A COMPARATIVE ASSESSMENT OF THE SOCIO-ECONOMIC AND SPATIAL FACTORS IMPACTING THE IMPLEMENTATION OF RENEWABLE ENERGY IN MARGINALISED COMMUNITIES: THE CASE OF INANDA AND BERGVILLE

by

SUVESHNEE MUNIEN

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PREFACE

The work described in this thesis was carried out in the School of Agriculture, Earth and Environmental Sciences, University of KwaZulu-Natal, Westville campus, from January 2011 to December 2016, under the supervision of Professor Urmilla Bob and Dr Alan Matthews.

This study represent original work by Suveshnee Munien and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

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I, Suveshnee Munien declare that:

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2. This thesis has not been submitted for any degree or examination at any other university.

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DECLARATION 2 - PUBLICATIONS

The results obtained in this study and key literature have been published in peer-reviewed and accredited journals:

Publication 1

Munien, S. and Ahmed, F. 2012. A gendered perspective on energy poverty and livelihoods- Advancing the MDGs in developing countries. Agenda 26, 112-123.

Publication 2

Munien, S. 2014. Rural energy profiles and the role of solar energy in climate change mitigation–a gendered perspective. Agenda 28,115-126.

Publication 3

Munien, S. 2015. Solar thermal cookers: opportunities and constraints in a rural community, KwaZulu-Natal, South Africa. Southern African Journal of Energy [*in review*]

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ABSTRACT

Access to modern, safe and cost effective energy is undisputed in its ability to facilitate development among poor countries, however, achieving energy security is plagued by challenges. Renewable energies and technologies have been described to address multiple needs and is implemented widely in developing contexts. However, the implementation of renewable energy sources and technologies are rarely guided by an understanding of community and household socio-demographic and energy profiles. Although South Africa displays high levels of electrification, many poor communities fail to sustain their use of modern sources such as electricity due to costs. This results in fuel-switching which is associated with the use of fuels such as fuelwood and paraffin, and raises health and safety concerns, in relation to the health of women and children in particular. Similarly, literature establishes the linkages between income, level of education, household size and reliance on specific energy sources. More importantly, studies show that energy profiles and willingness to adopt renewable energy sources is also influenced by factors such as culture, tradition and energy policy. Additionally, there is a dearth of empirically based studies that profile household energy practices, attitudes and perceptions. This study adopted a comparative approach in examining household energy profiles, practices and needs in relation to peri-urban (Inanda) and rural (Bergville) communities in KwaZulu-Natal, South Africa. A mixed methodological approach was adopted, and 800 households (400 in Inanda and 400 in Bergville) were profiled in relation to socio-economic conditions, energy profiles, and attitudes and perceptions of renewable energy sources. These findings were complemented by two focus group discussions (one in each of the communities), involving specific activities, including participatory mapping exercises. The households for the survey interviews were chosen using a multi-stage, spatially-based random sampling approach. The focus group discussion participants were purposively chosen. Results show that households and respondents from both communities display significant socio-economic and energy-related stressors, however, these effects are more pronounced within Bergville. The differences in household size and income between Bergville and Inanda resulted in significantly different energy behaviours. Households in Bergville show a higher reliance on collected, cheaper energy sources, for example, fuelwood and dung while Inanda households preferred paraffin, gas and electricity. This study also shows that household income and size, and respondents level of education, sex and employment status influenced level of awareness of renewable energy sources. Furthermore, the simulated indicators demonstrate that increases in household income are associated with an upward progression on energy ladders, specifically the increased consumption of and expenditure on modern sources of energy. Although awareness of renewable energy sources was limited, respondents did indicate a willingness to adopt and pay for technologies such as solar panels and cookers. Nevertheless, both groups of respondents associated the use of renewable energies with the idea of being poor. These strong socio-cultural factors may also prevail as potential obstacles in the up-take and use of renewable energy technologies. Additionally, respondents highlighted their reluctance with solar water heaters as they only meet one of their many energy needs. Concern was also raised in relation to the up-take of solar thermal cookers, specifically regarding its size. In this regard, energy policy needs to implement technologies that offer multiple energy services. A key finding of this study is that renewable energy technologies have significant potential in alleviating the energy-related stressors and lived experiences of energy poverty amongst the Bergville and Inanda communities. Moreover, targeted awareness campaigns may also improve the sustained use of these technologies. A key contribution of this study is the establishment of a conceptual model to inform the implementation of renewable energy and associated technologies within the rural and peri-urban contexts of South Africa.

