



COLLEGE OF HUMANITIES, DEVELOPMENT AND SOCIAL SCIENCES

**Attitudes towards new green technologies: A study of
households using solar water heaters in low income RDP
houses in Kwandengezi Coffee Farm, eThekweni
Municipality.**

by

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Submitted in partial fulfilment of the degree of Masters in Development Studies in the School of Built Environment and Development Studies, University of KwaZulu-Natal, Durban, 2013.

Declaration

I hereby declare that this dissertation is my own original work. All citations, references and borrowed ideas have been duly acknowledged. This dissertation is being submitted for the degree of Masters in Development Studies in the Faculty of Humanities, Development and Social Sciences, University of KwaZulu-Natal, Durban, South Africa. None of the current work has been submitted previously for obtaining any degree or examination in any other University.

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank God the Father, the Son and the Holy Spirit for the knowledge, wisdom and guidance.

I would like to acknowledge the following people who contributed to the completion of this dissertation:

- To my mother Nonduduzo Nxumalo for her continuous emotional and financial support.
- To my late father Alpha Clement Nxumalo (Zwide KaLanga) for blessing me before you left to be with God.
- To my supervisor Professor Richard Ballard, for believing and encouraging me, inspiring me, providing me with constructive criticism, direction and guidance in every aspect of the dissertation. I would like to pass my gratitude and appreciation to you Prof. Ballard for having accepted to be my supervisor. May God Bless you.
- To the community members of Kwandengezi Coffee Farm for their participation and sharing their experiences with me.
- To government officials from eThekweni Municipality.
- And last but not least, to my family and friends, for your prayers and encouragement.

God Bless you all.

Words of Wisdom: *Hebrews 11: 1*

“Now faith is the substance of things hoped for, the evidence of things not seen”.

Abstract:

Within the international context, energy has become a central factor in our everyday ways of life. There is increasing dependence on energy resources such as electricity to improve people quality of life. In developing countries, many people still do not have access to energy due to several challenges that have hindered infrastructural development and economic growth. At the same time, there is a growing interest in the protection of the environment and addressing issues of climate change. Green technologies such as solar water heaters are identified as technologies that meet the need of both its end-users and the environment through the provision of hot water. Access to 'hot water' is seen to be an important element resulting in an improved quality of life. In addition, several methods of heating water are explored to assess the attitudes and perceptions that people have towards solar water heaters.

The dissertation involved in-depth interviews with residents from low income RDP houses in Kwandengezi Coffee Farm and government officials from eThekweni Municipality involved in the solar water heater programme for low income communities. The interviews revealed that renewable energy interventions such as the solar heater programme for low income communities contribute significantly to an improvement in people's quality of life. The availability of solar heaters allows people to enjoy hot water at a free cost, hence an improvement in the quality of life. The research further revealed that such renewable energy interventions can contribute to a reduction in negative environmental impacts, hence facilitating the acquisition of hot water with less dependence on electricity resources.

ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ANC	African National Congress
COP17	Conference of the Parties
DFID	Department for International Development
DME	Department of Minerals and Energy
EM	EThekweni Municipality
ESKOM	Electricity Supply Commission
GHG	Green-House Gas
IEA	International Energy Agency
KZN	KwaZulu-Natal
NGO	Non-Governmental Organization
PBMR	Pebble Bed Modular Reactor
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
RDP	Reconstruction and Development Programme
REP	Rural Electrification Project
RSA	Republic of South Africa
SWH	Solar Water Heaters

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Chapter One

1.1 Introduction

The following research emerged out of the author's strong interest in the field of energy and development. The focus of the research was on energy efficiency and the application of new green technologies, specifically solar water heaters, in low-income RDP houses for sustainable development. The dissertation interrogates the attitudes and perceptions towards new green technologies. It further examines the issues surrounding the provision of solar water heater systems, highlighting both international and local experiences. The research was conducted in eThekweni Municipality which includes the city of Durban.

Durban is a city located on the east coast of the province of KwaZulu-Natal. eThekweni Municipality is the local sphere of government that is responsible for administration, planning and development of the city. Durban is also the main economic hub for the province of KZN (Scott *et al.*, 2011). Scott *et al.* (2011) asserts that the population of eThekweni reveals a relatively young and vulnerable population group, characterized by high youth unemployment, high dependency rates, low life expectancy, poverty and high prevalence rates of HIV/AIDS (Scott *et al.*, 2011: 35-40).

1.2 Motivation for the Study

South Africa is a country characterized by high levels of poverty and inequality with economic policies having benefited some of the population. Millions of people suffer from poor service delivery by municipalities and not all citizens have enjoyed the benefits of water and electricity in their homes. Considerable progress has been made in rolling out infrastructure to many who have not historically had access. However, there have been hindrances to effective service delivery. In particular, cost structures and repayment systems have further impaired the ability of poor people to enjoy the full benefits of water and electricity in their homes. Moreover, the urgency of enabling today's generation to benefit from such basic services is therefore an important issue of sustainability and sustainable development.

Solar water heaters have been identified as being a cost effective strategy for allowing people to have access to hot water (eThekweni Municipality, 2011). eThekweni Municipality has adopted an active role in delivering solar water heaters to low income households. The use of such hot water systems provides an alternative to accessing hot water without the use of electricity. In addition, solar water heaters have been introduced for energy saving as Durban moves towards becoming a 'low carbon city'.

Little research has focused on community responses in relation to renewable technologies for development in poor local communities within eThekweni Municipality. There is a dearth of literature about the user friendliness and sustainability of renewable technologies from the perspective of end-users. The study hopes to contribute to literature on attitudes and perception that people have towards renewable technologies and towards the low carbon agenda.

In 2011, eThekweni Municipality developed a solar heater programme for low cost to contribute to a reduction in energy consumption. The programme was aimed at providing affordable solar heater systems for low-income households to have access to hot water. In addition, this study will play a critical role of informing the Municipality on how communities are responding to solar heater systems. The community's perceptions and attitudes revealed by the study are important in guiding the Municipality's further collaborative planning and investments in solar heater programmes. This dissertation intends to contribute to eThekweni Municipality's vision of being a 'low carbon city' and towards their mission of mitigating the effects of climate change. The city of Durban hopes to reduce the amount of energy used by low income households to heat water. EThekweni Municipality affirms that significant reductions in energy consumption and greenhouse gas emissions are achievable (eThekweni Municipality, 2011).

1.3 Overview of Literature

The study investigates the application and provision of renewable technologies for low income RDP housing programmes. The study is informed by development theories of sustainable development. Sustainable development is a comprehensive term, also known as a 'boundary

term' (Gieryn, 1999 cited in Scoones, 2007: 589) that can be used to create a space for linking environment, economic growth and development concerns (Scoones, 2007). The Brundtland Report defines sustainable development as "development that meets the need of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987a: 43). The production of energy resources remains a big concern for sustainable development.

Globally, energy has become a central factor in our everyday ways of life because of high dependence on energy resources for everyday living (IEA, 2010a). In developing countries, many people still do not have access to energy due to several factors exacerbated by stagnant infrastructural interventions. Energy further plays a major role in development and poverty reduction. It is therefore vital to examine the shift from using fossil fuels which are cost effective, but harmful to the environment, to exploring innovative ways of energy production that have increased socioeconomic and environmental benefits (see also Hagraдзе *et al.*, 2007; IEA, 2010a; Ijumba and Sebitosi, 2010; Haselip *et al.*, 2011).

Moreover, looking at international studies, Sovacool and D'Agostino (2012) explore three countries in the global south, namely China, Papua New Guinea and Laos. They articulate that these studies focus on the dissemination of solar heater systems in countries within the global south. Kapadia (2003) further notes that solar heater technologies have been largely promoted by the World Bank and through the global environment facility programmes in other countries within the global south. Wlokas (2011) mentions that solar water heaters have been proved to be an important technological innovation project that contributes towards increasing access to energy services and hot water infrastructure in poor communities, particularly in rural areas where there is still insufficient electricity infrastructure.

Karekezi (2002) states that several energy analysts have had different perspectives in analyzing the energy sector within the global south. In contrast, ideologies from the developed world have largely focused on long-term worldwide environmental impact of contemporary patterns in the production and utility of heat energy. Whereas in some countries, the focus has been on addressing poverty and increasing access to energy services in disadvantaged communities.

Moreover, the DFID (2002) argues that social concerns have received less attention within the energy sector. Therefore, there is a strong need to examine such concerns so as to find the gaps that exist in literature. This thesis also looks at the ways in which solar water heaters have improved poor people's quality of life. In addition, the dissertation will explore two major themes namely affordability and sustainability of solar water heaters. It concludes by highlighting and analysing end-user responses.

1.4 Aims and Objectives of the Study

The aim of this dissertation is to investigate the attitudes and perceptions toward new green technologies held by people living in low-income RDP houses in Kwanengezi Coffee Farm. It further uncovers the cost and benefits of using solar water heaters and identifies end-user responses of people living in low-income households. Moreover, it intends to create awareness for government and stakeholders involved in the renewable energy industry.

The objectives of this research are the following:

- To assess the attitudes and perceptions of people living in low-income households of Kwanengezi toward solar heater systems.
- To assess the user friendliness of solar water heaters to low income households.
- To evaluate the costs and benefits of using solar water heaters in low income households in Kwanengezi Coffee farm and the sustainability of these solar heater systems.
- To reflect on the relationship between low income households and renewable technologies using solar water heaters as an empirical lens.

1.5 Research Questions

- What attitudes and perceptions do people living in low-income households of Kwanengezi Coffee Farm have towards solar water heaters?
- What mechanisms are there to ensure the user friendliness of solar water heaters to low income households?

- What are the costs and benefits of using solar water heaters in low income households in Kwandengezi (Coffee farm)?
- What mechanisms are there to ensure that solar heater systems are sustainable?
- What is the relationship between low income households and renewable technologies (solar water heaters)?

1.6 Overview of Methodology

This research study makes use of a qualitative research design. A qualitative research design is a useful method for conducting research as it provides a researcher with first hand primary data. This research design was selected because it provides more in-depth and descriptive qualitative data. It further provided a more detailed and accurate image which uncovers the subjective experiences of people who have been using solar water heaters while living in low-income (see also Neuman, 2000).

The study further made use of primary and secondary data. Primary data emerged from in-depth interviews and secondary data was drawn from published and unpublished data within eThekweni Municipality and a wide range of published academic literature. In addition, participants were asked to complete a one full day schedule regarding their use of hot water and interaction with solar water heaters on a daily basis. This provided an indication of when solar water heaters are mostly useful and at which particular times of the day for households. Secondary data assisted the researcher to identify the gaps in the existing literature so as to provide a greater understanding of people's perception towards solar water heaters.

This qualitative study also made use of in-depth interviews and discussions which lasted approximately forty five minutes to one hour. The study examined the attitudes and perceptions that people have towards solar heaters. The sample consisted of males and females living in low income RDP households. The study further made use of the purposive sample technique. Neuman (2006) describes purposive sampling as based on the judgment of the researcher regarding characteristics of the sample and is used for special circumstances. In addition, the researcher also has a predefined group in mind when making use of the purposive sampling

technique for the research study (Neuman, 2006). The key respondents that were considered for this research study were sixteen household members living in low income households of Kwandengezi Coffee Farm above the age of 18; with the sampling consisting of eight women and eight men. The low income houses were selected along the main street of Coffee Farm (200129 Street) on Google earth map shown in chapter four.

In addition, officials from eThekweni Municipality's Energy Office and Housing Department were interviewed and two other stakeholders who are involved in the design and implementation of the solar heater programme were consulted. Although the researcher did not receive any feedback from the two stakeholders involved in the designing of the solar heater programme, he relied on information displayed on their company websites. People participating in the research study participated on a voluntary basis and no names of participants were mentioned in this research. All data collected were recorded, transcribed and translated. NVIVO was used to code all data and formulate themes emerging from the data. The study took a period of approximately six months for completion. All research findings were then compared with the rest of the data in order to identify information that was consistent with the organized themes (Strauss and Corbin, 1990 as cited in Akintola, 2010a: 56).

1.7 Chapter Outline

The dissertation is divided into 6 chapters of which this is the first. Chapter 2 develops a theoretical framework and unpacks international experiences on solar water heaters. It further reviews the concept of energy and development within the international context, and investigates development theories that inform the concepts of renewable energy resources and green technologies. Chapter 3 analyses the role of solar water heaters in low cost housing programmes within the local context. Recent and relevant research sources are used to develop a discussion around four key points. Chapter 4 unpacks the research method and approach that was followed to unpack the purpose of this dissertation. The qualitative research design was used to primarily make effort to assess the attitudes and perceptions that people living in low income households have towards new green technologies, precisely solar water heaters.

Chapter 5 presents the findings and analysis of the research from the interviews that were conducted. It further incorporates findings from eThekweni Municipality and service providers that install solar water heaters in low income communities. Chapter 6 focuses on the discussion and draws on the key themes that were derived from the research and then concludes.

Chapter Two: Theoretical Framework and International Experiences

2.1 Introduction

This chapter develops a theoretical framework and unpacks international experiences on solar water heaters. It reviews the concept of energy and development within the international context, and further investigates development theories that inform the concepts of renewable energy resources and green technologies. The purpose of this chapter is to contextualize state-provided solar water heaters within a broader set of considerations including development, the importance of energy consumption in development, and the implications of types of energy production sources for the environment and end-users. The discussions have been thematically broken down into five sections.

The first section defines the concept of renewable energy and green technologies and further explores the theories of development that informs renewable energy technologies and their application through the concepts of Sustainability and Sustainable Development. This discussion further tackles the environmental, economic and social pillars of sustainable development. The second discussion examines the uses of energy in the development context and uncovers the relationship between energy and development. It explores several key points on how energy resources improve people's quality of life. The third section examines the production of energy and highlights various implications for end-users. The fourth section discusses the implications that renewable energies have on the environment. The fifth section focuses on solar water heater case studies in three global south countries and then concludes.

2.2 Theoretical Framework: Sustainable Development

The study is informed by theories of sustainability and sustainable development. Sustainability is defined as “the capacity to maintain some entity, outcome, or process overtime” (Jenkins, 2009: 380). The sustainability approach highlights how environmental problems endanger economic growth, health and social processes (Jenkins, 2009). Jenkins (2009) asserts that sustainability is defined by social circumstances. For example, Jenkins mentions that this

includes an economic policy or a cultural practice that may be regarded as sustainable if it does not weaken the support of a political community (Jenkins, 2009).

The sustainability approach incorporates social responses to environmental and social concerns in societies (Jenkins, 2009). The theory of sustainable development and the green economy has been the subject of a series of conferences within the United Nations and around the globe. They have encouraged the adoption of policies that are aimed at improving and informing government planning towards environmental protection. The following will refer to some of these landmark events and documents.

The approach of sustainability emanates from the framework of sustainable development and informs the basis of this research study. The energy crisis has been and continues to be a global challenge or a ‘sustainability concern’ facing developed world and developing countries. Globally, the political transformation of sustainability has elevated a combination of essential problems and wide-ranging targeted goals (Jenkins, 2009). Sustainability has clarified mutual effects between environmental decay caused by the activities that humans participate in.

There are three pillars of sustainability namely environmental, economic and social pillars. I argue that sustainable development is both useful and limited as a concept, because it can be easily claimed by those interested in ‘green washing’ their activities occurring within the environmental, economic and social spaces. Sustainable development is defined as being a comprehensive term, also known as a ‘boundary term’ that can be used to create a space for linking environment, economic growth and development concerns (Gieryn, 1999 cited in Scoones, 2007: 589). The Brundtland Report defines sustainable development as “development that meets the need of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987a: 43).

Scoones argues that “the term *sustainability*, and more particularly sustainable development, drew on longer intellectual debates across disciplines in the 1980s” (2007: 589). This resulted in a continuous dialogue on the conceptualization of these two terms in order to address

concerns about the environment. In the early 1980s, the Brundtland Commission on Environment and Development supported the idea behind the establishment of the sustainable livelihoods approach (WCED, 1987a). This resulted in planned consistent policy debates and engagements that were achieved through established methods of incorporating socioeconomics and environmental deliberation (Scoones, 2007).

