SOLAR ENERGY IN PERI-URBAN AREAS OF INANDA, SOUTH AFRICA: EXAMINING ATTITUDES AND CHALLENGES

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PREFACE

The work undertaken in this study was carried out in the School of Agricultural, Earth and Environmental Sciences, College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Durban, University of KwaZulu-Natal. This research was completed under the supervision of the following academic staff:

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The contents of this work have not been submitted in any form to another University and, except where the work of others is acknowledged in the text, the results are the author's own investigation.

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I certify that the above statement is correct:

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Prof Urmilla Bob

ABSTRACT

Access to modern energy is central to addressing important global development challenges including poverty, inequality, climate change, food security, health and education. The understanding of the concept of energy poverty is critical when making any attempts to alleviate it. Lack of access to sustainable energy is also a major factor preventing social and economic development, both of which are linked to sustainable poverty reduction. However, worldwide access to energy has shown very slow progress because of the costs associated with electric grid extensions and decentralized systems by which power is offered. This study investigates the viability of implementing solar energy in poor communities in Inanda, which is located in Durban, South Africa. Inanda is known to be an area with high unemployment and high poverty levels. Most important to this study are high energy poverty levels in the area. It was found that these communities prioritised energy for cooking, lighting and heating. The results of this study also indicate that in most households, multiple sources of unsustainable energy sources were being used. These included electricity, fuelwood, gas, paraffin and candles. Illegal electrical connections are a growing problem in this community, and other traditional sources were found to have numerous effects on human and environmental health. Upon investigation of the potential for renewable energy implementation in these communities, it found that there was a high willingness to use it, specifically solar energy; however, more education is needed regarding solar energy and related benefits. It was also indicated that the provision of sustainable energy will allow more time for income-generating activities in the community. The biggest challenge with regard to provision of solar energy was cost. These communities cannot afford to pay high start-up and maintenance costs for the technology. It is for this reason that efforts should be made to subsidize these costs and integrate this plan into policy-making. This will not only provide poor communities with sustainable energy, but also help advance the renewable energy industry in South Africa.

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LIST OF ACRONYMS AND ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
CDM	Clean Development Mechanism
GWh	Gigawatt hour
HDR	Hot Dry Rock
INK	Inanda, Ntuzuma and KwaMashu
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hour
MDG	Millennium Development Goals
OFDI	OPEC Fund for International Development
OPEC	Organisation of the Petroleum Exporting Countries
PPM	Parts per Million
PV	Photovoltaic
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCED	World Commission on Environment and Development

CHAPTER 1
INTRODUCTION

1.1 Introduction

The term “energy” may be defined as an ever-present entity, occurring in forms of heat, electricity and motion that ultimately drive every aspect of human life (Armaroli and Balzani, 2006: 2). Over the past few decades, issues such as “energy crisis” and “greenhouse gases” have captured the attention of people due to the resulting energy supply shortages (Liu et al., 2007: 1). The lack of energy and type of energy used may be considered to be a severe problem for humanity because issues of food, environment, water, health and education are all dependent on the availability of and types utilised. Thus, access to and type of energy available is linked to the health and well-being of people and also contributes to environmental impacts associated with global warming. Despite this, there is still an enormous discrepancy between the extensive use humans make of energy and the limited knowledge we have of it (Armaroli and Balzani, 2006: 2). The availability of energy can dramatically increase the spectrum of choices and opportunities that are necessary for overall human development (United Nations Development Programme - UNDP, 2000: 19). The term “sustainable energy” may be defined as energy production that supports long-term human development incorporating social, economic and environmental dimensions. However, current energy usage and practices do not comply with sustainable energy supply. The world’s current energy situation in terms of production and consumption cannot be sustained if technology were to remain unchanged. Over 2 billion people do not have access to modern energy and an equal number rely on traditional sources of energy (UNDP, 2000: 20). This compromises economic development and improved standards of living (UNDP, 2000: 20).

Access to energy is one of the important factors which enable socio-economic development. In sub-Saharan countries such as Liberia, Burkina Faso and Tanzania, access to modern energy is low. Over 95% of the populations in these countries still rely on traditional sources of energy (Brew-Hammond, 2010: 2292). This figure is projected to increase over the next 25 years because access to modern energy is directly linked to per capita income. Since household incomes of these populations are not expected to increase high enough, switching to modern energy is not an option (Brew-Hammond, 2010: 2293).

In sub-Saharan Africa, the rural population makes up almost 70% of the total population which relies mainly on traditional energy use in the form of unprocessed biomass. In some sub-Saharan countries, reliance on biomass energy accounts for 70-90% of total energy use (Karekezi, 2002: 2). Some sub-Saharan countries which are considered oil-rich still rely mainly on biomass to meet household energy needs (Karekezi, 2002: 2). Brew-Hammond (2010: 2292) indicates that the number of people relying on traditional sources of energy will stabilize and possibly decrease in countries with a high economic growth rate. In sub-Saharan Africa it is projected that by 2030 the number of people relying on traditional biomass will increase to 700 million. If this trend continues beyond 2030, sub-Saharan Africa will be the region with the largest number of people without access to modern energy (Brew-Hammond, 2010: 2292).

Access to modern energy is central to addressing important global development challenges including poverty, inequality, climate change, food security, health and education (Nussbaumer et al., 2012: 2). The understanding of the concept of energy poverty is critical when making any attempts to alleviate it. Lack of access to sustainable energy is also a major factor preventing social and economic development, which are linked to sustainable poverty reduction (Organisation of the Petroleum Exporting Countries - OPEC and Fund for the International Development - OFID, 2010: 54). However, worldwide access to energy has shown very slow progress because of the costs associated with electric grid extensions and decentralized systems by which power is offered (Pereira et al., 2011: 168). Poor people prioritise access to energy not only for the energy itself but for the services it provides, such as cooking, heating and lighting. Without access to modern energy, poor communities depend largely on biomass sources including charcoal, fuelwood and animal waste for cooking and heating purposes (Pereira et al., 2011: 168). As mentioned earlier, Madubansi and Shackleton (2006: 1) indicate that the main sources of energy used in rural households include fuelwood, paraffin, candles and batteries. These sources often result in unwanted fires and the spread of fires in communities. There are also low levels of electrification in rural areas. In most rural areas, electricity is generated from dry cells, and some people use car batteries as a source of energy which need to be carried long distances to recharge (Ellegard and Gustavsson, 2004: 1059). Kanagawa and Nakata (2007: 3) reiterate that by 2030, 2.6 billion people will have an unimproved, unchanged energy situation.

The provision of electricity has often been associated with the notion that it promotes development, specifically economic development. It was largely acknowledged that electricity is necessary but is not efficient to catalyze economic development (Wamukonya, 2005: 6). Most African governments rely on loans to provide electricity to their countries. However, over 60% of African populations do not have access to electricity (Wamukonya, 2005: 6). The majority of these populations reside in rural and peri-urban areas, where access to the grid is not financially viable. Solar home systems are therefore becoming more popular as the decentralized technology is increasingly being promoted in developing countries. This is often justified on the basis of its cost effectiveness and has consequently resulted in the general perception that solar energy technologies have the potential to meet the energy demand of developing countries (Wamukonya, 2005: 6).

Wamukonya (2005: 6) contends that after the 1970 energy crisis, solar energy systems gained popularity, however due to the fossil fuel shortage, interest in solar technologies began to slow down. In recent years, concern about environmental degradation and climate change led to an interest in renewable energy technology. Davidson and Sokona (2001: 18) assert that there is a promising future for renewable energy technology specifically for African countries due to the lack of provision of modern energy and the availability of renewable energy resources.

Karakezi (2002: 5) argues that the energy sector in Africa brings with it enormous opportunities for implementing renewable energy programmes that are environmentally friendly and provide sustainable energy to the poor. It is noted that renewable energy sources are well distributed in Africa and therefore worth the investment. With regard to conventional energy, there are high distribution costs when considering the decentralized arrangement of homesteads among Africa’s poor. Renewable energy technology therefore plays a competitive role in providing modern energy (Karakezi, 2005: 5). In sub-Saharan countries, there has also been rapid institutional development within governmental and non-governmental organisations that are willing to address the challenges associated with renewable energy technology (Karekazi, 2002: 1065). This simultaneously provides an avenue through which information on renewable energy may be provided to the poor, which bridges the gap between implementation and education associated with these technologies (Karekazi, 2002: 1065).

The uptake of renewable energy for low income areas in South Africa started in 1999 as part of the National Electrification Programme which aimed to deliver more than 300 000 solar home systems to rural areas (Lemaire, 2011: 227-283). This initiative encountered a number of challenges specifically with respect to cost and awareness. This study interrogates these factors at a community level in addition to examining current energy usage and its impact.

1.2 Motivation

Energy plays a vital role in improving the living standards of people, particularly in poor communities. Economic growth and development are directly or indirectly linked to the utilization of and access to energy (Nguyen, 2007: 1). Improved energy access has great potential to influence the development of rural areas (Kanagawa and Nakata, 2007: 5) and this is relevant to marginalised communities more generally. Since there is an explicit link between energy and poverty, alternate sources of energy are necessary to improve socio-economic conditions in rural areas. Energy in rural areas is consumed most at a household level, mainly for cooking, lighting, and heating. Consumption levels and the types of energy used depend on a number of factors, including availability and the cost of the energy (Karekezi and Kithyoma, 2002: 6). Low-income households depend mainly on biomass as a source of energy, while high income households use modern fuels such as kerosene (Karekezi and Kithyoma, 2002: 6). Firewood is also a predominant source of fuel in African countries (Karekezi and Kithyoma, 2002: 6). This may be attributed to its availability, despite the harmful health effects. There are also low levels of electrification in rural areas. In most rural areas, electricity is generated from dry cells, and some people use car batteries as a source of energy which need to be carried long distances to recharge (Ellegard and Gustavsson, 2004: 1059).

Renewable energy also has many environmental benefits and can play a role in climate change mitigation. It is a well-known and highly published fact that global warming and climate change may be attributed to an increase in the burning of fossil fuels in the forms of coal, oil and natural gas. Many scientists and academics stress that global warming and climate change have reached their "tipping point" (Chang et al., 2011: 1). It is further recognized that the risks and impacts associated with climate change is intensifying (Leggett and Ball, 2012: 1). This is particularly concerning for developing countries where there is limited capacity to adapt. Milton and Kaufman (2005: 2) highlight that the implementation of renewable energy even on a small-scale basis can considerably contribute to a reduction in greenhouse gas emissions while simultaneously improving the quality of life of developing civilisations. Mertz et al. (2009: 1) stipulate that although greenhouse emissions are a result of combustion of fossil fuels, most abundantly from industrialised countries, the effects of climate change are most severely felt in developing countries. This is because the physical impacts are relatively large and it is a worldwide phenomenon that poor communities settle in very unhealthy and hazardous environments. It is these conditions that ultimately cause the suffering of poor communities from the impacts of climate change (Douglas et al., 2008: 2). Further increasing of temperatures in regions that are already considered hot will lead to large evaporation losses. This has further consequences as many developing countries rely largely on income derived from agriculture which are affected directly by climate change (Mertz et al., 2009: 1). The economic and technological capacity to adapt is often very limited in developing countries, which increases the vulnerability of the poor (Mertz et al., 2009: 2).

In studies pertaining to renewable energy (particularly solar energy), there is often a tendency to provide descriptive studies, with a lack of empirical research. Studies pertaining to community perceptions and willingness to use cleaner sources of energy are also limited. There is further an assumption that favours the implementation and use of solar energy. This study uses empirical and statistical techniques to examine community attitudes and concerns regarding renewable energy, specifically solar energy. A study of this nature tests the viability of solar energy in peri-urban areas in an attempt to provide cleaner energy sources to the community.

1.3 Aim

The aim of this study was to critically examine the attitudes and challenges with respect to solar energy uptake in peri-urban communities of Inanda, using empirical techniques.

1.4 Research Objectives

1. To examine current energy uses, using a case study of a peri-urban community, specifically Inanda, and ascertain whether alternative sources are being used.
2. To critically examine gaps and limitations in terms of the promotion of solar energy currently in Inanda.

3. To identify and assess the challenges and opportunities that exist for solar energy uptake in peri-urban areas.
4. To forward recommendations based on the research findings.

1.5 Methodological Approach

Inanda is located north of the city centre of Durban (Hemson, 2003: 2), and has an adult population of approximately 92 974 (Everatt and Smith, 2008). The study focuses on the peri-urban communities of Inanda, living in low income households where a significant proportion of the poor communities rely primarily on farming as a livelihood, and spend significant time and money on unsustainable energy sources. Poverty in Inanda is not uniform. The poorest communities are located in distant, underdeveloped zones, in informal settlements (Hemson, 2003: 2). Undeveloped areas of Inanda which are furthest from access roads have the largest population (Hemson, 2003: 3).

In this study, purposively selected peri-urban areas within Inanda were the demarcated sites of the study. These consisted of Enumerator Areas (EAs) which were made up of 210 households each. Ten EAs were randomly selected in the areas in Inanda that were deemed to be "energy poor". Twenty questionnaires were administered in each chosen area. The specific households were selected using a spatially-based random sampling approach. This was done using the Geographic Information System (GIS), where point sampling was used to make the selection. Twenty points in each EA were randomly selected, and the household at or in closest proximity to the sampled point was interviewed. If a member of the household was not available or did not want to participate, the nearest neighbour was approached.

The sample was used to examine community attitudes in relation to the links between solar energy and the benefits of implementing solar energy as an alternative renewable energy source. Household surveys were conducted to determine current energy uses and practices. To interrogate the needs and concerns of the community, a focus group discussion was also held. This allowed for close interaction with community members which complemented the statistical findings of this study.

The collected data were analysed quantitatively using Predictive Analytics Software (PASW), previously known as Statistical Package for Social Scientists (SPSS). These analyses included thematic and statistical analysis.

1.6 Chapter Outline

The first chapter includes an introduction to the research topic, outlining the aims, objectives and motivation for this study. The second chapter entails a detailed literature review describing various aspects that relate to the study, and evaluating other studies with similar themes. The third chapter provides a site description of Inanda, and the methods used to acquire data; it provides an account of the statistical analyses used in this study. The fourth chapter reveals the results obtained after completing the data analysis. Also included in this chapter is a discussion of the results and their implications. The fifth and final chapter concludes the study by summarising the results obtained, as well as providing a few recommendations.

1.7 Conclusion

Implementation of solar energy in rural or peri-urban areas will assist in the socio-economic development of poor communities, and help attain sustainable livelihoods, while providing alternative and environmentally friendly energy. While academics reveal that renewable energy is worth the investment, it is important to note that there is still debate regarding how cost-effective implementation of renewable energy is. This study will help identify the attitudes towards and challenges associated with solar energy in peri-urban areas. This will allow researchers to determine the viability of the implementation of solar energy in peri-urban communities and ascertain the level of willingness to use solar technologies.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter includes an extensive literature review which discusses issues of climate change, energy poverty and renewable energy in the context of poor communities. The potential for solar energy in particular is explored in this chapter. The potential for solar energy in poor communities was investigated as a means of providing poor communities with sustainable energy, as well as promoting environmental health by mitigating climate change through the expulsion of current energy sources used in poor communities. The chapter includes a review of the theoretical framework used in this study, namely, sustainability science.

2.2 The Phenomenon of Climate Change

The concept of climate change, according to the Intergovernmental Panel on Climate Change (IPCC), refers to any change in climate over time, which may be attributed to natural variability or human activity (Alley et al., 2007: 2). This differs from the definition stipulated by the United Nations Framework Convention on Climate Change (UNFCCC), which defines climate change as a phenomenon caused directly or indirectly by human activity resulting in a change of the composition of the atmosphere, in addition to natural climate variability occurring over time (Alley et al., 2007: 2). Atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased drastically since 1750, and at present exceed pre-industrial values (Alley et al., 2007: 2). The increases in carbon dioxide concentrations may be attributed mainly to the use of fossil fuels and changes in land use, while methane and nitrous oxide increases may be attributed to agriculture. Carbon dioxide is the most important and abundant greenhouse gas. Atmospheric concentrations of carbon dioxide since pre-industrial times have increased from 280 parts per million (ppm) to 379 ppm in 2005 (Alley et al., 2007: 2). The rate of increase of atmospheric carbon dioxide was larger from 1995-2005, with an average of 1.9 ppm per year, than from 1960-2005, with an average 1.4 ppm per year (Alley et al., 2007: 2).

Malyshev (2009: 6) summarises the major impacts of climate change identified by IPCC:

- Firstly, an increase in the magnitude of extreme events; these include droughts, floods, and cyclones. There is also consensus among scientists that the impact of these events will be dire and wide-ranging.
- Secondly, there is a predicted detrimental effect on agriculture as droughts become more frequent and aggravated desertification causes a reduction in productivity and crop yield.
- Thirdly, ecosystems will be affected as glaciers shrink as a result of warming. This warming will also have consequences for the distribution of forest cover, causing an increase in insect infestations and outbreaks of disease, and in evaporation in lakes.
- Fourth, warming will further reduce the amount of runoff in rivers and reduce freshwater supplies.
- Fifth, rising sea levels will make human adaptation more difficult. For example, in India, one-quarter of the population live in coastal areas and endure increased intensity of coastal surges and storms. Hurricanes are also likely to become more frequent, resulting in more coastal erosion.
- Sixth, when considering impacts on industry, the energy and transport industry will be highly affected by climate change. A rise in temperature will affect the stability of building material, while rainfall increases will create a rise in maintenance costs.
- Seventh, climate change will have serious implications for human health. Heat waves will occur, and fluctuations in temperature will also cause the spread of infectious diseases such as malaria and dengue fever. Climate change could increase the spread of malaria in malaria-prone areas as well introduce malaria to new areas.

The fourth assessment report of the IPCC and the documentary “An Inconvenient Truth” by Al Gore (produced in 2006), resulted in increased awareness of global warming and human induced climate change (Mertz et al., 2009: 1). It also sparked research into the possible drivers of climate change, environmental impacts, adaptation and mitigation measures, understanding complex relationships within the phenomenon of climate change, and observing human responses to climate change (Mertz et al., 2009: 1). Although there are uncertainties about the nature and long-term impacts of climate change, it is clear that this phenomenon has detrimental environmental, social and economic consequences. Some impacts are more serious now than had first appeared and other impacts are at present irreversible (Stern, 2006: 2). The permanent change in the climate accelerates the process of global warming and leads to further emissions of greenhouse gases into the atmosphere. For example, the melting of permafrost due to global warming results in huge methane emissions into the atmosphere (Stern, 2006: 2). Rapid changes in weather patterns also create uncertainties for activities that are weather-dependent. Countries that rely on activities such as agriculture, are particularly affected (Bie, 2008: 10). Fluctuations in temperature, increased frequency of extreme events, and erratic rainfall and wind patterns as a result of climate change continue to challenge and threaten rural populations (Bie, 2008: 10).

It cannot be ignored that the energy sector contributes to climate change but is also sensitive to climate change affecting the demand and supply of energy. To date, the majority of climate change research has focused primarily on measures to reduce greenhouse gas emissions, and recently more research has been carried out to determine impacts and adaptation strategies (Mirasgedis et al., 2007: 1). With regard to energy supply, studies tend to focus on the impacts of climate change rather than mitigation through renewable energy sources. Yet it is argued that future climate change and its impacts will influence the total demand for energy both directly, as a result of differences in heating and cooling requirements, and indirectly, through changes in economic activity (Mirasgedis et al., 2007: 1).

2.3 Renewable Energy as a Climate Change Mitigation Strategy

Combustion of fossil fuels contributes significantly to climate instability and change. Increased reliance on these sources of energy also contributes to environmental degradation and increased global warming. Evrendilek and Ertekin (2003: 1) note that the scarcity of these fossil fuels presents a great challenge with regard to the availability of energy. It is for this reason that renewable energy options should be explored to alleviate these challenges as well as contribute to socio-economic development. Efforts in an attempt to mitigate climate change are broad. Verbruggen et al. (2010: 2) stress that renewable energy technology serves as a good substitute for unsustainable energy sources, and is an option to help alleviate the impacts of climate change. The Third Assessment Report of the United Nations (IPCC, 2001) revealed that the changing climate as a result of human activity, specifically the burning of fossil fuels, provides an opportunity to explore a range of renewable energy options that could potentially reduce greenhouse gas emissions over the next 20 years (Sims, 2004: 1). In addition to this, the implementation of renewable energy has potential in growing new industries, increase the earning capacity in existing ones and contribute to job creation (Sims, 2004: 1).

The United Nations considers Africa as one of the continent's most vulnerable to climate change and its impacts. This is due to its high dependency on agriculture, current water crises and low adaptive capacity (Pegels, 2010: 2). Pegels' (2010) study on renewable energy in South Africa provides useful insights that are discussed here. Common resulting impacts of climate change in Africa include changes in water availability, extreme weather events and adverse health impacts. The impacts of climate change in Africa differ across the continent. In South Africa, vulnerability is high with regard to water supply in particular (Pegels, 2010: 2). Climate change is found to intensify water scarcity, increase demand for water, affect water quality and intensify desertification. These impacts on water are concerning considering that South Africa is already an arid country. Droughts and floods resulting from the impacts of climate change will affect agricultural output and capacity, which will not meet the needs of the rapidly growing population (Pegels, 2010: 2). With regard to health, the higher temperatures resulting from climate change are expected to cause serious health effects. A few include the occurrences of skin rashes, dehydration and heat strokes. Rising temperatures and erratic rainfall patterns will further create breeding grounds for infectious diseases such as malaria and bilharzia leading to increased mortality (Pegels, 2010: 2). The low adaptive capacity of the country further constrains the population to cope with the impacts. Since the majority of the population depends on agricultural production, erratic weather patterns that impact agricultural yields further increase vulnerability within the country and worsens the already existing problem of poverty (Pegels, 2010: 2).

Although South Africa is severely affected by climate change, the literature reveals that it is also a contributor to climate change, in the form of greenhouse gas emissions. In 2005, South Africa contributed to an estimated 1.1% of global greenhouse gas emission, where 43% came from sub-Saharan Africa (Pegels, 2010: 2). As household incomes rise, and increased efforts are made in attempts to provide universal access to conventional electricity, the greenhouse gas emissions of the country are expected to rise further. At present, coal is the primary energy source used for electricity production. Renewable energy is not a common source, although in some regions hydropower is used (Pegels, 2010: 2). The coal used for electricity production is of poor quality but easily accessible. South Africa has the sixth largest coal reserve in the world. The country is, however, experiencing energy shortages as Eskom is operating at almost full capacity with very narrow reserve margins. Rising demand for electricity and lack of investment in additional supply may also be attributed to the shortage of energy in the country (Pegels, 2010: 2). Energy shortages and the impacts of climate change that marginalised communities currently face, warrant the need for urgent corrective action. Pegels (2010: 3) stipulates that renewable energy is a viable solution to the energy supply challenges and attempts to reduce greenhouse gas emissions (Pegels, 2010: 2). Despite the country's potential for renewable energy, there has been inadequate progress made in implementation. Although the challenges associated with large dissemination of renewable energy are numerous, Pegels (2010: 3) stresses that they not impossible to overcome. The following section provides an account of literature findings regarding the viability of solar energy as a climate change mitigation strategy.

2.4 Solar Energy as a Climate Change Mitigation Strategy

It is a well-known and highly published fact that global warming and climate change may be attributed to an increase in the burning of fossil fuels in the forms of coal, oil and natural gas. It is further recognized that the risks and impacts associated with climate change are intensifying (Leggett and Ball, 2012: 1). According to Leggett and Ball (2012: 1), ‘‘climate change is happening even faster than previously estimated; global carbon dioxide emissions since 2000 have been higher than even the highest predictions”. Another threat to civilisation is the near-term peaking in fossil fuel production (Leggett and Ball, 2012: 1). “Peak fossil fuel” is a recently developed term which may be explained by the concept of growing fossil fuel production reaching a maximum and slowly declining so that it cannot meet demands (except at increased prices). Leggett and Ball (2012: 1) stress that a solution to climate change and energy poverty challenges lies in the transitioning from fossil-fuel-based energy sources to non-fossil fuel source, that is, renewable energy. Leggett and Ball (2012: 1) suggest that is it possible and affordable to induce this change at a global level by exploring wind and solar energy options. These sources can meet the needs of the various energy-use sectors, i.e. electric power, transportation and heating. Chang et al. (2011: 1) also recognize that the implementation of renewable energy in the form of solar energy not only alleviates climate change impacts, but also empowers governments and individuals, creates employment and allows for systematic change in the energy sector.

Milton and Kaufman (2005: 2) highlight the fact that that the implementation of renewable energy, even on a small-scale basis, can considerably contribute to a reduction in greenhouse gas emissions while simultaneously improving the quality of life of developing civilisations. Chang et al. (2011: 1) indicate that among the various applications of renewable energy technologies, solar water heating systems represent the highest potential in mitigating climate change through reducing greenhouse gas emissions. The heating of water typically represents one of the highest percentages of energy consumption in households. Solar water heating is promising as it is simple and cost-effective. When solar water heaters are used as a replacement for conventional heaters, they consequently replace the fuel that would have originally been used (Milton and Kaufman, 2005: 2). This will result in the reduction of air pollutants such as oxides of nitrogen, carbon monoxide, sulphur dioxide, volatile organic compounds and large amounts of carbon dioxide (Milton and Kaufman, 2005: 2). Although the conventional systems use various carbon intensity baseline fuels, the average emission of carbon as a result is generally high. The use of solar water heaters will consequently reduce greenhouse gas emissions and improve air quality. Milton and Kaufman (2005: 2) indicate that financial support and carbon trading schemes are effective ways of making progress in implementing solar water heaters and thereby mitigating climate change.

Chang et al. (2011: 1) stipulate that solar water heaters have potential particularly in South Africa. Since the country is located in the subtropical belt, there is abundant solar radiation throughout the year. However, there is hesitation in large scale implementation due to the costs. Solar water heaters are more expensive when compared to conventional forms of heating which are those of liquefied petroleum gas, natural gas or electricity.

As part of the United Nations Framework Convention on Climate Change (UNFCCC) there have been many attempts to adopt frameworks for the implementation of renewable energy as a means to replace conventional energy with environmentally clean technologies in developing countries (Doukas et al., 2009: 1). For example, the Global Environmental Facility is an initiative established under the UNFCCC to support and enhance environmentally friendly technology and knowledge transfer from developed to developing countries. The Conference of the Parties (COP 7) also called for assessments of renewable technologies as a mitigation strategy for climate change. The Kyoto Protocol was another major instrument in orchestrating this, where market mechanisms were provided as an initiative for developing countries to reduce greenhouse gas emissions (Doukas et al., 2009: 1). This was stipulated in the Clean Development Mechanism (CDM) for developing countries. Many CDM projects around the world are making progress and a focus has been created to raise the energy profile of the countries in which it has been implemented. More recently, CDM projects are prioritised to collectively reduce emissions resulting from small household activities in developing countries. Thus, it may be noted that renewable energy options do exist for developing countries within the context of climate change and can be useful in the promotion of greenhouse gas mitigation and reduction (Doukas et al., 2009: 1).

While developed countries can assume leadership with regard to solar energy usage, Doukas et al. (2009: 4) stipulate that developing countries are also taking on the challenge of solar energy usage, specifically in isolated areas of India, Kenya, Morocco and China. The main objective here is to supply energy or electricity to poor communities in order to meet basic needs. In Kenya, approximately 20 000 rural households use PV technology as an alternate source of energy. As a result, the market for PV technology grew spontaneously without government subsidies (Doukas et al., 2009: 4). This led to the idea that solar energy implementation has great potential especially for developing counties to meet energy needs of the poor in isolated areas and reduce the greenhouse gas emissions of the country (Doukas et al., 2009: 4). Solar electricity also proves to be economically viable where connection to the grid and fuel transport is not possible. However, due to the lack of a regulatory framework and high initial costs, there is often hesitation in the implementation of the technologies (Doukas et al., 2009: 4).

Over the last ten years, South Africa has seen substantial economic growth. The implementation of housing and electrification programmes has exerted increased pressure on energy demand and supply. A study by Donev et al. (2012: 2) provides useful insight to this. The strain on the national electricity grid has forced the South African government to explore and invest in new capacities to meet the energy demand of the country. Growing demand together with the energy crisis and deficit of the country, express a need for renewable energy. With an average of approximately 320 days of sunlight a year, South Africa has great potential to harness solar energy as an alternate source of energy. Household activities for heating purposes utilise significant amounts of energy and energy resources. Therefore the use of renewable technologies, particularly solar thermal energy technologies, is urgent and mandatory given the energy crisis (Donev et al., 2012: 2).

South Africa has also recognized the need to limit the use of fossil fuels for the production of energy and is signatory to a pledge following the Copenhagen Accord, where the country committed to a 34% reduction of greenhouse gas emissions by 2020 (Donev et al., 2012: 2). The government is currently establishing policies to incorporate the development of a renewable energy industry. The aim is to produce sustainable energy supply which is a non-subsidized alternative to conventional energy sources. Currently, there is an underutilization of solar energy as an alternative to fossil fuel burning. Only 1% of homes use solar water heaters despite the favourable climatic conditions. Water heating is largely influenced by income and location. Ninety percent (90%) of urban households use conventional electricity, while 42% of rural households do not have electricity (Donev et al., 2012: 2).