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LIST OF ABBREVIATIONS

ABED	Adult Based Education
ABM	Area Based Management
ARI	Acute Respiratory Disease
CL	Confidence Limit
CO	Carbon monoxide
CO^2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
DME	Department of Mineral Energy
DoE	Department of Energy
DPLG	Department of Provincial and Local Government
EA	Enumerator Area
EDI	Energy Development Index
ESKOM	Electricity Supply Commission
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation
FIT	Feed in Tariff
HDI	Human Development Index
HIV/AIDS	Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
Gj	Gigajoules
GNP	Gross Net Product
Gt	Gigaton
GW	Gigawatts
IAP	Indoor Air Pollution
ICT	Information Communication Technology
IDP	Integrated Development Plan
IEA	International Energy Agency
IEP	Integrated Electrification Plan
IFAD	International Fund for Agricultural Development

INK	Inanda Ntuzuma and KwaMashu
IPCC	International Panel for Climate Change
IPP	Independent Power Producer
IREA	International Renewable Energy Agency
ISRDP	Integrated Sustainable Rural Development Programme
J/s	Joules per second
Kg	Kilogram
KWh	Kilowatt hour
KZN	KwaZulu-Natal
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MW	Megawatt
MWh	Megawatt hour
NERSA	National Energy Regulator of South Africa
NO_x	Nitrous oxides
NSWHP	National Solar Water Heater Programme
OE	Oil equivalent
PGIS	Participatory Geographic Information System
PPP	Purchasing Power Parity
PQLI	Physical Quality of Life Index
PV	Photovoltaic
RDP	Reconstruction and Development Programme
RET	Renewable Energy Technology
REIPPP	Renewable Energy Independent Power Producers Programme
REEEP	Renewable Energy and Energy Efficiency Partnership
RSPM	Respirable Suspended Particulate Matter
SAPP	Southern African Power Pool
SD	Standard Deviation
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SET	Solar Energy Technology
SLA	Sustainable Livelihoods Approach

SPSS	Statistical Package for the Social Sciences
SSA	Statistics South Africa
STT	Solar Thermal Technology
SWH	Solar Water Heater
TB	Tuberculosis
TES	Thermal Energy Storage
TW	Terawatt
TWh	Terawatt hour
UKZN	University of KwaZulu-Natal
URP	Urban Renewal Programme
USD	United States Dollar
UN	United Nations
UNDP	United Nation Development Plan
UK	United Kingdom
VOC	Volatile Organic Compound
WEC	World Energy Council
WHO	World Health Organisation

CHAPTER ONE
INTRODUCTION

1.1 Preamble

Access to sustainable, cost-effective and reliable energy sources is deemed to play a fundamental role in facilitating socio-economic development by unlocking several livelihood options, especially amongst the poor (Bastakoti, 2003; Chaurey et al., 2004; Modi et al., 2006; Haw & Hughes, 2007; Pegels, 2010; Kaygusuz, 2011; Sovacool, 2012; Ang et al., 2015). Consequently, over the last decade the energy discourse has undergone several advances, particularly in relation to sustainable development and climate change concerns (Brown & Huntington, 2008; Parajuli, 2011; Nussbaumer et al., 2012). In this regard, several studies highlight the importance of securing access to modern energy services, which include improved maternal and child health due to a reduction in indoor pollution and alleviation of physical burdens associated with the collection and use of traditional energy sources (Clancy et al., 2003; United Nations Development Plan [UNDP], 2004; Kaygusuz, 2011); improved access to education and educational achievement among women and children due to extended work hours (Denton, 2002; Barnes et al., 2011; Fredman et al., 2016); and improved capacity to diversify livelihood strategies, thereby enhancing the potential to generate income (Kanagawa & Nakata, 2007; Barnes et al., 2011; Nussbaumer et al., 2012). Accordingly, access to energy has the potential to advance a number of development objectives embodied in the Millennium Development Goals (MDGs) (Modi et al., 2006; Openshaw, 2010; Munien & Ahmed, 2012), and more recently the Sustainable Development Goals (SDGs) (Lu et al., 2015; Bongaarts, 2016; Costanza et al., 2016).