In addition, the idea behind sustainability and sustainable development was extended and outlined through the framework Agenda 21. The UNCED Report (1992) cited in Scoones (2007: 589-595) further provides a comprehensive idea behind the aim of Agenda 21. The report states that the plan behind this policy intervention was to accomplish sustainable development through achieving widespread goals for poverty reduction, reduction in inequality and achieving sustainable livelihoods (see also Scoones, 2007; UNDP, 1997). The encouragement of sustainability and sustainable livelihoods in local communities enabled policy interventions to address development and its challenges (Scoones, 2007). This included poverty eradication, inequality reduction and sustainable management of natural resources (Scoones, 2007). In essence, the sustainable livelihoods approach provides a comprehensive framework for analysing the complex underlying causes of poverty (see also DFID, 2002; Scoones, 2007).

Moreover, the concept of sustainability is further defined as “the ability of a system to bounce back from such shocks and stresses and adopt stable states” (Scoones, 2007: 590). Debates on environment and development translated to the establishment of multiple versions of sustainability namely; weak and strong sustainability, big ‘S’, small ‘s’ and a narrow and broad sustainability (Scoones, 2007: 590). Moreover, Peet and Watts (1996) argue that the later ideologies behind sustainable development put “emphasis on nature-society relations in the context of concerns over the growing polarity of world income and has its genesis in a distinctive intellectual and political-economic atmosphere” (UNDP, 1992 cited in Peet and Watts, 1996: 1). These several meanings of sustainability gave further insights on how the broader project on sustainable development was seen.

2.2.1 Environmental Sustainability

The first pillar of sustainable development is environmental sustainability. Boyle *et al.*, (2011) state that environmental sustainability centers around the firmness of biological and physical systems that have a strong interest on preserving access to a healthy natural environment. Peet and Watts (1996) state that the conventional view of sustainable development demonstrates an intention to eradicate poverty and promote the enhancement of livelihoods while encouraging environmental sustainability. Therefore, there is a strong link between energy and the environment since many sources of energy are drawn from the natural capital. Hence, natural resources have to be managed in a sustainable manner, thus regulating any form of emissions from fossil fuels to reach beyond levels that affect global environmental degradation that results in rapid climate change (Boyle *et al.*, 2011).

There are two main ways in which energy might be environmentally unsustainable. The first relates to whether it might run out – which means that it is not renewable. Fossil fuels such as coal and oil are classic examples of non-renewable resources because they cannot grow back. Wind and solar energies are, by contrast, examples of renewable resources that cannot be exhausted. The second form of sustainability relates to whether it pollutes the environment. The most global concern in this regard is the possibility of climate change as a result of pollution.

Climate change is one of the major concerns caused by poor management of the environment (UNEP, 2011). An assessment report produced by the International Panel on Climate Change (IPCC) highlights the significance of embarking on clean technologies in order to mitigate climate change. This drive has been influenced by climate change concerns through the excessive burning of fossil fuels and carbon emission of greenhouse gases to the atmosphere (UNEP, 2011). In addition, the costs of mitigating climate change are estimated to be high and can worsen the conditions of poverty within the global south if such concerns do not receive attention (UNEP, 2011). Therefore, there has been a strong need to adopt the agenda of sustainable development and creating sustainability within the global south.

According to the UNFCCC (2009), the global cost of adapting to climate change is estimated to be US\$ 49 to US\$ 171 billion by the end of 2030 (UNFCCC, 2009. cited UNEP, 2011: 206).

Hence, the high costs of mitigating climate change has the potential to exacerbate global inequality due to funding being distributed to initiatives supporting environmental management and less investments on other development sectors.

In addition, UNEP (2011) notes that the Intergovernmental Panel on Climate Change (2007) and International Energy Agency (2008c) affirm that;

...in an attempt to limit average global temperature rise to 2 degrees Celsius, the concentration of greenhouse gases should not surpass 450 parts per million (ppm) CO₂-eq. This translates to a peak of global emissions in 2015 and at least a 50 per cent cut in global emissions by 2050, compared with 2005 (UNEP, 2011: 207).

As a result, the G8 economies in the world have committed themselves to environmental policies that promote 80 per cent reductions in global greenhouse gas emissions by the year 2050 (UNEP, 2011). Therefore, global GHG emissions have enabled environmental policies to be extensively promoted in both developed and developing countries. This can lead to the achievement of the 2050 vision of an environmentally friendly society and a 50 per cent reduction in global emissions (IEA, 2010a).

Globally, cities have adopted policies aimed at reducing carbon emissions and promoting the low carbon agenda. Scott *et al.*, (2011) define a low carbon city as “...a normative concept implying that a city has achieved an acceptable state in terms of its GHG emissions” (Scott *et al.*, 2011: 31). In addition, “a low carbon city is also one that strives to reduce its GHG emissions and increase its carbon sinks, while simultaneously adapting to anticipated climate change impacts” (Scott *et al.*, 2011:31 – 32). Therefore, in order for cities to be classified as being low carbon, they have to undergo a process of transition through adopting green policies and mainstreaming the climate change agenda into their planning and implementation processes, hence achieving sustainable development. Scott *et al.*(2011)assert that climate change is a controversial issue of the 21st century consisting of comprehensive issues beyond increasing in temperature. These include rising sea levels, epidemiology transition of diseases

such as cholera, malaria, and other interrelated issues that affect the environment (Scott *et al.*, 2011). In addition to environmental sustainability, it is important to take economic and social sustainability factors into consideration. The following concepts are explained below as they form part of the main aim of this dissertation.

2.2.2 Economic and Social Sustainability

The issues of economic and social sustainability are equally important issues that have to be addressed when engaging in issues of environmental sustainability. In terms of economic sustainability, the major concern has largely been the dependence on non-renewable energies (such as coal and oil) for energy production. For government, the major economic sustainability challenges consist of renewable energy and cost of addressing environmental pollution. Investments need to be made at a large scale to address climate change and several governments in developing countries have moved towards adopting the low carbon agenda. Therefore, air pollution is seen as not to be economically sustainable and needs to be addressed at macro and micro scale (see Scott *et al.*, 2011; IEA, 2010a; Kenny, 2006; Winkler, 2006).

In terms of social sustainability, the challenge lies in people continuing to having access to renewable energy resources in the long term so as to improve their quality of life. Therefore, one of the ways of tackling the social sustainability problem has been through the promotion of energy efficiency programmes that enable disadvantaged communities to have access to hot water services. For low income communities, solar water heater systems have been rolled out in RDP houses to provide access to hot water services and also promoting energy efficiency (eThekweni Municipality, 2011).

This serves as government's commitment to social justice and equity. Solar water heaters are perceived as having enough capacity of sustaining people's hot water needs in the long term future, since they rely on the sun for heat energy. The next section focuses on the uses of energy in the development context.

2.3 Uses of Energy in a Development Context

The general key objective of development has been to improve the living conditions of the poor. Birol (2007) argues that energy plays an important role in improving people's quality of life within the broader development context. It is one of the major key objectives to be achieved in global south countries. Goldemberg (2000) argues that energy consumption has been identified as a useful indicator of the scale of social and economic problems that have affected global south countries.

The availability of energy services can improve aspects of the incomes of poor household (Cabraal *et al.*, 2005). Energy services can enable people living in poor households to spend less time collecting crop residue, dung, or fuel wood, and hence spending their time on income generating activities. In addition to negative environmental effects as mentioned above by Birol (2007), the use of biomass is extremely time-consuming because large quantities are required to generate heat for preparing food and heating water. Therefore, the provision of electricity in rural areas and access to stoves using modern cooking fuels can result in less time being spent on looking for biomass. Time can be allocated on other economic and educational activities (Cabraal *et al.*, 2005). Moreover, energy services contribute to more labour productivity. Extended lighting can result in people being able to participate in livelihood activities beyond day light hours. People can work during extended hours and nightshift in order to increase productivity (Cabraal *et al.*, 2005). Therefore, there is a positive correlation between energy services and an improvement in people's quality of life.

2.3.1 Education and Energy Resources

In terms of education, energy resources play an important role in the educational lives of young children in disadvantaged communities. Firstly, electricity plays a major role in terms of school attendance, performance and quality of teaching and schools. Access to electricity enables children to spend less time collecting biofuels such as wood and dung in order to boil water in the morning and perform their daily household chores which consist of cooking, washing and cleaning (Cabraal *et al.*, 2005).

Secondly, children can study for longer hours if they have access to electricity within their households. In this regard, the female child is often disproportionately burdened with the job of collecting fuels and water. Hence, female children are likely to be at a greater disadvantage because they cannot attend school due to household responsibilities and financial constraints which may result in them getting involved in income generating activities (Cabraal *et al.*, 2005). Therefore, electricity has a positive impact on education because extended lighting hours enables children to spend more time studying during night hours.

Thirdly, the retention of teachers in poor underdeveloped rural areas has been a problem. Therefore, the provision of electricity and running water in rural schools is beneficial for development. Electricity enables teachers to have access to essential services in order to live decent lifestyles and have improved working conditions. This issue will be further developed under the case study of Papua New Guinea on solar water heater experiences.

2.3.2 Health, Gender Equality and Women Empowerment

Energy services play a significant role in the public health sector for peri-urban and rural development. They present direct and indirect impacts on human health and development. Cabraal *et al.* (2005) state that energy services play a significant role for rural development since ~~they~~ improve health service delivery, increase access to safe drinking water, provide clean fuels that reduce indoor pollution, and can make available various communication tools (e.g. radio, television, and the internet)” (2005: 132). A lot of medical equipment used in health care facilities requires electricity. These tools can then be utilized effectively against AIDS, Tuberculosis, Malaria and other diseases through effective medical equipment as well as public information campaigns.

In addition, energy services also have indirect impacts on health. This includes improving health through increasing literacy levels, reducing malnutrition and promoting the empowerment of women (Cabraal *et al.*, 2005). Cabraal *et al.* (2005) insists that a rise in women’s literacy levels and education reduces child mortality, HIV/ AIDS and malnutrition. This also compliments goal number four in the Millennium Development Goals devised by the

World Bank (2002) on reducing child mortality. In terms of malnutrition, it is stipulated that “95 percent of staple foods need cooking before they can be eaten” (Cabral *et al.*, 2005: 135). Electricity has proven to be essential for households to meet all such needs.

Another gender related argument that one may raise is the issue on the formation of rural markets. Sen and Barnes (2004) observe that rural markets do not provide electric appliances that cater for women’s needs in rural areas. Markets lack the provision of labour-saving appliances such as cookers, grinders, mixers, dishwashers and washing machines. However, on one hand these labour-saving appliances may elevate the costs of energy services resulting in people being unable to pay for electricity services (Sen and Barnes, 2004). On the other hand, there is no doubt that electricity can enhance the wellbeing of women in rural areas, and therefore most countries in the global south are embarking on rural electrification programmes.

2.4 Production of Energy

Primarily, there are several reasons why people choose to use some energy resources over others. For low income communities, some of the choices include, unemployment, off-grid connections, geographically dispersed rural households, poverty, convenience and saving electricity. Most low income communities are forced by conditions of poverty to use biomass resources to generate heat energy which is mainly used for heating water and cooking. Therefore, it becomes important to reflect on some of the key debates around energy production and its advantages and disadvantages on its users in the development context.

There are two main points that are captured in this section to clarify the arguments on the production of energy and its implications on users. The first point is to note that there are different sources of energy, and the kind of energy people rely on has important implications for the wellbeing of both users and the environment. In addition, there is a basic division between energy that is produced elsewhere (accessed through an electricity grid) and self-generated household energy.

Although electricity is occasionally generated on site, the households that concern this study do not generate grid electricity since this occurs externally, but they do generate their own energy through heat from burning or light from candles and lamps within households. For the purpose of this dissertation, the main focus is on different ways of accessing hot water in low income households. Therefore, it becomes important to note that although electricity is commonly used to heat water, there are other different sources of energy that can be utilized to heat water. Water can be heated through using self-generated energy that includes a kettle, or fire (from biomass such as wood, dung and crop residues), using gas from a gas cylinder, from kerosene or from a solar water heater.

The second point to note is that each of the above mentioned varieties of sources of energy has advantages and disadvantages for end-users. In part this determines what form of energy is used by households to achieve the outcomes of accessing hot water. However, in any given context, it is important to note that the use of the source of energy over the other is also determined by factors such as accessibility, cost and convenience to end-users.

Moreover, end-users do not have a choice of the source of energy they use when they use grid electricity because it is produced in energy plants within South Africa and sometimes outside the country, irrespective of its source of production. For example, household appliances such as kettles, irons and ICT equipment cannot be powered by burning biofuels within households, but need to be plugged into electricity. Hence, the form of energy used has big implications for cost as most poor households are not able to pay for electricity.

The following table on the next page outlines the types of energy sources used to produce electricity or heat energy, and the advantages and disadvantages to end-users. It is important to note that this study is limited to water heating as the main focus is on affordability and sustainability of solar water heaters.

Table 1: Sources of Energy and the Advantages and Disadvantages to End-users

	<u>Source of Energy</u>	<u>Advantages for Users</u>	<u>Disadvantages/ Limitations for Users</u>
Produced Elsewhere (Energy plants, wind farms, etc) and can be accessed through Electricity Grid).	Nuclear	<ul style="list-style-type: none"> ➤ Convenient and easy to use. ➤ Instant (saves time) ➤ Serves a multipurpose as it supports several kinds of electricity uses. ➤ Reduced air pollution within households. 	<ul style="list-style-type: none"> ➤ Cost – need to pay a monthly bill or prepaid. ➤ Need to be on the electricity grid ➤ Users cannot choose the source of electricity (coal/gas/wind).
	Coal (Non-renewable)		
	Gas (Non-renewable)		
	Wind (Renewable)		
	Hydro-electric Power (Renewable)		
Self-Generated/ Produced on site.	Kerosene/ Paraffin (Non-renewable)	<ul style="list-style-type: none"> ➤ Can be used where there is no grid ➤ It might cost time (rather than money) to collect. ➤ Biomass fuels: may be free, however, kerosene and wood still costs money. ➤ Solar heaters=> Cost is only for the equipment during installation (the energy is free). 	<ul style="list-style-type: none"> ➤ Not versatile (only generates heat) usually for heating water and cooking. ➤ Time consuming to collect ➤ Indoor air pollution (serious health consequences, sometimes fatal). ➤ Inconvenient to use (takes more time to generate heat) ➤ SWHs are not consistent – depends on the weather ➤ Maintenance.
	Biomass (Renewable)		
	Biogas		
	Solar Water Heaters (Renewable)		

Source: (Author’s interpretation, 2013).

2.4.1 Produced Energy (Grid Electricity)

The five sources of energy identified under this column have different implications for users. The advantages for users in this case are that electricity is convenient for users and serves a multipurpose within households. Household members are able to use instant electricity without having to worry about how it was produced. Electricity is also versatile and leads to improved health within households as hot water becomes available instantly and users tend to save time to engage in activities that may lead to an improvement in people’s quality of life.

The first identified disadvantage to users is that there is a monthly cost to have electricity in households and most low income households cannot afford to pay electricity bills. The second disadvantage is that people need to be connected to the national electricity grid and users cannot choose the source of electricity. Sovacool and D'Agostino (2012) state that governments in developing countries have lacked sufficient resource capacity to install off-grid electrification infrastructure in all rural households due to the geographical nature of the rural landscape.

2.4.2 Self-Generated Sources of Energy

Self-generated energy for heating water consists of paraffin, biomass and solar water heaters. The first advantage of these self-generated sources of energy is that they can be used where there is no electricity grid. Rural communities, irrespective of their geographical location can utilize these sources of energy to heat water and meet their hot water needs. Secondly, biomass resources cost time rather than money, unless if people choose to buy wood. In poor communities where most people are unemployed, people may have more time to look for biomass to heat water. Thirdly, in terms of solar water heaters, energy gathered from the sun is used to heat water – in this instance hot water is accessed for free. However, there is payment for the equipment and installation of solar heaters in low income households which is often subsidized by either government or donor agencies.