Since 2005, there has been a steady increase in the sales of solar water heaters. This continued into 2009 together with marketing support programmes run by ESKOM (Donev et al., 2012: 2). However, the rate of growth is not high enough. Donev et al. (2012: 6) indicate that there is still a lack of awareness about the negative impacts of conventional heating using electricity, and the benefits of solar water heaters to reduce energy bills and contribute to promoting efficient and environmentally friendly energy use. Furthermore, there is still an underestimation of the potential of solar water heaters to reduce oil and fossil fuel demand. Donev et al. (2012: 7) also stipulate that more legislation will allow for the expansion of renewable energy in the country.

The South African government has targeted renewable energy to contribute to 10 000 GWh for the total energy consumption of the country. The Department of Minerals and Energy indicates that solar water heaters can contribute up to 23% in meeting this target (Donev et al., 2012: 7). Donev et al. (2012: 10) stress that the positive impacts of implementing solar water heaters in South Africa go far beyond direct emission reduction. Solar water heaters can also reduce electricity bills by up to 30% and employment opportunities can be created, thereby alleviating the job creation challenges that the country faces (Donev et al., 2012: 10). The major limiting factor causing the slow implementation of solar energy in South Africa is the high initial cost. If this can be overcome, South Africa can reduce greenhouse gas emissions, thereby mitigating climate change and enjoy the other benefits of solar energy.

2.5 Climate Change and Poverty

Vulnerability to the effects of climate change varies worldwide. Research reveals that low latitude areas as well as less developed areas are more severely impacted than higher latitude and more developed areas (Smith et al., 2009: 5). This is due to the high ecological sensitivity of these areas and limited capacity to adapt to the changes experienced as a result of climate change. The vulnerability to climate change also varies within countries. The poor and elderly in developing and developed countries are highly vulnerable (Smith et al., 2009: 5). Smith et al. (2009: 5) make reference to Hurricane Katrina and the 2003 European heat wave, where the capacity to adapt was lower than expected and hence gave rise to the fact that vulnerabilities are often higher than expected, even in developed countries. Mertz et al. (2009: 1) argue that although greenhouse emissions are a result of combustion of fossil fuels, most abundantly from industrialised countries, the effects of climate change are most severely felt in developing countries (Douglas et al., 2008: 2). This is because the physical impacts are relatively large and it is a worldwide phenomenon that poor communities generally settle in unhealthy and polluted environments. It is these conditions that result in the suffering of poor communities from the impacts of climate change (Douglas et al., 2008: 2). Further increasing of temperatures in regions that are already considered hot will lead to large evaporation losses. This has other consequences, as many developing countries rely largely on income derived from agriculture which is affected directly by climate change (Mertz et al., 2009: 1). The economic and technological capacity to adapt is often very limited in developing countries which increase vulnerability in the poor (Mertz et al., 2009: 2).

Jones and Thornton (2008: 2) indicate that climate change is expected to have significant impacts on agricultural systems in developing countries. Climate model projections infer an increase in the range between 1.8 $^{\circ}$C to 4.08 $^{\circ}$C increase in temperature by 2100. This will have serious consequences for crop yields in the tropics and subtropics (Jones and Thornton, 2008: 2). The warming and drying will result in a decrease of approximately 10-20% by 2050 (Jones and Thornton, 2008: 2). Short-term impacts due to heat stress, drought and flooding are also expected. A change in climate will result in changes in the frequency of storms and increased intensity of extreme events (Jones and Thornton, 2008: 2). This will have detrimental effects on natural resources, livelihoods, food production and ultimately, food security. These effects are particularly pertinent to Africa and will force rural communities to change their livelihood strategies in order to preserve food security (Jones and Thornton, 2008: 2). Jones and Thornton (2008: 9) further confirm that impacts on the cropping lands of Africa are highly likely to be severe affecting the poor communities and those who reside in remote areas. Discussed below is a study conducted by Schwarz et al. (2011) that provides an account of the effects of climate change on communities residing on islands.

Solomon Island is a sovereign state in Oceania, located east of Paupa New Guinea. The island consists of many rural poor communities which are considered remote and economically under-developed (Schwarz et al., 2011: 2). The communities face the classic challenges of growing population size in the context of struggling to cope with limited natural and agricultural resources. In addition to this, islands of the Pacific region are highly vulnerable to the impacts of climate change, particularly rising sea levels. This exposes the island to increasing risks of extreme events (Schwarz et al., 2011: 2).

Over 80% of Solomon Islanders live in rural areas, and are dependent primarily on root crops or imported food and marine resources for survival. These sources are threatened by climate change and its impacts (Schwarz et al., 2011: 2). For example, in April 2007, the island experienced an earthquake with magnitude 8.1 on the Richter scale; followed by a tsunami. During this event fishers' homes were destroyed along with fishing gear and canoes (Schwarz et al., 2011: 2). This had serious implications for the livelihoods of fishers and caused serious social distress. In this study, climate change was recognized as one the factors leading to vulnerability in communities (Schwarz et al., 2011: 2). In addition to this, another significant finding was that communities' perceptions of climate climatic risks and impacts were changing. Climate change impact as a source of future vulnerability was discovered and it is clear that there is growing awareness about the phenomenon on the island (Schwarz et al., 2011: 10). These findings suggest that the impacts of climate change on islands are severely felt by the communities and that there is potential for these impacts to have detrimental effects on livelihoods and overall development of the community (Schwarz et al., 2011: 10). This can also be related to the effects of climate change on African countries.

A study conducted by Sissoko et al. (2011) illustrates the impacts of climate change on agricultural production and livelihoods in West Africa. The West African Sahel, for example, is a stressed environment where rapid population growth occurs, which exerts pressure on natural resources that are already scarce (Sissoko et al., 2011: 1). The Sahel is composed of savannah-typical vegetation, grasses and trees. The transition zone is arid in the northern region and tropical forests can be found in the southern region (Sissoko et al., 2011: 2). Annual rainfall in this region varies greatly. Water is a very scarce resource, and infertile soils and challenging socio-economic conditions are major constraints to agriculture which are most common as a source of income and livelihood in this region (Sissoko et al., 2011: 2). Increased temperatures and erratic rainfall patterns have significant impacts on the natural resources on which agriculture depend (Sissoko et al., 2011: 1). Changes in rainfall patterns and frequent extreme events as a result of climate change will have detrimental and direct impacts on crop yields in the region and could subsequently threaten food security. In this case, climate change increases the vulnerability of agricultural-based livelihoods and further accelerates and deepens the levels of poverty and environmental degradation (Sissoko et al., 2011: 1).

Research reveals that in recent years, the dynamics of climate change have shifted from being an environmental issue to a development issue (Sissoko et al., 2011: 3). Focus on the identification of the impacts and action to alleviate immediate impacts is common in order to prevent worse situations. In the case of the West African Sahel, adaptation strategies are prioritised to mitigate the impacts of climate change on agricultural production (Sissoko et al., 2011: 3). This involves measures such as switching to crops that are able to cope with Sahelian conditions, and diversifying agricultural production in hopes of reducing the risk of further losses (Sissoko et al., 2011: 3). In many cases, it is noted that climate change is expected to compound developmental issues through rises in temperatures, water scarcities, erratic rainfall, weather variability and increased frequency in extreme events (Sissoko et al., 2011: 3).

2.6 Adaptation Strategies and Climate Change in Poor Communities

In the context of climate change, adaptation may be described as an "adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Adger et al., 2009: 3). The increasing risks associated with climate change warrants the urgent need for adaptation strategies, especially in the developing world among poor communities. Generally, adaptation decision and strategies are made by individuals, groups, organisations and governments acting on behalf of society. Adger (2003: 3), however, argues that all decisions end in certain groups benefitting more than others, creating a situation of winners and losers. Effective ways of adapting to climate change depend on accepting the options for adaptations in a social context, institutional constraints, and place of adaptation with regards to economic and social development. It is clear that appropriate resource management is mandatory in adaptation strategies. In this case, vulnerability is often a driver in the various scales involved in adaptation. This vulnerability is triggered often by extreme events affecting vulnerable communities (Adger, 2003: 3; Ziervogel et al., 2008: 19).

As mentioned above, the effects of climate change on agriculture cannot be ignored. In this context, adaptation should aim to mitigate and develop coping mechanisms to address these impacts (Ziervogel et al., 2008: 19). Although most agricultural systems have some sort of inherent adaptation capacity, the current rate of climate change will impose other overwhelming pressures on these systems. This is reinforced when considering the secondary impacts which are that of the undermined ability of people coping and recovering from extreme climate events (Ziervogel et al., 2008: 19). Given this, the IPCC therefore encourages "planned adaptation" which involves creating appropriate coping mechanisms which help communities deal with climate change impacts (Adger, 2003: 3; Ziervogel et al., 2008: 19). These coping strategies should be aimed at securing the well-being of communities given climate variability, change and biophysical and social constraints. Building resilience may be considered a significant factor when considering climate change adaptation. This involves building a system that can endure shocks without collapsing into a different state. Strategies of this sort are particularly pertinent to Africa, where 60% of Africans depend greatly on natural resources as a means of survival (Adger, 2003: 3; Ziervogel et al., 2008: 19). Given that agricultural practices are heavily dependent on climate, any rapid variability imposes major threats to communities and hence warrants urgent and effective adaptation strategies (Ziervogel et al., 2008: 20).

Climate change impacts on agriculture and food security are critical factors affecting climate change intervention due to the detrimental effects on rural poor communities. Vermeulen et al. (2012: 5) argue that these impacts depend on both location and adaptive capacity. The challenge for these households to adapt lies in the fact that certain constraints pose limits to how far poor households can adapt and, in many cases, adaptation warrants major changes in livelihood strategies. Studies in rural areas of Uganda, Tanzania and Kenya reveal that households are trying to diversify their livelihoods as much as possible in response to erratic weather conditions (Vermeulen et al., 2012: 5).

As a response to inadequate rainfall and water shortages which affect crop production, poor communities must adapt. They often respond by utilizing resource-conserving technologies in order to attain sustainable agricultural production (Chikozho, 2010: 5). In order to build resilience, the first step is to understand how these communities are already adapting. It is argued that the ability of these resource-dependent communities must be enabled and enhanced in an attempt to adapt to climate variability (Chikozho, 2010: 5). A study by Chikozho (2010: 12) investigated adaptation strategies of 11 countries across Africa evaluating adaptation strategies. These strategies that are deemed appropriate by farmers include: "using different crop varieties; varying the planting and harvesting dates; increasing the use of irrigation; minimum tillage farming; increasing the use of water and soil conservation techniques, shading and shelter; shortening the length of the growing season; and diversifying from farming to non–farming activities" (Chikozho, 2010: 5). Complementary to this, rainwater harvesting is also a common practice as a response to mitigate dry spells. In the Gokwe District in Zimbabwe, farmers have responded by diversifying their crops to more drought-resistant ones or planting crops in periods that coincide with rainfall onsets. Most farmers also resort to short-season hybrid crops because of the shorter periods of growing season. These strategies are often employed on a small scale and have not been implemented worldwide (Chikozho, 2010: 5).

While agriculture is severely affected by climate change and variability, adaptation strategies also go beyond these adaptations in poor communities. Discussed below is a case study from Mozambique which illustrates how extreme events as a result of climate change results in resource-dependent communities changing their entire lifestyles in an attempt to adapt and cope.

Flooding of the Zambezi delta in Mozambique is a common and historical phenomenon. In the 19th century, a record of 21 floods occurred. There are approximately one million people who reside on the delta and depend on its resources (Artur and Hilhorst, 2011: 5). Livelihoods are built mostly on agriculture and fishing; lifestyles are thus affected by the frequency and magnitudes of the floods. Climate change has induced floods of greater magnitude which has exerted pressure on these communities to adapt and cope. In response, some households are now located at heights or constructed with grass or wood (Artur and Hilhorst, 2011: 5). Although the material used to construct the house might be poverty-related, the rationale is that grass, wood as well as brick constructed homes will be washed away by floods. With regard to livelihood adaptation, people have the tendency to avoid the accumulation of large livestock such as goats and cattle. People are also forced to invest in canoes and radios, as a means of transport and warning mechanisms in the event of extreme flooding (Artur and Hilhorst, 2011: 5). Large furniture, beds and tables are avoided due to losses experienced during flooding. From this study, it evident that adaptation strategies go far beyond the diversification of livelihoods. As Artur and Hilhorst (2011: 5) indicate, extreme flooding has exerted great pressure with regards to striking a balance in people's adaptive lifestyles, thus increasing vulnerability in these communities. As a result, people often depend on external sources in order to cope with extreme flooding events (Artur and Hilhorst, 2011: 5).

The literature reveals that the impacts of climate change on poor, resource-dependent communities are in some cases dire and warrant significant changes in lifestyle in order to cope. Given that the impacts are directly related to jeopardizing livelihoods among other outcomes, it can be suggested that access to appropriate and sustainable energy can alleviate this problem by assisting in the diversification of livelihoods and allowing for communities to engage in other activities.

The following sections discuss energy and the prospects of renewable energy to allow for socio-economic development of communities faced with poverty and specifically energy poverty.

2.7 Energy Poverty

Armaroli and Balzani (2006: 2) make reference to the problems experienced by humanity due to energy poverty. The availability of energy can dramatically increase the spectrum of choices and opportunities that are necessary for overall human development (UNDP, 2000: 19). Energy poverty will be discussed in the context of how the lack of access to energy affects the lives of people, more specifically poor people.

Definitions of "energy poverty" are numerous and well documented. The World Economic Forum defines energy poverty as "the lack of access to sustainable modern energy services and products". Khandker et al. (2010: 6) define energy poverty as the "level of energy used by households below the known expenditure or income poverty line". Given that the poverty line is defined for most countries, this approach and definition may be considered fairly robust (Khandker et al., 2010: 6). Another approach to defining energy poverty is one that is based on energy expenditure as a proportion of total household income (Khandker et al., 2010: 7). This approach is well-suited to the context of this study as it is clearly established that poor households spend a large proportion of their income on sources of energy (Khandker et al., 2010: 7). While this could not be confirmed for Inanda specifically, Khandker's assertion in relation to rural India suggests that this may be the case in developing countries generally.

Access to modern energy is central to addressing important global development challenges including poverty, inequality, climate change, food security, health and education (Nussbaumer et al., 2012: 2). The understanding of the concept of energy poverty is critical when making any attempts to alleviate it. According to Pachauri and Spreng (2011: 3), in order to enable this, a structured approach to defining, measuring, monitoring, recording and reporting energy poverty is a good starting point. Appropriate and clearly defined indicators are important for monitoring energy poverty alleviation. This involves not only knowing who are the energy poor but how and why communities suffer from a lack of access to modern energy. The basis and understanding of this is mandatory to implement effective programmes and policies (Pachauri and Spreng, 2001: 3). Pachauri and Spreng (2011: 3) further stipulate that energy poverty is caused by complex synergy of some of the following factors: the lack of physical availability to energy sources, low incomes and high costs associated with modern energy. According to Nussbaumer et al. (2012: 2), current attempts to alleviate energy poverty are not succeeding in terms of scale and pace. It is estimated that by 2030 there will be a higher number of people worldwide suffering from energy poverty, given that current trends continue (Nussbaumer et al., 2012: 2). Driving change in this pathway requires forceful global political commitment that involves a set of actions with associated benchmarks (Nussbaumer et al., 2012: 2).

2.8 Quantifying Energy Poverty

Over the years there have been many approaches used to establish energy poverty levels in a country. These are usually based on measures of physical energy requirements or energy expenditure (Barnes et al., 2010: 6). One of the earliest approaches, known as the Bravo Method, estimates energy poverty based on the technical provision of energy services. This method estimates the minimum quantity of energy that is required to have a reasonable quality of life. Direct energy in this approach includes provisions for cooking, heating, lighting, ironing, pumping of water and recreational uses. Indirect energy needs refer to energy required and used for additional goods and services used in households (Barnes et al., 2010: 6). The Bravo measure delves into great detail in attempts to quantify a household's direct energy needs, while simultaneously measuring variations in energy sources and their efficiencies. It also considers differences between urban and rural areas, as well as climate conditions which affect the dynamics of measuring energy poverty (Barnes et al., 2010: 6).

Attempts to quantify energy poverty have been associated with linking energy poverty to a lack of access to modern energy. However, there is a limited spectrum of indicators and datasets to compare levels of energy poverty globally. Pachauri and Spreng (2011: 4) make reference to the Energy Development Index (EDI). This is an index published by the International Energy Agency (IEA) and has produced comparable levels of energy poverty for 75 countries. The EDI compares three indicators which are equally weighted: "per capita commercial energy consumption, share of commercial energy in total final energy use, and the share of the population that has access to electricity" (Pachauri and Spreng, 2011: 4). These indices require "value-laden judgments to be made" (Pachauri and Spreng, 2011: 4). This EDI has significant value when comparing international energy poverty levels, and can quantify the status of development in a country for a given year (Pachauri and Spreng, 2011: 4). However, it does not allow for significant comparisons of long periods of time because the computation involves normalizing values of the indicators against the "maximum and minimum values of that indicator among the sample of nations included for the estimation in a given year" (Pachauri and Spreng, 2011: 4). Apart from the EDI, further efforts to quantify energy poverty internationally are lacking. Although there are institutions that have proposed indicators to measure energy access and poverty, there is no system for data collection to assist with estimation and reporting on these (Pachauri and Spreng, 2011: 4). On an international level, therefore, it is clear that more research effort is needed in order to create a robust measuring framework with improved data collection systems in order to measure and compare energy poverty on a global level. This will subsequently enable monitoring and reporting (Pachauri and Spreng, 2011: 4).

On a national level, the literature reveals considerable attempts to measure energy poverty. Pachauri and Spreng (2011: 5) make reference to a study conducted in Guatemala which estimates an energy poverty line. This was done by calculating the average amount of energy that is consumed by households which were identified as living below the national poverty line, in a monetary context. Although this measure included the important factor of affordability and also accounted for quantity of energy consumed, it assumes a perfect correlation and congruency between two people who are financially poor *and* energy poor. Pachauri and Spreng (2011: 5) also note that it fails to include and account for non-monetary transactions which are quite common in these energy-poor communities.

2.9 The Energy-Poverty-Climate Nexus

The literature reveals that close to two thirds of the poorest people worldwide live in rural areas. A study conducted by Casillas and Kammen in 2010 provides an accurate account of the integration of issues pertaining to energy, poverty and climate change. The eradication of rural poverty is largely dependent on access to goods, services and information (Casillas and Kammen, 2010: 1181). However, it is important to note that the eradication of poverty is challenged by two inter-linked phenomena: lack of access to standard energy services and the detrimental environmental impacts due to climate change (Casillas and Kammen, 2010: 1181). The mitigation of climate change, improved energy access, and alleviation of rural poverty may be synergistically used to define the Energy-Poverty-Climate Nexus.

According to Casillas and Kammen (2010: 1181), over 1.5 billion people worldwide do not have access to electricity; another 1 billion do have access to electricity but it is unreliable, and almost half the world's population depends on traditional biomass fuels for cooking, heating and lighting. Energy poverty is a serious reality in rural areas. It results in unmet basic needs, and suppresses economic and educational opportunity. These effects are felt particularly among women and children (Casillas and Kammen, 2010: 1181). Access to basic, modern energy will catalyze economic activity in rural areas and improve the quality of services available to meet business and domestic needs. This will be made possible as improved lighting and access to information (TV, radio and cellular phones) become available. Also, the provision of higher quality public lighting allows for increased security and improvement in the delivery of health and education (Casillas and Kammen, 2010: 1181).

Detrimental environmental impacts as a result of the effects of climate change have severe effects on the most vulnerable communities. Poor communities in rural areas have limited capacity to adapt to the impacts resulting from climate change and are jeopardized further. Hence, improved delivery of affordable energy is critical in enabling them to adapt and cope. It is for this reason that natural energy sources should be considered. The following section provides a detailed account of energy poverty in communities.

At present global efforts exist to improve the household energy situations of billions. This forms a major part of the Millennium Development Goals (MDGs), one of which is aimed at alleviating energy poverty (Pachauri and Spreng, 2011: 1). It is estimated that a quarter of the world's population, mostly residing in rural areas, suffer with energy poverty, and 40% still rely on traditional biomass to meet energy requirements (Sagar, 2005: 1). According to Kanagawa (2005: 1), it is estimated that by 2030, 1.4 billion people will not have electricity access and 2.6 billion people will have an unimproved situation with regard to access to energy for cooking and heating.

Energy poverty affects poor communities in developing countries more severely and more directly. The poor are more vulnerable and spend large proportions of their income on sources of energy (Kammen and Kirubi, 2008: 1). The majority of the world's energy poor are found in South Asia and sub-Saharan Africa. Sub-Saharan Africa has the highest levels of poverty and the least access to modern energy. It is projected that by 2030 in sub-Saharan Africa, the number of people relying on traditional biomass will increase to 700 million. If this trend continues beyond 2030, sub-Saharan Africa will be the region with the largest number of people without access to modern energy or electricity (Brew-Hammond, 2010: 2292).

In rural areas of developing countries, energy is considered a basic requirement (Kanagawa and Nakata, 2007: 2). Access to energy allows for the development of these areas and improves socio-economic conditions. Fossil fuels and modern energy such as electricity are seldom used in rural areas. Karekezi and Kithyoma (2002: 1072) indicate that this is mainly due to the costs involved in conventional electrification. Most of these traditional users are rural communities in developing countries (Kanagawa and Nakata, 2007: 2).

The lack of access to safe and clean energy has resulted in the poor subsisting on animal dung, crop residue and wood (Sagar, 2005: 1). This has resulted in some of the following consequences:

- Significant time and effort spent on the procurement of firewood and other biomass sources. This affects women in particular. Sagar (2005: 1) indicates that in rural areas of sub-Saharan Africa, African women carry on average of 20kg of firewood approximately 5km per day.
- The "possibly high price per unit of energy services since subsidies often increase as one moves up the energy ladder" (Sagar, 2005: 1). The energy ladder refers to the changes

between the usages of traditional energy sources commonly used in developing countries versus modern energy sources in the form of alternate energy. The inefficient combustion of fuelwood and other biomass traditional sources results in severe health impacts. Indoor pollution and smoke inhalation is the cause of many deaths, especially among women and children.

In some villages, communities are reluctant to switch from firewood to an alternative source because of food tastes, safety and the variety of cooking methods that an open fire offers. Women and children are affected by this as they spend most of their time around the cooking fire. Studies by Karekezi and Kithyoma (2002: 4) show a link between biomass combustion and respiratory illnesses in women and children. In Kenya, it was found that women were exposed to twice the amount of particulate emission than males, and were therefore more likely to endure respiratory problems. This link between rural household energy and its effect on women and children is particularly pervasive, yet often ignored (Karekezi and Kithyoma 2002: 4).

Energy in rural areas is consumed mostly at a household level, mainly for cooking, lighting and heating. Consumption levels and the types of energy used depend on a number of factors, including availability and the cost of the energy (Karekezi and Kithyoma, 2002: 6). Low-income households depend mainly on biomass as a source of energy, while high income households use modern fuels such as kerosene. Firewood is also a predominant source of fuel in African countries. This may be attributed to its availability, despite its harmful health effects (Karekezi and Kithyoma, 2002: 6). Kanagawa and Nakata (2007: 3) reiterate that by 2030, 2.6 billion people will have an unimproved, unchanged energy situation. It is for this reason that more emphasis should be placed on natural energy sources as a means of providing cleaner, sustainable energy. Discussed in the following sections are literature findings on natural energy sources, with a focus on solar energy.

2.11 Natural and Renewable Energy Sources

Energy sources may be split into three broad categories, according to Dresselhaus and Thomas (2001: 1). The first is chemical energy, which involves the oxidation of a reduced substance or the absorption of solar energy to generate heat. The second is nuclear reactions which work by either splitting heavy nuclei or combining light nuclei. The third is thermo-mechanical energy which is generated from “wind, water or geological sources” (Dresselhaus and Thomas, 2001: 1).

The IPCC defines renewable energy as energy that is “obtained from the continuing or repetitive currents of energy occurring from the natural environment and includes non-carbon technologies such as solar energy, hydro power, wind, tide and waves and geothermal heat, as well as carbon-neutral technologies such as biomass”. Renewable energy sources have huge potential in meeting world energy demands (Brown, 2000: 220). They result in enhancement of diversity in energy supply markets, provide energy security in terms of long-term energy supplies, and contribute to a reduction in atmospheric emissions. Therefore, they can compete with conventional energy supply. The following sub-sections present the literature reviews of wind, hydro, geothermal and solar energy.

2.11.1 Wind energy

Before the industrial revolution, wind energy was a widely used source of power. This was later replaced by fossil fuels because of cost and reliability differences. However, the oil crises in the 1970s sparked a renewed interest in the utilization of wind energy for electricity production, water pumping and supply of energy to remote areas (Brown, 2000: 220).

Wind energy is harnessed mainly from onshore winds. Onshore winds can provide 20 000-50 000 terawatt-hours a year (Nayak, 2005: 26). Devices capable of slowing down moving air can be used to extract the wind energy and convert it to useful work (Nayak, 2005: 26). Wind turbine systems are used during the harnessing of wind energy, by converting kinetic energy to mechanical energy. If the power generated exceeds the demand, wind turbines can store the excess energy in batteries in the form of chemical energy. Additionally, it can be stored in water power storage system, in a state of mechanical energy state (Nayak, 2005: 32). The various options of storage of excess energy make wind energy technologies a versatile source of alternative energy. Wind turbines are safe and are a source of clean energy which poses no environmental hazards.

2.11.2 Hydro energy

Hydro energy is harnessed from the natural evaporation of water through solar energy. It is considered the largest renewable resource and is used for electricity generation (Brown, 2000: 163). Water evaporation is greater for oceans than land and is assisted by wind. Evaporation is the primary process for the transfer of water vapour to land. To obtain global water balance it is required that precipitated water on land should eventually return to the ocean in the form of runoff from rivers (Brown, 2000: 163). Hydroelectricity involves the conversion of potential energy of water to mechanical energy. Quantification of potential energy requires knowledge of locational and geographical parameters of runoff from rivers. According to Demirbas (2005: 1), almost all of Norway's electricity is supplied by large-scale hydro power systems. Other countries such as Portugal, Spain, Ireland, Greece and Belgium use small-scale hydro power systems to generate electricity. Small and large-scale hydro power systems vary in different countries with regards to how they are defined. Demirbas (2005: 7) indicates that small hydro power systems can be a valuable form of energy supplied to rural communities. These systems may be implemented anywhere, and have minimal impact on the environment. Hydropower electricity is also a cost-effective way of providing clean energy.

2.11.3 Geothermal energy

Electricity generation from geothermal energy has been utilised and produced commercially since 1913. Over the last three decades, the utilization of this type of energy has increased significantly (Chaudhari, 2005: 146). This type of energy does not emit greenhouse gases and has been classified as a renewable source by international authorities.

Geothermal energy refers to heat that is found below the earth's crust. This may be brought to the surface in the form of steam or hot water. A geothermal heat pump system is used during the process of extracting energy from this resource. It comprises a heat pump, air delivery system, and heat exchanger (Chaudhari, 2005: 146). Geothermal heat pumps use the earth's relatively low and constant temperature to provide low cost heating and cooling. For electricity generation, wells are drilled into the ground. Direct uses for geothermal energy involve activities such as the heating of buildings, growing plants in greenhouses, drying of crops and several industrial uses. A common type of geothermal energy source is hot dry rock (HDR) resources. These occur five to ten meters below the surface of the earth (Pusz, 2001: 31). The process of accessing this resource involves the injection of cold water down a well, allowing it to circulate through hot fractured rock, and thereafter drawing off heated water from another well (Pusz, 2001: 31).

Geothermal energy is an environmentally friendly source of energy and meets stringent environmental regulations. These technologies are also highly reliable and can operate 24 hours a day (Pusz, 2001: 33). Direct use of these energy sources in homes reduces energy costs, and is therefore a highly economical source of energy.

2.11.4 Solar energy

The sun may be regarded as the primary source of energy. However, this source is not consumed to its full extent due to the fact that not all parts of the earth receive useable amounts of solar energy. This energy is an environmentally friendly source of energy and harmless to living organisms because “the harmful short wavelength ultra-violet rays are absorbed before reaching the troposphere by the stratospheric ozone layers and weakened by the air composition and moisture in the troposphere” (Sen, 2004: 9). Solar energy activates the atmosphere and as a result climatic phenomena occur. The rest of the energy is utilised and absorbed by materials and organisms on the earth, and is converted to heat energy. Solar heating systems are divided into two categories, passive and active systems. Passive systems have no mobile parts (Sen, 2004: 9). These include fans and pumps. In these systems, energy is converted through transfer and storage and is based on natural processes in buildings. Active systems consist of collecting devices to harness solar radiation (Sen, 2004: 9). They employ electric fans or distribute heat from the collectors. Most systems now also have built- in storage systems to provide energy for when the sun is not shining. Over the last two decades, these two systems have gained popularity. Solar thermal systems and solar electric systems have become common in the harnessing of solar energy. Solar thermal systems operate by converting radiant energy of the sun into heat energy, while solar electric systems convert radiant energy into electric energy (Sen, 2004: 9). A collector and storage unit are two components necessary for functional solar energy generation. A collector collects solar energy and then converts it to other useable forms. The storage unit captures excess energy from the sun during periods of high productivity, and stores it when productivity is low.

Solar thermal energy is harnessed by exposing a collection device to the sun's rays. Solar thermal systems utilise the heat absorbed by the collector and can be used to heat water, and generate steam (Sen, 2004: 19). These systems range from simple residential hot water systems to multi-megawatt electricity-generating systems. Simple, small-scale systems use flat plate collectors, while the more complex systems use concentrating devices to achieve high temperatures necessary to produce steam for power (Sen, 2004: 19).