Even though energy is recognised to have a central role in sustaining livelihoods, almost 2 billion people worldwide do not have access to modern and cost-effective energy (Kaygusuz, 2011). The lack of access to and availability of energy options signifies a global phenomenon referred to as energy poverty (Sovacool et al., 2012). Although there are several definitions of energy poverty, few capture the complexities and underlying linkages. Masud et al. (2007: 47), for example, define energy poverty as “the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development”. Similarly, Sovacool et al. (2012) define energy poverty as the deprivation of opportunities and ability to engage in modern lifestyle practices. Buzar (2007) suggests that energy poverty captures the interactions of economic, institutional and technical structures within the economy and is therefore a fundamental discourse in poverty and development studies.

Sagar (2005) suggests that energy poverty represents a critical discourse, with the impacts being most discernible in developing countries. Similarly, temporal and geographical differences in the level of energy poverty have been well-documented (Karekezi, 2002; Barnes et al., 2011; Marktanner & Salman, 2011; Nussbaumer et al., 2012; Bouzarovski & Petrova, 2015; González-Eguino, 2015) and studies have shown that sub-Saharan Africa and South Asia have the largest concentration of energy poor individuals worldwide (Kowsari & Zerriffi, 2011). Ironically, the African continent holds 7% of global fossil fuel resources (coal, oil and gas), and has substantial potential to generate renewable energies, including solar and geothermal energy (Kaygusuz, 2009). The various definitions of energy poverty highlight complexities such as large-scale poverty, lack of infrastructure and capital, and uneven distribution of, and access to resources which have constrained progress in the energy sector within developing countries (UNDP, 2004). More recent energy studies indicate that issues such as energy efficiency, affordability and fuel-switching add to the complexities of attaining energy security (Buzar, 2007; Kaygusuz, 2011; van der Kroon et al., 2013; Day et al., 2016). This suggests that energy security in developing contexts is multi- dimensional and therefore cannot be resolved by simply ensuring physical accessibility to energy sources like electricity.

Energy security, described by Nissing and von Blottnitz (2010) as ‘energisation’, is increasingly seen as an opportunity to address environmental sustainability and socio-economic development simultaneously. Current trends in policy, for instance the White Paper on Renewable Energy (Department of Mineral Energy [DME], 2003), suggest a shift towards Renewable Energy Technologies (RETs), such as solar energy, to address socio-economic and environmental sustainability goals concomitantly. Several studies show that RETs such as solar water heaters (eThekwini Municipality, 2013), photovoltaic (PV) panels and solar cookers (Saxena et al., 2011), and gasifiers (Openshaw, 2010) have been successfully integrated into households and service a portion of the household energy needs. The present study explores the factors that influence household energy profiles and behaviours, and renewable energy use in poor rural and peri-urban contexts. In doing so, household energy profiles were investigated as well as the attitudes towards and willingness to embrace renewable energy options, such as solar energy. According to Solangi et al. (2011), solar energy can be defined as clean energy that does not impact the environment negatively or add to global warming and is therefore considered a suitable alternative form of energy that can be used to improve overall quality of life.

In countries such as South Africa, which display significant contrasts in the delivery of and access to basic services, energy debates have evolved into more complex issues such as affordability and sustaining the use of modern, environmentally-friendly and cost-effective energy sources within poor households (Madubansi & Shackleton, 2007). According to Eberhard (2010), approximately 3.4 million households do not have access to electricity in South Africa. Roos (2009) states that 27% of South African households are not electrified, with 54% of rural households being unconnected to the grid. This emphasises the inequalities in service delivery and accessibility across the urban-rural gradient. Kayguzus (2009) asserts that if energy services were to succeed as a tool for poverty reduction, then the needs of the marginalised should be the key focus, and not the supply of energy. Adding to the argument developed above, Buzar (2007) states that providing an energy source alone is not the solution as it fails to address the underlying causes of poverty. The author goes on to state that poor and low-income households lack the capacity to respond to changes in the energy sector. More recent studies indicate that understanding livelihood strategies is fundamental to unpacking the potential of energy services in poverty reduction (Kayguzus, 2011; Bouzarovski & Petrova, 2015). Furthermore, Nussbaumer et al. (2012) state that secured energy access is directly related to securing livelihoods and improved quality of life.