The first disadvantage is that this type of self-generated energy is not versatile which means that it only serves a single purpose of generating heat energy to heat water and cooking. Secondly, the collection of biomass is a time consuming process and kerosene is expensive. Thirdly, there are severe health impact caused by these fuels to users which include lung diseases, burns and other respiratory diseases (World Health Organization, 2006)

2.5 Environmental Implication for Energy Use

It is important to note is that each of the above mentioned varieties of sources of energy have different implications for the environment. This section will give a brief overview of the

environmental implications of common renewable energy resources in South Africa that are used to generate grid electricity. In addition, this section will focus on self-generated heat energy that is produced through biomass, kerosene and solar water heaters, particularly focusing on solar heaters as being most appropriate for the environment.

Table 2: Sources of Energy and Advantages and Disadvantages on the Environment

	<u>Source of Energy</u>	<u>Advantages for the Environment</u>	<u>Disadvantages/ Limitations for the Environment</u>
Produced Elsewhere (Energy plants, wind farms, etc) and can be accessed through Electricity Grid)	➤ Nuclear	➤ Relatively little greenhouse gas emissions. ➤ Little source material required (very efficient).	➤ Produces toxic waste from uranium. ➤ Release of radioactive gases ➤ Possibility of melt downs releasing large quantities of fission products to environment (Chernobyl, Fukushima, etc.)
	➤ Gas (Non-renewable)	➤ Much cleaner than coal to burn.	➤ Concerns about fracking chemicals and fracking water usage
	➤ Wind (Renewable)	➤ No pollution in the process of generating electricity.	➤ Wind turbines alter the landscape ➤ Making the equipment requires energy and materials.
	➤ Hydro-electric Power (Renewable)	➤ Clean, green and renewable. ➤ Does not contribute to air local pollution	➤ Disrupts aquatic ecosystems ➤ Disruptions in surrounding areas (People and animals).
Self-Generated/ Produced on site.	➤ Kerosene (Non-renewable)	➤ Products such as premium kerosene produce less CO ₂ and this is a benefit for the environment	➤ Pollution CO ₂ gas emissions ➤ Contributes to climate change
	➤ Biomass (Renewable).	➤ Could potentially be renewable	➤ Greenhouse house emissions ➤ Loss of biodiversity
	➤ Solar water heaters (Renewable)	➤ No emission of pollution or greenhouse gasses during use.	➤ Making the equipment requires energy and materials.

Source: (Author’s interpretation, 2013).

2.5.1 Renewable Energy Sources and the Environment

The abovementioned renewable energy sources have several implications for the environment. There are two issues that need to be clarified when trying to understand such implications of renewable energy on the environment. The first issue is relates to whether renewable resources are sustainable and reliable. The second issue relates to whether renewable energies are polluting the environment. Therefore, it is important to note that renewable energies such as biomass do contribute to air pollution. Therefore, excessive burning of such renewable energies may not be good for sustainable development. Moreover, renewable technologies such as solar water heaters may be more sustainable for the environment in the long term.

Secondly, solar water heaters are more appropriate technologies for the environment since they do not produce any CO₂ during use. These technologies are both renewable (infinite energy from the sun) and are non-polluting to the environment once they have been made, installed and operational. However, they have been criticized for producing environmental damage during their manufacturing processes (see Kenny, 2006; DBSA/ISES, 2000; IEA, 2010a). Norton *et al.* (1998) argue that there is a lot of energy used in the processing of materials and manufacturing of solar heater technologies. Some of the gases that are released during these processes consist of ‘CO₂, SO₂, NO_x’ emissions that vary according to location (Norton *et al.*, 1998 cited in Tsoutsos *et al.*, 2005: 289). Moreover, some of the negative impacts on the environment include ‘accidental discharge of chemicals used by the system which could have negative effects on ecosystems, flora and fauna (especially birds) and the use of toxic and flammable materials which pose negative health risks for humans’ (Tsoutsos *et al.*, 2005: 291).

Kenny (2006) states that biomass is useful for generating biodiesel, methanol and other fuel energy substances. However, it poses many environmental and health threat for low income communities that are dependent on biomass resources. Biomass fuels have negative effects on the environment and climate change due to greenhouse gas emissions (Hardie *et al.*, 2012; Garnett *et al.*, 2011). The World Health Organization (2006) recognizes that the use of biomass fuels such as firewood has been related to several environmental concerns which have included deforestation, soil erosion and loss of biodiversity (World Health Organization, 2006). In addition, although in theory biomass fuels are renewable their sustainability may become a

challenge. They can be harvested at a rate faster than plant growth and reproduction of fuel biomass, resulting in these resources becoming depleted over time.

The International Energy Agency, United Nations Development Programme, and United Nations Industrial Development Organization (2010) state that the high utilization of biomass in developing countries has perpetuated negative effects on health due to “indoor air pollution mostly from biomass combustion for cooking causes about 1.5 million premature deaths per year, more deaths than from malaria or tuberculosis” (Sovacool and D’Agostino, 2012: 316). According to Heltberg (2004) once most rural households have access to electricity; there would be a decline in the demand for solid biomass fuels. This will reduce air pollution, household hazardous incidences and carbon dioxide emissions (Heltberg, 2004).

Having contextualized different kinds of energy in terms of their advantages and disadvantages for both users and the environment, the next section focuses on solar water heaters and their application in different global south countries.

2.6 Solar Water Heaters

There are many programmes worldwide that focus on green technologies and renewable energies for development. In particular Hagraдзе *et al.* (2007) cited in Sovacool and D’Agostino (2012) mention that there are over 44 national programmes on solar heater systems, whereby over 1.3 million solar heater systems have been installed. By 2007, over \$USD 700 million had already been spent on solar water heaters (Hagraдзе *et al.*, 2007 cited in Sovacool and D’Agostino, 2012; 316-320).

There are various factors that contribute to an interest in green technologies such as solar water heaters. The IEA (2010a) argues that the increased use of solar heater systems has positive benefits for development since they reduce pressures on the environment and lessen energy demands within developing countries (IEA, 2010a). The cost of energy production is identified as a crucial matter that has received enormous attention when promoting renewable

technologies. Hach (2006) states that “rising energy costs are a good breeding ground for solar water heaters; they provide them a comparative advantage, since high prices for alternative energy sources shorten payback periods making solar water heaters even more attractive” (Hach, 2006: 2). In addition, Hach further insists that contemporary, solar water heaters have gained a lot of potential in developed countries and developing countries are quickly adapting to these technologies. Hence, this presents many development opportunities for developing countries such as South Africa. For example, solar market expansion can result in employment opportunities, accelerated economic growth and customer satisfaction.

Moreover, developing countries possess high solar radiation making solar heaters more effective (Hach, 2006). Therefore, there is a huge need for global south countries to adopt such technologies in order to make energy resources available and improve poor people’s quality of life. Increasing investments in green technologies has positive effects on the environment and climate change. Climate change and sustainability targets can be accomplished through addressing issues of energy related poverty by adapting to green technologies.

In order to provide a basis for international comparison, a summary of solar water heater projects will be provided for three developing countries namely China, Laos and Papua New Guinea. This section presents key technological and market development approaches for solar water heaters that need to be adopted to achieve development. The first approach deals with the technological enhancement and market development for solar heater systems (Sovacool and D’Agostino, 2012). The second approach examines the possibilities of setting up cross-subsidization mechanisms and efficient energy service companies that promote solar heaters systems to achieve development objectives (Sovacool and D’Agostino, 2012). The third approach focuses on means of establishing platforms to disseminate solar heater systems and ensuring that they are affordable and accessible to poor people (Sovacool and D’Agostino, 2012).

2.6.1 Cost-effectiveness of Solar Heaters Systems in China

The beginning of the 1990s resulted in the government of China establishing and implementing sustainable development plans to address the energy crisis and energy related poverty. These plans enabled market development and technological improvements in solar heater market

industries. During the late 1990s, the World Bank (1999) established Renewable Energy Development Projects (REDPs) with a purpose of identifying renewable energy technologies as alternatives to addressing energy poverty in developing countries, particularly in rural communities largely affected by energy related poverty (Sovacool and D'Agostino, 2012).

The renewable energy sector in China became obliged to achieve growth and distribute more solar heater systems to meet increasing demands for energy resources. This was driven by an interest in renewable energy technologies as a result of technological improvements and market developments. Moreover, the increase of renewable energy technologies expanded job creation and increased market distribution of solar heaters in China and other parts of the world (Sovacool and D'Agostino, 2012). In addition, three factors have also contributed towards an interest in solar heater system installations for low income households in China. These factors include increasing access to electricity, inadequate investments in green technology manufacturing and excessive use of biofuels or coal-based production of electricity which pollute the environment (also see IEA, 2010a; Chang *et al.* 2011).

Investments in solar heater systems presented many opportunities for poor rural and low income communities in China. Sovacool and D'Agostino (2012) mention that "...the China Ministry of Science and Technology and World Bank's made investments to install about 10 Mega Watts or 350 000 units of solar heaters systems in the photovoltaic (PV) component of the project throughout China" (Sovacool and D'Agostino, 2012: 315). The purpose of this project was to improve the quality of solar heater systems through reducing the production and installation costs of electricity in rural households, since grid connection systems were costly and could not be rolled to all citizens living in dispersed rural communities.

This resulted in an improvement in people's quality of life since poor people could now access energy services at affordable rates. Therefore, this case study of China illustrated that increasing availability of renewable energy resources can have positive impacts on people's quality of life (see also World Bank, 1996; Miller and Hope, 2000; Murthy, 2001; Hach, 2006). In improving the cost and quality of solar heater systems in China, a Market Development Support Facility was established to expand the solar heater market industry. The purpose of this

support facility was to promote Solar Heater Systems (SHSs) throughout poor rural communities in China. The operations supported within the facility were categorized into three groups namely business, market and product development. These included “...product development, financial management, system improvement and ISO certification” (Sovacool and D’Agostino, 2012: 325). The main goals of technological improvements and market design were to increase the performance of SHSs while reducing the cost of energy production.

The case of China reveals the benefits of using renewable energy technologies. It was found that access to energy services enhanced people’s lives through making them feel incorporated within the modernizing process of the national economy (DFID, 2002). Secondly, DFID (2002) states that energy services have strengthened social capital networks through transport and communication services, since technology is highly dependent on energy services to function. This enables people to maintain social capital networks with extended family members and friends from all over the world. Therefore, the dissemination of solar heaters in China marked an important intervention in expanding energy resources to reach to the poor. However, there has been insufficient focus on assessments stressing the efficiency and sustainability of solar heaters systems that are disseminated and installed in poor communities. The next case study explores mechanisms that are employed to increase access to energy services in developing countries.

2.6.2 Cross-subsidization Mechanisms and Energy Service Companies in Laos

Laos presents a different approach towards the promotion of solar heater systems in poor rural communities. A Rural Electrification Project was established and managed in phases to install solar heater systems in poor communities. A range of key strategies was employed to encourage poor people to have access to such green technologies. These consisted of low-interest loans and government subsidization to the private sector. Sovacool and D’Agostino (2012) explain that the first phase of the rural electrification project aspired to increase access to electricity in rural households amongst targeted provinces and to further attain sustainable development within the energy sector. Increasing access to energy resources through SHSs contributed positively to addressing broader development challenges in Laos such as energy-

related poverty, infrastructural development and environmental sustainability (Sovacool and D'Agostino, 2012).

In addition, the Laos government lacked sufficient resource capacity to install off-grid electrification infrastructure in all rural households due to the geographical nature of the rural landscape. Indeed Sovacool and D'Agostino (2012) argue that:

—In Laos, SHSs were installed in over 9 000 households. Rural Electrification Project followed an energy service company (ESCO) model, by leasing equipment to households for a monthly fee and retaining equipment ownership. However, neither the Ministry of Energy and Mines nor Electricite du Laos (EDL), the state-owned electric utility, had the institutional capacity or resources to support installation and implementation of off-grid electrification” (Sovacool and D'Agostino, 2012: 325).

The above observation captures some of the obstacles that the Laos government faced, in capacitating itself to provide electricity to all citizens, particularly the poor. These obstacles were addressed by the Laos government in two ways. The first method was through the cross-subsidization of electricity rates in other sectors. The Laos government authorized Electricite du Laos to impose high electricity tariffs on commercial, industrial, government and international electricity customers (Sovacool and D'Agostino, 2012). This enabled government to provide and sell electricity to the poor at low costs and expanding energy services to reach the poorest of the poor.

The Laos government decided to appoint an external service provider to support the initial phase of the rural electrification project. This initial phase of the REP project lasted for a duration of three years, giving all spheres of the Laos government enough time to build their capacity to avail energy resources (Sovacool and D'Agostino, 2012). Several strategies such as Village Off-grid Performance Schemes were employed to try and manage electrification companies that ran operations at provincial and local levels (Sovacool and D'Agostino, 2012). These electrification companies were accountable for —planning, installation, operations and

maintenance of the off-grid systems” (2012: 326). They were also responsible for distributing solar heater systems through various financing schemes to expand these services and make them more affordable to low income communities.

In summary, the case of Laos demonstrates an approach that was used to enable poor communities to have access to renewable technologies to meet their electricity needs. Hence, the initial phase of the REP1 project became a success since repayment costs enabled people in poor rural and low income communities to afford to have a solar heater system within their household. This case also demonstrated the role of government within service delivery through assisting and enabling poor communities to have access to energy services and thus, improving people’s quality of life. This was achieved through government subsidizing private sector companies to disseminate and install solar heater systems in poor communities at low cost returns and extended payment plans.

2.6.3 End-user Financing in Papua New Guinea: Teacher’s Solar Lighting Project

The case of Papua New Guinea illustrates a more targeted solar heater programme that was aimed at assisting teachers residing in remote rural communities. The major challenge that was identified in remote areas in Papua New Guinea was teacher retention. Schools facilities in rural areas usually lack infrastructure and basic services such as water and electricity while schools in urban areas have access to such services (Cabraal *et al.*, 2005). Several microfinance methods such as low interest loans, and government subsidies enabled teachers in rural areas to purchase and own solar heater systems that improved their quality of life through access to electricity (Sovacool and D’Agostino, 2012).

Electricity enabled teachers to have access to essential services in order to live decent lifestyles and have improved working conditions. In addition, Cabraal *et al.*, (2005) further asserts that the Department of Education and other Provincial Divisions of Education in Papua New Guinea speculate that a large number of teachers have abandoned rural schools due to poor working conditions not conducive for teaching young learners. They mention that:

--- there are approximately 36 000 primary, elementary and secondary school teachers that have offered job opportunities throughout the country, with 90 percent of the teachers being employed in rural allocations and serve predominantly the rural population” (Cabraal *et al.*, 2005: 129).

The above statement represents the availability of employment for teachers in remote areas. In essence, poor service delivery of infrastructure has negative impacts on development. It results in poor administration due to employment of unqualified teachers to teach in rural areas, and further contributes to poor educational outcomes (Cabraal *et al.*, 2005). In trying to address this problem, the World Bank initiated several solar heating programmes. These were aimed at supplying solar energy in a manner to provide hot water to disadvantaged communities and teachers in poor rural schools in developing countries (World Bank, 2005 cited in Cabraal *et al.*, 2005: 131).

The Teacher’s Solar Heater Project enabled teachers to have access to electricity services and improvements in their working conditions, thus creating an enabling educational environment. The case of Papua New Guinea reveals the benefits of solar heater systems on education. Solar heaters are certainly important for development because they reduce energy-related poverty within poor local communities lacking infrastructural resources and grid energy facilities.

2.6.4 Outcomes of the Case Studies

The above section began by identifying possible factors that have supported the adoption of renewable energy technologies in countries within the global south, hence making solar heaters beneficial for development. Secondly, it highlighted international experiences of solar heaters in three developing countries namely; China, Laos and Papua New Guinea. The three case studies further illustrated three financing mechanisms that governments use to promote solar heaters. These include direct grants, low interest loans, and policies mandating government to subsidize solar heater systems. In addition, the case studies presented three different approaches that were used by governments to promote and disseminate solar heaters in order to meet energy poverty needs within poor communities located in remote areas. Hence, the above case

studies have not further elaborated on end-user responses of solar water heaters. More research can be undertaken to explore technology impact assessment approaches towards evaluating efficiency, sustainability, perceptions and attitudes that people have towards such green technologies.