The use of solar thermal technologies is highly advantageous because hot water and electricity can be produced at the same time. Furthermore, fewer pollutants are produced when using solar energy and it is sometimes more efficient than conventional energy (Sen, 2004: 21). Although this type of energy technology is used mostly for domestic purposes, it can also be harnessed and utilised commercially.

The harnessing of natural sources of energy could be a way forward in combating issues of energy poverty and socio-economic development. The following section explores the role of renewable energy in poor communities, where issues such as the lack of access to sustainable modern energy prevail.

2.12 Prospects of Renewable Energy Technologies in Poor Communities

Energy plays a vital role in improving the living standards of people, particularly in poor communities. Economic growth and development are directly or indirectly linked to the utilization and access to energy (Nguyen, 2007: 1). Energy derived through thermal conversion was used as early as 1948. Renewable energy technologies such as solar thermal technologies have considerable advantages over conventional energy supply, especially in poor communities (Nguyen, 2007: 1). According to Nguyen (2007: 1), they may be situated closer to the demands, thereby reducing transmission costs as well as energy and capacity loss. Also, the operation of solar thermal technologies does not require fuel. From a social point of view, the installation, operation, and maintenance of these technologies has great potential for creating employment, and consequently promoting socio-economic development. Nguyen (2007: 1) also stipulates that these technologies have an environmental advantage because they are considered "clean" and produce minimum waste products. The use of solar thermal technology in poor communities will provide environmental benefits by contributing to the reduction of greenhouse gas emissions and other pollutants (Nguyen, 2007: 1; Karekezi and Kithyoma, 2002: 2).

According to Onyango and Ochieng (2006: 1), appropriate harnessing of alternate energy has the potential to significantly improve the lives of poor communities. Often these technologies do not require expensive technological installations or highly skilled labour to implement them. These technologies are therefore suitable for African countries, particularly in poor communities. The use of renewable energy technology can revitalize poor communities because there is potential to create local industries and businesses where they are implemented. Consequently, this could reduce the mass migration of people from rural areas into urban areas in search of job opportunities.

In Africa, it is noted that rural areas are home to the majority of the population, despite the growing urban population. This is especially true for sub-Saharan Africa where it is estimated that 68% of the population reside in rural areas (Karekezi and Kithyoma, 2002: 2). Therefore, the provision of adequate energy supply is crucial for these areas. Sub-Saharan Africa is the least electrified region in the world, and because a large proportion of the population resides in dispersed homesteads, connection to the conventional grid systems have high costs associated with it. This problem is more severe in Eastern and Southern Africa (Karekezi and Kithyoma, 2002: 2). Since the cost of implementing electrified grid systems to these dispersed homesteads remains high, renewable energy technology is recommended. It was suggested by Karekezi and Kithyoma (2002: 2) that PV systems are most attractive in terms of renewable energy in Africa. Africa is seen to be the most important region for the implementation of PV systems, given the abundance of solar irradiation available. PV systems are also attractive for rural homes, especially those that are located far from the national electricity grid as they can supply small amounts of energy close to or at the point of demand (Green and Erskine, 1999: 223).

Karekezi and Kithyoma (2002: 12) indicate that efforts in providing conventional electricity are unlikely to succeed in addressing the energy needs of the rural poor sustainably due to the costs associated with connecting dispersed homesteads to the grid (as mentioned above). An urgent call therefore should be made in an attempt to provide energy that can increase the household incomes of poor communities. Since significant time and effort is spent in the collection of resources for energy, implementing solar thermal technologies could uplift communities by allowing more time for income-generating activities, thereby contributing to socio-economic development of these communities. This is further asserted by Wamukonya (2005: 5), who justifies the use of solar energy by emphasizing that it leaves more free time for communities to engage in productive and constructive activities in their lives, enabling further development as individuals and communities. Solar energy systems were implemented in rural areas of Nyimba, Nepal in 2000 (Gustavsson and Ellegard, 2004: 8). Households reported that this provided great benefits. Children benefited the most, as it allowed for more time to study, and provided more possibilities for entertainment (Gustavsson and Ellegard, 2004: 8). Outputs from this technology also created new possibilities, by changing the daily routine of people and their livelihoods. Access to and higher quality of light allowed for the completion of domestic chores during the night, and for reading and studying at night. Electricity derived from these solar home systems also allowed for other forms of entertainment, such as listening to the radio and watching videos at night (Gustavsson and Ellegard, 2004: 9).

2.13 Solar Energy Uptake in South Africa and Challenges

For emerging economies, energy supply plays an important role in economic development as well as sustainable development. The need for developing countries to increase clean energy uptake in both urban and rural areas is a challenge which requires market infiltration of low carbon technologies (Paul and Uhomoibhi, 2012: 2). Discussed below is a case study of a rural concessions scheme for solar home systems in South Africa (Lemaire, 2011: 227-283).

Post-apartheid electrification programmes focused mainly on urban electrification. During this time, it was realized that connecting remote and poor areas to the national electricity grid was unrealistic. This initiated the fee-for-service concession scheme launched in 1999 as part of the National Electrification Programme which aimed to deliver more than 300 000 solar home systems to rural areas. One of the concessions was located in KwaZulu-Natal. The concession contract for deployment of solar home systems was outsourced to a private company, NuRa. The business plan was approved by the regulator to achieve 25 000 installations by the end of 2005. However, by 2006, only 11 500 were implemented due to a disruption in government subsidies for the solar home systems. This is the first challenge that may be captured. In the case of the NuRa concession, government subsidies formed a major part of the total cost of the solar home system. Dependency and delays in activating this funding were found to have affected the rate of implementation.

In this concession, the average capital cost per solar home system was R4 000 (year 2006), which was less than Eskom's rate of conventional connection to the grid for remote areas (R10 000 – R15 000). Government subsidy amounted to R3 500. To get connected, a household needed to pay a start-up fee of R500 in 2006, and pre-pay a monthly fee of R61. The launch of the Free Basic Energy Policy in 2003 gave local municipalities the option to subsidize up to R41 (or not subsidize) the monthly fee. The result was that some municipalities did and others did not. This presented another challenge as municipalities can amend policies according to their priorities, which in some cases resulted in non-payment of the monthly fee.

Logistical constraints were also encountered in the NuRa concession scheme. Daily maintenance of the system not only required technicians to perform regular site visits to address small failures, but to also administer training to household members on how to use the solar home system. In developing countries, theft is also a risk with respect to solar appliances and systems. In this case of KwaZulu-Natal, people who can afford solar installations usually work outside the area. It was found that 2% of solar home systems were not operational due to theft. The dissatisfaction with the supply of electricity itself is another factor that solar energy projects should consider. The provision of electricity from cleaner sources should also be provided with other energy services, such as solar water heaters and solar thermal cookers.

Although the above case study is an account of solar energy deployment for remote areas, it is relevant to the context of this study with respect to an awareness of the challenges facing poor communities in adopting solar technologies. Some challenges are lack of awareness, costs and infrastructure risks associated with solar energy usage (as discussed above). The following section provides an account of energy policy in South Africa and reviews legal frameworks for clean energy.

2.14 Energy Policy in South Africa

South Africa has great potential to utilise its renewable energy resources and convert these to productive energy. The government's 2003 White Paper on Renewable Energy Policy indicates that major sections of South Africa do not have access to electricity. The policy suggests that more than two million households, mainly in rural areas, do not have access to the electricity grid (Disenyana et al., 2010: 12). The implementation of renewable energy, according to Disenyana et al (2010: 12), is almost non-existent, with less than 1% of the total electricity produced in the country coming from renewable energy sources. Off-grid projects slowly being implemented are solar home systems, which are being considered for rural areas. It is well known that a common cause of death in rural households results from the burning of harmful energy resources such as paraffin (Disenyana et al., 2010: 12). Disenyana et al. (2010: 12) stress that the main problem with the implementation of solar home systems in rural areas is the high initial costs of retailing and distribution.

Up until 1990, there was a focus on the exploitation of large coal reserves in South Africa. Eskom's focus was on electricity while Sasol's was on synthetic fuels and natural gas. Since then, energy policies have been revised, where the focus is primarily on energy for development purposes. Major consultation processes have redefined the priorities of the country with respect to energy, and resulted in the publication of a White Paper on the energy policy in December 1998 (Disenyana et al., 2010: 19). The White Paper focuses on prioritizing access to affordable energy, particularly for poor communities. Another important aim of the White Paper is to increase competition to enhance privatization and allow for some deregulation of the monopoly structure, Eskom. The 1998 White Paper evolved and was further expanded into the White Paper on Renewable Energy, 2003 (Disenyana et al., 2010: 19). This paper emphasises the need, importance and potential of renewable energy in South Africa. Its main objective is to diversify energy production through the implementation of renewable energy, thereby ensuring energy security in the country and improving environmental protection. The policy also stresses the benefits of locally manufactured renewable energy technologies, and suggests a strategic Programme of action that is needed to better develop South Africa's renewable energy resources. The focus and intention here is to move away from coal-based power generation towards more sustainable energy resources (Disenyana et al., 2010: 19).

The National Energy Act of 2008 is South Africa's first legislation which addresses the need to invest in cleaner energy resources. One of the aims of the Act is to promote the "production, consumption, investment, research and development of renewable energy" (Disenyana et al., 2010: 23). The Act provides a framework for the formulation of policies with regard to renewable energy, and is also designed to mitigate and combat deficiencies in the energy industry (Disenyana et al., 2010: 23).

To understand the legal framework pertaining to clean energy in South Africa, it is important to understand our system of governance. There is a three tier system comprising national government, provincial government and local government. Work conducted in the Western Cape and eThekwini Municipality indicates that the provincial governments are more effective in driving progress towards to clean energy in the country, rather than national governments (Disenyana et al., 2010: 23). Given the fact the natural resources are unevenly distributed in the country geographically, Disenyana et al. (2010: 25) argue strongly that it is practical for the provincial government to identify these sources and subsequently implement clean energy. They (Disenyana et al., 2010: 25) also stress that provincial governments and municipalities are completely able to implement their own laws and develop projects of their choice. Nevertheless, despite such limitations, it was found that the Provincial Government of the Western Cape has been most progressive in implementing clean energy, while eThekwini Municipality, Durban has also made significant strides.

The Renewable Energy Feed-in Tariff of 2009/2011 is another important policy in the energy industry. This policy document revealed that the availability of finance was a barrier to promoting renewable energy. However, the policy was shown no favour by the government, and was not implemented because it was found to be unconstitutional (Amigun et al., 2011: 3). The IPCC stresses that governments play an important role in technology transfer with respect to renewable electricity generation technologies. According to Amigun et al. (2011: 7), these roles include "removing barriers to technology transfer, building human and institutional capacity, providing an enabling environment that is suitable for the investment, provision of infrastructure for research and development, and information transfer and provision of support mechanism for renewable energy deployment". When designing policies, Amigun et al. (2011: 7) find that the identification of barriers to implementing renewable energy technologies must be considered for effective policy and renewable energy project implementation. Suggested measures by Amigun et al. (2011: 7) include the following:

- To overcome regulatory challenges, the standardization of regulatory requirements must occur across all departments. Establishing a single authority tasked with coordinating regulatory requirements could also help streamline the processes of implementing effective policies.

- Effective action of policies and renewable energy implementation requires a reduction in resistance from the public. Public awareness about the economic, social and environmental benefits of renewable energy technology must be conducted so that informed decisions can be made. This may also help streamline the development of projects.

- The provision of financial mechanisms which support renewable electricity generation cannot be ignored. This will allow for the implementation of policies that promote diversification of energy provision, such as the White Paper on Renewable Energy, 2003.

- Investment needs to be made with respect to "capacity building, skills development and technology transfer". Increased understanding of renewable energy generation and active research in this field will better inform policies and allow for easier implementation of these policies and renewable energy projects. This will subsequently have a positive effect on economic growth and job creation in South Africa.

The following section discusses the theoretical framework used in this study.

2.14 Theoretical Framework: Sustainability Science

This study is framed within the sustainability science framework, which originates from the concept of sustainable development proposed by the World Commission on Environment and Development (WCED). Komiyama and Takeuchi (2006: 1) provide an appropriate account of sustainability science aligning to this study. Sustainable development may be defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Komiyama and Takeuchi, 2006: 2). Worldwide support has been given to the concept of promoting the coexistence of the environment and the economy in light of development. "Sustainability" may be considered a key issue facing the world today. Sustainability science is a concept and discipline that steers us towards creating a sustainable society. As indicated by Komiyama and Takeuchi (2006: 2), this discipline involves the integration of three systems i.e. global, social and human systems. These systems may be considered crucial to the coexistence of humans and the environment. Komiyama and Takeuchi (2006: 2) emphasise that the crisis of sustainability may be interrogated through the disintegration and linkages among these systems.

The global system refers to the planetary base upon which humans survive. This includes the "geosphere, atmosphere, hydrosphere, and biosphere" (Komiyama and Takeuchi, 2006: 2). The earth provides an ecosystem that sustains human life. This ecosystem is made up of all natural resources and energy. The global system experiences great fluctuations with respect to the earth's climate and crust. These fluctuations impact human activity and survival (Komiyama and Takeuchi, 2006: 2). However, in contrast, human activity has become so demanding of the earth's natural resources that it has resulted in significant contributions to the fluctuations in the global system. Global warming and ozone depletion are two examples of human activities that disrupt the global system (Komiyama and Takeuchi, 2006: 2).

The social system refers to structures that form a societal base for the fulfilment of human existence. Some of these structures include the "political, economic and industrial" (Komiyama and Takeuchi, 2006: 2). Fulfilment in this context is often associated with economic growth and advances in technology. However, it is important to note that development arising from this is often the main cause of environmental degradation and social inequality (Komiyama and Takeuchi, 2006: 2). Environmental degradation extends itself beyond the social system into the global system. Komiyama and Takeuchi (2006: 2) show that the social system is further affected by declining birth rates particularly in developing countries, which raises concerns about the sustainability of families.

The human system is "the sum total of factors affecting the survival of individual human beings" (Komiyama and Takeuchi, 2006: 2). This system is largely linked to the social system and aims to promote healthy living for a fulfilled human experience. Human beings, however, are greatly challenged by physical, emotional and mental illnesses, which cause a disruption of this system. Also affecting the system are the inequities of the social system (Komiyama and Takeuchi, 2006: 3). As these stressors and stresses increase and the environment further degrades, the human system functions in an unhealthy way.

Global warming and climate change may be viewed as a problem which arises from the interaction of the global and social systems. This problem is crucial and demands the development and implementation of low carbon technologies to reduce greenhouse emissions (Komiyama and Takeuchi, 2006: 3). Problems represented by the interaction of the social and human system include the generation of waste. Komiyama and Takeuchi (2006: 3) stress that reduce-reuse-recycle policies need to be developed to target issues of waste. This should also be accomplished by resource conservation during manufacturing processes. Lastly, the global and human systems interact with each other, causing serious impacts that ultimately affect human survival (Komiyama and Takeuchi, 2006: 3). This is expressed in a number of ways, such as the spread of infectious diseases as a result of global warming, increases in cancer cases due to ultraviolet exposure caused by depletion of the ozone layer, and emigration of people because of habitat loss caused by the rising of sea levels (Komiyama and Takeuchi, 2006: 3; Kajikawa, 2008: 2). To promote sustainability, Komiyama and Takeuchi (2006: 3) argue that is it crucial to solve these problems, which ultimately threaten human existence. The purpose of sustainability science is to improve sustainability in these three systems and achieve the goal of sustainable development. Sustainability science may thus be viewed as the interactions and behaviours that result from a combination of natural and social systems. The outcome of these behaviours informs decision-makers and draws their attention to critical environmental, social and global issues (Swart et al., 2004: 1). According to Kajikawa (2008: 2), sustainability science is a useful framework to promote research that is of a multidisciplinary nature. Research fields within agriculture, fishery, forestry, water, energy, economics, sociology and other sciences may be incorporated into this framework, allowing integrative analysis. This framework also allows for multiple research fields to collaborate in the context of sustainability.

2.1.5 Conclusion

For the purposes of this study, the sustainability science framework offers an appropriate lens through which social, global and human systems can be viewed. At an environmental level, this framework stresses the need to conserve natural resources and to promote alternative technology in the provision of energy in an attempt to create a low carbon society, thereby combating global warming and climate change. On a social level, this framework is also appropriate to this study because in promoting environmentally friendly technology, it enables access to clean energy, thereby meeting people’s daily energy needs, and allowing for socio-economic development and a fulfilled, healthy lifestyle. This may in turn be linked to the global system, where there are great fluctuations due to human activity and conventional sources of energy, causing global warming and climate change. Against this context of the need for this study and the arguments made in the literature around renewable energy, the next chapter outlines the methods and methodological approaches used in this study.

CHAPTER 3
METHODOLOGY

3.1 Introduction

As mentioned earlier, the aim of this study was to critically examine attitudes and challenges surrounding solar energy uptake in peri-urban communities of Inanda, and current energy use, using empirical techniques. This chapter provides a background to Inanda and outlines the methods used during data collection and analysis.

3.2 Background to the Study Area

Inanda is situated north of the city centre of Durban (Figure 3.1), and has an adult population of approximately 92 974 (Everatt and Smith, 2008: 5). Its boundary is more than 20 km from Durban's city centre, and extends into deep river systems. Almost half a million people live on 9 423 hectares. According to the Inanda, Ntuzuma, and KwaMashu (INK) Nodal Economic Development Profile (2006: 5), over 65% of the population is younger than 29 years of age. Figure 3.2 shows the locations of Inanda, Ntuzuma and KwaMashu. Inanda constitutes one the largest conglomerations of low income residential areas in South Africa (Khan, 2007: 1). Everatt and Smith (2008: 7) find that Inanda was developed to house communities that were forcibly removed from other areas such as Cato Manor. Inanda eventually evolved as an area which was inhabited by both Indians and Africans, who coexisted and shared common social and political constraints (Khan, 2007: 13). According to Everatt and Smith (2008: 8), half the households in Inanda are informal households and only a third of the residents actually own the land on which they reside. It was an area designated for one "population group" (Africans), and economic activities that could have enabled development of communities were actively prohibited (Khan, 2007: 1). The majority of people living in Inanda have done so since 1996, while approximately 8% have moved to the area over the last five to ten years (Khan, 2007: 1). The prevalence of the Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) remains a problem in Inanda. A study conducted by Smith and Everatt (2008: 61) reports that 74% of the respondents in their study perceived HIV/AIDS to be the biggest health problem facing Inanda.

This literature finding, together with high unemployment rates and deteriorated physical living conditions, calls for integrated anti-poverty strategies to uplift communities. The Department of Provincial and Local Government (DPLG) notes that "the population is increasingly youthful with high unemployment, low levels of education, high levels of poverty, high levels of crime, inadequate criminal justice capacity, poor traffic and road safety, and land/legal complications" (Khan, 2007: 1).

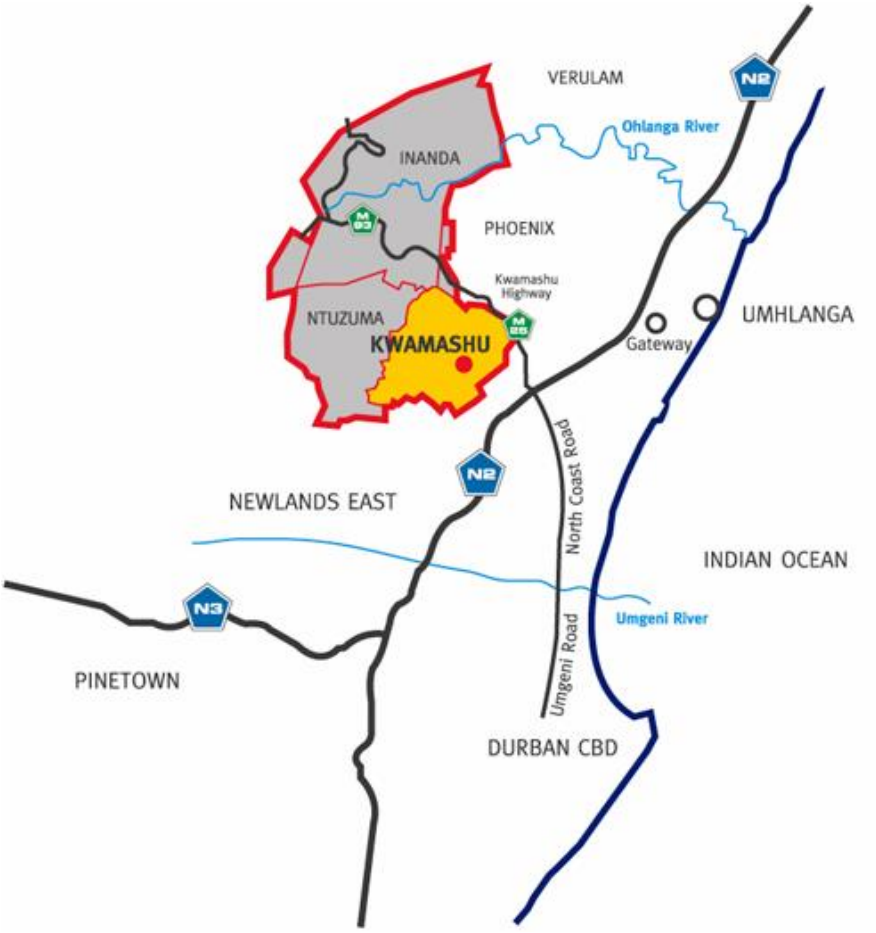
Poverty in Inanda is not uniform. The poorest communities are located in distant, under-developed zones, in informal settlements (Hemson, 2003: 2). Undeveloped areas of Inanda which are furthest from access roads have the largest population (Hemson, 2003: 3). Smith and Everatt (2008: 12) confirm that Inanda's poverty levels are the worst when compared to the province and country. Perception studies show that apart from the elderly, AIDS orphans, unemployed youth, and single parents show a great sense of motivation to change their situation of vulnerability (Khan, 2007: 4). However, the lack of resources and incoherent efforts of intervention have to a large extent reversed, or worked against, such motivation. This has resulted in the youth becoming demotivated and further marginalised (Khan, 2007: 5).

Education is another serious issue in Inanda. The INK Economic Sector Report (2008) indicates that only 26% of the adult population has a matric or higher education qualification. The majority of the population has only a primary school education, which makes them literate but able only to occupy semi-skilled positions.

Economic activities do exist in Inanda but there is a scarcity, a lack of drive to develop them. According to the INK Economic Sector Report (2008: 15), Inanda does engage in tourism activities. These occur through the presence of historically significant sites and heritage routes. There are also a number of informal economic activities, including food vending, salon and hair cutters, grass cutters, dress makers, shoe repairs, back yard panel beating and loan sharks (INK Economic Sector Report, 2008: 15). Khan (2007: 5) notes that tuck shops are considered to add better value to the community than big shops. This is because they require minimal capital investment with regard to set up costs, they are flexible, provide credit, and are open till late. Taverns are also a common form of business in Inanda; however, this phenomenon has also spawned many social problems (Khan, 2007: 5). As a result, underage drinking, poor health, violation of trading conditions, crime and violence have become major concerns for local residents (Khan, 2007: 5). These problems extend themselves to juvenile delinquency, teenage pregnancy and rape. Their indirect effects are perceived to be a major contributor to the growing rates of HIV/AIDS in Inanda. Therefore, to go back to Khan's (2007: 5) observations, there is a common perception that taverns as a form of economic activity must be discouraged. Vulnerability in Inanda is exacerbated through the lack of provision of government services. Basic services, including water and electricity, are not provided to a significant proportion of the population. In instances where these services are provided, lack of affordability and rising levels of disconnections further contribute to vulnerability (Khan, 2007: 5).

Source: Department of Social Development, Building Sustainable Livelihoods (2006)

Figure 3.1: Map of Inanda, Durban and KwaZulu-Natal showing the location of KwaZulu-Natal and the study area, Inanda



Source: eThekwini Municipality: INK Annual Business Plan (2009-2010)

Figure 3.2 Location Map of INK showing the areas Inanda, Ntuzuma and KwaMashu

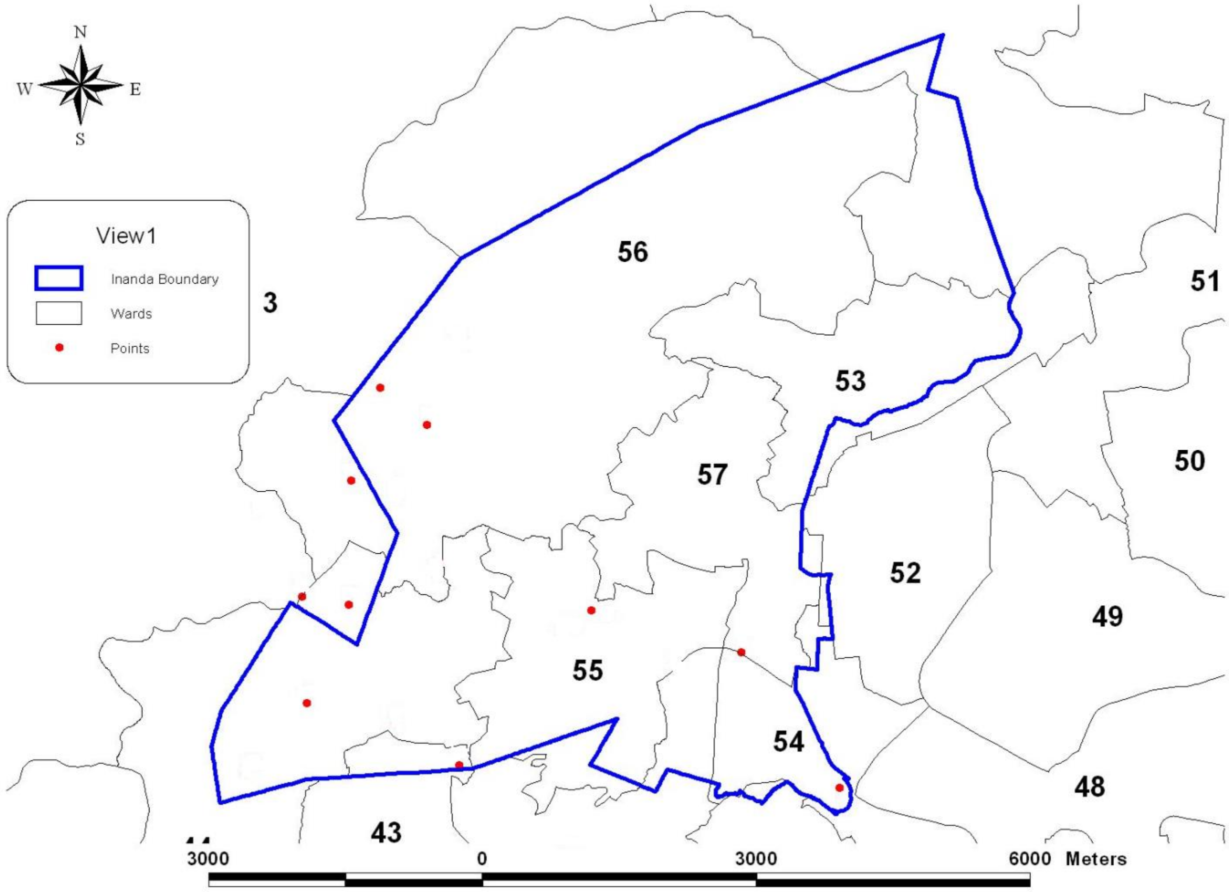


Figure 3.3: Map of Study Area, Inanda

In the figure above, the blue demarcated area represents the boundary of Inanda, with the red dots indicating various points where the questionnaires in this study were administered. Questionnaires were administered in Ward 54 (Besters and Newton C), Ward 55 (Newton A, Newton B, Bhambayi, Inanda B and Phola Mission), and Ward 56 (Amatikwe, Tafula Inanda and Inanda Congo). In 2007, Councillor Vela Cecil reported that an important need of the aforementioned wards was access to proper electricity, amongst other things (Source: eThekwini Municipality, 2007: Ezasegagasini Metro: 8).

3.3 Methodological Approach

The methodological approach used in this study can be described as a mixed method triangulation approach. This approach involves the combination of qualitative and quantitative research techniques (Onwuegbuzie and Collins, 2007: 1). Triangulation may be defined as "the combination of methodologies in the study of the same phenomenon" (Johnson et al., 2007: 3).

There are four types of triangulation techniques. Data triangulation refers to using a variety of sources in a study; investigator triangulation uses different researchers in a study; theory triangulation involves using many perspectives and theories to analyse results, and methodological triangulation involves using multiple methods in addressing a research problem (Johnson et al., 2007: 3).

Methodological triangulation was used in this study and has several advantages. Triangulation allows for researchers to have more confidence in their results; it allows for creative ways of data collection, leading to richer data, and due to the comprehensive nature of the output results, can serve as a baseline to compare competing theories (Johnson et al., 2007: 5). The two types of methodological triangulation are simultaneous and sequential. Simultaneous refers to using qualitative and quantitative methods simultaneously, where there is no interaction between the two during the data collection stage. However, the results complement each other in the data interpretation stage. Sequential triangulation is used "when the results of one approach are necessary for planning the next method" (Johnson et al., 2007: 5). For the purposes of this study, the simultaneous methodological approach was used.