This inability of households to access and sustain the use of modern energy sources such as electricity, is widespread in developing countries and often results in the use of multiple sources to meet energy demands (Madubansi & Shackleton, 2007; Prasad, 2008; Winkler et al, 2010; van der Kroon et al., 2013). The practice of fuel-switching, also referred to as energy hybridisation, suggests that households utilise a specific form of energy to the point where income or financial assets permit (Kowsari & Zerriffi, 2011). One of the key issues emerging from the practice of energy hybridisation is that often modern energy options may be available at the household level but due to financial constraints, the use of these energy options are limited (Winkler, 2005; Madubansi & Shackleton, 2007). Likewise, Kowsari and Zerriffi (2011) indicate that low-income households, in particular, engage in hybridisation practices when income has been exhausted or for activities that may require large amounts of energy (for example, cooking and heating of water). As mentioned earlier, the poor are most at risk to the impacts of energy poverty and the main target of ‘pro-poor’ energy options. However, very little is known about the impacts that modern energy options have on the household; for example, electricity is considered a modern energy source but is often financially inaccessible to many and as a result many poor households revert to the use of traditional energy sources.

To gain a deeper understanding of household energy consumption patterns, various models have been utilised in this study in an attempt to quantify and examine household progression or regression in terms of existing energy models. The most prominent of which is the energy ladder, which was designed specifically for developing households (Hosier et al., 1987). Models such as the energy ladder incorporate patterns of energy behaviour and practices of the poor to provide insight into underlying causes of energy insecurity. van der Kroon et al. (2013) show that fuel-switching or hybridisation of energy choices can be explained using both the energy ladder and processes of energy stacking. These models emphasise the importance of addressing factors such as lack of infrastructure (for example, roads, basic services, and telecommunication), low household income, limited access to information, poor market access, and skills development in alleviating energy insecurity.

Pachauri and Rao (2013) highlight another dimension of energy consumption, that is, the distribution of power within the household, which is as an important factor in energy consumption. These authors suggested that the ability of households to embrace modern forms of energy is impacted by household power dynamics which is influenced by institutional and cultural norms, such as patriarchy (Pachauri & Rao, 2013). Ishihara and Pascual (2009) assert that consultation with marginalised individuals, particularly women, is often limited in terms of energy consumption and decision-making processes within the household. Similarly, Cherni et al. (2007) show that the processes of energy prioritisation and household energy needs are critical factors that should be integrated into energy policy and the development of appropriate technology. This highlights some of the underlying factors that govern energy practices and profiles which are often neglected in energy policy design and planning.

Social scientists suggest that behaviour and the factors that determine attitudes and perceptions are important aspects that need to be considered in energy studies, and they emphasise that changing energy practices involves unpacking the links between human behaviour and technology (Kok et al., 2011; Kastner & Stern, 2015; Romero-Jordán et al., 2016). Cognitive norms and culture influence an individual's behaviour, understanding and preference towards various energy options and technologies (Stephenson et al., 2010). However, according to Wilson and Dowlatabadi (2007), improving levels of awareness and changing attitudes may not necessarily alter an individual's behaviour. Rather, they argue that socio-technical systems and collective transformation processes, such as strengthening livelihood opportunities, are key elements that can promote changes in energy behaviour of the poor.

von Borgstede et al. (2013) show that people are more likely to adopt pro-environmental behaviours when costs are minimised, rather than having an improved understanding of the environmental impacts of their actions. This highlights some of the challenges associated with sustaining the use of modern, safe and environmentally-friendly energy options within low-income communities. In this regard, there is a paucity of information on exactly how low income households respond to changing energy climates and how they prioritise their energy needs. The issues highlighted above bring to the fore the multiple dimensions and complexities associated with addressing energy security, particularly in developing countries. This study attempts to unpack the complexities associated with addressing energy security by examining household energy profiles, practices and preferences, and understanding how prevailing socio-economic, environmental and political factors influence household energy dynamics. An attempt is also made in this study to inform the design of energy implementation strategies for low-income households in peri-urban and rural environments. In recognising that access to energy is a complex issue, this study also provides evidence for the need to address energy related development using more holistic approaches within which the underlying causal factors of energy poverty are seen as opportunities to inform policy and promote sustainable development.

