sustainable competitive advantage when resources are managed such that their outcomes cannot be imitated by competitors, which ultimately creates a competitive barrier (Mahoney and Pandian 1992 cited by Hooley and Greenley 2005, p. 96, Smith and Rupp 2002, p. 48). RBV explains that a firm’s sustainable competitive advantage is reached by virtue of unique resources.
being rare, valuable, inimitable, non-tradable, and non-substitutable, as well as firm-specific (Barney 1999 cited by Finney et al. 2004, p. 1722, Makadok 2001, p. 94). These authors write about the fact that a firm may reach a sustainable competitive advantage through unique resources which it holds, and these resources cannot be easily bought, transferred, or copied, and simultaneously, they add value to a firm while being rare. It also highlights the fact that not all resources of a firm may contribute to a firm’s sustainable competitive advantage. Varying performance between firms is a result of heterogeneity of assets (Helfat and Peteraf 2003, p. 1004) and RBV is focused on the factors that cause these differences to prevail (Grant 1991, Mahoney and Pandian 1992, cited by Lopez 2005, p. 662).

Fundamental similarity in these writings is that unique value-creating resources will generate a sustainable competitive advantage to the extent that no competitor has the ability to use the same type of resources, either through acquisition or imitation. Major concern in RBV is focused on the ability of the firm to maintain a combination of resources that cannot be possessed or built up in a similar manner by competitors. Further such writings provide us with the base to understand that the sustainability strength of competitive advantage depends on the ability of competitors to use identical or similar resources that make the same implications on a firm’s performance. This ability of a firm to avoid imitation of their resources should be analyzed in depth to understand the sustainability strength of a competitive advantage

2.10.3 Theory of Reasoned Action

According to Brown, Massey and Burkman, (2002) the theory states that both attitude and subjective norm are important determinants of people’s intention to adopt and use technology in enterprises. Further the intention to adopt and to continue using technology is influenced by ones attitude. The theory states that an individual behavior is influenced by his or her behavior’s intention which is influenced by his or her attitude towards behavior of subjective norm (Venkatesh et al, 2000).

Behavioral intention measures a person's relative strength of intention to perform a behavior. Attitude consists of beliefs about the consequences of performing the behavior multiplied by his or her evaluation of these consequences (Fishbein & Ajzen, 1975). Subjective norm is seen as a combination of perceived expectations from relevant individuals or groups along with intentions
to comply with these expectations. In other words, "the person's perception that most people who are important to him or her think he should or should not perform the behavior in question" (Fishbein & Ajzen, 1975). To put the definition into simple terms: a person's volitional (voluntary) behavior is predicted by his attitude toward that behavior and how he thinks other people would view them if they performed the behavior. A person's attitude, combined with subjective norms, forms his behavioral intention.

Fishbein and Ajzen suggest, however, that attitudes and norms are not weighted equally in predicting behavior. "Indeed, depending on the individual and the situation, these factors might be very different effects on behavioral intention; thus a weight is associated with each of these factors in the predictive formula of the theory. For example, you might be the kind of person who cares little for what others think. If this is the case, the subjective norms would carry little weight in predicting your behavior" (Miller, 2005, p. 127).
2.11 Conceptual Framework

Independent Variables

Knowledge and Awareness of solar technology.
- Access Information on existence of solar devices
- Availability of solar firms or installations in the area.
- Informal training on solar technology.

Level of Income of Households
- Regular income
- Assets
- Shares

Availability of Alternative Sources of Power
- Proximity Grid electricity
- Proximity to Firewood/kerosene charcoal
Knowledge of available substitutes

Dependent Variable

Adoption of Solar Power Technology for Domestic Usage
- Homesteads using solar energy.
- Requests for installation of solar equipment
- Availability of providers of solar equipment

Government Policies
- Established legal framework
- Provision of incentives

Moderating Variable

Figure 1: Conceptual Framework

The figure above shows that the study considered the Dependent variable to be the Adoption of solar power technology for domestic use. This was influenced by the independent variables: (1) Knowledge and Awareness of solar technology, (2) Level of Income of Households and (3)
Availability of Alternative Sources of Power. It was expected that the afore-mentioned variables greatly affected the adoption or lack of adoption of solar energy use in households. This study sought to establish to what extent the level of knowledge and awareness affects adoption of solar energy in households with respect to access to information, training and even the presence of solar technology providers, if available does it influence the level of adoption? Similarly, the study sought to find out the influence of the disposable income per household on adoption of solar power technology and also the influence of availability of alternative source of power.

There are some government policies in place specific to solar energy in Kenya and though they are relatively new the study considered them as moderating variables.

2.12 Summary of Literature Review
In this section it was noted that adoption was a function of social, institutional and technological characteristics. A global shift towards adoption of renewable energies was noted with wind and solar leading this campaign. Previous studies in other countries identified factors affecting the adoption of solar power technologies including: Knowledge and Awareness of technology, Level of Income, Proximity to Service and Gender Issues.