The combinations of qualitative and quantitative approach are effective during research design, data collection and data interpretation. According to Sale et al. (2002: 46), the combination of qualitative and quantitative approaches is useful in producing sound research, as both share a unified logic and the rules of inference. During the design stage, "quantitative data can assist the qualitative component by identifying representative sample members, as well as outlying cases", while qualitative data can complement quantitative data by assisting with "conceptual and instrument development" (Johnson et al., 2007: 5). At the stage of data collection, quantitative data is important in providing baseline information, thereby avoiding the occurrence of bias, while qualitative data assists in facilitating a structured data collection process (Johnson et al., 2007: 5). At the analysis stage, quantitative findings offer a numerical calculation, while qualitative findings are useful for describing, clarifying and validating the quantitative findings (Johnson et al., 2007: 5).

This analysis of data in this study was driven largely by quantitative analysis, but also involved the use of qualitative analysis to complement quantitative findings. This was done to address the research objectives in a way that covers different angles of analysis and interpretation.

To complement the quantitative findings, a focus group discussion was conducted. Focus group research is a technique used to gather qualitative data. It involves gathering a group of parties that is of relevance to the subject matter, and engaging in a discussion pertinent to the research objectives. It is a useful technique to collect data from multiple individuals simultaneously (Onwuegbuzie et al., 2009: 2). Focus group discussions work particularly well for studies that aim to determine perceptions and attitudes towards a certain issue. It differs from other group discussions, where the goal is to reach a final conclusion or decision. Focus group discussions proceed in a more natural sense where discussions may be directed without the influence of other factors (Krueger, 2000: 12). They are useful because they generate inductive information, can be used to assess people's needs, develop appropriate plans and interventions, improve existing programmes and evaluate outcomes of particular situations (Krueger, 2000: 19). It was therefore found to be an appropriate investigative technique for this study, to complement its quantitative findings.

3.4 Methods

In this study, 200 household surveys were conducted in selected wards in Inanda, as indicated in Figure 3.3. Due to language barriers, two field workers who were conversant in *isi*Zulu and English were trained to administer the questionnaires in the chosen areas. The results from these surveys produced the quantitative results of this study, which make up the major portion of the analysis.

As mentioned earlier, quantitative data was complemented by qualitative data in the form of a focus group discussion. This involved engaging with community members on the various energy issues in their area and ascertaining their willingness to use renewable energy, specifically solar energy.

3.5. Data collection instrument and data analysis

The data collection instrument was a structured, coded questionnaire (see Appendix 1). The questionnaire was designed in consultation with the supervisor and was structured to include the following themes:

- Socio-economic and demographic profile
- Energy profile of households
- Respondents perceptions of alternate energy (which also includes renewable energy)

The data were analysed thematically, using Predictive Analytics SoftWare (PASW 18.0), also known as SPSS. Data analysis tests performed on the data included descriptive statistics, frequency distributions and inferential statistics. The quantitative analysis included thematic analysis, and statistical analysis using PASW 18.0. Using PASW 18.0, frequency tests, cross tabulations and Fisher's Exact Test analyses were computed.

Frequency distributions present data in a way that shows each category for each variable and the frequency of the category's occurrence in the dataset (University of Glasgow, College of Social Sciences, ND: 17). In this study, frequency tests allowed for the demonstration of findings with respect to the socio-economic profile of the respondent population. Contingency tables (cross tabulations) provide a summary of the number of observations that have particular combinations of values for two or more variables (University of Glasgow, College of Social Sciences, ND: 18). Cross tabulations are useful for nominal or ordinal data. Cross tabulations and Fisher's Exact Tests were run to demonstrate the findings of the categorical data. Fisher's Exact Test is an alternative to Pearson chi-square tests and can be applied to categorical data (Mehta and Patel, ND: 157). Mehta and Patel (ND: 13) further indicate that in some cases, some parts of the dataset consist of small sample sizes (few responses) or are poorly distributed which may produce unreliable results. In this case Fisher's Exact Test statistics can be used to obtain an accurate p value. Fisher's Exact Tests produce reliable statistics for sample sizes of less than 5 ($n<5$), which was appropriate for this study. The p value indicates whether there is a significant relationship between variables (Mehta and Patel, ND: 157). The p value was used to determine whether there were significant relationships between sources of energy used and certain socio-economic variables. In this study a p value less than 0.05 inferred a statistically significant relationship with a 95% confidence interval for the exact p value.

The data analyses were split into themes of socio-economic and demographic profile; energy profile; sources of energy used for cooking, heating and lighting; obtaining energy sources, and perceptions of alternate energy, specifically solar energy. The structure of the questionnaire was framed so that information could be collected for the entire household (applying specifically the socio-economic and demographic profiles). Data collected from the focus group discussion were analysed and discussed in conjunction with the quantitative results.

3.6 Survey Methodology and Sampling Framework

Statistics South Africa (2011) defines Enumerator Areas (EAs) as small geographical units which divides the country for surveying and census purposes. In Inanda, each EA has approximately 210 households which have been sectioned by the eThekwini Municipality. In this study 10 EAs were randomly selected in the purposively chosen wards (that is, Wards 54, 55 and 56 as indicated in Figure 3.3) that were considered to use non-renewable sources of energy. One adult member over the age of 18, per household, was interviewed. The questionnaires were administered during the day on weekends to attain a fair representation of all socio-economic variables of the study (age, gender, employment status, education level and additional sources of income). Twenty questionnaires were administered in each chosen EA. The specific households were selected using a spatially-based random sampling approach. This was done using a Geographic Information System (GIS) programme where point sampling was used to make the selection. Twenty points in each EA were randomly selected and the household at or in closest proximity to the sampled point was interviewed. If a member of the household was not available or did not want to participate, the nearest neighbour was approached. This approach ensured that the selection of the households was unbiased.

The focus group discussion was used to gain further insight into the energy issues in the community, as well the attitudes towards solar energy uptake. The focus group discussion was conducted with the assistance of project managers involved in the Inanda, Ntuzuma and KwaMashu (INK) Area Based Management projects. They were contacted to assist with the identification of community members to provide insight into the following themes:

- Current energy sources
- Current energy utilization and its challenges
- Awareness and understanding of alternate energy resources in the community
- Potential of solar energy uptake in the area

This information was used to support the quantitative findings in each of the themes.

3.6 Conclusion

The acquisition of data using the methodology and instruments described was followed by a rigorous data analysis. The following chapter presents the quantitative and qualitative results, followed by a discussion of significant findings.

CHAPTER 4
RESULTS

4.1 Introduction

The aim of this study was to critically examine the attitudes and challenges with respect to solar energy uptake in peri-urban communities of Inanda and current energy use, using empirical techniques. This chapter comprises quantitative and qualitative findings derived from the statistical analysis and focus group discussion. The first part of this chapter presents frequency results in relation to the following themes: socio-economic and demographic profiles of respondents, which provides an indication of age, employment status, occupation, education level, overall household income, size of household and current activities that take place in the study area. The second part of this chapter examines the energy profile of the community with a focus on the most common sources of energy used for cooking, heating and lighting. The third part presents how the most common sources of energy, that is, electricity, fuelwood, gas, paraffin, and solar energy, are obtained. The fourth part of this chapter has an emphasis on alternate energy. In this section, respondents' perceptions of alternate energy were ascertained to determine the overall awareness with respect to alternate energy sources. Respondents were also asked about the sources of their information and their willingness to use alternate energy. This chapter moves on to focus on solar energy particularly. The fifth section tests awareness with regard to solar energy and examines respondents' willingness to use this particular form of energy as an alternate source. This section further investigates whether respondents are willing to pay for the solar energy and how much they are willing to pay. The last section provides an account for the discussion that took place during the focus group discussion.

4.2 Socio-economic and Demographic Profiles of Respondents

This section provides the socio-economic and demographic profiles of the respondents. This includes the following factors: age, employment status, occupation, education status, household income and additional sources of income. The purpose of this section is to ascertain the level of poverty in the community and relate this to their sources of energy. This should give an indication of what types of energy sources the community can afford.

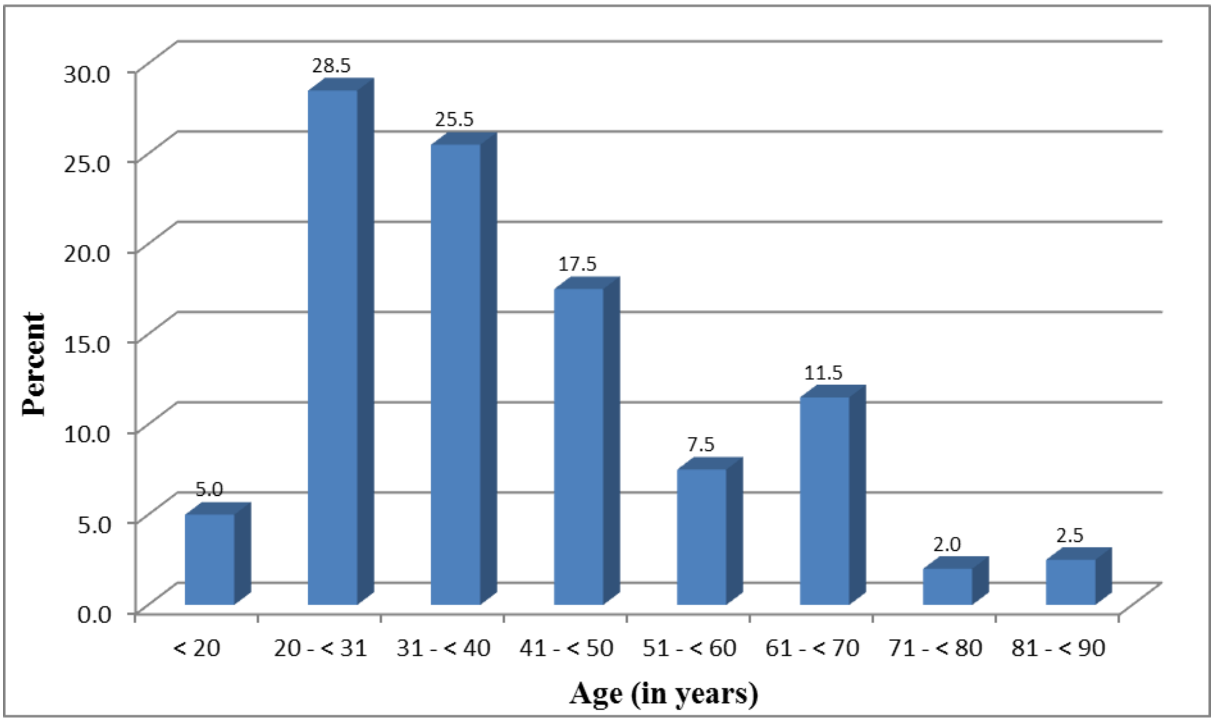


Figure 4.1: Age of respondents in years (n=200)

Figure 4.1 shows that there was a high prevalence of young respondents. Approximately 29% of respondents were between the ages of 20 and 31 years. The range and average for the above was calculated between males and females: Average = 39 years; Range = 70 years.

Table 4.1: Gender and employment status (n=200)

			Employment Status			
Age distribution	Gender (%)		Employed (%)		Unemployed (%)	
	Male	Female	Male	Female	Male	Female
<20	2	3	0	0	2	3
20-< 30	12	16.5	2.5	5.5	8	12.5
30-< 40	10	15.5	5	4	3	13.5
40-< 50	4	13.5	1.5	3.5	2	10.5
50-< 60	2.5	5	1	0.5	1	5
60-< 70	2	9.5	0	0	2	9.5
70-<80	0.5	1.5	0	0	0.5	1.5
80-<90	2	0.5	0.5	0	1.5	0.5

The male-female split was: 35% male and 65% female overall. The unemployed among the respondents included the retired, medically boarded and students. In all age categories, 10.5% of males were employed and 20% of males were unemployed. Similarly, in all age categories, 13.5% of females interviewed were employed and 49% were unemployed. Per age category, 30.5% of males and 63.5% females interviewed were employed and contribute towards the household income.

Table 4.2: Employment status of the respondent

	Percentage household income contribution
Total Employed	**24**
Self-employed	7
Other Employment	17
Total Unemployed	**51.5**
Retired	8.5
Medically boarded	1
Student	8
Other	34

Table 4.2 indicates that 24% of the respondents interviewed were employed, of which 7% were self-employed. Slightly over 50% of the respondents (51.5%) were unemployed, with 17.5% of the respondents were unemployed because of being retired, medically boarded and in a study Programme.

Table 4.3: Occupation of respondents (n=200)

	Percentage
Unskilled labour	31
Sales/marketing	6.5
Administrator/manager	1
Business person	5
Professional eg. Teacher	4
Artisan/technician	3
Manufacturing	1.5
Housewife	14
Student	7.5
Cashier	0.5
Domestic worker	0.5
Pensioner	0.5
Street trader	0.5
Unemployed	24.5

The results of the employment status are illustrated in Table 4.3. From those that are employed, 31% were those in unskilled forms of employment.

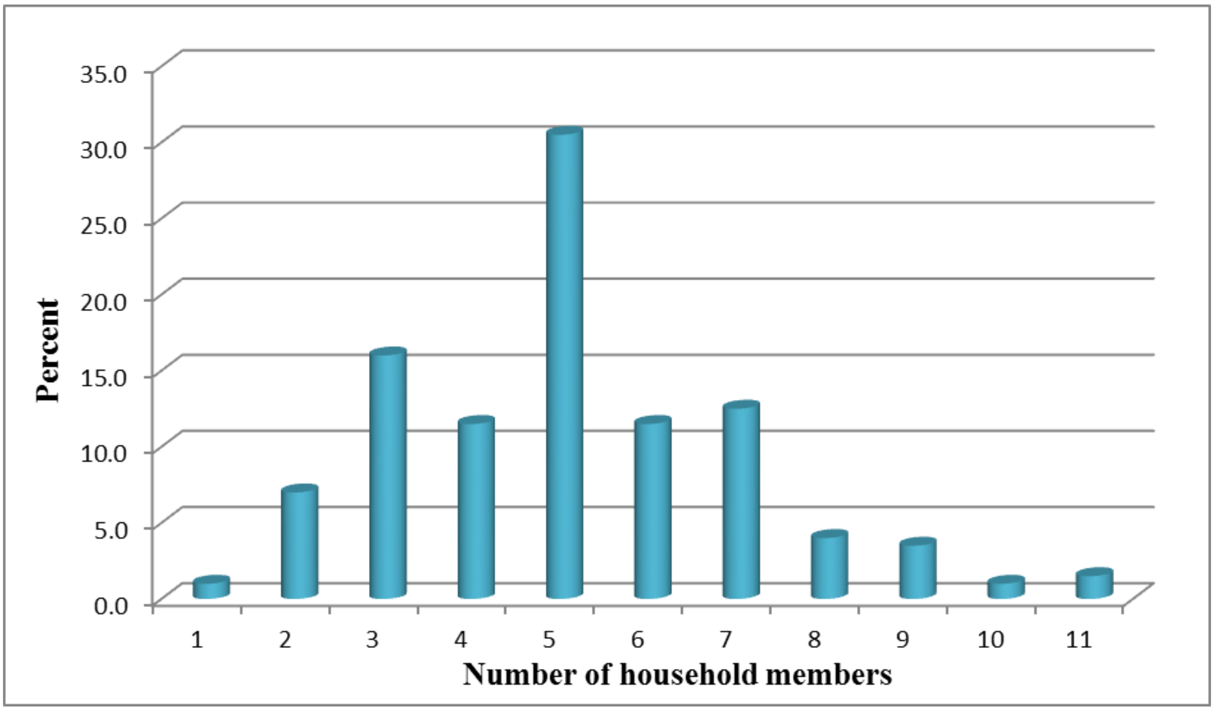


Figure 4.2: Number of household members

Figure 4.2 indicates that 30% of households had 5 members, with 1% of households having 10 and 1 members. Other statistics calculated for the Figure above: Mean = 5.08; Range = 10.

Table 4.4: Education level of respondents (n=200)

	Percentage	Percentage employed
No formal education	3.5	1
Partial primary	7.5	0.5
Primary completed	9	1
Secondary - Grade 10	29	7.5
Secondary completed – Grade 12	41	10
Certificate/diploma	6	2.5
Undergraduate degree	1.5	0
Postgraduate degree	2	1.5
Adult-based education	0.5	0

Table 4.4 presents the education levels among respondents: only 41% of the respondents had completed high school, while only 9.5% had attained formal education beyond school in the form of diplomas, undergraduate degrees and postgraduate degrees. Table 4.4 indicates that 7.5%

of respondents who had completed secondary education up to Grade 10 were employed, whereas 10% of respondents who had completed secondary education up to Grade 12 were employed. Only 2.5% of respondents had diplomas and 1.5% had postgraduate degrees.

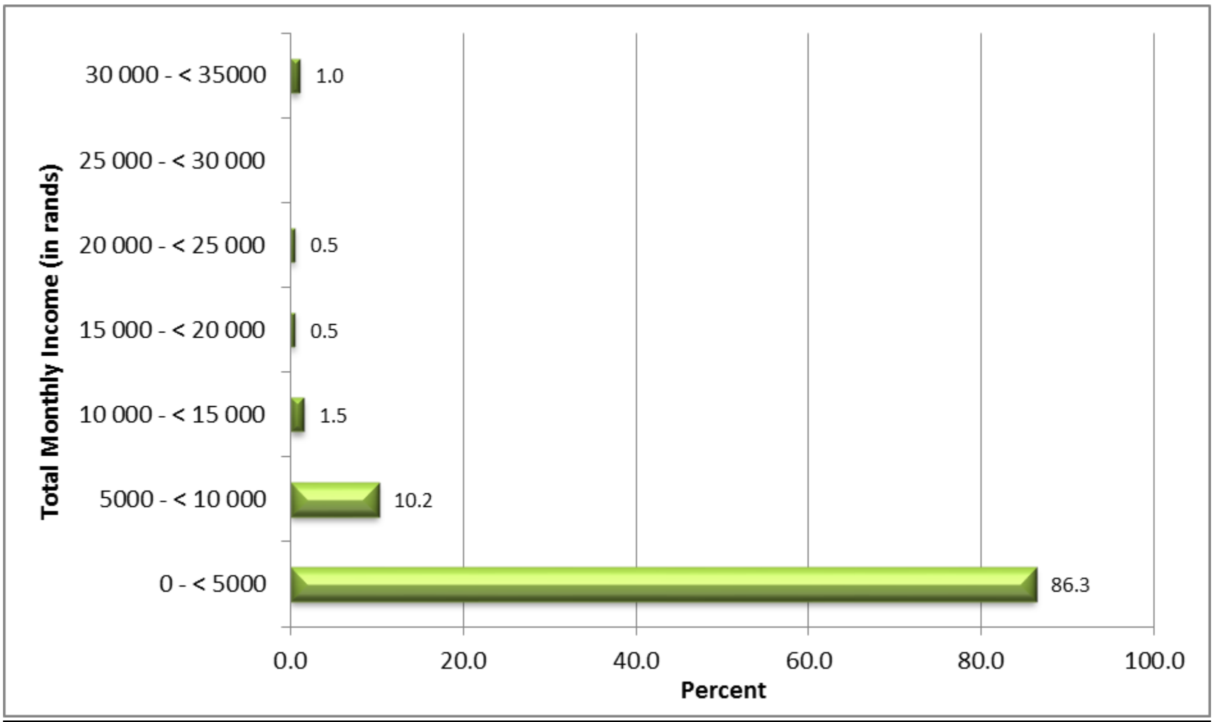


Figure 4.3: Total household income per month (n=200)

Figure 4.3 illustrates that 86.3% of households had an income up to R5 000 per month with 13.7% of households that earned an income of more than R5 000. Other statistics for the Figure above: Mean = R3 333; Range = R32 000.

Table 4.5: Cross Tabulation between total monthly household income in Rands and household size (n=193), statistical significance at 0.05

		Household size										
Household Income		1	2	3	4	5	6	7	8	9	10	11
0 (n=6)	Frequency	0	1	1	0	0	3	0	0	1	0	0
	Percentage	0	16.7	16.7	0	0	50	0	0	16.7	0	0
1-<100 (n=1)	Frequency	0	0	0	0	1	0	0	0	0	0	0
	Percentage	0	0	0	0	100	0	0	0	0	0	0
101-<500 (n=21)	Frequency	0	1	6	4	4	3	0	0	0	2	1
	Percentage	0	4.8	28.6	19	19	14.3	0	0	0	9.5	4.8
501-1000 (n=4)	Frequency	0	1	2	0	0	0	1	0	0	0	0
	Percentage	0	25	50	0	0	0	25	0	0	0	0
1001-2000 (n=87)	Frequency	1	6	14	12	21	7	15	7	3	0	1
	Percentage	1.1	6.9	16.1	13.8	24.1	8.0	17.2	8	3.4	0	44.2
2001-3000 (n=1)	Frequency	0	0	0	0	1	0	0	0	0	0	0
	Percentage	0	0	0	0	100	0	0	0	0	0	0
3001-4000 (n=50)	Frequency	1	2	6	5	22	4	7	0	3	0	0
	Percentage	2	4	12	10	44	8	14	0	6	0	0
4001-6000 (n=16)	Frequency	0	1	0	1	7	4	2	0	0	0	1
	Percentage	0	6.3	0	6.3	43.8	25	12.5	0	0	0	6.3
6001-8000 (n=4)	Frequency	0	1	0	0	2	1	0	0	0	0	0
	Percentage	0	25	0	0	50	25	0	0	0	0	0
8001-10000 (n=3)	Frequency	0	0	2	1	0	0	0	0	0	0	0
	Percentage	0	0	66.7	33.3	0	0	0	0	0	0	0

There were 193 respondents who disclosed household income; however, 3.5% of respondents chose not to disclose their household income. There was no statistically significant relationship between monthly household income in Rands and household size. However, Table 4.5 indicates that 45% of respondents have a total household income of approximately R2000, and 24% of these respondents came from five-member households. Twenty-six percent of respondents indicated that their household earning are approximately R4000 per month, and 44% of these respondents were from five-member households.

Table 4.6: Additional sources of income (n=200): Multiple responses

Additional sources of income	Percentage
Remittances	20.5
Old age pension	15.5
Child grant	51
Disability	6.5
Sale of agricultural produce	2.5
Tuck shop	0.5
No additional income	2

Table 4.6 above indicated that slightly more than half of the households interviewed (51%) rely on child grants as an additional source of income. Remittances (20.5%) and old age pension (15.5%) are also additional sources of income for households.

4.3 Energy Profile of Inanda

Energy use in poor communities occurs mainly at a household level for cooking, lighting and heating. This section determines the main sources of energy for these specific activities, followed by how these sources are obtained.

4.3.1 Cooking

The following tables illustrate the main sources of energy used for cooking in the community. Some of the frequency values were less than 5. The Fisher's Exact Test was used to determine the relationship (same interpretation as Chi Square values).

Table 4.7: Main energy source used for cooking (n=200): Multiple responses

Energy Source	Percentage of respondents
Electricity	93.5
Gas	2
Paraffin	4.5
Fuelwood	18
Candles	0.5
Generator	1

Table 4.7 reveals that electricity was the main source of energy used for cooking in 93.5% of households interviewed. Although there was more reliance on electricity, there was also reliance on fuelwood (18%). Further inspection of the cross tabulation from the statistical tests suggests that electricity had the highest number (93.5%) of users when compared to gas (2%) and paraffin (4.5%).

Table 4.8: Cross tabulation of main source of energy used for cooking against gender (n=200), statistical significance at 0.05

		Sex of respondent	
		Male	Female
Electricity (n=187)	Frequency	67	120
	Percentage	35.8	64.2
Gas (n=4)	Frequency	2	2
	Percentage	50	50
Paraffin (n=9)	Frequency	1	8
	Percentage	11	88.9

There was no significant relationship between gender and the main energy source used for cooking among the respondents (p=0.915).

Table 4.9: Cross Tabulation between main energy sources used for cooking and employment status of respondents (n=200)

Main energy source used for cooking		Employment status of respondents						Total
		Employed	Unemployed	Self employed	Retired	Medically boarded	Student	
Electricity	Count	44	97	13	17	2	14	187
	Percentage with cooking as an energy source	23.5	51.9	7.0	9.1	1.1	7.5	100.0
	Percentage respondents employed	91.7	94.2	92.9	100	100	87.5	93.5
Gas	Count	2	1	1	0	0	0	4
	Percentage with cooking as an energy source	50	25	25	0	0	0	100
	Percentage respondents employed	4.2	1.0	7.1	0	0	0	2
Paraffin	Count	2	5	0	0	0	2	9
	Percentage with cooking as an energy source	22.2	55.6	0.0	0.0	0.0	22.2	100.0
	Percentage respondents employed	4.2	4.9	0	0	0	12.5	4.5

The cross tabulation indicated that there was no relationship between main source of energy used for cooking and employment status (p=0.258): 91.7% of the respondents who were employed, used electricity as the main source of energy for cooking, while 94.2% of respondents who used electricity as the main source of energy for cooking were unemployed. 4.2% of respondents who were employed used gas as a main energy source for cooking, while 1% of respondents who were unemployed used gas as a main source for cooking. There were 4.2% of employed respondents who used paraffin for cooking and 4.9% of unemployed respondents who used paraffin for cooking.

Table 4.10: Cross tabulation of sources of energy used for cooking and household size (n=200), statistical significance at 0.05

		Household size										
		1	2	3	4	5	6	7	8	9	10	11
No response (n=32)	Frequency	0	6	4	7	6	3	3	2	0	0	1
	Percentage	0	18.8	12.5	21.9	18.8	9.4	9.4	6.3	0	0	3.1
Electricity (n=7)	Frequency	1	0	1	0	1	1	1	0	1	0	1
	Percentage	14.3	0	14.3	0	14.3	14.3	14.3	0	14.3	0	14.3
Fuelwood (n=36)	Frequency	0	0	5	5	8	2	8	1	4	2	1
	Percentage	0	0	13.9	13.9	22.2	5.6	22.2	2.7	11.1	5.6	2.8
Gas (n=35)	Frequency	0	1	1	3	18	6	4	0	0	2	0
	Percentage	0	2.9	2.9	8.6	51.4	17.1	11.4	0	0	5.7	0
Paraffin (n=109)	Frequency	1	8	24	9	33	11	12	5	5	0	1
	Percentage	0.9	7.3	22	8.3	30.3	10.1	11	4.6	4.6	0	0.9
Candles (n=1)	Frequency	0	0	0	0	1	0	0	0	0	0	0
	Percentage	0	0	0	0	100	0	0	0	0	0	0
Generator (n=2)	Frequency	0	0	1	0	1	0	0	0	0	0	0
	Percentage	0	0	50	0	0	0	0	0	0	0	0

The Fisher's Exact Test indicated that there was a significant relationship between household size and sources of energy used for cooking (p=0.019). It was found that 51.4% of the gas users were from 5 member households and 30.3% of paraffin users were from 5 member households.

There were 14.3% of the households that used electricity, which was not specific to a household size. Therefore a relationship between electricity usage and a specific household size cannot be determined. The percentage of fuelwood users in the category of 5 to 7 member households was 22.2% for a household size of 5 members, 5.6% for a household of 6 members and 22.2% for a household with 7 members.

4.3.2 Lighting

The following section illustrates results for lighting and energy use.

Table 4.11: Main energy source used for lighting (n=200): Multiple responses

Energy Source	Percentage of respondents
Electricity	98.5
Solar Energy	0.5
Generator	2.5
Paraffin	2
Candles	89.5

Table 4.11 indicates that the majority of the respondents (98.5%) used electricity as the main energy source for lighting in addition to candles (89.5%). As main sources for lighting a few respondents indicated paraffin (2%), generators (2.5%) and solar energy (0.5%). Since electricity was the main source of energy used for lighting, independent of socio-economic factors, further statistical analysis was required to determine whether relationships existed between the other energy sources used.

Table 4.12: Cross tabulation of sources other than electricity used for lighting against employment status (n=184)

		Employment status of respondents						Total
		Employed	Unemployed	Self-employed	Retired	Medically boarded	Student	
Paraffin	Count	0	2	2	0	0	0	4
	Percentage within other sources of energy used for lighting	0	50	50	0	0	0	100
	Percentage within employment status of respondents	0	2	15.4	0	0	0	2.2
	Percentage of total	0	1.1	1.1	0	0	0	2.2
Candles	Count	38	99	7	15	1	14	174
	Percentage within other sources of energy used for lighting	21.8	56.9	4.0	8.6	0.6	8.0	100
	Percentage within employment status of respondents	100	98	53.8	93.8	100	93.3	94.6
	Percentage of total	20.7	53.8	3.8	8.2	0.5	7.6	94.6
Generator	Count	0	0	4	1	0	0	5
	Percentage within other sources of energy used for lighting	0	0	80	20	0	0	100
	Percentage within employment status of respondents	0	0	30.8	6.2	0	0	2.7
	Percentage of total	0	0	2.2	0.5	0	0	2.7
Solar	Count	0	0	0	0	0	1	1
	Percentage within other sources of energy used for lighting	0	0	0	0	0	100	100
	Percentage within employment status of respondents	0	0	0	0	0	6.7	0.5
	Percentage of total	0	0	0	0	0	0.5	0.5

With respect to Table 4.12, The Fisher's Exact Test showed a statistically significant relationship between choice of source used for lighting and employment ($p<0.05$). Approximately 54% of candle-users were unemployed and 21% were employed.