1.2 Motivation for the study

South Africa relies heavily on coal-based electricity to supplement national energy demands. However, growing concerns on the depletion of coal supplies, increased demand for energy and climate change mitigation strategies requires a more sustainable approach to energy provision. Even though South Africa produces the cheapest coal and has the lowest domestic electricity prices worldwide, the majority of poor households still rely on traditional fuels to supplement their lifestyles (Madubansi & Shackleton, 2007). Understanding and revealing critical links among energy sources, climate change and reducing carbon emissions at the household and community level, add value to the development and implementation of alternate energy technologies (Nussbaumer et al., 2012).

Buzar (2007) avers that energy poverty is most prevalent amongst low-income households but is still disproportionately rural in nature. However, Jorgenson et al. (2010), show that the majority of the world's population now reside in urban centres and the migration to urban spaces creates substantial changes in housing, transportation, social epidemiology and social inequalities; thus, challenging the assumption of the 'poor' being primarily rural. Moreover, South Africa's political history of inequality and racial discrimination has produced stark contrasts in socio-economic conditions across urban and rural environments. Based on the above assertions, this study examines household energy profiles in both rural and peri-urban settings to incorporate both contemporary and historical contexts of the term 'poor', and examine the underlying factors that may govern energy insecurity within these households.

Bergville and Inanda were selected as the sample communities for this study, and represent rural and peri-urban contexts, respectively. Inanda is located within the eThekwini Municipality (within the province of KwaZulu-Natal [KZN], in South Africa) and is considered to be one of the most impoverished regions within the Municipality (Department of Provincial and Local Government [DPLG], 2007; Statistics South Africa [SSA], 2011). Additionally, Inanda comprises formal and informal settlement types and is characterised by high levels of unemployment, poverty and Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (HIV/AIDS) infections (DPLG, 2007). The rural community, Bergville, is located within the Okhahlamba Municipality (within the province of KZN, in South Africa) and comprises of seven smaller settlements. Bergville is characterised by high levels of poverty, low household incomes and high unemployment rates (SSA, 2011). The socio-demographic characteristics of Inanda and Bergville are comparable (SSA, 2011), however, they represent different contexts in terms of service delivery and energy profiles, particularly, the use of traditional energy options (Buzar, 2007).

Over the past 10 years, large-scale electrification programmes initiated as part of government's Integrated Electrification Plan (IEP) (DME, 2003) have resulted in increased electrification within the country; however, households continue using multiple sources of energy to supplement their energy needs (Winkler et al,, 2010). Madubansi and Shackleton (2007) attribute this energy mix to financial inaccessibility to appropriate energy infrastructure and technology as well as high-priced monthly electricity costs. If South Africa were to successfully transform from traditional to modern and ultimately renewable or environmentally-friendly energy options, a finer inspection of household level energy practices is crucial. O'Sullivan and Barnes (2006) posit that household energy and socio-economic profiles provide essential information which can be used to facilitate the energy transition, and can serve to develop indicators to inform broader energy policy objectives. Despite almost three decades of probing various measurements of household energy, there is still a lack of understanding around household energy profiles, particularly in the context of the developing world (Kowsari & Zerriffi, 2011).

Whilst various energy sources and carriers are being investigated in an attempt to alleviate the current energy crisis, specifically within poor rural communities, there is currently a paucity of information on the relationships between RETs and rural livelihood sustainability. Although access to energy holds paramount importance in most developing economies, the success of these RETs is dependent on issues of cost, technical know-how, ownership and long-term maintenance (Sovacool & Mukherjee, 2011; Munien & Ahmed, 2012; Munien, 2014). Even though conventional coal-generated electricity remains the dominant source of energy globally, the growing awareness around greenhouse gas emissions and climate change has shifted focus from provision of electricity to the implementation of alternate renewable energy sources such as Solar Thermal Technologies (STTs).