The literature concerning the adoption of domestic solar power systems is limited and typically paints a pessimistic picture of the potential for solar power systems. In summary, most insights on fuel choice stem from the empirical analysis of cooking fuel choices. In addition, the determinants for the adoption of solar energy technologies are typically examined without putting them into the context of a particular fuel choice and often based on non-representative samples and case studies. As lighting fuel choices and the role of lighting in energy use in developing countries have not been investigated as thoroughly as cooking fuel choices, we focus our analysis on the fraction of household energy consumption that goes to lighting.

It was evident that a lot of effort has been put in place by the Kenyan government through policies and renewable energy strategies to support adoption of the solar technologies. It was noted that there were many theories put forward to explain various levels of adoption without concrete corroborating data. It therefore makes it to establish the various factors that directly
limit the adoption of solar technologies in the Kenyan market. This investigation is important not only due to the role of lighting in household energy use, but also as increased access to lighting is expected to contribute to better adoption of solar technology, the achievement of the UN’s Millennium Development Goals (IEA 2008) and to Kenya’s vision 2030.
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction
This chapter outlines the type of research methodology that was applied in the study. It covers the type of research design, sample and sampling procedure method, target population, Accessible population and sample size. Further data collection procedure and analysis, research instruments the study adopted. It also looks at the validity and reliability of instruments and ethical issues.

3.2 Research Design
The research adopted a descriptive survey design. According to Kothari, (1985), descriptive design allows the researcher to describe record, analyze and report conditions that exist or existed. The research study used both quantitative and qualitative approaches. The data was collected to study the factors affecting adoption of household solar technology in Kitengela area.

3.3 The Target Population
The target population is that which researcher wanted to generalize the results of the study (Mugenda and Mugenda, (2003). The population for the study comprised of the households in Kitengela area. Population was 32,762 (Male – 16,928 and Female – 15,834. The number of Households in the Constituency was 6,733. The Data above was given by the ministry of planning and vision 2030. This study was concerned with the adoption of solar especially in households. The target population in consideration was 6,733 households as recorded by the ministry of planning based on 2009 Census.

3.4 Sample Size and Sampling Procedure
The study adopted a stratified random sampling method. The reason for the choice of this method was because the target population is divided into divisions, locations, wards and villages (Krejcie, Robert, Morgan, Daryle 2010). In this case the target population was divided into villages. The sample size was 365.

The decisions about sample size should take into consideration the size of the target population being researched (e.g. all residents in a particular community, members of a particular club or association, people in a particular occupation.) and the level of accuracy one require from the
research (Fleiss, 1981). Hence the consideration of all the households, whether headed by women or men of any age group.

**Table 3.1: Sampling Frame**

<table>
<thead>
<tr>
<th>No.</th>
<th>Villages</th>
<th>Households</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ilbisil</td>
<td>645</td>
<td>35</td>
</tr>
<tr>
<td>2.</td>
<td>Athi-Kaputiei</td>
<td>1383</td>
<td>75</td>
</tr>
<tr>
<td>3.</td>
<td>Isinya</td>
<td>1106</td>
<td>60</td>
</tr>
<tr>
<td>4.</td>
<td>Olturoto</td>
<td>2711</td>
<td>147</td>
</tr>
<tr>
<td>5.</td>
<td>Enkasiti</td>
<td>888</td>
<td>48</td>
</tr>
<tr>
<td>6.</td>
<td>Total</td>
<td>6733</td>
<td>365</td>
</tr>
</tbody>
</table>

**3.5 Data Collection Method**

A self-administered questionnaire was used as a data collection instrument. It comprised of both open ended and close ended questions. The use of questionnaires enabled the respondents to remain anonymous and be honest in their responses (Cooper and Schindler, 2003). The choice of the questionnaire was based on the fact that it is easy to analyze the collected data statistically. Further it is not biased and the responses were gathered in a standardized manner so they would be more objective in their results. The questionnaire were divided into sections that examined the different variables that assisted in the discovery of what the real factors are that influences the adoption or lack of adoption of the technology by the Kitengela area people.

**3.6 Instrument Validity**

Validity is the degree to which an instrument measures what is supposed to measure (Kothari, 1985). It is the degree to which results obtained from the analysis of the data actually represent the phenomenon under study. The validity was enhanced through appraisal of the tools and verification by the supervisor who is an expert. Furthermore, the questionnaire was subjected to pre-test to detect any deficiencies in it. The necessary improvements were made.
3.7 Instrument Reliability
Mugenda and Mugenda, (2003) define reliability as a measure of a research instrument yields consistent results or data after repeated trials. To test reliability a test re-test method was employed to the same categories of respondents after a period of two weeks to examine the consistency of response between the two tests in a pilot study. This was done in the neighboring lower Kaputei area where a 10% of the intended sample was submitted to the instrument. This was a sample of 37 households selected randomly.

3.8 Data Analysis
Data analysis consists of examining categorizing; tabulating or otherwise recombining the evidence to address the initial prepositions of the study. The data collected was cleaned and coded. This was to enhance basic statistical analysis. The data analysis involved quantitative and qualitative methods (numerical and descriptive). Qualitative data was analyzed based on content analysis while quantitative data was analyzed using descriptive and inferential statistics. Data was analyzed with the help of electronic spreadsheet SPSS Program which has analysis tools. The collected data was presented using statistical techniques which included percentages and frequency distribution tables.