Table 4.13: Cross tabulation of sources other than electricity used for lighting and household size (n=184)

		Household size											Total
		1	2	3	4	5	6	7	8	9	10	11	
Paraffin	Count	0	2	0	0	1	1	0	0	0	0	0	4
	Percentage within other sources of energy used for lighting	0	50	0	0	25	25	0	0	0	0	0	100
	Percentage within household size	0	16.7	0	0	1.7	5.6	0	0	0	0	0	2.2
	Percentage of total	0	1.1	0	0	0.5	0.5	0	0	0	0	0	2.2
Candles	Count	2	10	30	21	53	17	22	8	7	2	2	174
	Percentage within other sources of energy used for lighting	1.1	5.7	17.2	12.1	30.5	9.8	12.6	4.6	4.0	1.1	1.1	100
	Percentage within household size	100	83.3	100	100	89.8	94.4	95.7	100	100	100	100	94.6
	Percentage of total	1.1	5.4	16.3	11.4	28.8	9.2	12	4.3	3.8	1.1	1.1	94.6
Generator	Count	0	0	0	0	4	0	1	0	0	0	0	5
	Percentage within other sources of energy used for lighting	0	0	0	0	80	0	20	0	0	0	0	100
	Percentage within household size	0	0	0	0	6.8	0	4.3	0	0	0	0	2.7
	Percentage of total	0	0	0	0	2.2	0	0.5	0	0	0	0	2.7
Solar	Count	0	0	0	0	1	0	0	0	0	0	0	1
	Percentage within other sources of energy used for lighting	0	0	0	0	100	0	0	0	0	0	0	100
	Percentage within household size	0	0	0	0	1.7	0	0	0	0	0	0	0.5
	Percentage of total	0	0	0	0	0.5	0	0	0	0	0	0	0.5

In relation to Table 4.13, the Fisher's Exact Test indicated that there was no statistically significant relationship between sources other than electricity used for lighting and household size ($p=0.636$). In households of 5 to 7 members, there was reliance on candles for lighting.

4.3.3 Heating

The following section indicates the types of energy sources used for heating in Inanda.

Table 4.14: Main energy source used for heating (n=200): Multiple Response

Energy Source	Percentage of respondents
Electricity	96.5
Solar energy	0.5
Paraffin	43.5
Fuelwood	11.5
Gas	14.5
Candles	0.5
Generator	0.5

Table 4.14 showed a reliance on electricity as source of energy for heating (96.5%), combined with the next most common source, paraffin (43.5%), followed by gas (14.5%), fuelwood (11.5%), candles (0.5%), generator (0.5%) and solar energy (0.5%).

Table 4.15: Cross tabulation of sources other than electricity used for heating against employment status (n=131)

		Employment status of respondents						Total
		Employed	Unemployed	Self-employed	Retired	Medically boarded	Student	
Fuelwood	Count	4	15	0	1	0	2	22
	Percentage within other sources of energy used for heating	18.2	68.2	0	4.5	0	9.1	100
	Percentage within employment status of respondents	12.5	22.4	0	10	0	18.2	16.5
	Percentage of total	3	11.3	0	0.8	0	1.5	16.5
Gas	Count	10	6	6	3	1	2	28
	Percentage within other sources of energy used for heating	35.7	21.4	21.4	10.7	3.6	7.1	100
	Percentage within employment status of respondents	31.2	9	54.5	30	50	18.2	21.1
	Percentage of total	7.5	4.5	4.5	2.3	0.8	1.5	21.1
Paraffin	Count	18	43	5	5	1	6	78
	Percentage within other sources of energy used for heating	23.1	55.1	6.4	6.4	1.3	7.7	100
	Percentage within employment status of respondents	56.2	64.2	45.5	50	50	54.5	58.6
	Percentage of total	13.5	32.3	3.8	3.8	0.8	4.5	58.6
Candles	Count	0	1	0	0	0	0	1
	Percentage within other sources of energy used for heating	0	100	0	0	0	0	100
	Percentage within employment status of respondents	0	1.5	0	0	0	0	0.8
	Percentage of total	0	0.8	0	0	0	0	0.8
Generator	Count	0	1	0	0	0	0	1
	Percentage within other sources of energy used for heating	0%	100	0	0	0	0	100
	Percentage within employment status of respondents	0	1.5	0	0	0	0	0.8
	Percentage of total	0	0.8	0	0	0	0	0.8
Solar	Count	0	0	0	0	0	1	1
	Percentage within other sources of energy used for heating	0	0	0	0	0	100	100
	Percentage within employment status of respondents	0	0	0	0	0	9.1	0.8
	Percentage of total	0	0	0	0	0	0.8	0.8

In relation to Table 4.15, up to 68.2% of fuelwood users were unemployed; some were employed (18.2%), while up to 35.7% of gas-users were employed and unemployed (21.4%). Among paraffin users, 55.1% were unemployed and 23.1% were employed. The Fisher's Exact Test confirmed that there was no a statistically significant relationship between the choice of energy source used for heating (other than electricity) and employment status ($p=0.055$).

Table 4.16: Cross tabulation of sources other than electricity used for heating and household size (n=131)

		Household size										Total
		1	2	3	4	5	6	7	8	9	11	
Fuelwood	Count	0	0	0	5	7	2	6	1	1	0	22
	Percentage within other sources of energy used for heating	0	0	0	22.7	31.8	9.1	27.3	4.5	4.5	0	100
	Percentage within household size	0	0	0	41.7	17.1	11.1	28.6	25.0	16.7	0	16.5
	Percentage of total	0	0	0	3.8	5.3	1.5	4.5	0.8	0.8	0	16.5
Gas	Count	0	1	2	1	15	5	3	1	0	0	28
	Percentage within other sources of energy used for heating	0	3.6	7.1	3.6	53.6	17.9	10.7	3.6	0	0	100
	Percentage within household size	0	16.7	9.1	8.3	36.6	27.8	14.3	25	0	0	21.1
	Percentage of total	0	0.8	1.5	0.8	11.3	3.8	2.3	0.8	0	0	21.1
Paraffin	Count	1	4	19	5	18	11	12	2	5	1	78
	Percentage within other sources of energy used for heating	1.3	5.1	24.4	6.4	23.1	14.1	15.4	2.6	6.4	1.3	100
	Percentage within household size	100	66.7	86.4	41.7	43.9	61.1	57.1	50	83.3	50	58.6
	Percentage of total	0.8	3	14.3	3.8	13.5	8.3	9	1.5	3.8	0.8	58.6
Candles	Count	0	1	0	0	0	0	0	0	0	0	1
	Percentage within other sources of energy used for heating	0	100	0	0	0	0	0	0	0	0	100
	Percentage within household size	0	16.7	0	0	0	0	0	0	0	0	0.8
	Percentage of total	0	0.8	0	0	0	0	0	0	0	0	0.8
Generator	Count	0	0	1	0	0	0	0	0	0	0	1
	Percentage within other sources of energy used for heating	0	0	100	0	0	0	0	0	0	0	100
	Percentage within household size	0	0	4.5	0	0	0	0	0	0	0	0.8
	Percentage of total	0	0	0.8	0	0	0	0	0	0	0	0.8
Solar	Count	0	0	0	0	1	0	0	0	0	0	1
	Percentage within other sources of energy used for heating	0	0	0	0	100	0	0	0	0	0	100
	Percentage within household size	0	0	0	0	2.4	0	0	0	0	0	0.8
	Percentage of total	0	0	0	0	0.8	0	0	0	0	0	0.8

With respect to Table 4.16, the Fisher's Exact Test indicated that there was a statistically significant relationship between choice of secondary source used for heating and household size (p=0.009).

4.4 Obtaining Energy Sources and Attitudes Towards Current Energy Sources

This section provides an account of how electricity, fuelwood, gas, paraffin and candles are obtained, reasons for choosing these sources as well as a rating of the attitudes towards these sources. One respondent indicated that they were using solar energy, although negligible, and this has been included in this section. The following sections illustrate the different types of energy used in this community and how these sources were obtained.

4.4.1 Electricity

Almost all the respondents, with the exception of 1% (two respondents), purchased electricity. The respondents that did not purchase electricity forwarded reasons: it is not easily accessible as the distance to travel to purchase electricity was a challenge (one respondent), and from another respondent, that it was too expensive.

Table 4.17: Reasons for choosing electricity (n=200): Multiple responses

Reason	Percentage of respondents
Convenience	46
Easy accessibility	23.5
Only available option	32.5
Requires less time for preparation	14
Cost effective	2.5

Table 4.17 indicated that almost half the respondents (46%) chose electricity as it was the most convenient option. A significant proportion also reported that electricity was the only option available (32.5%), and for some it was easily accessible (23.5%). Some respondents indicated that electricity requires less time for preparation (14%), and others indicated that it is cost-effective (2.5%).

Table 4.18: Rating of electricity with regards to the following statements (n=200, in %)

	Agree	Neutral	Disagree	Did not know
Electricity is too expensive	3	7.5	88	1
Electricity is associated with health implication	7	6.5	76.5	10
Electricity is unreliable	47.5	20.5	30	2
There is a poor supply of electricity	43.5	19.5	36	1
Electricity causes pollution	8	7.5	73.5	11
Use of electricity is too time consuming	7	5	86.5	1.5
Electricity is environmentally friendly	13.5	9	72	5.5
Electricity is easily accessible	7	5	87.5	0.5
Electricity is easy to maintain	7.5	12	78.5	2
Electricity is easy to use	3	1	95.5	0.5
Electricity is safe to use	15	7.5	77	0.5
Access to electricity is safe	4.5	11.5	80.5	3.5

Table 4.18 indicates that respondents perceived that electricity is not too expensive (88%), almost half the respondents report that it is unreliable (47.5%) and a significant proportion felt that there was a poor supply (43.5%). Table 4.18 also shows that 73.5% of respondents disagreed that electricity causes pollution; 87.5% disagreed that electricity was easily accessible; 78.5% disagreed that electricity was easy to maintain and 95.5% disagreed that electricity was easy to use, 77% disagreed that electricity was safe to use, 72% also disagreed that electricity was environmentally friendly and 86.5% disagreed that the use of electricity was too time-consuming. A significant proportion of respondents also disagreed that electricity is easy to maintain (78.5%) and that access to electricity is not safe (80.5%). Illegal connections were observed in the field.

Table 4.19: P values for Fisher's Exact Tests results of rating of electricity with regards to household size, employment and household income (n=200), statistical significance at 0.05

	Household size	Employment	Household income
Electricity is too expensive	0.147	0.984	0.611
Electricity is associated with health implications	0.525	0.282	0.051
Electricity is unreliable	0.240	0.099	0.850
There is a poor supply of electricity	0.285	0.349	0.788
Electricity causes pollution	0.754	0.423	0.298
Use of electricity is too time consuming	0.354	0.622	0.519
Electricity is environmentally friendly	0.089	0.075	0.027
Electricity is easily accessible	0.647	0.424	0.118
Electricity is easy to maintain	0.598	0.868	0.452
Electricity is easy to use	0.513	0.282	0.358
Electricity is safe to use	0.009	0.021	0.105
Access to electricity is safe	0.399	0.759	0.991

Table 4.19 indicates a statistical significance between perceptions that electricity is environmentally friendly and household income ($p<0.05$). Perceptions of safety with electricity use correlates positively with household size and employment ($p<0.05$).

4.4.2 Fuelwood

Fuelwood was also found to be a common source of energy among the respondents despite the harmful effects. From the respondents who used fuelwood, 91.9% indicated that they collected it from nature and 8.1% indicated that they purchased it (n=185). The following tables provide an indication of the reasons fuelwood was used and not used as a source of energy.

Table 4.20: Reasons for choosing fuelwood (n=185): Multiple responses

Reason	Percentage
Convenience	17.6
Easy accessibility	35.3
Only available option	14.7
Requires less time for preparation	8.8
Cost effective	23.5

According to Table 4.20, 23.5% of the users of fuelwood found this source to be a cost-effective option, while 35.3% found it to be easily accessible and 14.7% reported that this was the only option available. A few (8.8%) stated that it requires less time for preparation.

Table 4.21: Reasons for not choosing fuelwood (n=15): Multiple responses

Reason	Percentage
Inconvenience	47.6
Not easily accessible	78.5
Not familiar with the source	50.5
Too time consuming	75.2
Too expensive	1.2
Unsafe to use	22.1

Table 4.21 shows that those respondents who did not use fuelwood, reported that it was inconvenient (47.6%) or not easily accessible (78.5%). Other respondents also indicated that they were unfamiliar with the source (50.5%); it was too time-consuming (75.2%); it was too expensive (1.2%) and unsafe to use (22.1%).

Table 4.22: Rating of fuelwood with regards to the following statements (n=200, in %)

	Agree	Neutral	Disagree	Do not know
Fuelwood is too expensive	30.5	7	22.5	40
Fuelwood is associated with health implication	16.5	11	9	63.5
Fuelwood is unreliable	22	9.5	44.5	24
There is a poor supply of fuelwood	17.5	9	42.5	31
Fuelwood causes pollution	14.5	5	7	73.5
Use of fuelwood is too time consuming	18	10	61	11
Fuelwood is environmentally friendly	62.5	4	16	17.5
Fuelwood is easily accessible	53	12.5	17	17.5
Fuelwood is easy to maintain	38	18.5	20	23.5
Fuelwood is easy to use	34.5	7.5	44.5	13.5
Fuelwood is safe to use	54.5	14.5	16	15
Access to fuelwood is safe	44	13.5	21.5	21

Table 4.22 indicates the perceptions of respondents towards fuelwood were in relation to specific statements. Less than half of the respondents (42.5%) disagreed that there was a poor supply of fuelwood, while 53% reported that it was easily accessible to them. Table 4.22 also reveals that 73.5% of the respondents were unsure as to whether the consumption of fuelwood causes pollution. Apart from the health hazards resulting from the combustion of fuelwood, Table 4.22 above also reveals that more than half the community (62.5%) recognized that the use of fuelwood was environmentally friendly.

Table 4.23: P values of Fisher's Exact Test results of rating of fuelwood with regards to household size, employment status and household income (n=200), statistical significance at 0.05

	Household size	Employment status	Household income
Fuelwood is too expensive	0.039	0.115	0.231
Fuelwood is associated with health implication	0.003	0.277	0.722
Fuelwood is unreliable	0.285	0.073	0.331
There is a poor supply of fuelwood	0.318	0.088	0.432
Fuelwood causes pollution	0.081	0.162	0.680
Use of fuelwood is too time consuming	0.022	0.781	0.095
Fuelwood is environmentally friendly	0.024	0.157	0.629
Fuelwood is easily accessible	0.521	0.381	0.515
Fuelwood is easy to maintain	0.316	0.356	0.260
Fuelwood is easy to use	0.249	0.812	0.655
Fuelwood is safe to use	0.577	0.614	0.560
Access to fuelwood is safe	0.144	0.387	0.682

Table 4.23 indicates that household size was a factor that influenced the perception that the use of fuelwood was too time-consuming and had health implications ($p<0.05$). The table also indicates a significant relationship between perception of fuelwood being too expensive and household size. Table 4.23 reveals that there was a statistically significant relationship between the perception that fuelwood was environmentally friendly, and household size.

4.4.3 Gas

Twenty-one percent of respondents indicated that they used gas as source of energy. These users reported that they purchased this source. In this section, reasons for their reliance on gas were investigated as well as reasons for not using gas (for those that did not use gas).

Table 4.24: Reasons for choosing gas (n=42): Multiple responses

Reason	Percentage
Convenience	40.5
Easy accessibility	45
Only available option	20
Requires less time for preparation	4.5
Cost effective	12

Table 4.24 indicates that among those respondents who used gas as a source of energy this is due to convenience (40.5%), easy accessibility (45%) and in some cases it is the only option available (20%).

Table 4.25: Reasons for not choosing gas (n=158): Multiple responses

Reason	Percentage
Inconvenience	7.1
Not easily accessible	5.1
Not familiar with the source	18.8
Too expensive	44.2
Unsafe to use	50.5

Table 4.25 indicates that there was some consciousness associated with the dangers of using gas, as 50.5% of respondents that did not use gas, refrained from it for safety concerns. Other reasons for not using gas were the cost: 44.2% of respondents indicated that it was too expensive, inconvenient (7.1%), not easily accessible (5.1%) and they were not familiar with the source (18.8%).

Table 4.26: Rating of gas with regards to the following statements (n=200, in %)

	Agree	Neutral	Disagree	Did not know
Gas is too expensive	4	12	58.5	25.5
Gas is associated with health implication	6	5.5	69	19.5
Gas is unreliable	27	24.5	27.5	21
There is a poor supply of gas	34.5	16	13	36.5
Gas causes pollution	18.5	12.5	42	27
Use of gas is too time consuming	47	18	17	18
Gas is environmentally friendly	38	18	22	21
Gas is easily accessible	16.5	16	43.5	24
Gas is easy to maintain	10.5	16.5	42.5	30.5
Gas is easy to use	18.5	14	46.5	21
Gas is safe to use	9	13.5	62.5	15
Access to gas is safe	10	24.5	43.5	22

Table 4.26 indicates that less than half of the respondents (43.5%) disagreed that gas was easily accessible and 42.5% disagreed that it was easy to maintain. Another significant result is that 62.5% disagreed that gas was safe to use. Table 4.26 indicates that 27% of respondents agreed that gas was unreliable and 47% of respondents agree that gas was too time consuming.

Table 4.27: P values of Fisher's Exact Test results of rating of gas with regards to household size, employment status and household income (n=200), statistical significance at 0.05

	Household size	Employment status	Household income
Gas is too expensive	0.000	0.373	0.000
Gas is associated with health implication	0.043	0.478	0.014
Gas is unreliable	0.016	0.881	0.076
There is a poor supply of gas	0.001	0.013	0.253
Gas causes pollution	0.517	0.436	0.092
Use of gas is too time consuming	0.014	0.166	0.225
Gas is environmentally friendly	0.000	0.286	0.033
Gas is easily accessible	0.040	0.043	0.035
Gas is easy to maintain	0.546	0.046	0.156
Gas is easy to use	0.036	0.903	0.056
Gas is safe to use	0.013	0.177	0.001
Access to gas is safe	0.180	0.168	0.580

Table 4.27 indicates significant relationships between the perceptions that gas was too expensive, had health implications, was unreliable and was too time-consuming, with household size. There were also significant relationships between the perception that gas is easy to use, is safe, easily accessible and is environmentally friendly, with household size ($p<0.05$). However, there was also a statistically significant relationship between the perceptions of gas being in poor supply with household size ($p<0.05$).

There was a statistically significant relationship between the perception that gas is easy to maintain and is easily accessible with employment status ($p<0.05$). There was also a statistically significant relationship found between the perception that there is a poor supply of gas and employment ($p<0.05$).

Table 4.27 indicates significant relationships between the perceptions that gas is too expensive and associated with health implications, with household income ($p<0.05$). There was also statistically significant relationship between the perception that gas is environmentally friendly, easily accessible and safe to use, with household income ($p<0.05$).

4.4.4 Paraffin

Paraffin was a common source of energy used in poor communities. It was found that 62% of the respondents indicated the use of paraffin for household purposes. All respondents confirmed that they purchased the source. The results below demonstrate reasons for the reliance on paraffin as a source of energy.

Table 4.28: Reasons for choosing paraffin (n=122): Multiple responses

Reason	Percentage of respondents
Convenience	45
Easy accessibility	45
Only available option	20
Requires less time for preparation	45
Cost-effective	40

Paraffin as a source of energy is a popular choice for convenience (45%), easy accessibility (45%) and because it requires less time for preparation (45%). Other reasons for choosing paraffin were that it was for respondents the only available option (20%) and cost-effective (40%).

Table 4.29: Reasons for not choosing paraffin (n=71): Multiple responses

Reason	Percentage of respondents
Inconvenience	12.7
Not easily accessible	5.6
Not familiar with the source	16.9
Too time-consuming	2.8
Too expensive	19.7
Unsafe to use	42.3

Those respondents who chose not to use paraffin refrained from it because of safety reasons (42.3%). Other respondents indicated that paraffin was inconvenient (12.7%), not easily accessible (5.6%), an unfamiliar source (16.9%), too time-consuming (2.8%) and too expensive (19.7%).

Table 4.30: Rating of paraffin with regards to the following statements (n=200, in %)

	Agree	Neutral	Disagree	Did not know
Paraffin is too expensive	16.5	11.5	65	7
Paraffin is associated with health implication	8.5	6	76.5	9
Paraffin is unreliable	34.5	14.5	40	11
There is a poor supply of paraffin	59	12.5	14	14.5
Paraffin causes pollution	15	9.5	58.5	17
Use of paraffin is too time consuming	34.5	12	44	9.5
Paraffin is environmentally friendly	53	11	24.5	11.5
Paraffin is easily accessible	9	11.5	73	6.5
Paraffin is easy to maintain	17	13	56	14
Paraffin is easy to use	16	8	70.5	5.5
Paraffin is safe to use	74.5	5.5	14.5	5.5
Access to paraffin is safe	8.5	16.5	61	14

Table 4.30 shows that a large proportion of the community agreed that there is a poor supply of paraffin (59%), and 58.5% disagreed that paraffin causes pollution. Over 50% of the respondents also reported that paraffin is not easy to maintain (56%) and not easy to use (70.5%). The respondents also had some idea of the dangers associated with access to paraffin, as 61% reported that paraffin is actually unsafe. Respondents also disagreed with the statements that paraffin is too expensive (65%), has health implications (76.5%), is unreliable (40%) and is safe to use (14.5%).

Table 4.31: P values of Fisher's Exact Test results of rating of paraffin with regards to household size, employment status and household income (n=200), statistical significance at 0.05

	Household size	Employment status	Household income
Paraffin is too expensive	0.052	0.213	0.008
Paraffin is associated with health implications	0.673	0.927	0.015
Paraffin is unreliable	0.388	0.793	0.617
There is a poor supply of paraffin	0.315	0.722	0.308
Paraffin causes pollution	0.034	0.292	0.568
Use of paraffin is too time-consuming	0.818	0.028	0.211
Paraffin is environmentally friendly	0.006	0.128	0.957
Paraffin is easily accessible	0.135	0.756	0.045
Paraffin is easy to maintain	0.337	0.158	0.080
Paraffin is easy to use	0.107	0.034	0.038
Paraffin is safe to use	0.188	0.257	0.463
Access to paraffin is safe	0.571	0.486	0.176

Table 4.31 indicates significant relationships between the perceptions that paraffin is easy to use and time-consuming, with employment status ($p<0.05$). There was a statistically significant relationship found between perceptions that paraffin is too expensive, has health implications, is easily accessible and easy to use, with household income ($p<0.05$). There was also a statistically significant relationship between perceptions that paraffin causes pollution and is environmentally friendly with household size ($p<0.05$).

4.4.5 Candles

Candles were also a common source of energy in the community, mainly used for lighting. Sixty-two percent of the respondents stated that they used candles as a source of energy, mainly for lighting. This section provides an indication of why candles are relied upon in this community.

Table 4.32: Reasons for choosing candles (n=124): Multiple responses

Reason	Percentage
Convenience	19.5
Easy accessibility	28
Only available option	28.5
Requires less time for preparation	2
Cost-effective	45

In this study, over 62% of the respondents indicated that they used candles. Table 4.32 indicates that users of candles chose this source because they are cost-effective (45%), easily accessible (28%) and are sometimes the only option available for some households (28.5%). Some respondents also indicated that candles were a convenient option (19.5%) and required less time for preparation (2%).

Table 4.33: Reasons for not choosing candles (n=76): Multiple responses

Reason	Percentage
Inconvenience	17.6
Not familiar with the source	17.6
Too time-consuming	5.9
Too expensive	5.9
Unsafe to use	53

In this study, only 38% of respondents stated that they do not use candles; however, of these, 53% % indicated that it is an unsafe option, and according to Table 4.33, 17.6% indicated that it was inconvenient, some indicated that they were not familiar with the source (17.6%), some stated that it was too time-consuming (5.9%) and others that it was too expensive (5.9%).

Table 4.34: Rating of candles with regards to the following statements (n=200, in %): Multiple responses

	Agree	Neutral	Disagree	Did not know
Candles are too expensive	43.5	18	35	3.5
Candles are associated with health implications	39	20.5	34	6.5
Candles are unreliable	40.5	18	37.5	4.
There is a poor supply of candles	76.5	8	8	7.5
Candles causes pollution	34.5	16.5	33.5	15.5
Use of candles is too time-consuming	47.5	8	37.5	7
Candles are environmentally friendly	29	13	45	13
Candles are easily accessible	8	5	82.5	4.5
Candles are easy to maintain	14.5	10.5	69	6
Candles are easy to use	12	3.5	82	3.5
Candles are safe to use	72	7.5	17	3.5
Access to candles is safe	11	7	14.5	67.5

Although there is a reliance on candles as a source of energy, especially for lighting, 43.5% of the respondents agreed that candles are too expensive; 40.5% agreed that they are unreliable; 76.5% agreed that there is a poor supply; 34.5% agreed that they cause pollution and 45% disagreed with candles being environmentally friendly. These findings indicated that respondents were aware of the negative effects associated with candles, yet there was still a dependence on the source. A strong finding from Table 4.34 was that 72% also agreed that candles are safe to use. There was also some awareness about health implications of candles, as 39% of respondents indicated that candles have health implications. The use of candles also appears to be time-consuming, as 47.5% agree with this statement.

Table 4.35: P values of Fisher's Exact Test results of rating of candles with regards to household size, employment status and household income (n=200), statistical significance at 0.05

	Household size	Employment status	Household income
Candles are too expensive	0.020	0.351	0.224
Candles are associated with health implications	0.048	0.776	0.099
Candles are unreliable	0.550	0.232	0.213
There is a poor supply of candles	0.492	0.474	0.475
Candles causes pollution	0.253	0.013	0.635
Use of candles is too time-consuming	0.561	0.269	0.765
Candles are environmentally friendly	0.018	0.006	0.038
Candles are easily accessible	0.299	0.297	0.129
Candles are easy to maintain	0.107	0.189	0.028
Candles are easy to use	0.142	0.025	0.588
Candles are safe to use	0.252	0.069	0.707
Access to candles is safe	0.228	0.426	0.285

There were statistically significant relationships between perception that candles cause pollution, candles are environmentally friendly and easy to use - with employment status (Table 4.35). There are also statistically significant relationships between the perception that candles are too expensive, candles are environmentally friendly and candles are associated with health implications –with household size. Lastly, statistically significant relationships are found between the perceptions that candles are environmentally friendly and easy to maintain – with household income.

4.4.6 Solar Energy

Although anticipated to be uncommon, the use of solar energy in the community was also explored to determine if there could be any inclination in the community towards renewable sources of energy. It was found that only one respondent actually used solar energy in their household. As indicated earlier, this respondent was a student who made use of a solar lamp. This could indicate that the respondent is more educated and probably more exposed to the benefits of using solar energy as an alternate source. The other respondents were then asked why they did not choose solar energy in addition to their other sources. The results are indicated below.

Table 4.36: Reasons for not choosing solar energy (n=199): Multiple responses

Reason	Percentage
Inconvenience	8.5
Not easily accessible	17.5
Not familiar with the source	64.5
Too time consuming	1.5
Too expensive	8
Theft	0.5

Only one respondent reported to the use of solar lamp and confirmed that they obtained the source by purchasing it and that it was a convenient source for them. When respondents were asked to provide reasons for not choosing solar energy as an energy source, a large proportion (64.5%) as shown in Table 4.36 reported that they were not familiar with the source, while 17.5% reported that it was not easily accessible. Only 8% of respondents reported that it was too expensive.

Table 4.37: Rating of solar energy with regards to the following statements (n=200, in %)

	Agree	Neutral	Disagree	Did not know
Solar energy will be cost effective	6.5	10	68	15.5
Solar energy will be safe to use	0	3.5	86.5	10
Solar energy will be reliable	28	11.5	44.5	16
The supply of solar energy will be poor	28	22	19	31
Solar energy will cause pollution	77	2.5	1	19.5
Solar energy will be environmentally friendly	3	3	80	14
Solar energy will have less health impacts	5.5	6	74.5	14
Solar energy will be easily accessible	5.5	24.5	47.5	22.5
Solar energy will be easy to maintain	6	16.5	48.5	29
Solar energy will conserve time	52.5	14	9	24.5

Table 4.37 shows that although there was a basic understanding of what solar energy is, there was also some confusion about its benefits. Up to 68% do not perceive it to be cost effective, 86% disagreed that it was a safer option, 44.5% did not trust the reliability, 74.5% disagreed that it has less health impacts, 48.5% did not think that it is easier to maintain, and 52.5% disagreed that it will save more time. Also, 80% of the respondents disagreed on the environmental benefits of solar energy and 77% indicated that it will cause pollution. With regards to accessibility, 47.5% with the statement that solar energy will be easily accessible and 31% did not know whether the supply of solar energy will be poor or not.

Table 4.38: P values of Fisher’s Exact Test results of rating of solar energy with regards to household size, employment and household income (n=200), statistical significance at 0.05

	Household size	Employment status	Household income
Solar energy will be cost effective	0.116	0.083	0.103
Solar energy will be safe to use	0.086	0.486	0.807
Solar energy will be reliable	0.371	0.073	0.178
The supply of solar energy will be poor	0.935	0.012	0.058
Solar energy will cause pollution	0.610	0.579	0.304
Solar energy will be environmentally friendly	0.097	0.857	0.462
Solar energy will have less health impacts	0.176	0.100	0.086
Solar energy will be easily accessible	0.204	0.033	0.045
Solar energy will be easy to maintain	0.674	0.078	0.001
Solar energy will conserve time	0.203	0.003	0.046

There were no statistically significant relationships found between any of the statements and household size ($p>0.05$). Table 4.38 shows statistically significant relationships between the perceptions that supply of solar energy will be poor, solar energy will be easily accessible and it will conserve time – with employment status ($p<0.05$). There were also statistically significant relationships found between the perceptions that solar energy will be easily accessible, easy to maintain and will conserve time – with household income ($p<0.05$).