The outcome of these case studies highlights the importance of community inclusion in planning and implementation processes of solar heater programmes. These programmes further pointed out the importance of paying for services with regard to renewable energy technologies by people living in these communities (Sovacool and D'Agostino, 2012). Furthermore, the programmes illustrated how community members became interested in the performance of solar heater systems; using several types of financing such as low interest loans from financial institutions to afford to pay for these services. Hence, some programmes increased community ownership through awareness campaigns that were engaged in the promotion of solar water heaters. The applicability of these case studies in the context of South Africa is explored in the next chapter.

Solar water heaters can also have good social and health benefits in low income households. Women are mostly responsible for their households' energy needs such as wood collection for heating water in low income and rural households. Therefore, solar water heaters can reduce the burden of women in terms of the time spent on gathering alternative energy sources such as wood and, time can be freed for other household needs (Milton, 2006). Other benefits of the introduction of solar water heaters include availability of hot water for improved hygiene (Milton, 2006; Spalding-Fecher and Thorne, 2002).

In addition, Milton (2006) highlights that solar heater systems contribute to local economic development through generating employment opportunities in the installation and maintenance processes. The expansion of the solar water heater industry has the potential to generate more job opportunities due to increasing demands for solar heater systems. However, in order for governments to promote technologies, there are several investments that have to be made in order to assist people living in poverty to have access to energy and other basic resources. Milton (2006) proposes three key points to eliminate high end-user costs of solar water heaters.

Firstly, government needs to intervene directly in the solar heater market so as to provide a capital subsidy to people in need such as low-income households. People who cannot afford to pay for such technologies need to be subsidized by government in order to improve poor people's quality of life.

Secondly, government needs to support 'low-or-no-interest' loan programs for people that need to buy solar heater systems. Thirdly, government needs to offer tax incentives such as sales tax exemptions and personal income tax deductions on solar heating equipment purchases (Milton, 2006). This means that government can advance the solar water heater market by lowering the costs of these technologies through subsidies so that more people can afford these heaters. The long-term effects of the installation of these technologies will then reduce carbon emissions and relieve environmental shocks and stresses (Scoones, 2007).

2.7 Conclusion

The chapter above illustrated that there are various types of renewable energy resources that help people to meet their energy needs, and not all of these resources are sustainable. Therefore, it became clear that what is good for the environment is not always expedient for users or utility providers and *vice versa*. Therefore, this opens a gap for extensive policy research interventions to come up with best practices to resolve these policy gaps. Energy efficiency remains a problem to government. The role out of energy efficiency programmes such as installation of solar water heaters illustrate governments' attempts to solve the energy crisis through encouraging citizens to save energy. This indicates that citizens also have a huge role to play in terms of reducing their energy consumption. However, increasing demand for energy might not be sustainable if it is based solely on renewable energy resources since they also produce carbon emissions to some extent. Therefore there is growing interest in providing energy from sources that do not deplete and pollute the environment.

In addition, programmes to provide solar water heaters have been implemented in various parts of the world and have successfully improved the quality of life of beneficiaries. The case studies have highlighted that there are different models through which solar heater systems can

be provided. For low income households, these systems include, low interest loans, government subsidies and government policies that promote the use of solar water heaters for energy efficiency. It is evident that government can play a huge role in promoting energy efficiency sustainably as the demand for energy resources continues to rise. However, this has not been practical as there have been several implementation challenges that have been encountered.

Chapter Three: A Role for Solar Water Heaters in South Africa

3.1 Introduction

The chapter analyzes the role of solar water heaters in low cost housing programmes within the context of South Africa. Recent and relevant research sources are used to develop a discussion around four key points. The discussions have been thematically broken down into the following. The first discussion will focus on the concept of energy production in South Africa and the experiences of the rich and poor when it comes to access to energy resources. The second discussion focuses on housing and policy challenges. It further explores local case studies on water and electricity and explores the implications for solar water heaters. The third discussion focuses on low income housing and attainment of sustainability within eThekweni. In addition, the discussions further draw on the drive towards the low carbon agenda and raises some of the current challenges that have been faced by people using solar water heaters.

3.2 Energy and Development in South Africa

The South African context presents several disparities in terms of access of energy resources. The apartheid era resulted in electricity resources being channelled towards sections of society that could afford to pay for electricity, resulting in many poor black communities being left without access to energy services. This section presents the history of energy production in South Africa arguing that energy policies have not been ‘pro poor’ in the sense that majority of poor citizens continue to suffer from energy-related poverty.

Cost recovery strategies employed by government and service providers have had negative cost effects thus presenting many electricity related challenges for the poor living in low-income households. The following section of the chapter will outline the importance of electricity resources for economic growth and development.

3.2.1 Electricity and Economic Growth

The introduction of energy resources in South Africa can be traced back from the late 1800s. Electricity was firstly introduced within the mining sector in Kimberly and it assisted with the functioning of production equipment within the mines. Fine and Rustomjee (1996) assert that the South African economy has been constantly dependent on non-renewable energy resources. In addition, they argue that the South African economy is heavily dependent on abundant and cheap supplies of electric power (Fine and Rustomjee, 1996). Hence, the mining sector also accounts for a high GDP per capita, thus indicating that the South African economy is electricity-intensive (Fine and Rustomjee, 1996).

One major argument raised by Fine and Rustomjee centres around national economic activities that consists of the industrial, mining and services sectors. They point out the importance of energy resources within these sectors. Electricity resources are fundamental in ensuring the functioning and operations of these sectors, thus promoting economic growth and development (Fine and Rustomjee, 1996). In addition, McDonald (2011) highlights that energy demands from the mining sector have played a major role in the expansion of electricity resources for the economic development of South Africa. Moreover, the mining sector's high reliance on electricity over the past century has been to operate mining equipment and drive the industry, thus improving mineral resource production (Fine and Rustomjee, 1996). Fine and Rustomjee (1996) termed this reliance of the mining sector on electricity as a 'minerals-energy complex'. This concept outlines the practices involved in extracting and processing of electricity-intensive minerals which have driven the growth of the South African economy (see also Christie, 1984; DME, 1996; Fine and Rustomjee, 1996; Winkler, 2006; McDonald, 2011).

The Business Day (2005) and Financial Mail (2005) further provide insights on the investments that have been undertaken by ESKOM to achieve economic growth in South Africa. These publications reported that "in September 2004, the Department of Enterprises announced plans to spend R 84 billion on new electricity infrastructure between 2005 and 2009" (Business Day, 2005; Financial Mail, 2005 cited in McDonald, 2011: 69-70). These developments in the energy sector presented a potential to meet the demands for energy by commercial industries, suburban households and the rest of the citizens of South Africa.

In 2007, ESKOM declared that it had scheduled to increase its capital expenditure for the following five years in order to extend power grids and avail electricity to the poor, as electricity forms a component of basic services (McDonald, 2011). However, in 2008 South Africans suffered from the global crisis, resulting in the energy sector also being affected indirectly. Energy blackouts also known as ‘_bad-shedding’ in Cape Town, Durban and Johannesburg presented many challenges for the manufacturing sector, suburban households and local communities within these cities. This energy crisis demonstrated high susceptibility of the South African economy, suburban households and manufacturing sector on electricity (Hammer, 2006). After the incidence of load-shedding, ESKOM had committed to increase their investments to meet rising power demands to electrify South Africa’s growing economy. Some of these investments have largely focused on energy efficiency programmes. This includes the promotion of renewable energies resources and green technologies such as solar heaters. Much debate has focused on whether ESKOM is serious about renewables alternatives. However, the scrapping of the pebble bed modular reactors (PBMR) in favour of new coal-fired generators reflects ESKOM’s ambiguity in promoting energy efficiency programmes (see Hammer, 2006).

3.2.2 Experiences of the Rich and Poor in South Africa – Inequalities in Access to Electricity Services

A large number of citizens have not enjoyed the benefits of electricity in their homes. McDonald (2011) argues that “electricity provision illustrates the intrinsically discriminatory nature of neo-liberal market policies and economies” (2011: 66). This argument reveals the inequalities of uneven development that persists within the post-apartheid era in South Africa. Poor and marginalized people still do not have access to adequate infrastructure in order to enjoy the benefits of electricity and efficient power supply (see Desai, 2002; McDonald, 2011).

Inequitable distribution of electricity and water infrastructure can be traced back to unjust apartheid policies. The lack of investment in such infrastructure exposed poor black South African to poverty and deprivation. In the late 1980s, efforts to deliver energy resources through electrifying poor townships, peri-urban and rural households started. Implementation of development initiatives also began to improve quality of lives of the poor (McDonald, 2011). In the early 1990s, the Department of Minerals and Energy (DME, 2006) reports that an

estimate of 30 000 households each year became electrified and this largely consisted of poor households. Additionally, ESKOM has connected over 2.5 million houses to the electricity grid in the past 18 years (DME-2, 2006 in McDonald 2011: 71-75).

Local government municipalities have also played a major role in the provision of electricity services to the poor in the post-apartheid era. However, researchers have noted that electricity cut-offs amongst poor households have also increased dramatically (see also McDonald, 2011, Deedat and Cottle, 2002; Desai, 2002; Winkler, 2006). This has marked an important era in development since there has been a noticeable increase in the distribution of energy infrastructural resources being channelled towards poor people. On the other hand, the rate of energy related poverty amongst the poor has not decreased (McDonald, 2011).

Comparatively rich people living in suburban communities have had efficient power supply when compared to people living in poor black communities (McDonald, 2011). As a result of such inequalities, a large number of poor black citizens have lived in communities where electricity blackouts occur more regularly. The provision of electricity has resulted in poor people being unable to afford electricity due to escalated prices, thus making electricity an expensive luxury service (McDonald, 2011). In addition, this illustrates the low levels of electricity infrastructure that poor people have been provided with, since peri-urban and rural low income communities have been marginalized from power grid infrastructure due to reasons such as geographical dispersion and cost of providing electricity (McDonald, 2011).

During the post-apartheid era, electricity has been extended to some poor and marginalized black communities. However, neoliberal economic policy reforms have perpetuated inequalities in terms of access and affordability of electricity services (McDonald, 2011). There has been a large increase in metering within government services (for example, water and electricity). Therefore, privatization of such services has not been an all-encompassing process since those that cannot afford to pay for services are unable to have access to basic services. In addition, municipal service providers have employed cost recovery approaches to encourage customers to pay for electricity and water services. In contrast, the government has claimed that it extended electricity services to poor households and rural communities as a result of its commitment to social justice. However, this reveals many gaps because the poor who cannot afford to pay for basic services are penalized, resulting in their electricity and water connections being cut off (see Deedat and Cottle 2002; McDonald, 2011).

3.3 Housing

Housing and service delivery in South Africa remains a huge challenge in the post-apartheid period. The current government inherited many complex development challenges. These include high poverty and unemployment rates amongst blacks, housing delivery and inadequate provision of health care, water and electricity services. Therefore, the notion behind the housing policy was to address and fulfil the basic needs of the population through the transfer of basic asset grants (Standing and Samson, 2003). Moreover, this view later changed to address poverty alleviation through improving access to resources from the transfer of basic income and asset grants (Standing and Samson, 2003). The housing policy was meant to provide tangible assets to those who were previously disadvantaged and living in poverty (Charlton and Kihato, 2006).

One of the post-apartheid state's flagship programmes for transcending the spatial and social legacies of apartheid has been the provision of low cost housing. The definition of low-cost housing that has been used for this study is drawn from eThekweni Municipality. EThekweni Municipality (2012) refers to low cost housing as —.individual ownership of serviced or un-serviced dwelling units by low-income households with incomes below R 3 500 per month” (eThekweni Municipality, 2012: 25-26). The eThekweni municipal region currently consist of about 948 000 households, while the Housing department reporting a housing backlog of 234 000 units (Scott *et al.*, 2011: 41).

3.3.1 Housing Delivery Process and Challenges

In the post-apartheid era, rapid urbanization has been largely driven by rural-urban migration in cities. Therefore, the government has a large low cost housing programme which operates through a capital subsidy system for households below the threshold income. The capital subsidy system involves the provincial government allocating a housing budget subsidy to build low income households for disadvantaged people around the country. Municipalities are then mandated to implement the housing projects. Municipalities then commission construction companies through tender processes to build new townships consisting of low cost housing. The allocation of the budget depends on the number of houses to be built. In eThekweni

Municipality, the money for RDP housing development is derived from budgetary allocations for housing subsidies of which eThekweni combines its own budget with the Provincial Department of Housing to accommodate more low income people to get better quality RDP houses within eThekweni. The Cornubia Human Settlements Project represents a recent project that is currently in progress within eThekweni. The project is estimated at R25 billion which is expected to provide 24 000 homes.¹

Furthermore, the African National Congress (ANC) led local governments have been largely faced with increasing pressures on housing delivery and the land question remains a critical issue. The domination of informal settlements within the urban surroundings has illustrated government's incapability to cope with rapid urbanization (see also Huchzermeyer, 2001). Amidst these challenges, the government still has an important role to play in terms of ensuring the provision of basic services such as housing, electricity and water in most poor communities. In particular local government, defined as "the sphere of government closest to the people" (White Paper, 1998) has assumed a key role in development, housing and service delivery. The later housing policy (Breaking New Ground, 2004) has attempted to be more integrated, hence focusing more on the quality than the quantity of low-cost housing.

According to the Department of Housing (2008), the vision of the Breaking New Ground policy is "to promote the achievement of a non-racial, integrated society through the development of sustainable human settlements and quality housing" (Department of Housing, 2008:5). In addition, Breaking New Ground Policy called for sustainability which had been under examination by the initial RDP housing policy. The purpose of the policy was to strengthen the vision of the Human Settlements Department, in order to encourage the achievement of a non-racial, integrated society through quality housing developments and sustainable human settlements (Breaking New Ground, 2004: 4-5).

One major challenge to housing delivery has been the issue of land distribution for low cost housing. Therefore, low income houses can either be built on a green field where no previous

¹NORTHGLEN NEWS (2013) *Article: Housing Allocation is Fair.*
(www.cornubia.co.za/news/summary/?p=1)

construction has occurred before, or they can be rolled over in the form of upgrades on existing lands where shack settlements get converted into low cost housing (see also Huchzermeyer, 2001). An estimated 160 000 houses have been delivered within eThekweni Municipality since 1994 (eThekweni Municipality, 2012). The provision of land is based on the boundaries of cities, next to townships, thus aiding urban sprawl (Charlton and Kihato, 2006). This further marginalizes poor people from having access to ‘centres of economic growth’, hence depriving poor people from establishing livelihoods. Urban sprawl further creates a financial burden on the poor through transport costs and having to travel to cities to search for employment (also see Charlton, 2006; Charlton and Kihato, 2006).

One of the major challenges in the housing delivery process has been the ‘allocation of houses’. The allocation of houses has been a highly contentious political issue in many low income housing projects. Recently, the Cornubia Human Settlements Project (situated north of eThekweni) highlighted some of the challenges that have slowed down the delivery of low income RDP houses to the poor. EThekweni Municipality’s members of the executive committee recently adopted a council resolution to ‘do away’ with housing waiting lists for the provision of RDP houses, after claiming for several years that there is a long list of people who have not yet received their house.

The Mayor of eThekweni, James Nxumalo in a Northglen newspaper article further defended the Municipality. He argued that “...waiting lists did not provide information on specific time-frames to determine when a person would receive a RDP house” and secondly that “...in most instances, it was discovered that by the time the person on the waiting list was due to be allocated a house, he/she would either be relocated or already owns a house or is sometimes deceased” (NORTHGLEN NEWS, 2013)². However, this serves to fuel accusations that housing allocation is not a fair and transparent process.