3.9 Ethical Considerations
The principle of voluntary participation was strictly adhered to. The respondents were not coerced into participating in the research. They were informed about the purpose of the study. The researcher guaranteed the participants confidentiality in the entire research process. The researcher sought authority from all the relevant authorities for conformity and in ensuring the study is not discontinued in the process. The researcher sought authority from the District Commissioners in Kitengela Township plus the divisional officers, chiefs and elders in the area of study by visiting their offices and presenting relevant documents required by each one of them.
### 3.10 Operationalization of Variables

#### Table 3.2: Operationalization of Variables

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>Variable-Independent</th>
<th>Indicator</th>
<th>Measurement</th>
<th>Measurement scale</th>
<th>Methods of data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To assess the extent to which the level of knowledge and awareness of solar technology influence the adoption of household solar technology in Kitengela.</td>
<td>Level of Knowledge and Awareness of solar technology</td>
<td>- Access to Information on existence of solar devices</td>
<td>- No of Solar installations seen in the area.</td>
<td>Ordinal</td>
<td>Descriptive-Correlation Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Availability of solar firms or installations in the area.</td>
<td>- No. of solar traders or providers available.</td>
<td>Ordinal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Informal training on solar technology.</td>
<td>- No. of informal trainers in the region.</td>
<td>Ordinal</td>
<td>-frequencies distribution tables</td>
</tr>
<tr>
<td>2. To investigate the extent to which the level of income of Households influence the adoption of Solar technology in home in Kitengela</td>
<td>Level of Income of households</td>
<td>- Regular income</td>
<td>- Ksh. Per month</td>
<td>Ordinal</td>
<td>Descriptive frequencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- assets</td>
<td>- No of tangible of assets</td>
<td>Ordinal</td>
<td>Inferential correlation analysis,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- shares</td>
<td>- No of shares held.</td>
<td>Nominal</td>
<td>hypothesis testing</td>
</tr>
<tr>
<td>3. To determine Availability</td>
<td>Availability</td>
<td>- Proximity</td>
<td>- distance from</td>
<td>Ordinal</td>
<td>Descriptive</td>
</tr>
</tbody>
</table>
the extent to which availability of substitute power source influence the adoption of household solar technology in Kitengela.

<table>
<thead>
<tr>
<th>Source of Power</th>
<th>Grid Electricity</th>
<th>Grid electricity</th>
<th>Ordinal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proximity to Firewood/kerosene charcoal</td>
<td>knowledge of available substitutes</td>
<td>Ordinal</td>
</tr>
<tr>
<td></td>
<td>distance to Kerosene shops</td>
<td>- No of people aware of alternative available</td>
<td>Inferential correlation analysis</td>
</tr>
</tbody>
</table>

Frequencies
CHAPTER FOUR: DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction
This chapter focuses on data analysis, interpretation and presentation. The purpose of this study was to investigate the factors influencing adoption of solar technology in Kitengela. The objectives of the study were (1) to assess the extent to which the level of knowledge and awareness of solar technology influence the adoption of domestic solar technology, (2) to investigate the extent to which the level of income of households influence the adoption of domestic solar technology and (3) to determine the extent to which the availability of substitute power source(s) influences the adoption of domestic solar power technology.

4.2 Response Rate
The response rate of respondents is presented in Table 4.1.

Table 4.1: Response Rate

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responded</td>
<td>301</td>
<td>82.5</td>
</tr>
<tr>
<td>Did not respond</td>
<td>64</td>
<td>17.5</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>100</td>
</tr>
</tbody>
</table>

From table 4.1 above, the researcher distributed 365 self-administered questionnaires to the sampled respondents, 301 questionnaires were returned and this represents an 82.5% response rate which the researcher found sufficient to proceed with data analysis. The high response rate is attributed to the fact that the researcher worked with a team of very close friends who had the necessary motivation to administer the questionnaires to the respondents.

4.3 Background Information of the Respondents
The researcher asked the respondents to indicate their gender, marital status, age, if they were the household head and if they were connected to electricity.

4.3.1 Gender of the Respondents
In this section the researcher sought to establish the gender of the respondents. Their responses are shown in table 4.2.
Table 4.2: Gender of the Household heads (n=300)

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>162</td>
<td>53.9</td>
</tr>
<tr>
<td>Female</td>
<td>138</td>
<td>46.1</td>
</tr>
</tbody>
</table>

53.9% of the household heads were males while as 46.1% of the household heads were females. This implies that there were more male respondents than females. This might be so because most homes are dominated by males as household heads. This however will not affect the responses from the respondents thereby creating any form of biasness.

4.3.2 Marital status of the Household Heads

In this section the researcher sought to establish the marital status of the household heads. Their responses are highlighted in the Table 4.3.