4.5 Knowledge and Attitudes Towards Alternate Energy

When considering the implementation of alternate energy in poor communities, it is important to determine the extent of knowledge with regards to it being a source of energy as well as how much overall awareness there is in the community. This will assist in testing the viability of alternate energy and whether the respondents are willing to use it. This section aims to quantify the levels of awareness in the community with respect to alternate energy.

Table 4.39: Respondents' opinion of alternate energy (n=200): Multiple responses

Opinion	Percentage
Did not know	78.5
It is a way of saving electricity	2
Alternative source of energy to electricity	9.5
Cheaper form of energy	2
Easily accessible energy	1.5
Energy from the sun	4
Energy that is not easily accessible	0.5
Energy that is unreliable	1.5
Energy that is too expensive	0.5

Table 4.39 indicates that 78.5% of the respondents did not have an opinion of alternate energy and 9.5% of respondents indicated that it is an alternative source to electricity. Only 3.5% made an association of alternate energy with energy from the sun and 9.5% of respondents were of the view that it is an alternate source of energy to electricity. Some respondents indicated that it was a cheaper form of energy (2%), it was energy that is easily accessible (1.5%) and it is energy that is unreliable (1%). The concept of alternate energy was then explained to the respondents and Table 4.40 shows what they recognized as different alternate energy types.

Table 4.40: Types of energy respondents consider being alternate (n=200): Multiple responses

Energy Type	Percentage
Solar energy	76.6
Fuelwood	9.4
Wind energy	7.8
Hydro energy	6.2

After explaining the concept of alternate energy (energy harnessed from natural resources that are different to the conventional resources presently used in the community) to respondents, Table 4.40 indicates that 76.6% recognized solar energy to be a form of alternate energy, 9.4% of respondents considered fuelwood to be alternate, 7.8% of respondents considered wind energy to be alternate and 6.2% considered hydro energy to be alternate.

Table 4.41: P values of Fisher's Exact Test of the relationship between types of energy respondents consider to be alternate and selected socio-economic variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.160
Employment status	1.000
Household income	0.929

Table 4.41 indicates there were no statistically significant relationships between the types of energy that respondents considered to be alternate and socio-economic variables (household size, employment status, and household income).

Table 4.42: Respondents' awareness of environmentally friendly sources of energy (n=200): Multiple responses

Energy Type	Percentage
Did not know	21.5
Solar energy	61.5
Wind energy	9
Hydro energy	5.5
Bio-energy	2.5

There was general awareness that solar energy is a form of alternate energy, and Table 4.42 indicates that 61.5% of respondents also recognized it to be an environmentally friendly source of energy. Wind energy (9%), hydro energy (5.5%) and bioenergy (2.5%) were also indicated as environmentally friendly sources of energy by the respondents. However, 21.5% of the respondents could not identify an environmentally friendly source of energy.

Table 4.43: Respondents' source of information on alternate energy (n=200): Multiple responses

Source	Percentage
Radio	27.5
Television	36.5
Magazine	6
Newspaper	6
School	10
Family member/friends/community members	37
Books	2
Internet	1

Respondents indicated that their sources of information regarding alternate energy were from the television (36.5%), radio (27.5%), magazines (6%) and family members, friends or community members (37%). Very few respondents indicated that their source of knowledge was from academic sources, for example, books (2%), school (10%) or newspapers (6%).

Respondents were then given a further background to alternate energy to determine whether they would be willing to use alternate energy sources. It was found that 84.5% indicated that they were willing to use alternate sources, while 15.5% were not.

Table 4.44: Reason for respondents' unwillingness to use alternative energy (n=31): Multiple responses

Reason Given	Percentage
Don't know	58.6
Not easily accessible	13.8
Inconvenient to use	13.8
Too time-consuming	14.3
Lack of awareness	3.2
Theft	3.2

Table 4.44 indicates that 15.5% of the respondents indicated that they were not willing to use alternate energy. Table 4.44 also illustrates that more understanding is needed with regards to alternate energy in the community, as 58.6% did not know why they were unwilling to use it, while 13.8% indicated that is not easily accessible, 13.8% indicated that it is inconvenient and 14.3% also thought that it is too time consuming. Within these respondents 3.2% indicated a lack of awareness and theft concerns (3.2%) with regards to unwillingness to use alternate energy.

Table 4.45: Type of alternate energy respondents are willing to use (n=200): Multiple responses

Type of alternate energy	Percentage
Solar	95.9
Wind	54.8
Hydro	72.6
Biogas	0.6
Biofuel	9.5
Biomass	66.7

Table 4.45 indicates that a large proportion of the respondents showed preference for the use of solar energy as an alternate source (95.9%), 72.6% indicated willingness to use hydro energy, 54.8% indicated willingness to use wind energy, 66.7% indicated willingness to use biomass, 0.6% indicated willingness to use biogas and 9.5% indicated willingness to biofuel.

Table 4.46: P values of Fisher's Exact Test of the relationship between types of alternate energy respondents are willing to use and selected socio-economic variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.068
Employment status	0.251
Household income	0.208

Table 4.46 indicates no statistically significant relationships between the types of energy that respondents are willing to use and socio-economic variables (household size, employment status, and household income).

Table 4.47: Types of activities for which respondents' are willing to use alternate energy (n=200): Multiple responses

Activity	Percentage
Cooking	73.5
Lighting	78
Heating	64
Sewing	3.5
Studying/reading	15
Income generating activities	19
Entertainment	35.5

Table 4.47 indicates that cooking (73.5%), lighting (78%) and heating (64%) were activities for which respondents were willing to use alternate energy. Other activities included sewing (3.5%), studying/reading (15%), income generating activities (19%) and entertainment (35.5%).

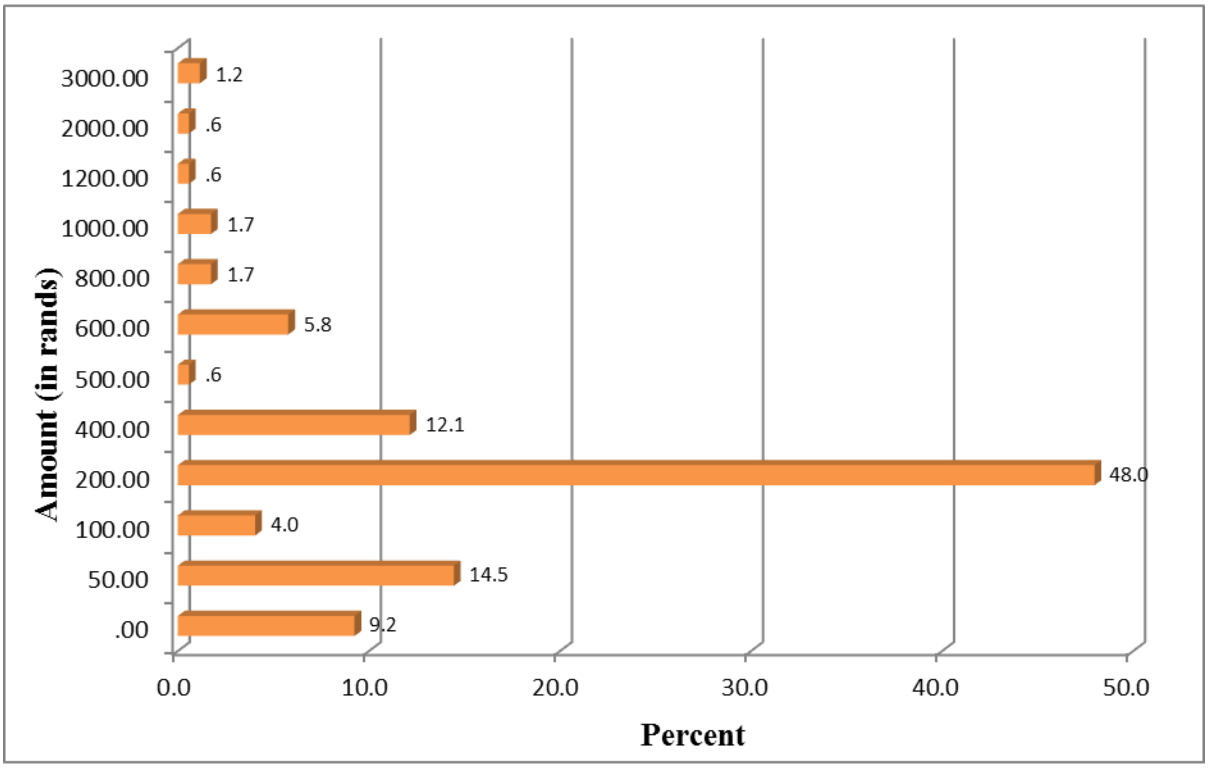


Figure 4.4: Amount respondents are willing to pay for start-up costs for alternate energy (n=200)

Figure 4.4 provides an indication of how much the respondents were willing to pay for start-up costs of alternate technology. Forty eight percent of the respondents were only willing to pay

R200 for start-up costs, 12.1% were willing to pay R400, 5.8% were willing to pay R600, 1.7% were willing to pay R800, 1.7% were willing to pay R1 000 and 9.2% were not willing to pay anything for start-up costs. The range for the above graph was R3 000 while the calculated mean was R277.7.

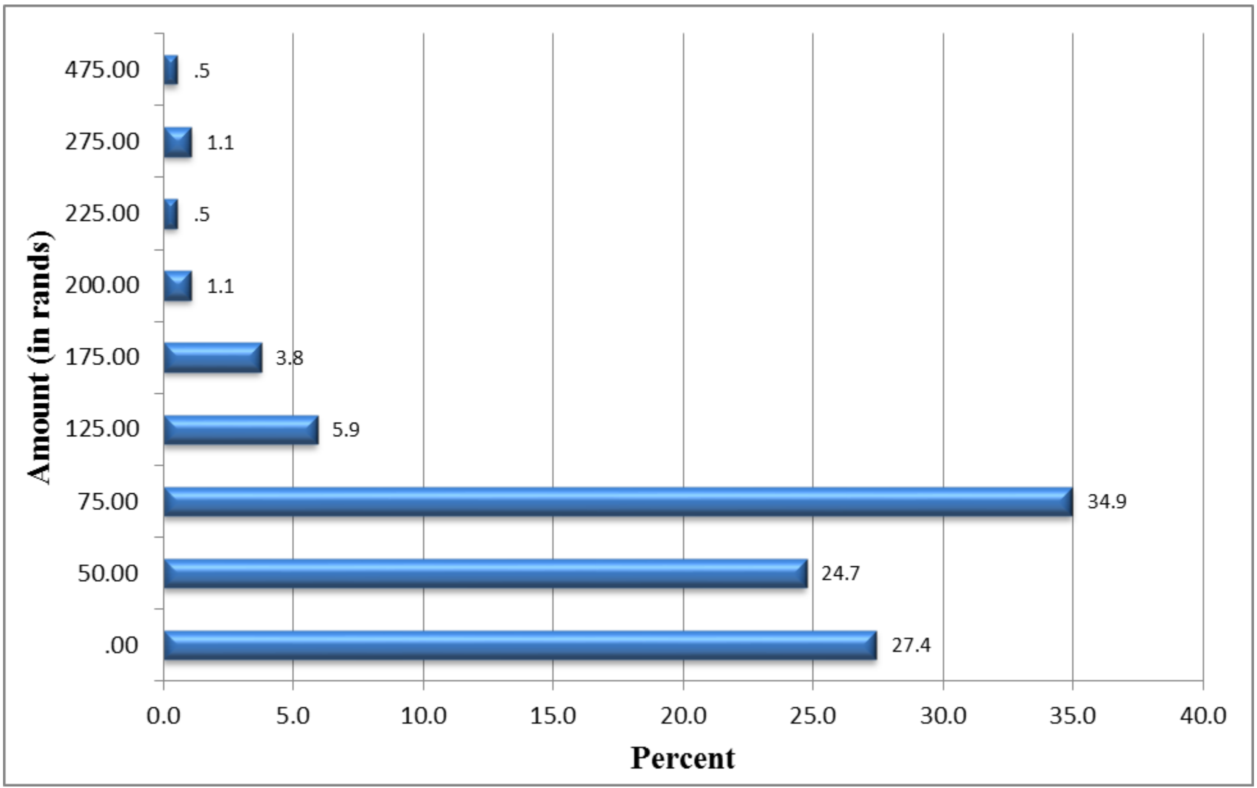


Figure 4.5: Amount respondents are willing to pay for monthly costs for alternate energy (n=200)

Figure 4.5 represents how much respondents were willing to pay as a monthly cost of alternate energy. The figure shows that 34.9% of the respondents were only willing to pay up to R75 per month for alternate energy, 24.7% were willing to pay R50, 5.9% were willing to pay R125, 3,8% were willing to pay R175, 1.1% were willing to pay R200, 1.1% were willing to pay R275 and 0.5% were willing to pay R475. Also important to note is that 27.4% of respondents are not willing to contribute at all to monthly costs. The range for the above graph was R475 and the calculated mean was R61.

Table 4.48: P values of Fisher's Exact Test results of the relationship between the amount respondents are willing to pay for start-up costs for alternate energy and selected variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.321
Employment status	0.646
Household income	0.000
Awareness of alternate energy	0.005

There were strong statistical relationships between the amount respondents are willing to pay for start-up costs for alternate energy with household income and awareness of alternate energy (p=0<05).

Table 4.49: P values of Fisher's Exact Test results of the relationship between amount respondents are willing to pay for monthly costs for alternate energy and selected socio-economic variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.000
Employment status	0.071
Household income	0.003
Awareness of alternate energy	0.552

There were strong statistical relationships between the amount respondents are willing to pay for monthly costs for alternate energy with household income, and household size (p=0<05).

Table 4.50: Types of problems associated with alternate energy (n=66): Multiple responses

Types of problems	Percentage
Not easily accessible	4.5
Too expensive	13.6
Inconvenient	3
Too time consuming	9.1
Negative health impacts	9.1
High maintenance costs	4.5
Unreliable	25.8
Environmental impacts	3
Inadequate supply of energy	27.3

Among the respondents who identified problems with alternate energy (33%), up to 27.3% indicated that the supply of energy will be inadequate. Some respondents indicated that alternate energy is an unreliable source (25.8%), too expensive (13.6%), too time consuming (9.1%), has negative health impacts (9.1%), is associated with high maintenance costs (4.5%), and has environmentally impacts (3%). Respondents were also asked if they were aware of any benefits associated with alternate energy (Table 4.51). The results show that 45.5% of the respondents indicated that they were aware of the benefits while 54.5% indicated that they were not aware.

Table 4.51: Types of benefits associated with the use of alternate energy (n120): Multiple responses

Benefits	Percentage
Did not disclose	54.4
Cheaper	20
Easy to use	9.2
No negative health impacts	11.5
Environmentally friendly	19.2
Reliable	6.7
Faster than conventional energy	1

Among those respondents who indicated that they were aware of the benefits associated with alternate energy, 20% indicated that it is a cheaper option, 11.5% recognized that there were no negative health impacts, 6.7% indicated that it was reliable, 1% indicated that it was faster than conventional energy and 19.2% indicated that is environmentally friendly. These were positive findings, however, these figures were not significant enough to deduce that there was adequate awareness of alternate energy in the community because 54.4% of respondents did not respond.

4.6 Solar Energy

South Africa has great potential to harness solar energy as an alternate source of energy (Donev et al., 2012: 2). This section provides an indication of the level of awareness of solar energy and whether the community is willing to use it. This is important in order to assess the viability of implementing solar energy technologies in this community. When asked whether respondents were aware of solar energy, 78% indicated that they were aware and 23% indicated that they were not. The basic definition of solar energy being energy from the sun was then briefly explained to respondents who indicated unfamiliarity.

Table 4.52: Perception of what solar energy is (n=200): Multiple responses

Perception	Percentage
Did not know	18
Replacement for electricity	3
Cheaper form of energy	4
Energy from the sun	55.5
Environmentally friendly energy	5.5
Sunlight electricity	12.5

As indicated in Table 4.52, only 55.5% of the respondents understood solar energy to be energy from the sun, 12.5% recognized it to be sunlight electricity, while 18% indicated that they did not know, 5.5% associated solar energy to be environmentally friendly energy, 3% indicated that was a replacement for electricity and 4% indicated that it was a cheaper form of energy.

Table 4.53: Source of information on solar energy (n=164): Multiple responses

Source of information	Percentage
Radio	32
Television	39
Magazine	5.5
Newspaper	10
School	10
Family/friends/community member	46.5
Place of work	1
Books	1.5

Table 4.53 above shows that the common sources of information with respect to solar energy were the radio (32%), television (39%) and either family friends or community members (46.5%). It is important to note that a very small proportion of respondents received information from academic sources. Only 10% referenced schools as a source 1.5% indicated books, 5.5% indicated magazines as a source, 10% indicated newspapers as a source and 1% indicated their place of work as a source. When asked about whether they were willing to use the source, 85.5% indicated that they were, while only 14.5% indicated that they were not willing.

Table 4.54: Reason for unwillingness to use solar energy (n=29): Multiple responses

Reason	Percentage
Did not know	89
Not easily accessible	3.5
Too expensive	2
Inconvenient to use	4.5
Too time consuming	3
Lack of awareness of solar energy	0.5
Theft	0.5

Among the respondents who indicated they were unwilling to use solar energy, 89% did not have a reason and some indicated that it would be inconvenient to use (4.5%). Only 2% indicated that cost is a factor, 3.5% indicated that it was not easily accessible, 3% indicated that it was too time consuming, 0.5% indicated that lack of awareness of solar energy was a reason and 0.5% indicated theft as a reason.

Table 4.55: Type of activities for which respondent is willing to use solar energy (n=200): Multiple responses

Activity	Percentage
Cooking	75.5
Lighting	79.5
Heating	64
Entertainment	35.5
Income-generating activities	18
Studying/reading	12.5
Crafting	2
Sewing	3

The three most prioritised activities for which respondents were willing to use solar energy were indicated again in Table 4.55. Cooking (75.5%), lighting (79.5%) and heating (64%) were important activities for which respondents were willing to use solar energy. Also important are entertainment (35.5%), studying/reading (12.5%), crafting (2%), sewing (3%) and income-generating activities (18%) for which energy is needed.

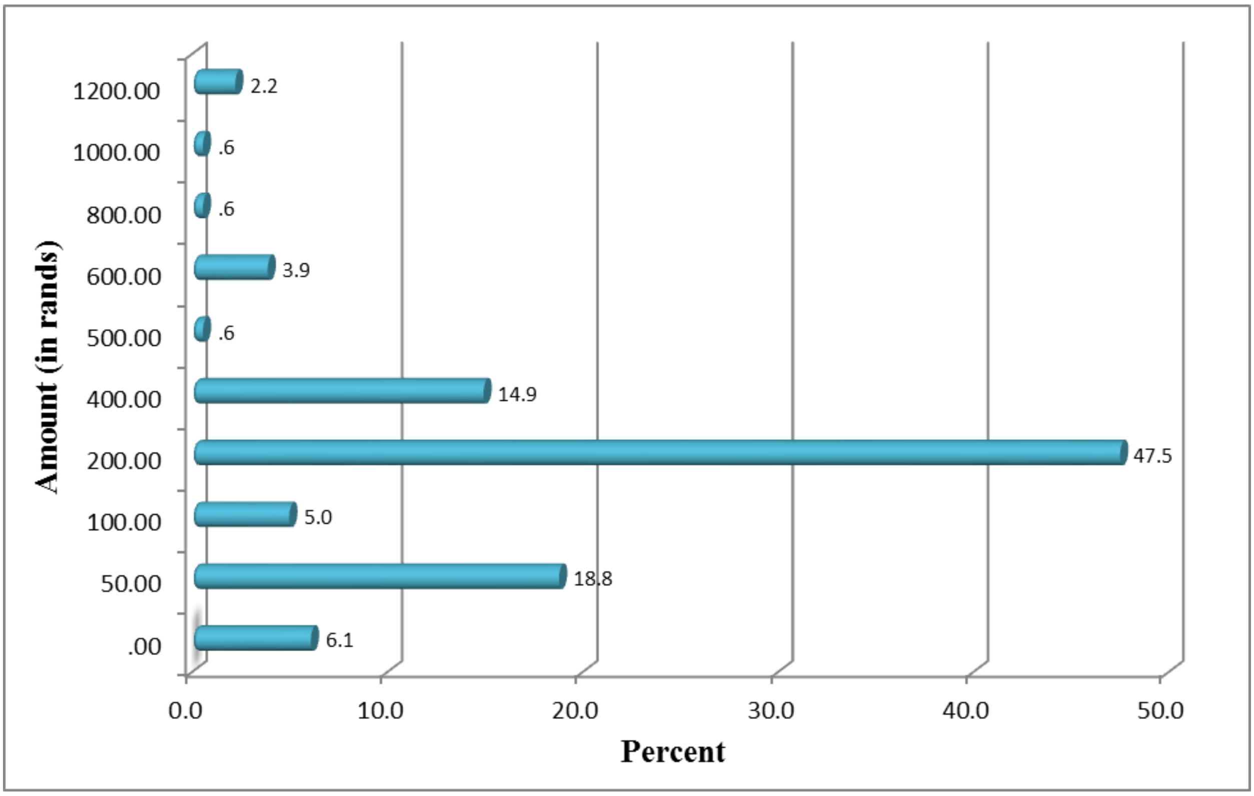


Figure 4.6: Amount that respondent is willing to pay for start-up costs for solar energy (n=200)

Figure 4.6 indicates how much respondents are willing to pay towards start-up costs for solar energy implementation. There were 18.8% of respondents who indicated that they were willing to pay R50 for start-up costs, 5% were willing to R100, 47% were willing to pay R200, 14.9% were willing to pay R400, 3.9% were willing to pay R600, 0.6% were willing to pay R600, 0.6% were willing to pay R1 000 and 2.2% were willing to pay R1 200. Six percent of respondents indicated that they were not willing to pay at all towards start-up costs for solar energy. The range for the above graph was R1 200 and the calculated mean was R231.

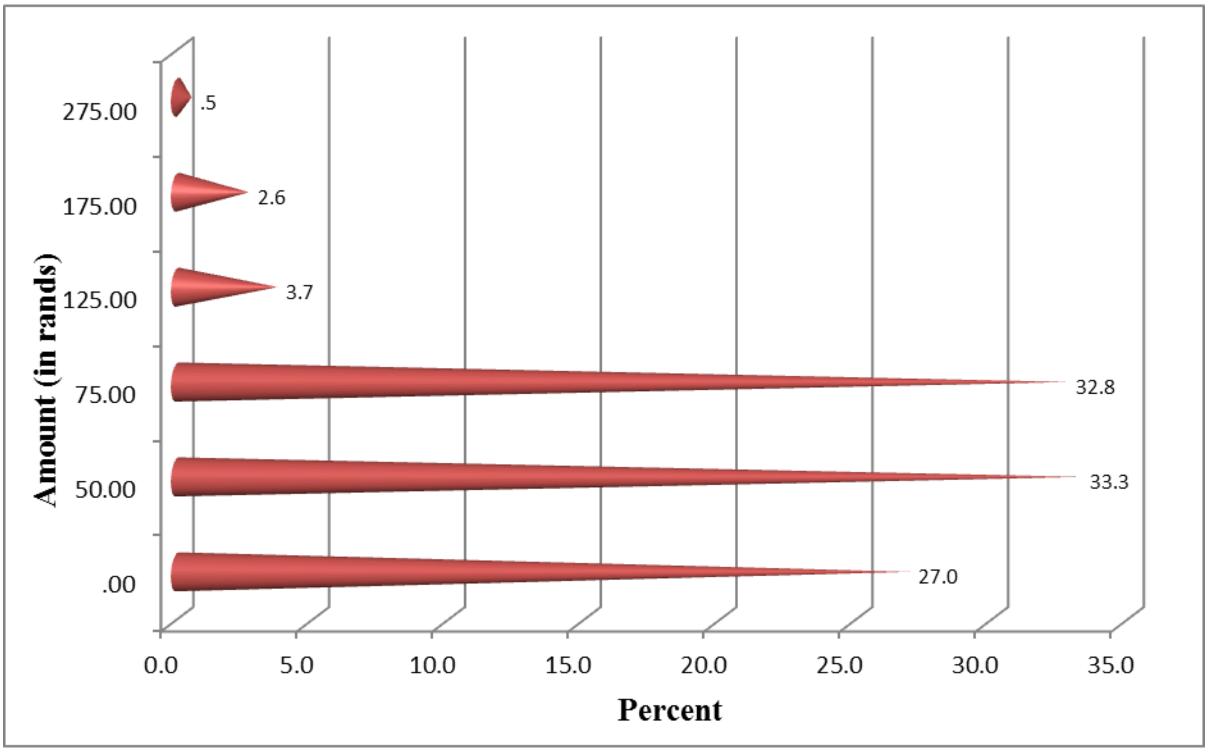


Figure 4.7: Amount that respondents are willing to pay per month for solar energy (n=200)

Figure 4.7 provides an indication of how much respondents were willing to pay for the monthly cost of implementation of solar energy. Thirty three percent of respondents were willing to pay R50, 32.% were willing to pay R75, 3.7% were willing to pay R125, 2.6% were willing to pay R175 and 0.5% were willing to pay R275. Also important in these results is the fact that almost 30% of respondents were not willing to pay anything towards start-up or monthly costs. The range for the above graph was R275 and the calculated mean was R52.

Table 4.56: P values of Fisher's Exact Test results of the relationship between amount respondents are willing to pay for start-up costs for solar energy and selected socio-economic variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.506
Employment status	0.945
Household income	0.000
Awareness of solar energy	0.622

Table 4.56 shows a statistically significant relationship between amount respondents are willing to pay for start-up costs for solar energy and household income ($p<0.05$).

Table 4.57: P values of Fisher's Exact Test results of the relationship between the amount respondents are willing to pay for monthly costs for solar energy and selected socio-economic variables (n=200), statistical significance at 0.05

Socio-economic variable	P value
Household size	0.124
Employment status	0.065
Household income	0.022
Awareness of solar energy	0.160

Table 4.57 shows a statistically significant relationship between the amount respondents are willing to pay for monthly costs for solar energy and household income ($p<0.05$).

4.7 Focus Group Discussion

The aim of the focus group discussion was to interact with community members and to gain further insight to the energy issues in the community as well the attitudes towards solar energy uptake. The target participants were those that were involved directly or indirectly in the energy sector and also lived in Inanda. The focus group discussion was conducted with the assistance of project managers involved in the INK Area Based Management projects. They were contacted to assist with the identification of target participants to discuss the following themes:

- Current energy sources
- Current energy utilization and its challenges
- Awareness and understanding of alternate energy resources in the community
- Potential of solar energy uptake in the area

4.7.1 Current energy sources

The focus group discussion opened with the topic of current energy sources. Participants (mainly community members) indicated that electricity, fuelwood, candles, gas and paraffin were the common source of energy used for household consumption. Participants then indicated which energy sources were used for specific household activities. Overall, they reported that electricity is the main energy source used for household activities. Fuelwood was commonly used for cooking and sometimes heating during cold seasons. Candles were heavily relied upon for lighting, particularly among students who studied at night. Gas was commonly used in households for heating and cooking. Lastly, paraffin was used for general lighting and heating but with caution.

4.7.2 Current energy utilization and its challenges

The topic of current energy utilization and its challenges was then discussed. Participants indicated that the use of electricity is sometimes unsafe. There are open connections to some households and this is life-threatening**.** The burning of fuelwood emits smoke and affects the lungs of those exposed to it. A household member reported: “Over the years I have experienced serious chest problems. We use the wood for cooking everyday and it leaves me coughing”.

The use of candles was also a concern as the leaking of gas canisters and the lighting of candles often resulted in explosions and fire**.** Participants confirmed that some members of the community are unaware of health effects of their sources, such as the effect of candles on eyesight especially on students studying at night. Leaking of canisters and inhalation of the gas often resulted in headaches. Participants indicated that their children often complain of these headaches despite leaving windows and doors open. Gas is also problematic as it is time consuming to refill gas cylinders since far distances have to be travelled and once refilled, the cylinders are heavy to carry back home**.** Paraffin is a common source, however, participants complained that it resulted in severe headaches and often caused fires. Paraffin often leads to unwanted fires.

4.7.3 Awareness and understanding of alternate energy resources in the community

The discussion was followed by assessing awareness levels with regards to alternate energy. It was found that participants who were employed identified solar energy in particular to be an alternate source of energy and also recommended that workshops should be held to inform the rest of the community about alternate energy. A project manager in the INK Area reported “Inanda is a community with serious clean energy needs, but they do not fully understand the technical aspects of alternate energy. Education programmes may help address this and open the willingness to use other forms of energy”**.** Participants then indicated that there was a high level of willingness to use alternate energy sources and that use of alternate energy would be beneficial for bigger households as they have more demand for energy**.** The provision of more energy and possibly alternate energy will allow the poor to explore more livelihood options and increase household incomes**.** Provision of alternate energy could also allow more time for other activities including education, catering, sewing, crafting and entrepreneurship.

Although awareness of alternate energy is a factor that needs to be addressed, affordability is also a factor preventing the use of alternate energy in the community**.** Project manager participants indicated that for successful implementation of alternate energy in poor communities, monthly maintenance costs should be accounted for in energy policies and should be subsidized by the government.

4.7.4 Potential of solar energy uptake in the area

Since the sun is a readily available resource, the potential of solar energy uptake in the area was discussed. Only a small proportion of the community knew the benefits of solar energy and therefore more effort should be made in educating poor communities. Women showed more interest in solar energy as a household option because they believe it to be better than the current sources of energy used for household purposes. One woman reported: “If we can use solar energy to provide electricity, we would be able to do all household chores easily such as cooking, ironing and heating of water. More electricity could even help us start small home businesses”.