²²NORTHGLEN NEWS (2013) *Article: Housing Allocation is Fair.* (www.cornubia.co.za/news/summary/?p=1)

3.3.2 Water, Electricity and Policy Challenges

The provision of electricity and free water are the key basic services that low income households have received from government. However, the free basic amount of water services is too low and many people are unable to afford to pay for such services as many are cut off (see also Mc Donald, 2002). In Durban, free basic water is 9 000 litres per month per household and water cut offs have not escalated when compared to other experiences in municipalities outside of Durban. Some also get electricity but again they are unable to afford it. Moreover, the introduction of neoliberal approaches in municipal administration and development has been a major challenge for poor communities. The privatization and „*commodification*“ of basic services by municipalities has resulted in poor communities being unable to pay for basic services. Therefore, water and electricity cut-offs have escalated over the past decade (see also Desai, 2002).

The „*commodification*“ of basic services works in the form of prepaid water meters and has impacted negatively in poor local communities around South Africa. For example, Deedat (2002) provides a case study that assesses the role of prepaid water meters in small towns in the Northern Cape. Deedat (2002) argues that ANC councillors made promises that the installation of water meters would be a good initiative for local communities; while on the other hand; their promises were contradicted by the reality that these services were not accessible and affordable. People defaulted from paying for basic water delivery and this resulted in water cut-offs (Deedat, 2002).

This meant that water meters became a tool which has been used by municipalities to encourage people to pay for basic services while people living in poor communities cannot afford to pay for such services. Low income households had to find ways of collecting and heating water. More electricity could be required to heat up the water through using several water kettles or other means for domestic purposes (Deedat, 2002). There are also policies of destitution, and there are systems to provide people with a free amount of water. This has been criticized for being too little of course, but there are policies which claim to accommodate those who are too poor.

In addition, water and electricity cut-offs created conflict within the community as the people whose water and electricity had been cut-off started stealing these basic services from the people who still had connections (Deedat, 2002). Each household was given a card which would allow them to control their own household consumption. This was one of the main reasons why water meters in this case became a successful initiative because they were aimed at alleviating corruption, illegal connections and theft of water (Deedat, 2002).

Moreover, Bond and Dugard (2010) draw on case studies on water privatization conducted in the city of Johannesburg. The study was conducted in a community called Phiri Township in Soweto whereby water services were privatized through the installations of water pre-paid meters. It was found that two little children residing in this township had been burnt after a house caught fire while local residents had to witness this without having any water to extinguish the fire (Bond and Dugard, 2010). Moreover, the absence of electricity is also a cause of some fires because people use candles which get knocked over. Therefore, the absence of water and electricity on a regular basis outlines some of the challenges that are faced by low income communities.

3.4 Low Cost Housing Programmes and Attainment of Sustainability.

This section provides an overview of how the city of Durban has used its low cost housing programme as a catalyst to pursue a 'low carbon agenda' through three key discussions. These discussions consist of; 'a drive towards a low carbon agenda', 'energy efficiency' and 'solar water heaters'. Swilling (2006) in Scott *et al.*, (2011) argues that housing intervention programmes within eThekweni have presented positive opportunities of transforming from low cost domestic housing towards a 'low carbon' future (Scott *et al.*, 2011: 41).

In addition, there have been several inter-departmental relations within eThekweni engaged in collaborative planning towards addressing the issue of climate change through housing delivery. For example, the city supports energy efficiency programmes in low income communities around the city as a drive to mitigate climate change.

3.4.1 Drive towards a Low Carbon Agenda

Climate change is one of the central factors that have driven eThekweni Municipality to explore ways of becoming a low carbon city. EThekweni has been at the forefront in adopting policies aimed at addressing climate change within the city of Durban. In addition, it is important to note the historical overview of the key strategic initiatives that eThekweni Municipality has embarked on, in its efforts to address climate change and promote sustainable development.

Scott *et al.*, (2011) state that eThekweni began its effort of addressing climate change through participating in an environment campaign hosted by the environmental division of the International Council for Local Environmental Initiatives (ICLEI). Roberts (2008) asserts that eThekweni had implemented a municipal buildings energy efficiency pilot project and also completed first greenhouse gas inventory. In 2004, the city established a Municipal Climate Protection Programme to mainstream the agenda of sustainable development through integrating all aspects of work undertaken by eThekweni to consider climate change and protection of the environment (Scott *et al.*, 2011).

The city of Durban later held its first Climate Summit in 2009 to address issues relating to climate change such as; rising sea levels, environmental conservation and more. The terms of reference for the Durban Climate Change Partnership (DCCP) had been compiled through a consultation process which consisted of a number of workshop discussions on climate change. EThekweni later held the ‘Conference of the Parties’ (COP17/CMP7) which resulted in the adoption of the Kyoto Protocol, hence committing itself to limit its GHG emissions (Scott *et al.*, 2011).

The COP17/CMP7 is a United Nations gathering between more than 190 countries from all over the world. The purpose of the conference was to find solutions to the global threat of human-made climate change from air pollution. The intention is to significantly reduce the amount of carbon dioxide and other greenhouse gases in the atmosphere from getting to a level

which would cause an increase in the world's climate system.³ Green technologies such as solar water heaters, form part of a climate mitigation programme that seeks to promote carbon free technologies to promote sustainable development.

3.4.2 Energy Efficiency

Nationally, ESKOM has partnered with over fifty corporations in the drive towards energy efficiency within the commercial sector (Eskom Distribution, 2012). Moreover, several funding models and market participation schemes have been designed and implemented to address existing market sectors. The commercial sector has been driven through adopting energy efficient technologies, hence reducing demands for energy. In addition, ESKOM has encouraged energy efficiency through power alert competitions on nation-wide radio stations and hence promoting solar water heaters as part of energy efficient programme (Eskom Distribution, 2012).

ESKOM, together with eThekweni Municipality has embarked on efforts to establish energy efficiency programme to roll out solar water heaters to low income communities. Moreover, ESKOM and eThekweni have further embarked on efforts to reduce per capita use of electricity in suburban communities and commercial sectors. The programme became a pilot project in several low income communities around the city of Durban. It aimed at providing affordable solar heater systems for households. Hence, it is important for the city authority to know how communities are responding to solar heater systems as this informs further collaborative planning and investments in solar heater systems to further promote energy efficiency programmes.

This will contribute to eThekweni Municipality's vision of being a 'low carbon city' and further assist in the mitigation of climate change. The city hopes to reduce the amount of energy used by low income households to heat water. EThekweni Municipality further claims that significant reductions in energy consumption and greenhouse gas emissions are achievable (eThekweni Municipality, 2011).

³(<http://www.icologie.com/news/>).

3.4.3 Solar Water Heaters

In 2011, eThekweni Municipality developed and implemented a low cost solar heater programme. The programme was led by eThekweni's Energy Office in partnerships with eThekweni Electricity (EE), Eskom and service providers that install passive solar heater systems in surrounding low income communities within Durban. The aim of the programme was to regulate and reduce the amount of energy that low income households use to heat water. In addition, the programme was intended to facilitate the provision of affordable solar water heater installations in low income housing development at no direct financial costs to eThekweni. Eskom was responsible for subsidizing the solar heater programme nationally, and all metropolitan municipalities facilitated the installation of solar heaters in low income communities within their locality. The programme was rolled out in two phases and during the first phase, "a total of 9042 solar water heaters were installed across low income housing developments within the city" (eThekweni Municipality, 2011: 1). The second phase was specifically meant for the conference of the parties (COP17-CMP7) that was to be held later in 2011 which targeted to install over "10 000 solar heater units" (eThekweni Municipality, 2011: 1).

Currently, it has been reported that eThekweni Municipality has "achieved and surpassed their 2015 goals of installing 10,000 residential solar water heaters (SWHs) two years in advance"⁴. A recent *Newsletter* article by Urban Earth (2013) further reported that:

The number of solar water heaters installed through the Municipality's programmes now sits at 30 550. Of this number 30 000 low pressure SWHs have been installed through the low cost SWH programme and 550 high pressure SWHs through the Shisa Solar Programme (Urban Earth, 2013).

However, several challenges have been reported in communities where solar heaters have been installed. A recent article by Kings (2013) in the *Mail and Guardian* (2013) presented some of the challenges that low income communities in Johannesburg have faced with regards to solar water heaters. Some of the reported challenges include; punctured roofs during installation

⁴(<http://urbanearth.co.za/articles/ethekweni-Municipality-reaches-10000-solar-water-heater-target-two-years-advance>).

which result in leakages during rainy weather, positioning, and functioning of the solar water heaters (Kings, 2013). The above-mentioned challenges question the sustainability of solar water heaters in many ways.

3.5 Conclusion

The above chapter began by highlighting the history of energy production and raised some of the experiences and policy challenges that the poor and rich people have faced within the development context. The second discussion focused on housing delivery and highlighted some of the policy challenges related to housing, electricity and water provision in low income households. The third discussion focussed on how the government has used its low cost housing programme as a catalyst to promote solar water heaters and attain sustainability. In addition, the solar heater programmes is a major driver towards eThekweni pursuing the low carbon city agenda.

Chapter Four: Methodology

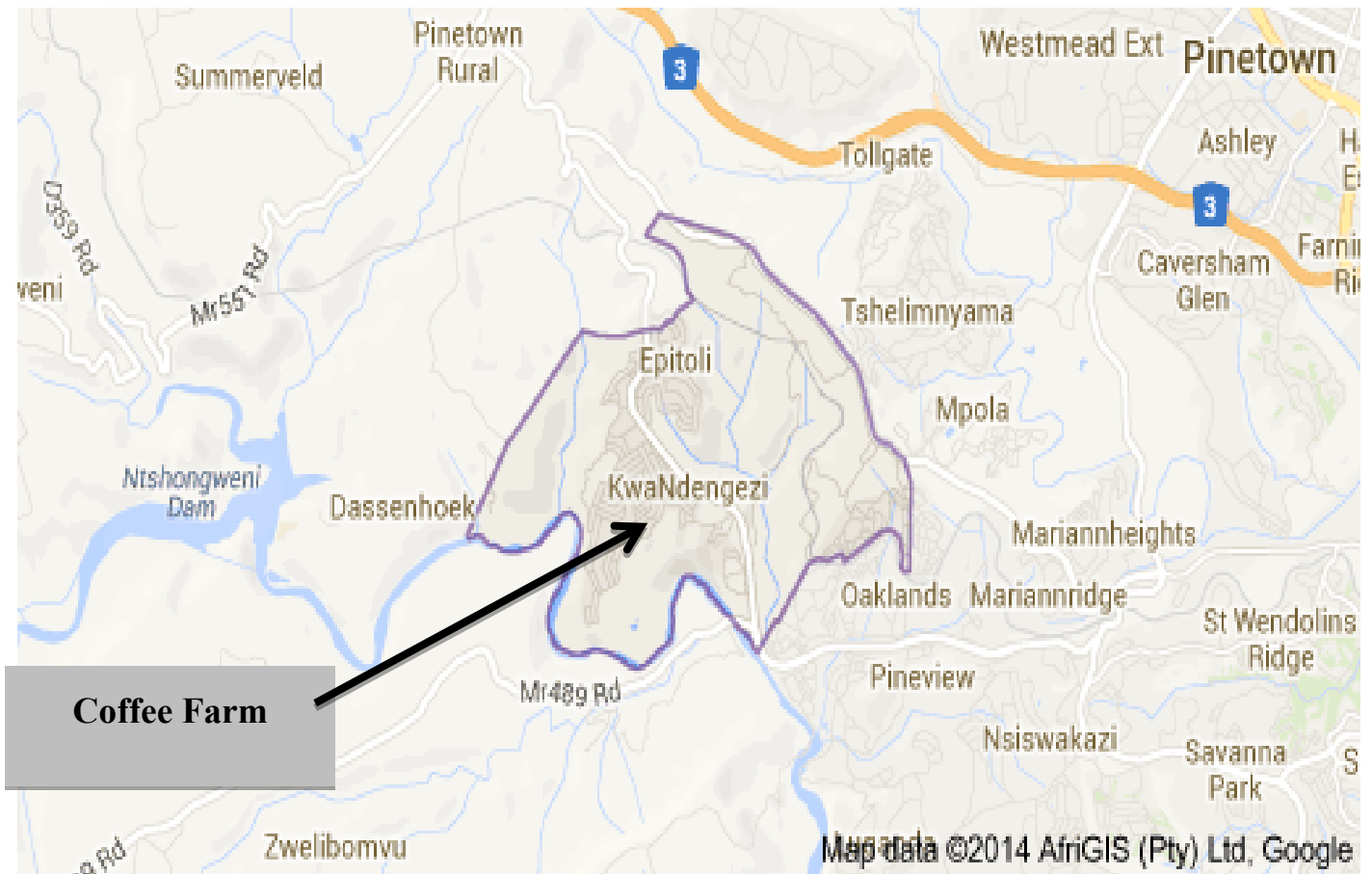
4.1 Introduction

This chapter introduces the research method and approach that was followed to unpack the purpose of this dissertation. Qualitative research methodology was used to assess the attitudes and perceptions that people living in low income households have towards new green technologies, precisely solar water heaters. Neuman (2000) states that a qualitative research design enables the researcher to provide a more balanced and reasonable account of the social lives of the population being studied. In addition, Babbie and Mouton (2001) avow that a qualitative research design makes use of concrete, everyday language of the participants themselves, hence creating an atmosphere that enables participants to reflect and express their views more positively. Lastly, the chapter will discuss a variety of methods that were used to achieve the rigour and quality of the research findings within the study.

4.2 Description of Area of Study and Population

The study was conducted in eThekweni Municipality within the township of Kwandengezi (Coffee-Farm), located in Ward 12, on the outer west of eThekweni Municipality. Coffee-Farm is a small area of Kwandengezi with several low-income RDP households. Some low-income households are free-standing and some were built on land near already existing households that can be classified as low-income. Kwandengezi Coffee Farm was chosen by the researcher because it is one of the low income communities within eThekweni Municipality that received preference during the first phase of the solar water heater installation programme. It is noted that the potential for solar water heaters to reduce energy consumption in low income households is to some extent, exaggerated. In addition, the researcher drew a comprehensive analysis from stakeholders that are involved in the solar heater programme. These groups are namely; members from low income community of Kwandengezi Coffee Farm and government officials from eThekweni Municipality (Energy Office and Housing Department).

Figure 1: The Satellite Map of Kwandengezi Coffee Farm Community.



Source: (Google Earth Image, 2013).

4.3 Primary Research: Target Groups

(i) Community Members from Low Income Households

The purpose of conducting these interviews was to investigate how residents of low income households responded to the use of solar water heaters. The interviews further provided assistance in the assessment of affordability, efficiency and sustainability of solar water heater use in low income households.

(ii) Government officials from eThekweni Municipality

Interviews with officials from eThekweni Municipality were undertaken to determine the programmes that the Municipality had put in place with regards to solar water heaters. In

addition, the researcher aimed to discover how the solar heater programme became a component of the eThekweni Municipality's low carbon agenda.

(iii) *Service Providers*

The aim was to gather information from service providers through the use of interviews. Email and telephone communication was attempted to interview two service providers. However, no positive responses were received from service providers as the researcher was referred to search for information from company websites.

4.4 Research Design and Approach

The qualitative research design was identified as a useful method of conducting research as this research required that the researcher provide a comparative analysis of how the solar heater programme was applied in the context of South Africa. The use of in-depth interviews within the research study further provided a detailed and accurate image to uncover the subjective experiences of people using solar water heaters in low-income households within Kwandengezi Coffee Farm. This assisted the researcher to observe the efficiency of solar heaters from a sustainability point of view. The observations were based on how effective solar water heaters were at providing hot water to households and identifying challenges that have been encountered within the solar heater programme.

In addition, the research approach further made use of primary and secondary data. Primary data emerged from in-depth interviews and secondary data was drawn from published and unpublished data by eThekweni Municipality and a wide range of published academic literature. In addition, participants were asked to complete a one day detailed schedule regarding their use and relation with solar water heaters on a daily basis. This provided an indication of when solar water heaters were mostly useful and at which particular times of the day. Secondary data assisted the researcher to identify gaps in the existing body of knowledge and provide a greater understanding of people's perception towards solar water heaters.