Table 4.3: Marital status of the Household Heads (n=300)

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>132</td>
<td>43.9</td>
</tr>
<tr>
<td>Single</td>
<td>150</td>
<td>49.8</td>
</tr>
<tr>
<td>Divorced</td>
<td>9</td>
<td>3.0</td>
</tr>
<tr>
<td>Separated</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Widower</td>
<td>10</td>
<td>3.3</td>
</tr>
</tbody>
</table>

49.8% of the household heads were single, 43.9% of the household heads were married, 3.3% of the household heads were widowed while as 3.0% of the household heads were divorced. This implies that most of those who responded were single. This did not affect the results collected from the respondents.

4.3.3 Age of the Household Heads

In this section the researcher sought to establish the age of the household heads. Their responses are highlighted in the Table 4.4.
Table 4.4: Age of the Household Heads (n=300)

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 to 24 yrs</td>
<td>152</td>
<td>50.6</td>
</tr>
<tr>
<td>25 to 30 yrs</td>
<td>81</td>
<td>26.9</td>
</tr>
<tr>
<td>31 to 35 yrs</td>
<td>37</td>
<td>12.3</td>
</tr>
<tr>
<td>36 to 40 yrs</td>
<td>10</td>
<td>3.3</td>
</tr>
<tr>
<td>41 to 45 yrs</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>46 to 50 yrs</td>
<td>4</td>
<td>1.3</td>
</tr>
<tr>
<td>Over 50 yrs</td>
<td>13</td>
<td>4.3</td>
</tr>
</tbody>
</table>

50.6% of the household heads were aged between 18 years to 24 years, 26.9% of the household heads were aged between 25 years to 30 years, 12.3% of the household heads were aged between 31 years to 35 years, 1.3% of the household heads were aged between 41 years to 45 years, 1.3% of the household heads were aged between 46 years to 50 years and 4.3% of the household heads were aged over 50 years. This shows that the largest population of the respondents was young as a result of which they were able to understand issues related to solar technology.

4.3.4 Head of the Household

Here the goal was to know if the respondent was the head of the household. Their responses are highlighted in the Table 4.5.

Table 4.5: Head of the Household (n=300)

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household heads</td>
<td>147</td>
<td>48.8</td>
</tr>
<tr>
<td>Not Household heads</td>
<td>154</td>
<td>51.2</td>
</tr>
</tbody>
</table>

51.2% of the respondents were not the household heads while as 48.8% of the respondents were the household heads. This implies that most of the respondents were not the household heads. This might be so because by the time the questionnaires were given out most of the heads were not at home. This however will not affect the responses from the respondents since they have enough information about their homes.
4.4 Level of Knowledge and Awareness of Solar

The researcher sought to address the first objective that looked at the extent to which the level of knowledge and awareness of solar technology influence the adoption of domestic solar technology in Kitengela. The table 4.6 below illustrate the study findings:

Table 4.6: Level of Knowledge and Awareness of Solar Technology

<table>
<thead>
<tr>
<th>Factors Under consideration</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of solar power in use E.g. charging a phone or in any other use</td>
<td>3.0</td>
<td>0.5</td>
</tr>
<tr>
<td>To what extent is the Solar system installed in your household</td>
<td>2.1</td>
<td>0.9732</td>
</tr>
<tr>
<td>What is the level of any formal or informal training on Solar systems you received</td>
<td>1.2</td>
<td>0.4320</td>
</tr>
<tr>
<td>Accessibility of any Solar Technology Providers in the area</td>
<td>1.0435</td>
<td>0.8763</td>
</tr>
<tr>
<td>Level of acquiring a solar household system</td>
<td>1.100</td>
<td>0.5432</td>
</tr>
<tr>
<td>To what extent do you use other forms of energy for lighting? i.e Paraffin, Gas, Firewood or dry cells</td>
<td>3.2</td>
<td>0.35</td>
</tr>
</tbody>
</table>

The study sought to seek information from the respondents on the level of knowledge and awareness of solar. Respondents agreed that the level of solar power in use e.g. charging a phone or in any other use was agreed to a very high extent with a mean of 3.0, this was possibly because there were few households currently using solar power and thus majority of people and neighbours within the household that has installed the solar system rely on it. On the extent that the Solar system installed in the households, respondents gave a moderate response of mean 2.1, on the level of formal/ informal training on Solar systems received respondents strongly disagreed that there is no training they underwent m=1.2, Accessibility of Solar Technology Providers in the area was also dismissed with a mean of 1.0435, Level of acquiring a solar household system was also found to be substantially low with a mean of 1.100 and the extent of using other forms of energy for lighting i.e Paraffin, Gas, Firewood or dry cells was positively found to be high with a mean of 3.2.
4.5 Level of income of Households
Respondents at this level of the study were asked to determine how level of income affect adoption of solar power in Kitengela. The table 4.7 below illustrate the study findings:

Table 4.7: Level of income of households

<table>
<thead>
<tr>
<th>Factors Under consideration</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the levels of investment in solar system for your house</td>
<td>2.4643</td>
<td>0.7532</td>
</tr>
<tr>
<td>Levels of employment of people on a monthly salary or savings</td>
<td>2.1863</td>
<td>0.7833</td>
</tr>
<tr>
<td>Level of regular income but not monthly –bi-monthly or otherwise</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Extent of involvement in “chama” that contribute money whose goals or aims are for solar household installations</td>
<td>2.4230</td>
<td>0.8765</td>
</tr>
<tr>
<td>Extent of borrowing loan for anything in the bank or with any microfinance institute</td>
<td>2.345</td>
<td>0.97</td>
</tr>
<tr>
<td>Degree of involvement in shares in any kind of Capital Authority shares</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Majority of the respondents m=2.4 indicated that levels of investment in solar system for households in Kitengela is too low, employment levels of people on a monthly salary or savings, regular income, involvement in chama and borrowing loan were also found out to be on low levels within the people of Kitengela. There was no level of involvement in shares of any kind of Capital Authority shares.