Participants indicated that there were a few manufacturing companies in the area of Inanda who were appealing to communities to purchase solar panels. However, these were too expensive for them. Participants indicated that it was generally the richer households that had some solar appliances which replace fuelwood for heating purposes, such as solar geysers. The provision of solar energy could help conserve time because significant time and effort is spent in the collection of sources such as fuelwood and paraffin. As indicated by one participant, solar electricity in particular could help in achieving household tasks faster, such as cooking and ironing. Participants expressed that the government should assist with the costs of implementing solar energy technology because there is a high willingness to use it. They also explained that they would like to use solar energy, but start up and maintenance costs must be subsidized in order for them to afford it.

4.8 Conclusion

In conclusion, it may be noted that respondents are aware that their current energy sources have harmful impacts to them and come with some challenges in acquiring them too. Although there is limited knowledge of cleaner energy source, respondents are willing to learn more about it and how they can use them to improve their lives. Affordability is a strong factor that needs to be considered when considering implementation of clean energy sources. These findings are explored further in the next chapter.

CHAPTER 5
DISCUSSION

5.1. Introduction

The aim of this study was to critically examine the attitudes and challenges with respect to solar energy uptake in peri-urban communities of Inanda and current energy use, using empirical techniques. This chapter provides an interpretation of the results in conjunction with available literature.

5.2. Socio-economic and demographic profile

The purpose of this section was to ascertain the level of poverty in the community and relate this to their sources of energy. This should give an indication of what types of energy sources the community can afford.

The age distribution as shown in Figure 4.1 is common in populations with high birth rates as found in most poor populations. According to the INK Economic Sector Report (2008), 70% of the Inanda population is under the age of 35 years. According to the report, this finding indicates that there is a need for youth development programme and entrepreneurship training to alleviate the prevailing poverty issues. With regards to gender and income distribution, Table 4.1 shows that there are more female respondents who answered the questionnaires hence, there is a higher response from females that are employed versus males (35% male respondents and 65% female respondents). This shows more of a bias towards a positive response of employment from female respondents. The reason is that more females are living in the households than males. According to Census 2011 (2011: 24), the average population in South Africa is predominantly female consisting of 48.2% males and 51.7% females. KwaZulu-Natal in particular has a high negative net migration pattern among males (Census, 2011: 33). Net migration loss was 30 684 people in 2011. A study conducted by Camlin et al. (2013: 1) investigates gender patterns of migration in South Africa, specifically in poor rural communities. In this study respondents indicated that men are more likely than females to out-migrate from a household. On this basis, it is therefore not unusual that most respondents of this study were female. This is further supported in Spalding-Fecher's (2005: 4) study that shows that in South Africa it is common in poor areas that many males are migrant workers in urban areas, leaving women responsible for agricultural and household tasks. Analysis from Table 4.2 found that the rate of unemployment among the respondent population was high and that the majority of the inhabitants of the respondents were young (between 20- <30 years) who have the potential to be economically active.

According to Francis (2006: 20), the responses of poor people to poverty are predetermined by governance, social relations and "culturally shaped practices". Most often, this is in the form of unskilled labour such as farming. This is applicable to this study as 31% of respondents indicated their employment status to be in the form of unskilled labour (Table 4.3). Food supply, according to Francis (2006: 20), offers a predictable form of income, where workers could also earn in the form of crops or sacks of grain. While this is a short-term solution to survival, it is not sustainable from a socio-economic perspective. The level of skills in poor communities needs to be developed to higher levels in order to increase the earning potential and create more sustainable livelihoods.

According to Reddy (2008: 35), poor communities in South Africa residing in rural and peri-urban areas are characterized by high unemployment and low literacy levels. These communities have limited access to public services, specifically electrification. Reddy (2008: 38) further asserts that low-income households move unpredictably between improved and worse economic situations and different energy sources are also resorted to in process. Reddy's (2008) study found that part-time employment and informal businesses in poor communities lead to the purchasing of paraffin, however, in the event of job losses or lack of access to income through remittances, fuelwood was used. In the event of power failures or lack of money for purchasing electricity, candles were substituted as a source of light. A similar finding emerged during the focus group discussion, as participants indicated that they used energy sources that were affordable to them at the time.

Since 64.5% of households had 5 or more members residing in one household (Figure 4.2), this could indicate that the energy needs and resources required would be more in these households. A study conducted by Reddy (2008: 6) indicates that there are significant relationships between household size, household income and energy consumption. Larger, poorer households spent more of their household incomes on traditional energy. It was also found that that as household sizes increase, the reliance on sources such as biomass fuels are more common (Reddy, 2008: 6).

Review of the formal qualifications of the respondents related to employment status indicates that 41% of the respondents that have completed secondary education up to Grade 10 are employed, and 10% of respondents that have completed secondary education up to Grade 12 are employed. The low postgraduate qualification is expected given the socio-economic profile of Inanda. The lack of formal education, however, may directly be related to poverty levels, energy provision and total household earning. Participants during the focus group discussion indicated that if cleaner and more reliable forms of energy were to be provided, it would allow them more time to engage in other activities, including educational ones. This is because significant time and effort is spent in the collection of sources of energy. Makinda (2007: 1) indicates that Africa's state of poverty may strongly be related to the lack of scientific and technical knowledge. Africa is well known for its abundance of natural resources. However, due to the high poverty and low education levels this proves to be of limited value because South African people are not equipped to adequately turn these resources into consumable income and thereby alleviate the poverty situation.

As indicated in Lemaire's case study (2011: 227-283), the average capital cost per solar home system was R4 000 (year 2006), which was less than Eskom's rate of conventional connection to the grid for remote areas (R10 000 – R15 000). Government subsidy amounted to R3 500. To get connected, households needed to pay a start-up fee of R500 in 2006, and pre-pay a monthly fee of R61. The launch of the Free Basic Energy Policy in 2003 gave local municipalities the option to subsidize up to R41 (or not subsidize) of the monthly fee. The result was that some municipalities did and others did not. This presented another challenge as municipalities can amend policies according to their priorities which in some cases resulted in non-payment of the monthly fee. Given that 86.3% of households had an income up to R5 000 per month (Figure 4.3), providing renewable energy, and specifically solar home systems is affordable provided that a government subsidy is in place. Furthermore, results from Table 4.5 indicate 45% of respondents have a total household income of approximately R2 000, and 26% of respondents indicated that their household earning are approximately R4 000 per month. Hence, there will be a need for the government subsidy.

A study conducted by Smith and Everatt (2008: 49) confirm that child support grants are the most common grants accessed by people in Inanda. Given the poverty levels, unemployment and lack of education in the community; it is not surprising to note that child grants are relied upon as an additional source of income (Table 4.6). The focus group discussion also confirmed that there is a significant reliance on grants and they are sometimes the only source of income in a household. High levels of poverty are a determining factor for the choice of energy sources in Inanda. The following section discusses results of the energy profile in Inanda.

5.3 Energy Profile of Inanda

5.3.1 Cooking

The findings indicate that reliance on conventional electricity for cooking was high. However, other forms of energy such as fuelwood, paraffin and gas also seem to be utilised but not as frequently as electricity. The percentage usage of electricity indicates that Inanda does have access to electricity and does not fall into the category of communities that are isolated from electricity (Table 4.7). Gender does not influence the choice of electricity as the main energy source in the community. However, the focus group discussion revealed that sustainable access to energy for cooking has a direct impact on women because women are responsible for the provision of daily meals for their families. There were a number of illegal electricity connections that were observed on field, which presents a concern about safety in using this source. These communities used the energy sources available to them despite the dangers in acquiring the sources. The statistics indicate that employment does not affect the main source of energy used for cooking, which is electricity (Table 4.9). There was no statistically significant relationship found between employment status and sources of energy used for cooking. Paraffin was used less frequently for cooking compared with electricity and gas. Electricity was utilised for cooking independent of household size, which implies that irrespective of the number of people living in a household, electricity is still a common source of energy (Table 4.10).

5.3.2 Lighting

Electricity was used as a main energy source for lighting, however, candles were also used (Table 4.11). This could imply that the community is trying to minimise costs associated with electricity usage by using candles. Madubansi and Shackleton (2006: 1) indicate that the use of candles often results in the spread of unwanted fires, especially in poor communities. Ferrer-Martı´ et al. (2012: 2) also assert that the burning of energy sources such as kerosene lamps and candles has harmful effects on lungs and eyesight. This further expresses a need for sources that do not create smoke.

Table 4.12 indicates that the uses of candles are more commonly used by the unemployed compared to those that are employed. A study conducted by Mdluli and Vogel (2010: 211) regarding energy use patterns in township areas indicates that the use of multiple sources of energy for lighting in addition to electricity is a common pattern. They also indicate that the persistence of unemployment and poverty is a key driver influencing why these communities resort to traditional sources of energy. This literature finding reinforces the findings in this study confirming that the use of candles can be related to employment status.

5.3.3 Heating

Heating is another household activity for which energy is prioritised. Chang et al. (2011: 1) indicate that the heating of water typically represents one of the highest percentages of energy consumption in households. During the focus group discussion it emerged that solar geysers would help with the heating of water, but the provision of solar electricity would be preferred for heating purposes. In this study, it was found that there was a high reliance on electricity for heating (96.5%), combined with the next most common sources, paraffin (43.5%) and gas (14.5%). Given the observed illegal connections of electricity and hazardous health effects of paraffin and gas, all three sources can be considered unsafe for heating purposes. Although the Fisher's Exact Test confirmed that there was no statistically significant relationship between the choice of energy source used for heating (other than electricity) and employment status ($p=0.055$), the results show a dependency on fuelwood, gas and paraffin among the unemployed. This could imply that affordability plays a role in the choice of energy source used for heating in the absence of electricity.

From the overall energy profile of the community as depicted in Chapter 4, it is clear that there was reliance on electricity for cooking, lighting and heating. However, what is also clear is that there were sources combined with electricity for these activities. For cooking, electricity and fuelwood were used; for lighting, electricity and candles are common; and for heating, electricity, paraffin and gas are predominant sources. It can be deduced that in one household multiple sources of unsafe energy-use occurs for the three prioritised activities in the community.

Paraffin and gas are highly flammable substances, while the use of fuelwood has a number of health impacts. It was observed that these households have very poor ventilation (often a window and a door) and indoor cooking using fuelwood is a common practice. As mentioned earlier, the literature reveals that respiratory illnesses caused by poor ventilation mechanisms mainly affect women and children. Karekezi and Kithyoma (2002: 4) indicate a link between biomass combustion and respiratory illnesses in women and children. The burning of the sources other than electricity (fuelwood, paraffin and gas) also emits harmful greenhouse gases, thereby compromising environmental health. The provision of cleaner and safer sources of energy may therefore help overcome the harmful effects of the current energy sources and reduce the risks of health hazards due to the use of flammable substances.

5.4 Obtaining Energy Sources

5.4.1 Electricity

The respondents perceive that electricity is not too expensive (76.5%). Field observations indicate that most electricity users have illegal connections and do not pay for the source. This implies that there is a need in poor communities for the provision of reliable and safer energy options. Renewable energy should therefore be considered for poor communities. Although electricity is the most common source of energy in the community, Table 4.18 shows that almost half the community reported that electricity it is unreliable (47.5%) and a significant proportion feel that there is a poor supply (43.5%). Table 4.18 also shows that 73.5% of respondents disagreed that electricity causes pollution and 72% disagreed that electricity is environmentally friendly. This could indicate some confusion with regards to electricity usage and environmental impacts. There are possibly low levels of awareness with regards to the environmental impacts during the production of electricity. This implies that there is a need to educate poor communities on the impact of their sources of energy. A significant proportion of respondents also indicated that electricity is not easy to maintain (78.5%) and that access to electricity is not safe (80.5%). This could be due to the dangers of acquiring the source through illegal connections, as observed in the field.

Findings from Table 4.19 show a statistically significant relationship between the perception that electricity is environmentally friendly and household income. Assuming that household income is indicative of employment, this result could indicate that those respondents who are employed are more informed and may therefore have some knowledge of electricity and the environmental impacts. There was also a statistically significant relationship between the perception that electricity is safe to use and employment

Energy utilization and demands for energy become higher in larger households. Multiple devices such as stoves, lights, geysers, radios, televisions etc. can be operated simultaneously with electricity as opposed to other sources such as gas, firewood or paraffin.

5.4.2 Fuelwood

According to Table 4.20, 23.5% of the users of fuelwood found this source to be a cost-effective option, while 35.3% found it to be easily accessible and 14.7% reported that this was the only option available. The finding of affordability was also confirmed in a similar study conducted by Shackleton et al. (2007: 4) in the Makana district of the Eastern Cape, where the use of fuelwood was more common among poorer households. During the focus group discussion, women participants indicated that fuelwood is also favoured in a household because it supports the quantities of cooking that they often engage in for entertainment purposes. It also helps heating of the home during cold weather. However, the smoke inhalation does have an effect on health. Participants during the focus group discussion further stated that the smoke affects their chest. While fuelwood is easily accessible and cost-effective for most, it is not a sustainable option due to the health implications from combustion. Table 4.21 shows those respondents that did not use fuelwood report that it was inconvenient (47.6%) or not easily accessible (78.5%). This difference could be due to the way that natural resources are dispersed in the community or the lack of person-power within the household that prevents people from collecting fuelwood. Literature reveals that there is significant time and effort spent on the procurement of fuelwood and other biomass sources. As mentioned by Sagar (2005: 1), in rural areas of sub-Saharan Africa African women carry large amounts of fuelwood and travel large distances to obtain this. This causes indoor pollution and smoke inhalation is the cause of many deaths, especially among women and children (Sagar, 2005: 1).

Table 4.22 further provides an indication of why fuelwood is a common source. Less than half of the respondents (42.5%) disagree that there is a poor supply of fuelwood while 53% report that it is easily accessible to them. A strong finding shown in Table 4.22 is that 73.5% of the respondents were unsure as to whether the consumption of fuelwood causes pollution. It was observed that most households have one window for ventilation. This is a cause for concern, especially for those that consume considerable amounts of fuelwood for cooking and heating. This was confirmed during the focus group discussion when participants indicated that smoke inhalation affected their chest. This was also found in a study conducted by Sagar (2005: 1) who asserts that the combustion of fuelwood and other biomass traditional sources results in severe health impacts. Indoor pollution and smoke inhalation is the cause of many deaths, especially among women and children (Sagar, 2005: 1). Appropriate types of renewable energy technology could therefore improve the lives of people in this community.

A statistically significant relationship was found between the perception that fuelwood is too expensive and household size (Table 4.23, $p<0.05$). Given that fuelwood resources would be readily available in the surrounding study area, it was found that there were households that perceived fuelwood to be expensive which could imply that fuelwood was being purchased in these households. Although fuelwood is a natural resource, households are still incurring costs for this source of energy. The purchasing of fuelwood was also found in a study conducted by Mlunga (2012: 1) in the townships of Tsumeb, Namibia where fuelwood is a common source used in households for the preparation of meals. The study confirmed that some households collected their fuelwood but often have to purchase it to meet their individual needs. Furthermore, the use of fuelwood is also perceived to be time consuming. This is supported by Sagar (2005: 1) who asserts that lack of access to safe and clean energy has resulted in the poor subsisting on animal dung, crop residue and wood. As a result, significant time and effort is spent on the collection of firewood and other biomass sources. Hence, the provision of cleaner or alternate energy sources would encourage these household members to spend their time on income-generating activities. There seems to be an awareness of the health implications associated with the use of fuelwood in bigger households. Table 4.23 indicates a statistically significant relationship between the perception that fuelwood is associated with health implications and household size ($p<0.05$). Sagar (2005: 1) indicates that the inefficient combustion of fuelwood and other biomass traditional sources result in severe health impacts. Indoor pollution and smoke inhalation is the cause of many deaths, especially among women and children. The perception of fuelwood being environmentally friendly was also statistically significant with household size which could indicate that there is a level of environmental awareness. Although the combustion of fuelwood is associated with negative environmental impacts (especially indoor pollution in these households), Menendez and Curt (2013: 7) reveal that on the basis of gathering branches and fallen trees, the use of fuelwood can be considered as sustainable and environmentally friendly.

5.4.3 Gas

Table 4.24 indicates a reliance on gas as a source of energy due to convenience (40.5%), easy accessibility (45%) and in some cases it is the only option available (20%). Gas as indicated earlier is consumed for cooking and heating purposes. It is evident that poor communities use the energy sources that are accessible and available to them. Poor communities depend largely on biomass sources, including charcoal, fuelwood and gas for cooking and heating (Pereira et al., 2011: 168). Sources like gas in poor communities are often hazardous as they are highly flammable and cause the spread of unwanted fires (Madubansi and Shackleton, 2006: 1). This is concerning because Table 4.24 indicates that source is used for its convenience and accessibility advantages. Table 4.25 indicates that there is some awareness associated with the dangers of using gas, as 50.5% of respondents that do not use gas, refrain from using it because of safety concerns. These sources also often result in unwanted fires and spread of fires in communities (Madubansi and Shackleton, 2006: 1). Although most respondents indicated that they did not use gas, it is still a common source of energy in poor communities and there is still reliance on it. Another significant result is that 62.5% of the respondents disagreed that gas is safe to use (Table 4.26). However, during the focus group discussion it was revealed that gas cylinders leak very easily and this sometimes leads to explosions and fires. This could imply that poor communities are aware of the dangers associated with their sources of energy but continue to use them because of the limited options available to them. Table 4.26 also indicated that 27% of respondents agreed that gas was unreliable. This could be due to the unreliability of the cylinders. It was also found that 47% of the respondents agreed that gas is too time consuming (Table 4.26). It was indicated during the focus group discussion that it is time consuming to refill gas cylinders, as large distances have to be travelled and once refilled, the cylinders are heavy to carry back home. This also reinforces the need for safer energy options.

There were significant relationships between the perceptions that gas is easy to use, is safe, easily accessible and is environmentally friendly with household size (Table 4.27, $p<0.05$).

However, there is also a statistically significant relationship between the perceptions of gas being in poor supply with household size ($p<0.05$). This could be attributed to the quantities of gas supplied to the region where gas is purchased. Though the point of purchase may be easily accessible, the supply to this point maybe insufficient. This was confirmed in an energy use study conducted in the Maphephethe area (similar to Inanda in terms of low household income and traditional energy use) in KwaZulu-Natal which indicates that gas is commonly used source of energy, however, this source is not available at local spaza shops or general dealers (Green and Erskine, 1999: 10).

Gas is perceived to have health implications. The focus group discussion indicated that gas and paraffin affect the health of those using it. Participants complained that it resulted in severe headaches. Bernstein et al. (2008: 2) reveal that gas appliances produce carbon monoxide, an odourless but poisonous substance. Inhalation of this substance often results in headaches, nausea, dizziness and fatigue. Increased exposure can lead to comas and death. This life-threatening source is a further call for cleaner energy supply in these households. In addition, gas is perceived to be expensive. This could be due to expenses associated with the transport of gas cylinders as well as increased utilization in these households which pre-empts frequent cylinder purchases to meet their energy needs. This was also a finding in Green and Erskine's (1999: 10) study which shows that gas was found to be the most expensive in terms of resource cost and cost of transport.

5.4.4 Paraffin

Paraffin as a source of energy is a popular choice for convenience (45%), easy accessibility (45%) and it requires less time for preparation (45%) (Table 4.28). Like gas, paraffin is also flammable and often leads to unwanted fires. This was confirmed during the focus group discussion. However, paraffin is more common than gas and this could be because it is less expensive. The focus group discussion indicated that gas and paraffin affect the health of those using it. As mentioned above, participants complained that it resulted in severe headaches. Those respondents that chose not to use paraffin refrained from it due to safety reasons (Table 4.29: 42.3%). Participants during the focus group discussion indicated that paraffin affected their health because it resulted in severe headaches. This finding is confirmed in a similar study conducted by Mdluli and Vogel (2010: 213) who found that the use of paraffin was disliked in township households because of the smoke emitted and negative health effects, such as stinging in the eyes and choking. Fires and explosions due to paraffin were also common as indicated during the focus group discussion. Mdluli and Vogel's (2010: 213) study also confirmed this finding and states that despite these problems, households continue to use paraffin because of affordability. In this study, 40% of respondents indicated that it was cost-effective.

A large proportion of the respondents agreed that there is a poor supply of paraffin (59%) and 58.5% disagreed that paraffin causes pollution (Table 4.30). This result may also be interpreted as a call for easier access to energy (electricity) or provision of cleaner sources of energy due the supply issues. The community also had some idea of the dangers associated with access to paraffin, as 61% reported that access to paraffin is actually unsafe. According to Disenyana et al. (2010: 12), it is well known that a common cause of death in rural households is due to the burning of harmful energy resources such as paraffin.

Employed individuals generally found paraffin to be easy to use and are able to purchase this source of energy; however, they also find it to be time consuming (Table 4.31). This is confirmed by Karekezi and Kithyoma (2002: 12) who indicate that significant time and effort is made in the collection of resources for energy and this often impacts on the socio-economic development of poor communities.

Results show a contradiction in perceptions of the effects of paraffin in being environmentally friendly and causing pollution (Table 4.31: statistically significant relationships between perceptions that paraffin is environmentally friendly and paraffin causes pollution with household size). This contradiction could be due to the lack of awareness of the effects of paraffin on the environment. In addition to the safety implications of paraffin, Karekezi and Kithyoma (2002: 4) indicate that the burning of sources such as paraffin and gas also emit harmful greenhouse gases, thereby compromising environmental health.

5.4.5 Candles

According to Ferrer-Martı´ et al. (2012: 1), candles and kerosene lamps in poor communities are often used for lighting purposes. These sources emit harmful smoke and have detrimental health effects, including damage to lungs and eyesight. They further suggest that the provision of electricity or clean sources of energy can provide lighting thereby substituting candles, and providing benefits for children by allowing them to complete homework during the evenings. The focus group discussion also confirmed that students found it difficult to study by candlelight and it did affect their eyesight. In this study only 38% of respondents confirmed that they do not use candles. Table 4.33 indicates that 53% of these respondents indicated that this was because candles were unsafe to use, and some also indicated that it was inconvenient (17.6%) and that they were familiar with the source (17.6%). Safety regarding the use of candles also emerged as a concern during the focus group discussion. The leaking of gas canisters and the lighting of candles often resulted in explosions and fires. However, a key finding in Table 4.34 is that 72% of the respondents agreed that candles are safe to use. This was confirmed during the focus group discussion. Participants confirmed that some members of the community are unaware of health effects of their energy sources, such as the effect of candles on eyesight and therefore need to be introduced to safer sources of energy. As mentioned earlier, Madubansi and Shackleton (2006: 1) report that candles are often used as an additional source of energy in poor communities and they often cause unwanted fires. This finding indicates that poor communities need to be engaged in awareness programmes regarding the impacts and dangers associated with their current sources of energy.

The results from Table 4.35 indicate contradictory findings of the environmental impacts of candles. Households may perceive candles as environmentally friendly, however some also perceive candles as causing pollution. This could be attributed to the lack of awareness of the environmental impact of candles. There was a significant relationship between the perception that candles have heath impacts and household size. This may be due to use of candles across all household sizes. According to Ferrer-Martı´ et al. (2012: 1), candles and kerosene lamps in poor communities are often used for lighting purposes and have harmful health effects.

5.4.6 Solar Energy

With regards to solar energy, the perceptions indicate that it will conserve time and will be easily accessible; however, it will be in poor supply. More than half of the respondents who indicated that solar energy will conserve time were employed. During the focus group discussion participants indicated that the provision of solar energy could help conserve time because significant time and effort is spent in the collection of sources such as fuelwood and paraffin. They further indicated that solar energy (in the form of electricity) in particular could help in achieving household tasks faster, such as cooking and ironing.

There was a significant relationship between employment status and the perception that solar energy will be easily accessible ($p<0.05$). Over half of the respondents who agreed with this statement were employed (61%). This finding was confirmed during the focus group discussion, where participants indicated that there are a few manufacturing companies in the area of Inanda who are appealing to communities to purchase solar panels. This is probably why access is not considered a major problem. More than half of the respondents who agreed that solar energy will be in poor supply were unemployed (57%). The perception that solar energy will be in poor supply could be influenced by current energy supply challenges that the community experiences at present.

5.5 Alternate Energy

Table 4.39 indicates that 78.5% of the respondents did not have an opinion of alternate energy and 9.5% of respondents indicated that it is an alternative source to electricity. Only 3.5% made an association of alternate energy with energy from the sun and 9.5% of respondents were of the view that it is an alternate source of energy to electricity. Some respondents indicated that it was a cheaper form of energy (2%), it was energy that is easily accessible (1.5%) and it is energy that is unreliable (1%). These results may be reinforced with findings from the socio-economic and demographic profile results, which provided an indication of the low education levels of the community in general. During the focus group discussion, the respondents who were employed identified solar energy in particular to be an alternate source of energy and also recommended that workshops should be held to inform the rest of the community about alternate energy. After explaining to respondents the basic concepts of alternate energy, it was found that 21.5% of respondents still could not identify environmentally friendly sources of energy (Table 4.42). This reiterates a further need to educate communities about these sources. Participants of the focus group discussion recommended that awareness programmes regarding these energy sources should be implemented so that communities are more informed of the benefits of alternate energy for their household as well as the environment. Since television and radios are sources of information, the level of understanding of alternate energy sources maybe attributed to the low education levels in the community. Table 4.45 indicated that a large proportion show preference for the use of solar energy as an alternate source (95.9%). This is a positive finding for the community as well as for the country. According to Gujba et al. (2012: 2), Africa has a number of available renewable energy options. There is particularly huge potential for solar energy which can help develop the energy sector. They further stipulate that provision of renewable energy sources has potential to upgrade the infrastructure in rural or poor areas and this could be a solution with respect to the provision of clean forms of energy to these communities, in addition to alleviating the current energy crisis on the continent.

The provision of renewable energy can also help alleviate climate change as it will provide clean energy and reduce the carbon footprint of the area. As indicated earlier, Milton and Kaufman (2005: 2) highlight that the implementation of renewable energy even on a small-scale basis can contribute considerably to a reduction in greenhouse gas emissions while simultaneously improving the quality of life of developing countries. Chang et al. (2011: 1) also support this argument and assert that solar water heating systems represent the highest potential in mitigating climate change through reducing greenhouse gas emissions. Although this study does not interrogate specific solar technologies that could be implemented, Chang et al. (2011: 1) indicate that the heating of water typically represents one of the highest percentages of energy consumption in households. Solar water heating is promising as it is a simple and cost-effective option. When solar water heaters are used as a replacement to conventional sources for heating, they consequently replace these sources that would have originally been used. This consequently results in the reduction of air pollutants such as oxides of nitrogen, carbon monoxide, sulphur dioxide, volatile organic compounds and large amounts of carbon dioxide (Milton and Kaufman, 2005: 2; Chang et al., 2011: 1).

There were no significant relationships found between types of alternate energy respondents were willing to use and employment status and household income (Table 4.46). This suggests that these factors do not influence respondents' willingness to use alternate energy. This may further emphasise the lack of awareness of the different types of alternate energy applications. It emerged during the focus group discussion that there were no current educational programmes directed at alternative energy. Participants indicated that there was a need for such programmes in the community.

Households have prioritised cooking, lighting and heating activities for which alternate energy should be considered. This is further supported by Onyango and Ochieng (2006: 1) who state that renewable energy technologies have the potential to significantly improve the lives of the poor. These technologies may be situated closer to the demands, thereby reducing transmission costs as well as energy and capacity loss. Access to sustainable energy would play an important role in improving the living standards of people, particularly in poor communities. Economic growth and development are directly or indirectly linked to the utilization and access to energy (Nguyen, 2007: 1). Also, the operation of solar thermal technologies does not require fuel (Nguyen, 2007: 1) which further reduces the need for resources that are not environmentally friendly, as well as those that have health implications.

In Lemaire's study (2011: 227-283), the average capital cost per solar home system was R4 000 (year 2006), with a government subsidy of R3 500. A difference of R500 was needed to be paid by the households. In the context of this study only 0.6% were willing to pay R500 for start-up costs of alternate energy (Figure 4.4). During the focus group discussion it emerged that affordability was a major factor preventing the use of alternate energy in the community. Nepal (2012: 6) asserts that although installation costs for all alternate energy technologies are capital intensive, they are worth the investment because of the long life-span of the technologies (up to 30 years). This was confirmed by Chang et al. (2011: 1) who state that there is often hesitation in large-scale implementation of alternate energy technologies due to the high costs. Donev et al. (2012: 5) indicate that average energy consumption in informal areas of South Africa equates to approximately 2065 kWh/year. This includes consumption for heating, cooking, refrigeration and lighting. For mini grid PV systems, Szabo et al. (2011: 4) estimate an electricity production cost at a rate of R6 kWh. They further stipulate the importance of ascertaining how much poor communities in Sub-Saharan Africa are willing to pay as 80% of the population lives on approximately R22 a day (US$2.5). Typical household consumption is 1-3 kWh per day. Solar mini grid options would still translate to high amounts spent on household energy. However, Szabo et al. (2011: 4) further stress that in some cases the equivalent or more is spent on traditional sources. From the results above, it is clear that the respondents of Inanda cannot afford this type of expenditure on energy. However, Szabo et al. (2011: 4) stress that PV systems are still viable through other financial mechanisms and external funding programmes to assist with the initial start-up costs.