4.4.1 Sampling and Data Collection

Table 3: List of Respondents⁵

Name	Gender F/ M	Age (yrs)	Firm/ Organization	Sector
Mam' Dee	F	45	Household 1	Community Members
Makaspuni	F	29	Household 2	
Mamzo	F	32	Household 3	
Maphindy	F	35	Household 4	
Mrs Baaitjies	F	50	Household 5	
MaLindy	F	40	Household 6	
Mazet-zet	F	22	Household 7	
Maqhoboza	F	37	Household 8	
Spykos	M	20	Household 9	
Shabzoh	M	44	Household 10	
Sylvester	M	21	Household 11	
Skobho	M	41	Household 12	
Sothondoze	M	36	Household 13	
Ndwandwe	M	25	Household 14	
Mkhatshwa	M	27	Household 15	
Zwide	M	30	Household 16	
Bra Dee	M	Unknown	Energy Office	Government
Sbuddah	M	Unknown	Housing Department	Government

The participants that were selected for this study consisted of eight males and eight females above the age of 18 years, living in low income RDP households. The purposive sampling technique was used to sample community members from Kwandengezi Coffee Farm. Neuman

⁵ Not real names.

(2006) asserts that purposive sampling is based on the judgment of the researcher regarding characteristics of the sample and is used for special circumstances. The researcher also had a predefined group in mind when he employed this purposive sample for the research study (Neuman, 2006). In avoiding gender bias, half of the participants were males and the other half were females. This enabled the researcher to highlight the individual experiences with regards to solar water heater use. Information was gathered from participants and several issues were raised with regards to solar water heaters.

The low income RDP houses were selected along the main street of Coffee-Farm as shown in the satellite map above. The researcher selected every fifth household along the main street mentioned above. All household members were found in the households as the research interviews were conducted during the school holidays in July 2013.

The second group of respondents were two government officials from eThekweni Municipality; one from the Energy Office and the other from the Housing Department. Purposive sampling was also used during this process to select the most relevant key department for this research. *Bra Dee* and *Sbuddah*⁶ from eThekweni Municipality were questioned about the role that the Municipality play in encouraging and promoting the solar heater programme for sustainable development. Moreover, *Bra Dee* was further questioned about the mechanism (strategies or policies) that are put in place to ensure that low income communities were receiving improved delivery of solar water heaters.

All face-to-face interview sessions lasted for approximately 30 minutes to an hour. The interviews were recorded using a digital voice recorder and all data was transcribed and translated. NVIVO was used to code all data and formulate themes emerging from the data. All respondents also signed consent forms and community respondents further filled in a daily schedule of their use of hot water in their households.

⁶ Not real names.

(i) *Validity*

Golafshani (2003) states that “the concept of validity is described by a wide range of terms in qualitative studies, and that this concept is a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies and projects” (Winter, 2001 in Golafshani, 2003: 602). In addition, Golafshani (2003) further states that “if the validity or trustworthiness can be maximized or tested then more ‘credible and defensible result’ may lead to generalizability...” (Golafshani, 2003: 603). Therefore, the study verified validity through outlining people’s attitudes and perceptions towards solar water heaters and not of the researcher’s accounts. The questionnaire guide was designed in a manner that documented the views of the interviewees and not of the researcher.

(ii) *Reliability*

Golafshani (2003) refers to reliability as a concept of generating understanding of the situation within qualitative research (Eisner, 1991 in Golafshani, 2003: 601). Therefore, the research study assisted the researcher to arrive at empirical evidence as the sample of the study avoided bias because both males and females were interviewed for the study. The study further generated understanding of the current situation of whether solar water heaters are environmentally, economically and socially sustainable. Respondents from low income households, government and service providers provided all-encompassing viewpoints to generate understanding of the research findings.

(iii) *Rigour*

Davidson Reynolds (1971) cited in Ryan-Nicholls and Will (2009: 70) refer to rigour as the “use of logical systems that are shared and accepted by relevant scientists to ensure agreement on the predictions and explanations of the theory”. In addition, Ryan-Nicholls and Will (2009) argue that rigorous research uses reasoning and recognised systems to reinforce researcher’s arguments within qualitative research. Therefore, this research study unearthed some of the crucial issues pertaining to energy-related poverty and access to hot water which required urgent attention within the community of Kwandengezi Coffee Farm.

In addition, this research further acknowledged the following principles: confirmability, dependability, and transferability to ensure that the research findings are valid and reliable. Ulin *et al.*, (2002) state that confirmability refers to the ability of a researcher maintain division

between their own personal values and the values of the participants throughout the research process.

(iv) *Dependability*

Dependability refers to the uniformity of the research process. It further relates to the degree to which attention is paid in following the rules and principles of qualitative methodology throughout the research process (Ulin *et al.*, 2002). The researcher ensured that the study acknowledged and followed the rules of the research process in order to meet the objectives of the study. The research process was followed accordingly to come to the results of the research and all the accounts were made by the respondents were documented and explained in the research.

(v) *Transferability*

Transferability refers to the aim of producing data that are conceptually representative of the research area in a specific context which can also be conceptually applied to other contexts (Ulin *et al.*, 2002). In order to confirm transferability, the research provided clarity about the context of the study, study population and the conditions under which the data was collected. This would allow other individuals wishing to use the research findings for academic purposes if they wished too. The questionnaire was developed using the objectives and research questions and was aimed at identifying the themes that emerged from the research.

4.5 Limitations of the Study

The first challenge that was encountered when conducting research was the lack of responses from the service providers that install solar water heaters in partnership with Eskom and eThekweni Municipality. Several attempts were made to interview them but they declined. The second problem that was encountered was that some people were not willing to share their experiences with solar water heaters. Hence they provided the researcher with limited answers. However, measures were taken to probe respondents and establish an enabling environment for the respondents to feel safe. The third problem encountered was the limitation of financial resources.

Chapter Five: Findings and Analysis

5.1 Introduction

The chapter presents the findings and analysis from the interviews that were conducted for the research. The main objective of the research was to provide an exploration of the relationship that people living in low income households have with solar water heaters and investigate some of the benefits of using solar water heaters for both the environment and end-users within eThekweni Municipality and surrounding areas.

It became necessary to also assess the cost and benefits of using solar water heaters in low income households and to evaluate the sustainability and efficiency of these renewable technologies. The research findings below have been divided into four sections. The first section examines the background of the households that were sampled for the study. It further draws on the solar heater programme; how it came about within eThekweni Municipality, and service providers that provide solar water heaters to communities. The second section focuses on the process of installation of solar water heaters in RDP houses. The third section focuses on the impact of solar water heaters in low income households. The fourth section discusses the comparisons between the different sources of energy that low income households use to heat water. In addition, it interrogates whether the sources of energy are sustainable for the environment, economy and-users.

5.2 Contextual background of Kwandengezi Coffee Farm

The first set of questions that targeted low income households were aimed at interrogating the demographics of low income households. It further examines when RDP houses were acquired, and whether solar water heaters were installed when the houses were built or afterwards within the Kwandengezi Coffee farm community. Out of the sixteen interviews, the first thing to note is that more than thirteen people indicated that they were from the community and had lived there for more than 10 years, since the beginning of the early 2000. This showed that a large number of people within the community of Coffee Farm may have acquired a RDP house as a

result of their household size and availability of land in people's yards within Coffee Farm. However, it was indicated that a proper procedure was followed in terms of registering to own a house through the councillor of Kwandengezi.

Secondly, the RDP houses in Kwandengezi Coffee Farm are not more than 8 years old in the community. Community members from Kwandengezi Coffee Farm stated that:

–We moved into this house in 2006, but we were already living in this property. We built this one (pointing at a four room house) and with these RDP houses, there was a public announcement in this area years back that people should go to the councillor's office to register for a house. Most houses got built in people's already existing properties and some were built on vacant sites" (*Mam "Dee"*).⁷

–No, no, no....this was not owned it was brought by the councillor we had applied for these houses and those that had applied for the houses were given these RPD houses. And who was in the list was provided with the houses" (*Mrs Baaitjies*).

–We moved in this house in 2008. But I have been living in this community since about 2001. It was a matter of putting RPD houses in vacant spaces between the houses of people who had already living here hence for those that were already owning properties their RDP houses were built within their properties and those that did not own properties before their RDP houses were built in vacant sites when they were done they moved in" (*Spykos*).

This indicated that most people in the area moved to RDP houses in the past 6 to 8 years and people that received RDP houses were permanent residents of Kwandengezi Coffee Farm and other surrounding areas within eThekweni Municipality. One respondent (*Makaspuni*) from the second household however indicated that they moved in to an RDP household two weeks back from the time the interview was conducted. *Makaspuni* indicated that she had bought the house from a person who had moved out of the Coffee Farm community to live elsewhere. The other

⁷ All names used in this research are false.

two respondents *Mrs Baaitjies* and *Zwide* indicated that they had moved into the community of Kwandengezi Coffee Farm after being allocated a house while coming from other poor communities within eThekweni Municipality.

The one problem that was raised by *Sbuddah* from eThekweni Housing was that people in low income communities such as Coffee Farm usually occupy a house once the structure and the roof is built. This illegal occupation of RDP houses occurs in the free standing RDP houses in communities that have not yet been assigned to anyone. Consequently, it was reported that this was caused by empty promises made by politicians and angry local residents who have been waiting too long for the delivery of RDP houses. After a person occupies the house for a while, that person automatically has rights to own the RDP house. This illegal occupation compromises the housing allocation process because RDP houses are sometimes not allocated accordingly with the predetermined housing lists that the housing keeps. Sometimes people from other areas occupy RDP houses within Coffee Farm, resulting in conflicts. The Municipality then refrain from installing water and electricity connections and owners of the RDP houses have to then apply for themselves.

Plate 1: Image Showing Solar Heater Heaters in RDP Houses.



Source: (DBSA, 2013).⁸

⁸http://www.dbsa.org/Research/EDigest/eDigest_ClimateChange/files/assets/seo/page8.html

5.2.1 Household Size

There are fifteen out of the sixteen households that consisted of three generations in one household and this composed of grandparents, parents and grandchildren. However, there are a large number of middle aged people in the community that are unemployed. In some cases, people were living in households with extended family members. The largest households which belonged to *Mam" Dee* consisted of about fifteen family members. However, some of the fifteen members also lived in the old self-built house and some stayed at the newly constructed RDP house. Additionally, resources are shared among the fifteen members of the household. Out of the sixteen households, the average household size was seven members per household.

5.2.2 Household Income

In terms of household income, ten participants indicated that they were largely dependent on the government child support and pension grants. The other six participants were participating in self-employed businesses such as selling cigarettes, operating a car wash near the old main road (Old Richmond Road). The middle generation (parents of children) are mostly unemployed and some are temporary employed in casual jobs such as retail and as taxi drivers within the local taxi industry. Therefore, this indicated that breadwinners within these households were under pressure to provide for their large families, hence, most families cannot afford to pay for services such as electricity and rely on the provision of free basic services by government.

5.2.3 Solar Water Heater Programme in eThekweni Municipality

The first set of interview questions for government officials from eThekweni Municipality's Housing Department and Energy Office were aimed at interrogating the solar heater programme from its planning phase to its implementation phase. After the 2008 energy crisis in South Africa known as load shedding, eThekweni Municipality established an Energy Office. As Eskom was responding to issues of load shedding, eThekweni's Energy Office aligned its ideas towards addressing the common issue. The solar heater programme was introduced to reduce energy consumption within the city of Durban from residential areas, RDP houses and

industrial areas. eThekweni commissioned a study to explore the issues of energy efficiency and the Energy Office was mandated to facilitate this programme on its behalf.

The programme started targeting RDP houses as a strategy to reduce household energy consumption. *Bra Dee*, a respondent from the Energy Office revealed that out of the two types of solar heater systems that existed (active and passive systems), the more appropriate solar heater systems for low income RDP houses was the passive heating system. The difference between the active and passive solar heater system is that the active system uses external sources of energy to power some of its components on electricity. This could consist of equipment that collects and stores solar energy for later uses. The passive solar heater system is not powered by electricity, and relies solely on solar collectors to heat water. This system only required solar heaters to be installed in a direction facing ‘north’ to properly heat water during a hot day. The passive solar heater system was chosen for low cost housing projects because it was more cost effective and is exclusively dependent on the sun to heat water.

5.2.4 Service Providers Providing Solar Water Heaters for eThekweni Municipality

There are two services providers that install solar water heaters for eThekweni Municipality. The first service provider *KwaManzi Ashisayo Solar* has been in operation since November 2007. It has completed more than 2000 high pressure and heat pump installations and more than 8000 low pressure solar installations, through government’s RDP housing projects. The company is also registered on the Eskom solar water heating programme and all other relevant government authorities.

The second company that currently works with the Energy Office *Amanzi Awumlilo Solar* is a sustainable energy company that focuses on supplying low and high pressure solar water heaters. The company started operating in 2007. It received accreditation and certifications from the South African Bureau of Standards, Sustainable Energy South Africa and Eskom and became included in the Eskom DSM programme. *Amanzi Awumlilo Solar* trains and employs two local community members with each company installer in every region where it has been

nominated to supply and install solar water heaters. It operates its own training academy to certify and deploy experienced solar water heater local accredited installers. The company recognizes suitable local installers to form small medium enterprises, in order to provide services for the constant maintenance issues that arise once the project is completed.

5.3 Installation

All participants within the community of Kwandengezi Coffee Farm revealed that solar water heaters were installed when they had already occupied a RDP houses. One participant, *Makaspuni* revealed that as a new member within the community, she occupied a RDP house when the solar water heater was already installed. All other members revealed that solar water heaters are not more than three years old. According to eThekweni Municipality (2011), the roll out of solar water heaters in low income communities such as Kwandengezi Coffee farm was part of a pilot project that initiated in 2011.

Plate 2: Image Showing Installation of Solar Water Heaters



Source: (DBSA, 2013).⁹

⁹http://www.dbsa.org/Research/EDigest/eDigest_ClimateChange/files/assets/seo/page8.html

5.3.1 Process of Installation

The general process of solar water heater installations that was discovered from the interviews was that the councillor in Kwandengezi Coffee Farm made an announcement around the community. Community members with RDP house were informed to go and register to have a solar heater system installed in their homes. People were informed to bring their identity documents and a copy of their water or electricity bills as an indication that they had access to these services. For example, participants mentioned that:

–We applied for them [solar water heaters] in the councillor’s office. They installed solar heaters in RDP houses that had electricity if you did not have electricity they did not put it for you. You see that RDP house too is also for this family but it does not have a solar geyser because it did not have electricity. I asked myself what does that has to do with electricity because this thing does not need electricity to work” (*Maqhoboza*).

–Everyone in this area that had running water in their houses was asked to come with their IDs and water payment slip to apply. There after there were people walking around installing them. If one was not going to be available during the day, they would leave their keys with neighbours so that when the people that install solar come they will not be left out” (*Mam “Dee*).

The above responses highlight some of the conditions that were put in place by eThekweni Municipality for people to gain access to solar water heaters. In terms of the installation process, solar heaters were promoted through low income RDP housing projects. *Bra Dee* from the Energy Office explained that before solar heaters are distributed and installed in RDP houses, the Energy Office firstly begins by arranging a meeting with the councillor and local people for a briefing session about the programme. People are informed about how the equipment functions and the conditions that apply to such technologies. After a meeting is held, the Energy Office collects the number of people who were able to register for solar water heaters and then a service provider is then commissioned to install solar water heaters. In addition, one of the challenges that were raised by *Bra Dee* was that it is always a challenge

when solar heaters are installed in some RDP house and not in others due to lack of cooperation by community members during the registration process.

5.3.2 Training

The general view of ‘training’ in the community was that there is a facilitator from the Municipality or a service provider that is commissioned to provide formal training to local people in the community hall. People would then acquire skills and knowledge of how to use and maintain solar water heaters. However, respondents disagreed on whether such training took place, nine participants said that there was no formal training offered. Out of the other seven people, four people stated that training was offered and the other three did not clarify as they may have not been in their houses when the solar heaters were installed.