In this regard, the Physics Department at the University of KwaZulu-Natal (UKZN) in collaboration with the Eduard Modlane University in Maputo and the University of Trondheim in Norway initiated a project aimed at developing STTs that may reduce reliance on fossil-fuel based energy and promote the adoption of RETs. It is proposed that installing STTs may catalyse diversification of activities at the household and community level by promoting more sustainable livelihood strategies. In addition to this, it is hoped that the availability of energy will promote gender equality (as women are predominantly involved in energy generating activities such as collecting of wood [Clancy et al., 2003]), improve household abilities to deal with and overcome stresses (climate or otherwise), improve health, and allow for improved access to education.

During the first phase of the project solar thermal cookers that collect and accumulate heat during the day for use after sunset (rather than standard box cookers that are typically based on the concept of positioning the pan in the focus point of a solar concentrator) were developed. The project now aims to develop a range of different types of technologies based on the same principle of heat storage. As indicated earlier, most studies on solar energy examine the technological aspects, such as their cost and functionality, with socio-cultural and environmental aspects being largely neglected. Hence, the need for the present study which aims to assess the suitability of novel STTs within poor communities. Moreover, this study examines the likely impacts of STTs on livelihood strategies at the household level in an attempt to better understand the relationships between energy provision/ access and socio-economic and environmental well-being.

Furthermore, a significant proportion of energy research tends to focus on the technical aspects of the solar machinery/ tools and ignores the social aspects. This motivated the present study to address these gaps in our knowledge of the opportunities and constraints of using solar energy systems in rural and peri-urban households, specifically in the context of Africa. This research will therefore also contribute methodologically to the broader field of energy and development studies. The study's findings and recommendations are envisaged to supplement our understanding of the essential requirements for the implementation of renewable energy. The proposed study will inform South Africa's plan to meet a number of developmental challenges and contribute to the knowledge economy upon which sustainable development depends.

1.3. Research aims and objectives

Given the multiple-dimensions associated with the provision of energy in developing countries, such as South Africa, and the wide scale promotion of renewable energy as a means to meet both developmental and environmental challenges, the aim of this study is:

> To undertake a critical assessment of the socio-economic, environmental and political factors that influence energy security and the implementation of renewable energies, such as solar, in low-income and poor communities within peri-urban and rural contexts.

An overall outcome of this study is to inform future implementation as well as monitoring and evaluation strategies for the sustainable introduction of renewable energies within low-income and poor communities in KZN, South Africa.

The above aim was addressed via the following objectives:

1. **To conduct an energy-based needs analysis for selected poor rural communities at the household and the community level.**
   This establishes the status quo in terms of service delivery, access to resources and facilities and reveals underlying community characteristics which can be used to formulate energy implementation strategies that suit and improve current livelihood strategies. Additionally, demographic variables such as age, income, gender and level of education are examined to provide the overall socio-economic context.

2. **To examine existing energy profiles and their impacts.**
   The household and community energy-mix is reflective of socio-economic and environmental conditions. It is only through understanding existing energy profiles that one can recommend alternative sources of energy that may best improve livelihood structures and achieve goals of social development, sustainability and environmental longevity.

3. **To investigate household preferences and attitudes towards energy sources and the likelihood of integrating renewable energy into their livelihood practices.**
   Livelihood improvement strategies are introduced into poor communities without understanding underlying networks, conflicts and needs. The successful integration of renewable energy into current practices is directly dependent on the levels of awareness, attitudes and perceptions of communities. Also, cultural and traditional structures are often not considered in energy research and development studies, leading to poor suitability and often failure of policies and prototypes introduced within communities. This objective includes an options assessment (preferences towards modern energy options) and examines key factors resulting in fuel-switching.

4. **To examine the perceived impacts and willingness to integrate renewable energy technologies such as the solar thermal cookers into livelihoods practices.**
   A number of studies show that improved service delivery within poor rural communities can contribute to strengthening and diversifying rural livelihood strategies (World Bank, 2004; Beltrán-Morales, 2007; United Nations [UN], 2010). This bottom-up approach to development and improved sustainability at the household and community level can be applied to other aspects of development, poverty alleviation and service delivery in poor communities. This objective involves an impact assessment as well as modelling of future scenarios.

5. **To construct a basic framework that will inform implementation strategies and monitoring and evaluation schemes for renewable energy in poor communities.**
   The results generated from this study are used to formulate a model that highlights the main factors to be considered for the implementation of renewable energy sources and technologies within the South African context.