Household income influences the amount respondents are willing to pay for start-up costs for alternate energy. Respondents that have awareness of alternate energy are willing to pay start-up costs for alternate energy. There was a strong statistical relationship between the amount respondents are willing to pay for start-up costs for alternate energy with household income and awareness (Table 4.48, $p < 0.05$). Household income also influences the amount respondents are willing to pay for start-up costs for alternate energy. This reinforces the issue of affordability and energy sources in poor communities. Poor communities are willing to use alternate energy and are aware that it is a more sustainable and viable option to meet their energy needs. Figure 4.4 illustrates that households can only afford to pay minimal amounts for start-up costs and some cannot afford to pay at all. Almost 50% of the respondents are only willing to pay R200 for start-up costs and 12.1% are willing to pay R400. Affordability is a major factor preventing widespread use of alternate energy in the community, which was also confirmed during the focus group discussion. This implies that energy policies should make provisions for the costs of providing alternate energy. As mentioned earlier, the IPCC stresses that governments play an important role in technology transfer with respect to renewable electricity generation technologies. According to Amigun et al. (2011: 7), these roles include "removing barriers to technology transfer, building human and institutional capacity, providing an enabling environment that is suitable for the investment, provision of infrastructure for research and development, and information transfer and provision of support mechanism for renewable energy deployment". When designing policies, Amigun et al. (2011: 7) stipulate that the identification of barriers to implementing renewable energy technologies must be considered for effective policy and renewable energy project implementation.

5.6 Solar Energy

According to Table 4.52, only 55.5% regarded solar energy to be energy from the sun, 12.5% recognized it to be sunlight electricity, while 18% indicated that they did not know. There is clearly still a lack of understanding of solar energy among the respondents. Solar energy concepts had to be explained further for respondents to get clarity. The focus group discussion indicated that there is a basic understanding about what solar energy is, however, participants stressed that people do not have an adequate understanding of it. It emerged that communities would like to know more about this source. They suggested that initiatives should be made to host workshops in the community about solar energy and how to use solar energy technologies.

Table 4.54 shows that among the respondents who indicated they were unwilling to use solar energy (n=29), 89% did not have a reason and some indicated that it would be inconvenient to use (4.5%). Only 2% indicated that cost is a factor. Lack of awareness is once again evident as more respondents did not have a reason rather than affordability being a factor for unwillingness to use solar energy. Donev et al. (2012: 10) assert that the major limiting factor causing the slow implementation of solar energy in South Africa is the high initial cost. This reiterates the need for external funding and investments for green initiatives in South Africa.

Figure 4.6 indicates how much respondents can afford to pay towards start-up costs for solar energy implementation. It is clear that on average respondents were not willing to pay more than R500 and some were not willing to pay at all. The graph also indicates that respondents are not aware of the exorbitant start-up costs associated with the implementation of solar energy technology. However, the focus group discussion revealed that affordability is a major factor preventing the use of solar appliances. It was indicated that government should provide subsidies for solar energy programmes.

Figure 4.7 provides an indication of how much the community can afford to pay for the monthly cost of implementation of solar energy. Also important in these results is the fact that almost 30% of respondents are not willing to pay anything towards start-up or monthly costs. This may be identified as a major barrier towards the implementation of renewable energy, especially in poor communities. During the design of policies, the IPCC suggests that the identification of barriers to implementing renewable energy technologies must be considered for effective policy and renewable energy project implementation. Suggested measures by Amigun et al. (2011: 7) include the following:

- To overcome regulatory challenges establishing a single authority tasked with coordinating regulatory requirements could help streamline the processes of implementing effective policies.
- Public awareness about the economic, social and environmental benefits of renewable energy technology must be conducted so that informed decisions can be made. This may help streamline the development of projects.
- The provision of financial mechanisms which support renewable electricity generation cannot be ignored. Investment needs to be made with respect to "capacity building, skills development and technology transfer". Increased understanding of renewable energy generation and active research in this field will better inform policies and allow for easier implementation (Amigun et al., 2011: 7).

Table 4.56 and Table 4.57 show a statistically significant relationship between the number of respondents who were willing to pay for start-up costs and maintenance costs for solar energy and household income. More than half of the poorer households (household income less than R2 000 per month) were not willing to pay at all. Similar findings also emerged during the focus group discussion where participants expressed that government should assist with the costs of solar energy technology because there is a high willingness to use it. This is also asserted by Amigun et al. (2011: 7) who state that governments play a major role with respect to providing renewable energy technologies to the poor.

5.7 Conclusion

In conclusion, the results of this study show that access to better energy is seriously needed in the community for cooking, heating and lighting activities. Current traditional sources of energy used in this community have harmful social and environmental effects, and are generally hazardous. It was indicated that an improved energy situation would allow the community to engage in uplifting socio-economic activities. The challenges of renewable energy provision include start-up and maintenance costs in this community due to high poverty in the area.

However, as suggested by the literature, this can be overcome through external funding, green financial investments and government subsidies.

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The results presented reveal that assessing the attitudes and challenges with respect to solar energy is of great importance, especially when considering the implementation of clean energy in poor communities. It is also of value when assessing the current forms of energy used in these communities and their implications for human and environmental health. As mentioned earlier, South Africa has potential for the harnessing of solar energy to provide sustainable energy, especially in poor communities. This study also tests the viability of implementing solar energy in poor communities as a means to provide sustainable and safer forms of energy. An important part of this study was to examine the attitudes and perceptions towards solar energy in order to ascertain the willingness of poor communities to use solar energy for household purposes as an alternative source. The aim of this chapter is to summarise the key findings in relation to the objectives, and to forward recommendations based on the findings of this study.

6.2 Summary of Key Findings

The socio-economic and demographic profile results of this study indicate that there are high levels of poverty in the Inanda community. It was found that overall household incomes remain very low. When the average age of the community was evaluated, it was found that the majority of the community were of a generation that is capable of working. Low-skilled labour is a common occupation; however, a large proportion of the community remains unemployed. There are very few sources of additional income. It was found that child grants are relied upon for additional income. This finding also emerged during the focus group discussion. Education levels are also very low in the community. Most of the community has only completed high school with a very small proportion that had some form of formal or higher education.

Common energy sources used in the community were electricity, fuelwood, paraffin, gas and candles. The key findings indicate that households in Inanda use a range of energy sources but rely on electricity as the main energy source. In terms of the energy options, affordability is the main influencing factor in relation to choice. Furthermore, poorer households tend to use less costly but more unsustainable energy sources such as paraffin, candles, gas and fuelwood. The respondents supported the use of solar energy but identified several challenges associated with solar energy usage such as start-up costs, maintenance and reliability.

The first objective of this study was to examine current energy uses and ascertain whether alternative sources are being used. As indicated earlier, Inanda was used as a case study of a peri-urban community. It was found that cooking, lighting and heating are the three most prioritised activities for which energy is required in a household. Main sources of energy used for cooking include electricity and fuelwood. For lighting purposes, the main sources of energy included electricity and candles. For heating, the main sources of energy included electricity, paraffin and gas. It can be deduced that in one household, multiple sources of unsustainable energy use occur for the three prioritised activities in the community. Also observed were a number of illegal connections to the electricity grid. It emerged during the focus group discussion that this was a major challenge in the community. With regard to alternate sources of energy, it was found that this is not a common practice in the community as only one household utilises solar energy, and it was noted that this source was purchased. However, the focus group discussion indicated that there was use of solar geysers in some households but these were considered suitable as the temperature of the water was largely weather-dependent. The method used to obtain current energy sources was also investigated and respondents indicated that electricity, paraffin, gas and candles were purchased, while fuelwood was generally collected from nature. It was also indicated that these sources are used for convenience as well as affordability. During the focus group discussion, it emerged that there were many difficulties with the use of gas and candles in particular. Participants stressed that the cylinders leaked very easily and caused explosions. The cylinders also needed to be refilled regularly and far distances had to be travelled; lastly, participants complained that the use of gas left them with severe headaches. Candles also affected the health of users, causing particularly eyesight problems among students who were studying. Fuelwood, although indicated as a favourable and affordable source, was also very time-consuming to collect and resulted in indoor pollution as well as health consequences.

The second objective was to critically examine the gaps and limitations in terms of the promotion of solar energy currently in Inanda. After engaging with the community about the benefits of solar energy, it was found that there was a positive attitude with respect to solar energy implementation and general willingness to use it. However, affordability does present a barrier to its implementation. Respondents can only afford to contribute very little to the start-up and maintenance costs for renewable energy technology. A large proportion is not willing to pay at all for the implementation of solar energy. The costs associated with renewable energy technology are a common barrier in large-scale implementation of the technologies (Disenyana et al., 2010; Chang et al., 2011). However, as mentioned earlier, Nguyen (2007: 1) asserts that this type of technology may be advantageous over conventional energy supply especially in poor communities, because they may be situated closer to the demands, thereby reducing transmission costs as well as energy and capacity loss. During the focus group discussion, further willingness to use solar energy emerged. Participants indicated that solar electricity in particular would be very beneficial to them. Women especially indicated that it would allow them more time for activities such as education, crafting, catering, sewing and business opportunities.

The third objective was to identify and assess the awareness of the challenges and opportunities that exist for solar energy uptake in peri-urban areas. As mentioned above, respondents had a basic idea of what solar energy was. Some respondents indicated that it could be unreliable, may result in inadequate energy supply and that cost could be a problem. Less than half of the respondents recognized the benefits of alternate energy. Those that did recognize benefits revealed that the provision of solar energy in the form of electricity would assist with household activities and chores. The focus group discussion indicated that there was a high willingness to use solar energy; however, it was stressed that communities need more insight into the benefits and how to use solar energy technologies. As mentioned earlier, affordability for solar energy technologies remains a limiting factor, and should be addressed at a regulatory level.

The last objective was to forward recommendations based on the research findings. These are discussed in the section below.

6.3 Recommendations

The socio-economic and demographic profile findings reveal that there are high levels of unemployment and poverty in the community and very low levels of education. In addition, there were also very high levels of energy poverty. The dangers associated with the current energy sources could be a factor limiting the socio-economic development of poor communities. It is recommended that provision of more energy and sustainable forms of energy could help improve socio-economic status of poor communities. Karekezi and Kithyoma (2002: 12) indicate that significant time and effort is made in the collection of resources for energy. Implementing clean energy technologies could uplift communities, by providing more energy and allowing more time for income-generating activities, thereby contributing to socio-economic development in these communities. This is further asserted by Wamukonya (2007: 5), who justifies the use of solar energy by emphasizing that it leaves more free time for communities to engage in productive and constructive activities in their lives, enabling further development of individuals and communities. To further address the unemployment levels, more research should be carried out to determine technical and practical skills within these communities, so that future employment needs can be met. It would be useful to implement training programmes that will empower individuals in the community, especially the youth, in manufacturing clean energy technologies and educating communities on how to use them. Also, a further look into the factors constraining the community in engaging in other income-generating activities should be taken, to allow development practitioners to incorporate this in their development programmes.

The provision of renewable energy in poor areas will not only provide more energy or safer energy, but will also help develop the country's energy sector. As mentioned earlier, Gujba et al. (2012: 2) assert that there is particularly huge potential for solar energy which can help develop the energy sector. They further stipulate that provision of clean energy sources has potential to upgrade the infrastructure in poor areas. Cleaner technologies also play a role in contributing to a low-carbon future which can help Africa achieve its commitment to reduce greenhouse gas emissions, thereby mitigating climate change.

As mentioned earlier, the use of solar energy technologies is highly advantageous because hot water and electricity can be produced at the same time. This is particularly pertinent to the needs of this community. During the focus group discussion, it emerged that the communities will have more time for income-generating activities if they were provided with solar electricity. Furthermore, fewer pollutants are produced when using solar energy and it is sometimes faster than conventional energy (Sen, 2004: 21). Although this type of energy application is used mostly for domestic purposes, it can also be harnessed and utilised commercially. This commercial use can be adapted to suit the needs of communities with respect to their livelihoods. The energy can be harnessed and utilised for home businesses, for example. In general, access to a sustainable energy will give the community a variety of options for livelihoods and this is will increase household income.

A key finding of this study mentioned earlier is that poor communities not only use unsafe sources of energy, but multiple combinations of unsafe sources. Candles, for example, are commonly used for lighting. Given the dangers and hazards associated with candles, it is recommended that solar lamps and other solar lighting appliances should be considered for the community as a means of replacing this source. Fuelwood, gas and paraffin are also hazardous substances that are heavily relied upon. The focus group discussion also indicated that these sources are unsafe and have resulted in explosions and health impacts. A call should therefore be made to attempt to educate communities on their current energy uses and introduce clean energy technologies in an attempt to replace the current ones.

Another significant finding of this study is that there is a lack of awareness with respect to solar energy and its benefits. The results show that poor communities are not familiar with solar energy technologies. More education is needed around solar energy as a cleaner and more sustainable option as opposed to the current energy sources used in these communities. More awareness also needs to be created on the prospects and benefits of renewable energy in general, especially with respect to the environmental benefits. It emerged during the focus group discussion that there would be greater willingness to use solar energy if community workshops were held with respect to how solar energy works. It was indicated that there was a need for more education regarding solar energy use to create a shift away from conventional sources of energy in poor communities. It is suggested that government should initiate more solar energy projects in these communities and generate socio-economic development by engaging communities during the manufacturing process. High willingness to participate in these activities emerged during the focus group discussion. Respondents indicated that it would help alleviate unemployment levels in the community. Furthermore, it would allow for skills development and help educate the community about solar energy.

The implementation of clean energy and for the purposes of this study, solar energy, is associated with high implementation costs. Poor communities can only afford to contribute very little to these costs and as indicated by the findings, some cannot contribute at all. A recommendation is that government and regulatory bodies take cognizance of this limitation and incorporate it into policy-making. Although South Africa has a number of renewable energy policies and initiatives, when designing policies, Amigun et al. (2011: 7) stipulate that the identification of barriers to implementing renewable energy technologies must be considered for effective policy and implementation. The provision of financial mechanisms which support renewable electricity generation cannot be ignored. This will allow for the implementation of policies that promote diversification of energy provision, such as the White Paper on Renewable Energy, 2003. Amigun et al. (2011: 7) also suggest that investment needs to be made with respect to “capacity building, skills development and technology transfer”. Increased understanding of renewable energy generation and active research in this field will better inform policies and allow for easier implementation policies and projects. This will subsequently have a positive effect on economic growth and job creation in South Africa (Amigun et al., 2011: 7).

6.4 Conclusion

The key findings of this study indicate that the provision of clean energy, particularly solar energy for poor areas, will have the following implications for poor communities:

- It will improve access to energy;
- It will save time and allow more time for income-generating activities, thereby improving the quality of life of consumers;
- It will allow access to safer forms of energy, and
- It will reduce greenhouse gas emissions that are produced by their current sources, thereby improving environmental health.

The findings further confirm the high potential for the implementation of solar energy in poor communities due the high level of willingness to use solar energy technology, as well as the socio-economic development that can result. The major limiting factor for large-scale implementation as indicated in the literature and the research findings is the high costs. If more effort can be made to attain funding for such projects, solar energy projects can be a major success for poor communities. Not only will this result in the development of poor communities, it will also help the renewable energy industry mature as well as promote environmentally friendly behaviour.

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Name:

Appendix 1 - Energy Needs Analysis Questionnaire

Community Name: **Inanda** Location: ______________________________________ Enumerator Name: __________________________________ Date Completed: __________________________

____

I am undertaking a survey of energy needs in your community on behalf of a student, for a post graduate degree at the University of KwaZulu-Natal. May I ask you a few questions in this regard? Your answers will be treated confidentially and anonymously. If at any time during the interview you feel that you do not wish to continue, please feel free to do so. Thank you for agreeing to be interviewed.

____

1. SECTION A: SOCIO-ECONOMIC AND DEMOGRAPHIC PROFILE OF RESPONDENTS

Person ID	A1. What is (…')'s age? *(Years)*	A2. What is (…)'s sex? *(Male or Female)*	A3. Who is the household head? *(indicate with an X)*	A4. Has (…) been absent more than 3 months in past 12 months? *(Yes or No)*	A5. What is (…)'s employment status? *(use codes)*	A6. What is the highest educational level attained? *(persons > 5 years only)* *(Education codes)*	A7. What is the overall household income (in Rands)? *(use codes)*
01							
02							
03							
04							
05							
06							
07							
08							
09							
10							
11							
12							
13							
14							

Codes A5
01 Employed
02 Unemployed
03 Self-employed
04 Retired
05 Under age

Codes A7 (in Rands)
00 None
01 1-1000
02 1001-2000
03 2001-3000
04 3001-4000
05 4001-5000
06 5001-6000
07 6001-7000
08 7001-8000
09 8001-9000

Codes A6
01 No formal Education
02 Partial primary
03 Primary completed
04 Secondary- Grade 10
05 Secondary completed
06 Certificate/ diploma
07 Undergraduate degree

2. SECTION B: ENERGY PROFILE OF HOUSEHOLDS

B1. Which sources of energy do you currently use (multiple responses permitted – ask for each)

01 Electricity		02 Fuelwood		03 Gas		04 Paraffin		05 Charcoal		06 Coal		07 Candles		08 Dung	09 Biomass	
10 Biofuel		11 Generator		12 Petrol		13 Car Battery		14 Solar		15 Hydro		16 Wind		17 Other (specify)		

I would now like to ask you a few questions regarding cooking, lighting and heating specifically.

Cooking

Source of energy	B2. Which source do you use for cooking? *(please tick)*	B3. Rank the source/s used for cooking in order of importance *(use codes)*	B4.1 How do you obtain this source/s? *(use codes)*	B4.2. If purchased, where do you purchase the source/s from? *(use codes)*	B4.3. How much (in Rands) do you pay for this source/s per month? *(use codes)*	B5. Why do you choose this source for cooking? *(multiple responses permitted – ask for each)*
01 Electricity						
02Fuelwood						
03 Gas						
04 Paraffin						
05 Charcoal						
06 Coal						
07 Biomass						
08 Biogas						
09 Biofuel						
10 Dung						
11 Generator						
12 Petrol						
13 Car battery						
14 Solar						
15 Hydro						
16 Wind						
17 Other (specify)						

Codes B3
01 Most important
02 Important
03 Neutral
04 Unimportant
05 Very unimportant

Codes B4.1
01 Collected from nature
02 Purchased
03 Other (specify)

Codes B4.2
01 Village Friends/neighbors
02 Spaza shop
03 Village store
04 Village market

Codes B4.3
01 <R100
02 R101-R200
03 R201-R300
04 R301-R400
05 R401-R500
06 R501-R600

Codes B5
01 Convenient
02 Easily accessible
03 Only option available
04 Requires time for less preparation

Source of energy	B6.1 The cost of (…) is a major concern	B6.2 (…) is associated with health implications	B6.3 (…) is unreliable	B6.4 There is a poor supply of (…)	B6.5 (…) causes pollution	B6.6 The use of (…) is too time consuming	B6.7 (…) is environmentally friendly	B6.8 (…) is easily accessible	B6.9 (…) is easy to maintain	B6.10 (…) is easy to use	B6.11 (…) is safe to use	B6.12 Access to (…) is safe
01 Electricity												
02 Fuelwood												
03 Gas												
04 Paraffin												
05 Charcoal												
06 Coal												
07 Biomass												
08 Biogas												
09 Biofuel												
10 Dung												
11 Generator												
12 Petrol												
13 Car battery												
14 Solar												
15 Hydro												
16 Wind												
17 Other (specify)												

Lighting

Source of energy	B7. Which source do you use for lighting?	B8. Rank the source/s used for lighting in order of importance	B9.1 How do you obtain this source/s?	B9.2 If purchased, where do you purchase the source/s from? *(use codes)*	B9.3. How much (in Rands) do you pay for this source/s per month? *(use codes)*	B10. Why do you choose this source for lighting? *(multiple responses permitted –*

	(please tick)	*(use codes)*	*(use codes)*			*ask for each)*
01 Electricity						
02 Fuelwood						
03 Gas						
04 Paraffin						
05 Charcoal						
06 Coal						
07 Candles						
08 Biomass						
09 Biogas						
10 Biofuel						
11 Dung						
12 Generator						
13 Petrol						
14 Car battery						
15 Solar						
16 Hydro						
17 Wind						
18 Other (specify)						

Codes B8
01 Most important
02 Important
03 Neutral
04 Unimportant
05 Very unimportant

Codes B9.1
01 Collected from nature
02 Purchased
03 Other (specify)

Codes B9.2
01 Village Friends/neighbors
02 Spaza shop
03 Village store
04 Village market
05 Vendor/hawker
06 Pension Market

Codes B9.3
01 <R100
02 R101-R200
03 R201-R300
04 R301-R400
05 R401-R500
06 R501-R600
07 R601-R700
08 R701-R800

Codes B10
01 Convenient
02 Accessible
03 Only option available
04 Requires time for less preparation

Heating

Source of energy	B11. Which source do you use for heating? (please tick)	B12. Rank the source/s used for heating in order of importance (use codes)	B13.1 How do you obtain this source/s? (use codes)	B13.2 If purchased, where do you purchase the source/s from? (use codes)	B13.3. How much (in Rands) do you pay for this source/s per month? (use codes)	B14. Why do you choose this source for lighting? (multiple responses permitted – ask for each)
01 Electricity						
02 Fuelwood						
03 Gas						
04 Paraffin						
05 Charcoal						
06 Coal						
08 Biomass						
09 Biogas						
10 Biofuel						
11 Dung						
12 Generator						
13 Petrol						
14 Car battery						
15 Solar						
16 Hydro						
17 Wind						
18 Other (specify)						

Codes B12
01 Most important
02 Important
03 Neutral
04 Unimportant
05 Very unimportant

Codes B13.1
01 Collected from nature
02 Purchased
03 Other (specify)

Codes B13.2
01 Village
Friends/neighbors
02 Spaza shop
03 Village store
04 Village market

Codes B13.3
01 <R100
02 R101-R200
03 R201-R300
04 R301-R400
05 R401-R500

Codes B14
01 Convenient
02 Accessible
03 Only option available
04 Requires time for less preparation

B38. Rate the following statements with regards to your existing energy sources for heating? **(00=I do not know, 1=Agree, 2=Strongly agree, 3=Neutral, 4=Disagree, 5=Strongly disagree,)**

Statements	B15.1 The cost of (…) is a major concern	B15.2 (…) is associated with health implications	B15.3 (…) is unreliable	B15.4 There is a poor supply of (…)	B15.5 (…) causes pollution	B15.6 The use of (…) is too time consuming	B15.7 (…) is environmentally friendly	B15.8 (…) is easily accessible	B15.9 (…) is easy to maintain	B15.10 (…) is easy to use	B15.11 (…) is safe to use	B15.12 Access to (…) is safe
01 Electricity												
02 Fuelwood												
03 Gas												
04 Paraffin												
05 Charcoal												
06 Coal												
07 Biomass												
08 Biogas												
09 Biofuel												
10 Dung												
11 Generator												
12 Petrol												
13 Car battery												
14 Solar												
15 Hydro												
16 Wind												
17 Other (specify)												

3. SECTION C: RESPONDENT PERCEPTIONS OF ALTERNATE ENERGY

C1.1 Are you aware of alternate energy?

01 Yes	02 No

C1.2 If yes, what in your opinion, is alternate energy?

____

____

C1.3 If yes, what types of energy do you consider to be alternative?

____

____

____

C1.4. What makes it an alternative source of energy?

____

____

C2. What green/environmentally friendly sources of energy are you aware of? (Multiple responses permitted-ask for each)

00 None		01 Solar		02 Wind		03 Hydro		04 Biofuel		05 Biomass		06 Biogas		07 Other (specify)	

01 Radio		02 Television		03 Magazine		04 Newspaper		05 Books		06 Internet		07 School		08 Family member/ friends/ community member	
09 Councilor		10 Place of work		11 Other (specify)											

C3. Where did you get this information from? (Multiple responses permitted-ask for each)

C4.1 Would you use alternative sources of energy?

C4.2 If no, state why?

01 Yes	02 No

____

C4.3 If yes, which source/s would you use? (Multiple responses permitted-ask for each)

01 Solar		02 Wind		03 Hydro		04 Biofuel		05 Biomass		06 Biogas		07 Other (specify)	

C4.4. If yes, which activities would you use the source of energy for? (Multiple responses permitted-ask for each)

01 Cooking		02 Lighting		03 Heating		04 Crafting		05 Radio		06 Television		07 Charge batteries		08 Sewing		09 Studying	

10 Reading		11 Refrigeration		12 Leisure		13 Other (specify)	

C5. Rate the following statements with regards to alternate energy. **(00=I do not know, 1=Agree, 2=Strongly agree, 3=Neutral, 4=Disagree, 5=Strongly disagree)**

Statements	C5.1 …energy will be cost effective	C5.2 …energy will be safe to use	C5.3 ….energy will be reliable	C5.4 The supply of … energy will be poor	C5.5 …energy will cause pollution	C5.6 …energy will be environmentally friendly	C5.7 … energy will have less health impacts	C5.8 …energy will be easily accessible	C5.9 …energy will be easy to maintain	C5.10 Using …energy will conserve time
01 Solar										
02 Wind										
03 Hydro										
04 Biofuel										
05 Biogas										
06 Biomass										
07 Nuclear										
08 Other (specify)										

C6. How much (in Rands) would you be willing to pay as startup costs for alternate energy?

01 <R100		02 R101-R300		03 R301-R500		04 R501-R700		05 R701-R900		06 R901-R1100		07 R1101-R1300		08 R1301-R1500	
09 R1501-R1700		10 R1701-R1900		11 Don't know		12>R1900 (specify)									

C7. How much (in Rands) would you be willing to pay for alternate energy per month?

01 <R100		02 R101-R300		03 R301-R500		04 R501-R700		05 >R700 (specify)	

C8. 1 Are you aware of any problems associated with using alternate energy?

C8.2 If yes, please specify.

____

C9.1 Do you know of any benefits of using alternate energy?

01 Yes	02 No

C9.2 If yes, please specify.

___

I would now like to ask you additional questions about solar energy.

C10.1 Are you aware of solar energy?

01 Yes	02 No

C10.2 If yes, what in your opinion is solar energy?

___

C11. Where did you get information about solar energy (specifically) from? (Multiple responses permitted-ask for each)

01 Radio		02 Television		03 Magazine		04 Newspaper		05 Books		06 Internet		07 School		08 Family member/ friends/ community member	
09 Councilor		10 Place of work		11 Other (specify)											

C12.1 Would you use solar energy?

01 Yes	02 No

C12.2 If no, why not?

___

C13.3. If yes, which activity/s would you use the solar energy for? (Multiple responses permitted-ask for each)

01 Cooking		02 Lighting		03 Heating		04 Crafting	05 Radio		06 Television		07 Charge batteries		08 Sewing		09 Studying	
10 Reading		11 Refrigeration		12 Leisure		13 Other (specify)										

C14. How much (in Rands) would you be willing to pay as startup costs for solar energy?

01 <R100		02 R101-R300		03 R301-R500		04 R501-R700		05 R701-R900		06 R901-R1100		07 R1101-R1300		08 R1301-R1500	
09 R1501-R1700		10 R1701-R1900		11 Don't know		12>R1900 (specify)									

C15. How much (in Rands) would you be willing to pay for solar energy per month?

01 <R100		02 R101-R300		03 R301-R500		04 R501-R700		05 >R700 (specify)	

THANK RESPONDENT FOR TIME AND COOPERATION AND END INTERVIEW

Appendix 2 - Cronbach's Data Reliability Analysis

Cronbach's alpha measures how well a set of items (or variables) measures a single unidimensional latent construct. When data have a multidimensional structure, Cronbach's alpha will usually be low. Technically speaking, Cronbach's alpha is not a statistical test - it is a coefficient of reliability (or consistency).

Cronbach's alpha can be written as a function of the number of test items AND the average inter-correlation among the items. Below, for conceptual purposes, we show the formula for the standardized Cronbach's alpha:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Here N is equal to the number of items, c-bar is the average inter-item covariance among the items and v-bar equals the average variance.

One can see from this formula that if you increase the number of items, you increase Cronbach's alpha. Additionally, if the average inter-item correlation is low, alpha will be low. As the average inter-item correlation increases, Cronbach's alpha increases as well.

This makes sense intuitively - if the inter-item correlations are high, then there is evidence that the items are measuring the same underlying construct. This is really what is meant when someone says they have "high" or "good" reliability. They are referring to how well their items measure a single unidimensional latent construct.

Thus, if you have multi-dimensional data, Cronbach's alpha will generally be low for all items. In this case, run a factor analysis to see which items load highest on which dimensions, and then take the alpha of each subset of items separately.

Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.70 or higher is considered as "acceptable".

The results are presented below.

(Introduction to SAS. UCLA: Academic Technology Services, Statistical Consulting Group, accessed November 24, 2007)

Section B – 13: Rating of energy sources

Case Processing Summary

		N	%
Cases	Valid	200	100.0
	Excluded[a]	0	.0
	Total	200	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.907	75

Section C: Rate the following statements with regards to alternate energy

Case Processing Summary

		N	%
Cases	Valid	200	100.0
	Excluded[a]	0	.0
	Total	200	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.866	10

Section C – 27: Rating of the following statements with regards to solar energy ??

Case Processing Summary

		N	%
Cases	Valid	200	100.0
	Excluded[a]	0	.0
	Total	200	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.805	12

The overall reliability scores for each section are high (greater than 0.70). This indicates a high degree of acceptable, consistent scoring for the different ordinal categories for this research. All of the ordinal categories have (high), acceptable reliability values.