4.6 Availability of Alternative Sources of Power
Respondents at this level of the study were asked to rate how availability of alternative sources of power affected the adoption of solar energy in Kitengela area. The table 4.8 below shows the study findings:
Table 4.8: Availability of alternative sources of power

<table>
<thead>
<tr>
<th>Factors Under consideration</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of electricity near you through schemes like REA? (Rural Electrification authority)</td>
<td>3.400</td>
<td>0.3</td>
</tr>
<tr>
<td>Level of usage of alternative energy sources that can be available to you</td>
<td>3.2</td>
<td>0.5</td>
</tr>
<tr>
<td>High accessibility of vendors who sell wood, charcoal, others wood based fuels from your home</td>
<td>3.0</td>
<td>0.438</td>
</tr>
<tr>
<td>Households at close proximity to Grid electricity</td>
<td>3.4554</td>
<td>0.6443</td>
</tr>
<tr>
<td>Knowledge of available substitutes</td>
<td>3.2</td>
<td>0.3482</td>
</tr>
</tbody>
</table>

Respondents argued that there was availability of electricity near their households through schemes like REA (Rural Electrification authority) and proximity to Grid electricity was not very far away from their localities m=3.4, indicating respondents might be shunning away from connecting the electricity grid due to the expense of installations. Level of usage of alternative energy sources, accessibility of vendors who sell wood, charcoal, others wood based fuels and knowledge of available substitutes were all agreed to a high extent with a mean above 3.0.
4.7 Correlation analysis

Table 4.9: Pearson’s Correlation

<table>
<thead>
<tr>
<th></th>
<th>Adoption of solar power</th>
<th>Level of knowledge and awareness</th>
<th>Level of income of households</th>
<th>Availability of Alternative Sources of Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption of solar power</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of knowledge and awareness</td>
<td>.536</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of income of Households</td>
<td>.752</td>
<td>.618</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Availability of Alternative Sources of Power</td>
<td>.667</td>
<td>.628</td>
<td>.747</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: Researcher (2014)

Two predictor variable are said to be correlated if their coefficient of correlations is greater than 0.5. In such a situation one of the variables must be dropped from the analysis. As shown in table 4.9 above, none of the predictor variables had coefficient of correlation between themselves less than 0.5 hence all of them were included in the model. The matrix also indicated high correlation between the response and predictor variables, which are level of knowledge and awareness, level of income, availability of alternative sources of power.

4.8 Regression Analysis

Using SPSS, a multivariate regression model was applied to determine the relative importance of each of the three variables with respect to the adoption of solar power in Kitengela, Kajiado County. The regression model was as follows:

\[ Y = \beta_0 + X_1\beta_1 + X_2\beta_2 + X_3\beta_3 \]

Where:

- \( Y \) = Adoption of solar power in Kitengela, Kajiado county
- \( X_1 \) = Level of knowledge and awareness
- \( X_2 \) = Level of income of households
X₃= Availability of alternative sources of power
β₀ = constant (y intercept)
β = coefficient
ε = error term

**Table 4.10: Model Summary**

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square(R²)</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
<th>Change Statistics</th>
<th>R Square Change</th>
<th>F Change</th>
<th>df1</th>
<th>df2</th>
<th>Sig. F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.918</td>
<td>.843</td>
<td>.805</td>
<td>.51038</td>
<td>.843</td>
<td>1.242</td>
<td>3</td>
<td>360</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

*Predictors: (Constant), Level of knowledge and awareness, Level of income of households, Availability of alternative sources of power*

*Dependent Variable: Adoption of solar power*

**Source: Researcher (2014)**

Analysis in table 4.10 above shows that the coefficient of determination (the percentage variation in the dependent variable being explained by the changes in the independent variables (Level of knowledge and awareness, Level of income of households and availability of alternative sources of power), R² equals 0.843, leaving only 15.7 percent unexplained. The P- value of 0.000 (Less than 0.05) implies that the model of Adoption of solar power is significant at the 5 percent significance.