–Yes there was a boy that came to educate us about them. He told us how they work and that they shall always have water in them and many other things like how we should take care of them” (*Maphindy*).

–No there was no training....they just installed them and we were left to see for ourselves how they work” (*Skobho*).

–It wasn’t training. There was no training” (*Mrs Baaitjies*).

The above responses revealed three perceptions with regards to ‘training’ in using solar water heaters. The first perception was that there was no formal training, after the installation of solar water heaters; the installers then explained their function, hence stating that they always need to be filled with water. The second perception was that there was no informal training. Noticeably, all the male participants had this perception of the process. They revealed that the solar heaters were installed and then left to understand how they functioned. This was due to the pressure from the number of houses where solar heaters needed to be installed. As such, problems were encountered as the level of installation quality was regarded as poor because of excessive leakages and roofs left with punctured holes.

Bra Dee stated that the training of how to use a solar heater is not a very technical process. Suppliers usually inform users how to utilize the whole system. As a result, several cases have emerged with regards to the maintenance of solar heater systems. Therefore the maintenance of these solar heater systems has presented many challenges for both eThekweni Municipality and local people. Literature reveals that eThekweni Municipality plans to establish a maintenance plan to improve the functions of solar heaters, hence making them more efficient and sustainable in the long term (eThekweni Municipality, 2011).

5.4 Impact of Solar Water heaters

5.4.1 Previous Methods of Accessing Hot Water

There are several methods of heating water that were identified from the interviews. When participants were asked to respond about their previous ways of attaining hot water, they highlighted that these methods consisted of boiling kettles, using urns, burning firewood, paraffin stoves and boiling a pot of hot water in the stove. For example, participants mentioned that;

–I used to use the kettle, you see even in summer I don't bath with cold water. As you can see for yourself I am a big woman I just plugged two kettles and bath. If there was no electricity I would use a paraffin stove and put a pot full of water to bath" (*Maphindy*).

–I used to use my urn and used to plug it in and use my electricity but now I do not. Hot water is readily available. You see with light like this [hot weather] the water is very hot. In the afternoon the water will be boiling hot you can even dilute it [with cold water]" (*Mrs. Baaitjies*).

–We used to plug the kettle or put the pot in the stove or make fire if electricity is low" (*Ndwandwe*).

Therefore, in the event where metered electricity was about to run out, it was identified that people would resort to burning firewood outside their houses or using paraffin and gas stoves to

heat water. In addition, the use of electricity to heat water was very common amongst all households. This highlighted that using an electric kettle was the most convenient way to get hot water.

5.4.2 Benefits of using Solar Water Heaters

Solar water heaters have been well received by the community of Kwandengezi Coffee Farm. Moreover, there were several benefits that were identified with regards to solar water heaters. The first benefit was that solar water heaters have contributed positively to households in terms of convenience. Participants highlighted that the hot water is readily available for use on a hot day. However, depending on the night temperatures, if the hot water is not used in the evenings, warm water becomes available the next morning for use. *Mrs Baaitjies* mentioned that in most cases —it has made things easy for my daughter and children because when they wake up in the morning to go to work and school, they are able to use readily available hot water, hence saving them time”. However, one of the challenges is that there is a tendency of using more hot water when it is available. Therefore, when the water is exhausted, people then resort to electric kettles once again.

The second benefit of solar water heaters is that they have reduced the amount of money spent towards paying for electricity in low income households. Most participants revealed that solar water heaters have resulted in households having access to electricity for up to a full month, whereas they used to run out in the past. They have further reduced the number of kettles used to heat water for additional use of hot water. In addition, all households indicated that solar water heater have assisted everyone within their households. More importantly, people that are responsible for paying for electricity and water services have had a reduced burden of paying for such services. However, *Maqhoboza* further states that;

—yes although what makes it unclear is that the government has brought us geysers but the problem was that these other people [Eskom] have also increased the electricity money which has overshadowed the good role and importance of these solar geysers”

Therefore one of the challenges that were raised was that although solar heaters have had a positive contribution to reduced electricity bills, recent increases in electricity costs have exerted pressure on household incomes. As a result, solar heaters have played an important role in reducing expenditure on electricity bills, hence reduced number of kettles used to boil water.

In terms of eThekweni Municipality, several benefits were recognized from in-depth interviews that were held with officials. Firstly, there was a decline in energy consumption amongst communities where solar water heaters had been installed. Secondly, the installation of solar water heaters in low income communities resulted in employment opportunities for local people. The tendering process requires that service providers employ local people during the installation phase of the project. In addition, *Bra Dee* stated that the local manufacturing of solar water heaters has further created jobs within the country in general. Thirdly, the installation programme contributed to eThekweni's efforts of becoming a low carbon city. Fourthly, solar water heaters decrease electricity grid demands, resulting in households spending less on electricity bills. However, according to the National Energy Regular cited in Kings (2013), the solar water heater programmes have not reached the target of reducing peak demands of reducing electricity consumption (Kings, 2013).

In terms of costs, solar water heaters programme is funded through an Eskom rebate programme. Eskom negotiates at a larger scale with solar heater providers to install low pressure passive solar water heaters. 'Economies of scale' reduce the cost of installing a solar heater per household. All costs are paid for by Eskom's subsidy programme and eThekweni implements the programme within its boundaries through low income housing projects. However any community member wishing to install a solar heater exclusively from the solar heater programme is required to pay a sum of money. Economies of scale also reduce the cost of installing a solar heater for community members that did not receive one during the roll out programme.

5.4.3 Uses of Hot Water

Hot water serves multipurpose uses within households. The most common uses that were identified in Kwandengezi Coffee Farm community were bathing, cooking, cleaning and washing clothes. Moreover, women mostly use hot water for cooking and cleaning; besides bathing. As argued by Milton (2006) this revealed that solar water heaters can reduce the burden of women in terms of times spend on gathering alternative energy sources to heat water. This implied that women can spend more time focusing on other household needs (Milton, 2006).

The participants in Coffee Farm revealed that hot water from the geyser is not drinkable. Therefore it is only used for bathing and cleaning. For example, *Maqhoboza* stated that;

–It is just for bathing because for the tea we use the kettle because we don't know how this solar was built, ...water stays for too long in there and you find that when you open the geyser up there it has got a green-blanket-thing-like that is caused by water that has stayed in one place for too long. You see when you open the tap you can literally see that thing coming out. If you put your hand inside the geyser you will realize that that there is a slippery thing inside which makes even the oncoming water to be dirty...” (*Maqhoboza*).

In most cases, the heated water from the solar geyser is perceived to be only limited to cleaning and bathing. During cold weather, the water in the solar water heater is not used more often. As a result, algae [green substance] may start developing on the bucket which acts as a ‘collector’. However, the hot water from the solar heater has helped all household members.

The following table indicates a daily consumption pattern of hot water use in all the interviewed households at Coffee Farm. From the collected data, the table presents some of the main uses of hot water on a single day within Coffee Farm. It was found that during the morning hours of the day, hot water may be accessed through the use of electric kettles. Since the study was conducted during the winter period, these were the outcomes of a one day hot water uses. An average of about two kettles is used to heat water by each person. The people that use water in the mornings are mainly children of school of going age, and those that are employed. During

the course of midday, solar water heaters tend to be more useful as they are able to heat water. In addition, it was found that depending on the availability of electricity [e.g. load shedding], other sources of heating water such as burning wood, gas and paraffin stoves may be used to heat water.

Table 4: Hot Water Use Diary

Time	Person pouring the hot water	Hot water used for:					Method of heating (you can tick more than one)					Amount of hot water (e.g. 1 bath, 2 cups, 1 pot)	
		Bathing	Washing dishes	Cooking food	Hot drink	Other (please state)	Solar water heater	Kettle or urn	Paraffin	Wood	Other (please state) gas stove		
05:00 – 07:00am	-Children going to school, temporary employed persons.	√			√		√	√				Depending on the availability of electricity within a particular household, either a gas or paraffin stove may be used to heat water through the using a pot.	2 Kettles per person. 1 Kettle for tea.
07:00 – 10:00am	-Mother and people present within households		√			√ (cleaning)	√						3 -5 Litres of water, depending on the weather
10:00 – 12:00pm	-Person in households, mother, father, grandparents (people present during the day).				√		√	√					1 dish equivalent to about 2-3 kettles of water.
17:00 – 20:00pm	-Mother/ female children/			√	√						√		3 kettles for cooking and having a hot drink

5.5 Challenges

5.5.1 Barriers to Accessing Solar Water Heaters

There are two categories of challenges that were found in Coffee Farm with regards to solar water heaters. The first category relates to the barriers of having a solar water heater installed in a RDP house. The first barrier to having a solar water heater installed was that people were required to have water and electricity bill slips. Those that were not up to date with their water payments did not acquire a solar water heater. In the case of water shortages on particular days, solar water heaters may malfunction since they require running water. For example, the case of *MaLindy* whose water had been recently cut off as a result of inability to pay for the household water bill reveals some of the challenges that threaten the functioning of the solar water heater that had been installed in her home. Therefore, she was unsure about the damages that have been caused on the solar water heater because of the system being neglected and functioning without water for a long time. In addition, this confirms the arguments made by scholars such as Deedat and Cottle (2002), and McDonald (2002) that water and electricity services have not been an all-encompassing process since those that cannot afford to pay for these services cannot retain them. Government's claims to extend electricity and water services to low income households as a result of commitments to social justice is not justifiable when services have to be cut off.

The second category relates to the negative effects of owning a solar water heater. Weather condition is the first identified problem in terms of how the solar heater functions. All the participants reported that the solar heaters function very well during hot days, mainly in summer as compared to a cold winter season, since they are less effective in cold weather. Moreover, participants reported that during winter, people tend to use more hot water (3 or more kettles of water) for bathing. In some cases, solar heaters may become inconvenient and ineffective as people still resort to boiling water in the kettle again. Moreover, it was found that people have a tendency of using more hot water when it is readily available on the solar water heater for bathing, hence consuming more water. As a result, the water bill may be subjected to increase.

5.5.2 Water Leakages

The second identified problem was the issue of water leakages as a result of poor installation. *Sylvester* reported that installers had punched holes on his roof top and the geyser would sometimes leak. During rainy days, the rain water penetrates inside the house through the punched holes on the roof. Moreover, leakages result in escalated water bills, hence resulting in failure to afford to pay for water services. In addition, about half of the participants that were interviewed revealed that solar water heaters have to be monitored on a regular basis in order to reduce or eliminate leakages caused by the overflow of water inlet pipes letting in too much water inside the geyser. People mentioned that ~~the~~ only negative problem about them [solar water heaters] is that they are leaking because there at the top when you try fix it for yourself it is difficult to control it” (*Sylvester*).

Moreover, another challenge that was raised by the residents was that they felt that they were beneficiaries of second class products that do not function efficiently because of leakages and poor maintenance. The participants revealed that service providers do not provide further service and maintenance after installing solar water heaters and people are then burdened with looking after the heaters if the system does not function properly. The interviews further revealed that in households where the men are present, people try to fix their own solar water heaters to reduce leakages which are said to have destroyed ceiling boards. An additional challenge was that when solar water heaters are installed, the taps are left outside the house. People have to channel the water pipes inside the house. Cheap material is also used, as a result, solar water heaters leak. For example, in some low income communities such as Riverlea in Johannesburg, residents raised the concern that solar water heaters are a basic need. However, they further stated that although government has provided solar water heaters, they were not satisfied at the way in which solar heaters functioned because of water leakages and poor installation and maintenance (*Mail and Guardian*, 2013).

5.5.3 Maintenance

The third identified problem was the issue of maintenance of solar water heaters. In the event where solar water heaters became dysfunctional, people took the initiative of fixing the solar

heater geyser for themselves. Some of the participants were unsure about who was assigned the role of providing maintenance services for the solar water heaters. As a result, the installers were also regarded as the people who should be responsible for providing maintenance services. In terms of service providers, the trained local people that are temporary employed during solar heater installations are the ones that could be contacted in the case of a faulty solar heater.

In addition, *Bra Dee* from the Energy Office stated that maintenance has been a serious concern that has been raised by people residing in low income RDP houses with solar water heaters. Therefore government has failed to address issues experienced in the programme more broadly. The programme has not been effectively monitored through ensuring that all solar water heaters are working efficiently, and to establish measures of addressing problems such as poor installation quality and maintenance of solar water heaters. Moreover, solar heater programme is criticized for only focusing on the roll out of solar water heaters without any maintenance plan put in place to ensure that solar heater systems function more efficiently.

Furthermore, it was noted that some of the components of solar water heaters are being stolen in low income communities. Participants in Coffee Farm revealed that there has been an increase in the theft of copper pipes, and brass taps. Theft of these components results in solar heaters becoming dysfunctional. Consequently, government may be reluctant to invest and promote the solar heater programme in low income communities.

Moreover, some of the components of solar water heaters (for example, photovoltaic cells) are made of glass of which is liable to get damaged. The last challenge that emerged was that solar heaters have to be installed in a direction facing north, in order for the energy collectors to function properly on a sunny day. In some households, this was unable to happen due to the land terrain and location of the house.

5.6 Opinions on Comparative Analysis of the Sources of Energy

Table 5: Comparative Analysis on the Methods of Heating Water

Methods of Heating	Advantages	Disadvantages
Paraffin	<ul style="list-style-type: none"> ➤ Saves electricity ➤ Good for cooking foods that require a lot of heat (steam bread, beans and tripe). 	<ul style="list-style-type: none"> ➤ Expensive ➤ Dangerous for Children ➤ Excessive Smoke ➤ Inconvenient
Bio Power Ethanol Gel	<ul style="list-style-type: none"> ➤ Smokeless ➤ Safe to use ➤ Saves electricity 	<ul style="list-style-type: none"> ➤ Takes longer to heat water
Wood	<ul style="list-style-type: none"> ➤ Cheap to use and no money required ➤ Able to heat a big pot full of water ➤ Saves electricity 	<ul style="list-style-type: none"> ➤ Too much smoke ➤ Collection of wood is time consuming ➤ Health Hazards
Urn or Electric Geyser	<ul style="list-style-type: none"> ➤ Convenient ➤ Fastest process of heating water ➤ Saves time 	<ul style="list-style-type: none"> ➤ Expensive ➤ Consumes a lot of electricity ➤ Not affordable to low income households ➤ Person uses more hot water when it is available
Gas	<ul style="list-style-type: none"> ➤ Smokeless ➤ Saves electricity 	<ul style="list-style-type: none"> ➤ Expensive ➤ Bad smell ➤ Not safe to use
Biogas	<ul style="list-style-type: none"> ➤ Provides a non-polluting and renewable energy. 	<ul style="list-style-type: none"> ➤ The process is not economically attractive on a large industrial scale
Solar Water Heaters	<ul style="list-style-type: none"> ➤ In sunny and warm places with high insulation values, solar water heating systems are very cost effective. 	<ul style="list-style-type: none"> ➤ High costs to own a solar water, and they require excellent overheating and freeze protection.

Source: (Author's interpretation, 2013).

The table above highlights some of the advantages and disadvantages of the various methods of heating water based on the opinions provided by residents of Kwandengezi Coffee Farm use. In addition to solar water heaters, the respondents were asked to provide a comparative analysis on the different methods of heating water used in their households. The first identified method of heating water was paraffin. All participants revealed that this was a disliked method of heating water as it was used in the case where electricity was not available. It was found that paraffin was expensive and people use it in the case where they were cooking food that consumes a lot of energy such as steam bread, beans and tripe. In the case of paraffin, bio power ethanol gel was considered to be more appropriate for use than paraffin inside their houses.

Fire wood was regarded as a cheap method of heating water. However, the disadvantages of using fire wood that were raised were that it is inconvenience and it is not easily accessible in Coffee Farm. Outside fires are usually fuelled by broken wooden pallets, which are not often available. The use of urns and electric geysers was regarded as the most convenient but expensive way of heating water. It was argued that people tend to use more hot water when it is readily available. Hence, these are costly methods of heating water to low income households. The last identified method of heating water was the use of gas stoves. These were regarded as expensive and not safe for use. The use of gas stoves does save electricity, however, gas stoves become more relevant in the case where one is hosting an event in the community and they have to cook for a number of guests. The following table draws on the methods of heating and their advantages and disadvantages to the environment.