**Table 4.11: Analysis of Variance (ANOVA)**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>.852</td>
<td>4</td>
<td>.213</td>
<td>1.242</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>20.35</td>
<td>360</td>
<td>.171</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22.64</td>
<td>364</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Predictors: (Constant) Level of knowledge and awareness, Level of income of households, Availability of alternative sources of power*

*Dependent Variable: Adoption of solar power*

**Source: Researcher (2014)**
ANOVA findings (P-value of 0.00) in table 4.11 shows that there is correlation between the predictors variables (Level of knowledge and awareness, Level of income of households, Availability of alternative sources of power) and response variable (Adoption of solar power)

Table 4.12: Coefficients of regression equation

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>.260</td>
<td>.460</td>
<td>0.565</td>
<td>.231</td>
</tr>
<tr>
<td>Level of knowledge and awareness</td>
<td>X₁</td>
<td>.512</td>
<td>.048</td>
<td>.254</td>
</tr>
<tr>
<td>Level of income</td>
<td>X₂</td>
<td>.170</td>
<td>.045</td>
<td>-.300</td>
</tr>
<tr>
<td>Availability of substitute</td>
<td>X₃</td>
<td>.051</td>
<td>.023</td>
<td>.113</td>
</tr>
</tbody>
</table>

Dependent Variable: Adoption of solar power

Source: Researcher (2014)

The established multiple linear regression equation becomes:

\[ Y = 0.260 + 0.512X_1 + 0.170X_2 + 0.051X_3 \]

Where

Constant = 0.260, shows that if Level of knowledge and awareness, Level of income of households and availability of alternative sources of power all rated as zero, Adoption of solar power would be 0.260

\[ X_1 = 0.512, \text{ shows that one unit change in Level of knowledge and awareness results in 0.512 units increase in Adoption of solar power} \]

\[ X_2 = 0.170, \text{ shows that one unit change in Level of income of households results in 0.170 units increase in Adoption of solar power} \]
X₃= 0.051, shows that one unit change in Availability of alternative sources of power results in 0.051 units increase in Adoption of solar power

4.9 Test of hypothesis
The study findings in table 4.13 show the probability (P) values for the hypotheses in the study.

Table 4.13: Hypothesis testing

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>P-Values</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₀: There is no significant relationship between level of knowledge and awareness and the adoption of solar power for domestic use in Kitengela area</td>
<td>P=0.001&lt;0.05</td>
<td>Accept H₁, Reject H₀</td>
</tr>
<tr>
<td>H₁: There is a significant relationship between level of knowledge and awareness and the adoption of solar power for domestic use in Kitengela area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₀: There is no significant relationship between level of income of households and the adoption of solar power for domestic use in Kitengela area</td>
<td>P=0.000&lt;0.05</td>
<td>Accept H₁, Reject H₀</td>
</tr>
<tr>
<td>H₁: There is a significant relationship between level of income of households and the adoption of solar power for domestic use in Kitengela area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₀: There is no significant relationship between availability of alternative sources of power and the adoption of solar power for domestic use in Kitengela area</td>
<td>P=0.002&lt;0.05</td>
<td>Accept H₁, Reject H₀</td>
</tr>
<tr>
<td>H₁: There is a significant relationship between availability of alternative sources of power and the adoption of solar power for domestic use in Kitengela area</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With the first objective, the study rejects the H₀ and accepts the H₁ concluding that there is a significant relationship between level of knowledge and awareness and the adoption of solar power for domestic use.

Similarly, with the second objective, the study rejects the H₀ and accepts the H₁ concluding that there is a significant relationship between level of income of households and the adoption of solar power for domestic use.

On the third objective, the study rejects the H₀ and accepts the H₁ concluding that there is a significant relationship between availability of alternative sources of power and the adoption of solar power for domestic use.
CHAPTER FIVE: SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction
This chapter presents the summary of findings, discussion and conclusions drawn from the findings and recommendations made. The conclusions and recommendations drawn were focused on addressing the purpose of the study, which was to investigate the factors influencing adoption of Solar Technology in Kitengela, Kajiado county.

5.2 Summary of the Major Findings
The table 5.1 below summarizes the findings of the study:

Table 5.2: Summary of findings

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influence of the level of knowledge and awareness of solar technology on adoption of domestic solar technology in Kitengela</td>
<td>The first Objective the study was to establish the extent to which Knowledge and Awareness of solar technology influenced adoption. The Study established that, 84.7% of the household heads have seen solar power in use; Most of them 74% have seen solar lamps. Awareness of the existence of solar technology in lighting is high in the community although, 79.7% of the household heads indicated they have never received any formal or informal training on solar systems, 91.4% of the 20.3% who indicated some training indicated they have been trained up to the certificate level on solar systems by the Service providers. The study concluded that knowledge and awareness of the availability of solar technology has positive effect on adoption on solar.</td>
</tr>
<tr>
<td>Objectives</td>
<td>Main findings</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Influence of level of income of households on the adoption of domestic solar technology in Kitengela</td>
<td>The second was to investigate the extent to which the level of income of households influenced the adoption of domestic solar technology in Kitengela. The findings of the study showed that the Majority of the people, 32.9% of the household heads have no regular income, 54.2% of the household heads indicated they had saving accounts. The income is irregular and Majority of them had no loans, no access to bank loans, no shares and no bank accounts. This indicates that the level of income has a negative influence on solar technology adoption.</td>
</tr>
<tr>
<td>Influence of availability of alternative source of power on the adoption of domestic solar technology in Kitengela</td>
<td>The third objective was to determine the extent to which availability of alternative source of power influenced the adoption of domestic solar technology in Kitengela. The findings showed that 60.1% of the household heads indicated that the vendor and the grid Electricity was less than 5 km from home, However less than half of them knew the cost of installing Electricity in their home or of using any other energy source apart from what they were used to. This indicates that increased distance of alternative source of energy does not positively influence adoption of solar technology.</td>
</tr>
</tbody>
</table>
5.3 Discussions
The Study finds that the level of knowledge and awareness of solar technology influenced the adoption of domestic solar technology in Kitengela positively. The findings showed that most of the residents in Kitengela used solar energy mainly for lighting. Majority of the residents here had seen a solar lamp and solar power in use and were aware of the solar technology providers in the area. This is supported by Rogers (2003) who theorizes that the process of adoption commences with an individual driven by precedent conditions such as a felt need to adopt an innovative product or service. The individual will pass along an innovation decision process at a pace that is influenced by their own level of innovativeness and by the perceived characteristics of the innovation. The decision making process is aided by communication channels; either mass-media communications or by local channels such as word-of-mouth However, most of the people both those who used or did not use solar energy indicated they had not received any formal or informal training on solar systems and for those who had received the training they had gone up to certificate level. This findings agree with earlier studies on integration of new concepts that state that, Prior knowledge is generally considered of high importance as it is deemed to serve both as the foundation for integration of new concepts and as a potential obstacle to conceptual change (Mason, 2002; Vosniadou, 2002; Chi and Roscoe, 2002).

The findings from the study showed that the level of income of households influences the adoption of domestic solar technology in Kitengela in a negative way although the technology is only adopted in a very basic way. This hypothesis assumes that a household’s fuel choice (or energy source) depends crucially on the household’s income level. As income rises, households move first from using traditional fuels, such as wood, to transitional fuels, like kerosene, and then to modern fuels, such as electricity from the grid (Leach 1992). The study revealed that most of the residents in Kitengela had no regular income, but were able to make some savings probably at different seasons of the year. This may have contributed to the high number of residents who have solar lamps or phone charging equipment powered by solar. Majority of the respondents did not have loans in the banks or in any microfinance institutions. The findings show that most of the residents did not have enough money to purchase and install solar energy and the lack of daily income influenced their ability to secure loans from banks and microfinance
institution. Indeed, the empirical literature has confirmed that income is one of the main demand side factors determining household fuel choice.

The third research question looked at the extent to which availability of alternative sources of power influenced adoption of domestic solar technology in Kitengela. The findings from the study showed that convenience or easy availability influenced adoption of solar technology products. Most of the residents in Kitengela were less than five kilometers from the charcoal vendor and the nearest electricity grid was more than 600 meters from their homes. The fact that they are familiar with the current energy source and its availability affects adoption of solar technology negatively. This is supported by Lee, J. and Eastwood, D. (2003), where he states that adoption of new technology is dictated by accessibility and need in A Two-Step Estimation of Consumer Adoption of Technology. The cost of installing small solar units in the households was known. Given these key factors that is availability of charcoal vendors and close electricity grids limited the full exploitation of solar energy. The resident’s knowledge of the cost of solar installations might have deterred them from adopting solar energy given that it was probably expensive to purchase and install the solar system.

The study also established that there is a positive correlation between the level of Knowledge and awareness and adoption of solar technology. This was the same for the level of income of households and the availability of alternative source of power. This means that the more the community is knowledgeable and aware on solar technology and the higher the level of income of households, the more likely they would adopt to solar technology. On the other hand the more the availability of alternative source of power, the less likely the community would be likely to adopt to solar technology. Given the above factors that influence the adoption of solar technology, most of the respondents were categorical that they would recommend the use of solar technology to others.

5.4 Conclusions
In light of the above findings, the study concludes that the people of Kitengela have not adopted much to solar power technology. Those who have are using solar for charging their Mobile phones and for lighting only. This may be due to the fact that they have never received any formal or informal training on solar systems and those who had, were trained up to the certificate level on solar systems by the Solar technology providers who only train on their products and are
not based in the area but make visits from time to time. This implies that the level of knowledge and awareness of solar technology and its use was relatively low. The level of knowledge and awareness from the individuals who had installed solar system in their household, had seen a solar lamp in use, had seen solar power in use, were aware of solar technology providers and had received both formal and informal training influenced the adoption of solar.

The study also concludes that lack of daily income and access to secured loans from banks and microfinance institution influenced the adoption of solar technology. The individuals who had savings account were able to secure loans easily adopted the use of solar.

Finally, the study concluded that the presence of alternative sources of power that may be cheaper to install might have deterred them from adoption of solar technology. The longer the distance is from the vendors of alternative sources, the higher the chances of adopting to use of solar.

5.5 Recommendations

Based on the above findings the researcher recommends that:

The Study showed that the there was a relationship between training and solar adoption. Those who were trained on solar use and installation are more likely to start using solar technology. The Government of Kenya and especially the Ministry of Energy need to provide training and education to increase the level of knowledge and awareness on the use of solar energy. This can be done through seminars, workshops and public barazas where members are invited for training and demonstration on the use and benefits of solar energy.