Table 6: Opinions on Methods of Heating Water and Impact on the Environment

Methods of Heating	Advantages	Disadvantages
Paraffin	<ul style="list-style-type: none"> ➤ Saves electricity 	<ul style="list-style-type: none"> ➤ Costly to the environment ➤ Hazardous fumes (carbon emissions) ➤ Inconvenient
Bio Power Ethanol Gel	<ul style="list-style-type: none"> ➤ Smokeless ➤ Safe to use ➤ Saves electricity ➤ Renewable 	<ul style="list-style-type: none"> ➤ Renewable ➤ Its production is harmful to the environment
Wood	<ul style="list-style-type: none"> ➤ Cheap to use and no money required ➤ Renewable ➤ Saves electricity 	<ul style="list-style-type: none"> ➤ Deforestation ➤ Excessive Smoke (carbon emissions) ➤ Soil erosion ➤ Carbon emissions Contributes to climate change
Urn or Electric Geyser	<ul style="list-style-type: none"> ➤ No pollution during use ➤ No carbon emissions during the heating of water 	<ul style="list-style-type: none"> ➤ Yes because there is no smoke, but its production has negative environmental impacts
Gas	<ul style="list-style-type: none"> ➤ Clean Burning ➤ No smoke (less carbon emissions). 	<ul style="list-style-type: none"> ➤ Hazardous
Biogas	<ul style="list-style-type: none"> ➤ Biogas plants lower methane emissions by entrapping and using it as fuel. ➤ Leads to improvement in the environment. 	<ul style="list-style-type: none"> ➤ It is difficult to enhance the efficiency of biogas systems. ➤ Biogas contains some gases as impurities which are corrosive to the metal parts of internal combustion engines
Solar Water Heaters	<ul style="list-style-type: none"> ➤ Help reduce dependence on fossil fuels 	<ul style="list-style-type: none"> ➤ Manufacturing of solar water heaters is an energy-intensive process which pollutes the environment.

Source: (Author's interpretation, 2013).

The table provides opinions of participants within Kwandengezi Coffee farm regarding different methods of heating water. Participants were asked to compare how the methods of heating water had an impact on the environment. They reported that paraffin had more negative impact on the environment as it releases fumes [carbon emissions] during combustion which is harmful to the environment. The use of bio power ethanol gel was regarded as being more appropriate for use since it was smokeless, and hence it was regarded as a better fuel than paraffin. Bio power ethanol gel is also a renewable energy however; its production is not good for the environment, as it involves the burning of corn which releases carbon dioxide which is not good for the environment.

Wood was regarded as a bad fuel to burn as it releases excessive carbon dioxide which is not good for the environment hence contributing to climate change. The use of electric urns and geysers were regarded as being good for the environment since there are no emissions produced on site. However, participants highlighted that the production of electricity however is not good for the environment as burning of coal releases carbon emissions.

5.7 Conclusion

The chapter above has presented the findings of the research conducted in Kwandengezi Coffee Farm during July 2013. The chapter focused on four key sections to assess the attitudes and perceptions that people have towards solar water heaters. The findings have been presented categorically and all responses from government and service providers have been incorporated in the findings with the responses of community members. The next chapter will present further themes and discussions that emerged from the findings.

Chapter Six: Discussion and Conclusions

This chapter provides a discussion on the relevant key themes that emerged from the research findings. From the research, four key themes relevant to the solar water heater programme for low income RDP households emerged. The following discusses the four key themes and then will conclude.

6.1 Sustainability and the Solar Water Heater Programme

6.1.1 Environmental Sustainability

In terms of environmental sustainability, the solar heater programme in eThekweni presents many opportunities for eThekweni Municipality to become a low carbon city, although the solar heaters have not been tested for reducing GHG emissions. Scott *et al.* (2011) define a low carbon city as “...one that strives to reduce its GHG emissions and increase its carbon sinks, while simultaneously adapting to anticipated climate change impacts” (Scott *et al.*, 2011:31 – 32). EThekweni’s Energy Office revealed that the programme has contributed to greenhouse gas reduction and has promoted a reduction in energy consumption.

EThekweni Municipality has further undergone a process of transition towards further adopting green policies that mainstream issues of climate change. The solar heater programme together with other energy efficiency initiatives ran by the eThekweni’s Energy Office and Electricity Department indicate eThekweni’s efforts towards adopting the low carbon agenda.

In terms of environmental sustainability, the project is intended to be sustainable in the long term since the solar water heaters do not require electricity, but are completely dependent on solar energy from the sun. Hence, this will reduce long term carbon emissions in the long term although it has been argued that the production of solar heaters is an energy intensive process that produces carbon emissions.

6.1.2 Economic Sustainability

In terms of economic sustainability, the major concern that was raised in the literature chapter was the large dependence on non-renewable energies (such as coal and oil) for energy production. The government's major economic sustainability challenges consist of renewable energy and cost of addressing environmental pollution. Therefore, investments have been made at a large scale to address climate change and several governments in developing countries have moved towards adopting the low carbon agenda (eThekweni Municipality, 2011). It has been largely noted by government that the solar heater programme has not achieved its targeted objective of reducing peak energy demand. Therefore, one other problem that emerged when *Bra Dee* was interviewed was contestations on the local manufacturing of solar heater rather than importing the systems. Therefore, the solar heater programme is seen to have created more jobs than addressing the issue of climate change. However, it may be economically sustainable in the long term to have solar heaters because as long as the system functions properly, the programme is likely to reduce the carbon footprints significantly (eThekweni Municipality, 2011).

6.1.3 Social Sustainability

In terms of social sustainability, the challenge that was raised in the literature chapter is that; can people continue using renewable energy resources such as burning firewood, using gas and other methods to heat water and fulfil their electricity needs. Therefore, from government's perspective, one of the ways that social sustainability has been addressed is through the promotion of energy efficiency programmes and roll out of solar water heaters.

For low income communities, the delivery of hot water infrastructure such as passive solar water heater systems and energy efficient light bulbs promotes energy efficiency and also enable people to have access to energy infrastructure to improve their quality of life (eThekweni Municipality, 2011). In the long term, solar water heaters are perceived as having enough capacity of sustaining people's hot water needs, since they rely on the sun for heat energy. Access to readily available hot water reduces the burdens of paying for electricity services.

6.2 Advantages and disadvantages of SWHs for Low income Households

The first advantage of solar water heaters is that they are a form of green technology that serve a multipurpose role of providing access to hot water at no cost to users and at the same time addressing issues of climate change. The second advantage is that the programme has been a driver of job creation through the manufacturing of solar water heaters. The third advantage is that solar heaters lead to long term energy cost savings within households. Fourthly, from a government perspective, the provision of passive solar water heaters is more cost effective than the construction of more power plants. However, rising energy demands will still result in more power plants being constructed.

The first disadvantage of the solar heater programme is the poor coordination by government with regards to monitoring installation quality and maintenance of the solar water heaters. In avoiding such challenges, government is supposed to ensure that regular inspections are conducted to monitor consistency in the quality of installations. The second disadvantage was the capital cost of providing solar water heaters to low income communities. As much as government invests in energy efficiency programme, electricity is remains a commoditized service that government generates revenue from. Therefore, the plan of the solar heater programme is to have return on investments; meaning the accomplishment of sustainability and reduction of household energy consumption.

The third disadvantage is that some of the components of solar water heaters are stolen by some community members and neighbouring areas. For example, there has been an increasing rate of the theft of copper pipes and taps located outside the RDP houses in Coffee Farm. As a result, this may cause the solar heater systems to be dysfunctional and government may be reluctant to further invest in the programme.

The fourth disadvantage relates to the installation. If solar heaters are not installed correctly in a direction facing north, they may become less efficient and worthless to community members, and to the ultimate goal of mitigating climate change. The last disadvantage relates to the fact that the photovoltaic cells are made of glass, hence liable to get damaged.

6.3 Attitudes towards Solar Water Heaters

In assessing the attitudes and perceptions towards solar water heaters, the participants revealed several factors to indicate how they felt about the solar water heater programme. Firstly, the interviewed residents of Kwandengezi Coffee Farm were very satisfied about the government's efforts of committing itself to social justice by providing the solar water heaters at no cost to people living in low income households. However, only those who had registered for the programme received the solar heaters. Consequently, the people that were excluded from the programme were unhappy about service delivery.

Secondly, people demonstrated excitement about the programme as the solar heater system provided free hot water, and hence reducing the burden of paying more for electricity. However, most of the interviewed people raised concerns encountered regarding their functionality. The common issues that were raised consisted of poor installations, continuous leakages and lack of proper maintenance.

Thirdly, it emerged strongly that residents of Coffee Farm felt as though they are beneficiaries of cheap, second class products that do not function properly because of excessive leakages and poor maintenance. Therefore, government support is required to train people on how to use the systems properly since it appears from the research that there is a general assumption that solar water heaters are user friendly, but people continue to encounter problems with regards to their use. In addition, there is a need for government and service providers to educate communities about the benefits of renewable energy technologies such as solar water heaters so that they can be of value to them. The case of Laos revealed that solar water heaters were rolled out at a cost to community members. As a result, residents in local communities took responsibility of the projects, since they had to pay back cash loans used to purchase solar water heater system. For example, the initial phase of the rural electrification project became a success because communities paid for solar water heater systems.

Fourthly, residents of Coffee Farm revealed that the delivery process of solar water heaters was exclusive as the criteria for registering for a solar heater required that people present

their water connection slips. *Sbuddah* from eThekweni Housing revealed that the challenge with regards to low income RDP house was the allocation process. During the construction of the RDP houses, many people who had already been living in the community of Coffee Farm for years illegally occupied the houses before they were completely built. Consequently, the housing department failed to remove these people and allocate people who were already in their housing lists. Moreover, the Housing department then decided not to facilitate the acquisition of water and electricity connections in the houses. Residents had to then go to the relevant department to register for such services. Those who had illegal connections could not register for solar water heater when the programme was implemented in this community.

6.4 Issues around government support and policy

There are two issues that were picked up with regards to government support of the project. The first issue was that the programme adopts a blueprint approach, where policy makers decide a cost effective strategy and of promoting energy efficiency in low cost houses. The solar heater programme is perceived as a best practice model of reducing household electricity consumption, since water heating, is one of the major constituent contributing to a high electricity bill.

Secondly, Eskom is the main driver of the solar heater programme at a national level. Therefore, one of the concerns raised by *Bra Dee* from the Energy Office was the lack of funds to further subsidize the continuation of the programme, resulting in a delay in the delivery of solar heater systems to low income communities. In addition, government took a rational policy decision to install passive solar heater systems which were regarded as being more affordable and appropriate for the poor, while residents did not have any say in the matter. Therefore, the application of a solar heater programme from other global south countries in the context of South Africa presents many challenges due to the complexity of development issues.

6.5 Conclusion

The dissertation has explored attitudes and perceptions that people have towards solar water heaters. Literature on energy and development was reviewed to locate the context for the research study from an international perspective of how global south countries are addressing the energy crisis and the broader issues of climate change. Literature revealed that social concerns have received less attention within the energy sector. Hence, this research gap caught the researcher's attention resulting in the proposal of this research study. The research was explored through the use of the sustainable development approach as a framework of analysis.

The interviews revealed several issues that have questioned environmental, economic and social sustainability of renewable technology programmes for energy provision in South Africa. The most interesting point regarding the programme was that the solar heater programme needs to also be extended middle income and upper income classes. This will significantly increase the environmental, economic and social impact of the programme, hence eliminating all negative stereotypes about the solar heater programme for low income housing.

In conclusion, it is of paramount importance that development practitioners in the public, private and third sectors [Non-governmental Organizations] critically plan and engage in energy efficiency interventions for low income houses, and all other kind of developments. Such interventions will contribute to the mitigation of climate, increasing access to sustainable energy services and the creation of jobs to improve people's quality of life. A further area of research that can be interrogated in the solar heater programme is job creation.

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ANNEXTURE A: RESEARCH INSTRUMENT

Section one: Households

Household

1. When did you move into this house?
2. How did you get this house? (Probe on the issue of self-build vs. upgrades and low cost housing)
3. Who lives here and what are the sources of income within this household?

Installation

4. Was the hot water system already here when you came to this house?
5. If no, explain the process through which the solar heater system was installed.
6. Was there training offered on how to use this hot water system?

Impact

7. How did you get hot water before you had a solar heating system?
8. How has this technology changed things for you?
9. What do you use hot water for?
10. Who has the hot water helped the most within the household?
11. Do you save money as a result of the solar heating system?
12. Does the solar water system work well? (Probe: Are there times when it does not hot water? What do you do to get hot water at these times? How often does this happen?)
13. Who is responsible for maintenance? (Probe: Has it ever broken? What happened?)
14. What are the negative effects of owning this solar heater system?

Comparison

15. Discuss each of the following systems for heating water with respect to each of these questions:

	i. Would this be a good method for you to use? Why?	ii. Is this a good method for the environment? Why?
Paraffin		
Wood		
Urn or electric geyser		

Section Two: Government Officials

Contextual Background

1. When did the programme start?
2. How many solar water heaters have been installed since the programme began?

Cost and Benefits

3. What are the cost and benefits of using solar water heaters for low income households?
4. What is the relationship between low income households and solar water heaters?
5. How has eThekweni benefited from installing solar water heaters in low income households?
6. What challenges has eThekweni Municipality experienced with regards to solar water heaters?

Installation

7. What are the costs involved in installing solar water heaters in low income households and what process of getting a SWH installed in your home?
8. Is there a consultation process involved between eThekweni Municipality and the community?
9. Is there any training involved on how to use solar water heaters? Who attends such training?
10. Who maintains these solar water heaters?

Sustainability and Efficiency

11. What approaches are there to ensure that the solar water heaters are sustainable?
 12. What can be done to improve the cost and efficiency of solar water heaters?
 13. Are solar water heaters a viable energy efficiency model for eThekweni Municipality towards becoming a 'low carbon city'?
 14. To what extent does the community participate in the development process?
-

Section Three: Service Providers

Contextual Background

1. How old is your organization?
2. When did you start supplying solar water heaters?
3. When did you start supplying solar water heaters to low income households within eThekweni Municipality?
4. What are the major difficulties of providing solar water heaters to government?
5. How many people have you employed in your company?

Cost and Benefits

1. What are the cost and benefits of using solar water heaters?
2. How has installing solar water heaters benefited low income communities?
3. What challenges have been experienced with regards to solar water heaters?

Installation

4. What are the costs involved in installing solar water heaters in low income households and what process of getting a SWH installed in your home?
5. Is there a consultation process involved between your organization and the community?
6. Is there any training involved on how to use solar water heaters? Who attends such training?
7. Who maintains these solar water heaters?

Sustainability and Efficiency

8. What approaches are there to ensure that the solar water heaters are sustainable?
 9. What can be done to improve the cost and efficiency of solar water heaters?
 10. Are solar water heaters a viable energy efficiency model for cities towards becoming a 'low carbon city'?
 11. To what extent does the community participate in the development process?
-

Hot water usage diary

Many thanks for contributing this information. Choose a 24 hour cycle (from midnight to midnight) in which to do this exercise. [e.g. midnight on Tuesday to midnight on Wednesday]. Please fill this on a week day (Monday-Friday) and not the weekend. Each time hot water is used in this household over that period please note the details.

Time of hot water use	Person pouring the hot water	Hot water used for					Method of heating (you can tick more than one)					Amount of hot water (e.g. 1 bath, 2 cups, 1 pot)
		Bathing	Washing dishes	Cooking food	Hot drink	Other (please state)	Solar water heater	Kettle or urn	Paraffin	Wood	Other (please state)	
e.g.: 6:00 am	1				√		√	√				2 cups

Household members

	Name	Age	Gender (M/F)
1.			
2.			
3.			
4.			
5.			