The study further found that the high cost of the solar equipment and the fact that most of the people did not have regular income and therefore had very low chances of accessing loans meant that they were unable to afford solar equipment. The Government should consider zero rating tax on Solar equipment so as to influence lower pricing thus making it more affordable for purchase and installation of solar system. This would be of assistance especially for the people living in the rural areas. Alternatively, the government could arrange for a plan that allows households to pay an agreeable small amount of money per month in a bid to increase the use of solar energy.
The Community used other sources of Energy, which were mostly wood based. The county Councils Need to get involved as energy solution providers regardless of the availability of alternative/substitute of other sources of energy. Solar power will eventually help the councils achieve better forest cover as Communities turn to solar and use less wood based fuel. The community should be encouraged to harness solar technology since it is cheaper and easily accessible compared to other sources of energy given that the community comes from a remote area where the sun is abundant.

The Grid Electricity in most of Kitengela is far from the community settlements and the likelihood of majority of the people living here getting grid electricity in the near future is slim. This means that Kenya Power needs to identify the opportunity provided by the gap in Kitengela and indeed in Kenya and import, sell and install solar systems that provide more than just lighting as the opportunity is there to assist other Kenyans who are not served by the Grid Electricity to access better energy solutions.

5.6 Areas of Further Researcher
The researcher recommends that more research needs to be done on

1. The relationship between training and adoption of solar technology.

2. How Gender affects solar adoption.

3. The relationship between Culture, Convenience and adoption of new technology.
REFERENCES


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Mason Jennifer (2002) Qualitative Researching, SAGE Publications Ltd.
Venkatesh V. and Davis FD, A theoretical extension of the technology acceptance model: Four Longitudinal Field Studies: Management Science 186-204
APPENDICES

APPENDIX 1: LETTER OF TRANSMITAL

NAOMI CHEPTOO NG’ENO
University of Nairobi,
School of Distance and Continuing Education,
Mombasa Campus.

Dear Sir/Madam,

I am a Masters student at the University of Nairobi, School of Continuing and Distance Education. In partial fulfilment of the requirement for a Master of Arts in Project Planning and Management, I am conducting a survey on the **FACTORS AFFECTING THE ADOPTION OF SOLAR POWER FOR DOMESTIC USAGE IN KAJIADO COUNTY, KENYA**

I kindly request for your assistance in completing the attached questionnaire which forms a major input of the research process. The information and data will be used for academic purposes only and strict confidence shall be observed on the same.

Your cooperation will go a long way in ensuring the success of this project.

I would like to thank you in advance for your valuable time and consideration.

Yours Sincerely,

NAOMI CHEPTOO NG’ENO
L50/76251/2009
University of Nairobi
APPENDIX 2: QUESTIONNAIRE

The research instrument has been formulated to collect data for the purpose of the research meant to create greater understanding on factors influencing adoption of solar technology. Please note that your response to these questions will be confidential and shall be used for the purpose of this research only.

INSTRUCTIONS
Please tick where appropriate and for explanation, please be brief

PART ONE: BACKGROUND INFORMATION

<table>
<thead>
<tr>
<th>1. Please indicate your gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Marital status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24yrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Are you the household head?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Are you connected to electricity?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Adoption Of Solar</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Do you already use solar energy in your home?</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>b) Would you like to own a solar system?</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>
4. Is there anything that may have prevented you from acquiring the use of Solar Technology? Please explain briefly

5. Would you recommend the use to solar technology to others?

Yes | No

**PART TWO. LEVEL OF KNOWLEDGE AND AWARENESS OF SOLAR**

To what extent do you agree with the following statements? (Select all the appropriate)

Give your ratings in the scale of 1-4 (where 1= disagree, 2= Agree to a small extent, 3= Agree to a high extent, 4= strongly agree)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a high Level of solar power in use per installation? E.g. charging a phone or in any other use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Many households have Solar systems installed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households have been given formal and informal training on Solar systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There are Accessible Solar Technology Providers in the area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Your household would consider acquiring a solar household system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households use other forms of energy for lighting to a large extent? i.e Paraffin, Gas, Firewood or dry cells</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**PART THREE: LEVEL OF INCOME**

To what extent do you agree with the following statements? (Select all the appropriate)

Give your ratings in the scale of 1-4 (where 1= disagree, 2= Agree to a small extent, 3= Agree to a high extent, 4= strongly agree)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a high level of investment in solar system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment of people mainly on a monthly salary or savings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is high level of people on regular income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Extent of involvement in “chama” that contribute money</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Extent of borrowing loan for anything in the bank or with any microfinance institute</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Degree of involvement in shares in any kind of Capital Authority shares</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Part Four: Availability of Alternative Sources of Power**

To what extent do you agree with the following statements? (Select all the appropriate)

Give your ratings in the scale of 1-4 (where 1= disagree, 2= Agree to a small extent, 3= Agree to a high extent, 4= strongly agree)

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is availability of electricity near you through schemes like REA? (Rural Electrification authority)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is high level of usage of alternative energy sources that can be available to you</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There is high accessibility of vendors who sell wood, charcoal,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
others wood based fuels from your home high

There is close proximity to Grid electricity near household

Household equipped with Knowledge of available substitutes

Thank you for responding to the questionnaire. Your time is highly appreciated.