1.4 Overview of conceptual/ theoretical framework

Since socio-economic development requires a multi-dimensional approach, this study is based on a multi-conceptual/ theoretical framework in order to unpack the key concepts associated with addressing energy security in a sustainable manner. The study draws on three fundamental perspectives: the Sustainable Livelihoods Approach (SLA), political economy and energy poverty concepts. Sustainable livelihood activities are especially important in poor communities that have to identify and implement effective ways to support their livelihoods and escape poverty. It is therefore important to understand the multiplicity of livelihood strategies adopted in poor households, especially as they relate to energy demands. According to the Development Study Group Zurich (2002), the SLA is a tool to improve the understanding of the livelihoods of poor people, issues that affect them and the distinct relationships between these issues. Additionally, access to energy sources (whether in the form of electricity, traditional biomass or renewable sources) can be viewed as a key enabling asset or resource at both the household and community level (Kaygusuz, 2011). The absence or presence of this resource can in turn influence quality of life and livelihood strategies (Barnes et al., 2011).

Accessing modern energy options is dependent on several political and economic factors (Sovacool, 2012), thus concepts from the political economy framework inform the design of this study. The political economy framework highlights the importance of addressing inequalities and uneven development which aligns itself with some of the key benefits of having secure access to modern energy sources. In relation to socio-economic development and securing access to modern energy sources, the political economy framework examines the socio-economic and political aspects within historical contexts, making it relevant to the prevailing conditions in developing countries such as South Africa. Additionally, South Africa's political history is reflected in the settlement patterns of marginalised communities, specifically in rural and peri-urban areas. In this regard, the political economy approach examines the distribution of people, which this study recognises as one of the pertinent factors in accessing services such as energy. Furthermore, the large-scale implementation plan for RETs influences local dynamics, and the political economy framework allows for an examination of influences across regional and international scales.

Additionally, the framework used to determine household energy choices and profiles can be considered a conceptual approach in itself which includes concepts such as nature and ecology, history, geographic location and international economic systems (van der Kroon et al., 2013). Levels of energy poverty, defined by energy ladders and energy stacking models, and household energy profiles draw on multiple interconnected concepts from politics, economics, psychology, sociology and environmental sciences (Keirstead, 2006; Brüscher, 2009; Stephenson et al., 2010; Sovacool & Mukherjee, 2011; Rehman et al., 2012; van der Kroon et al., 2013; Day et al., 2016). Moreover, these concepts relate to the SLA and political economy perspectives. In this regard, this study seeks to disaggregate some of the indicators of energy poverty prescribed in the literature to evaluate local characteristics and subsequent impacts on household energy preferences, attitudes and choices. The multi-conceptual framework approach complements the interrelatedness of the concepts concerning energy poverty and development, confirming its appropriateness. Furthermore, the perspectives selected accommodate for the inter-disciplinarity of this study and provide a suitable framework for addressing the objectives.

1.5 Overview of research methodology and data sources

A mixed research methodology was adopted for this study, which includes both quantitative and qualitative approaches to achieve the objectives. More specifically, this study ulitises the process of triangulation, which was considered most appropriate due to the inter-disciplinarity of the study (Olsen, 2004). Case studies were purposively chosen to highlight differences and/ or similarities in the energy sector across the urban-rural gradient, whilst maintaining the focus on low-income and poor households. The province of KZN, South Africa, was chosen to highlight the above issues as well as to minimise time and logistical constraints. Two communities, Inanda (a peri-urban community) and Bergville (a rural, agriculturally-based community), were selected to allow for comparative analyses and to highlight energy profiles under varying spatial and socio-economic conditions. Primary quantitative data sources used in this study include socio-economic questionnaire surveys and spatial data. Focus group discussions, participatory mapping and ranking exercises comprised the qualitative methods. A total of 400 households (*n*) per community were sampled, resulting in a total sample size (*N*) of 800 household surveys. Since both communities have less than 100 000 households, 400 is regarded as a statistically significant sample size (*n*) per community (at the 95% level of confidence) (Isaac & Michael, 1981). All data generated from quantitative surveys and focus group sessions were computed into the Statistical Package for Social Sciences (SPSS, IBM version 23) software and statistically examined using relevant descriptive and inferential statistical tests. This type of intensive, comparative, mixed-method approach is rarely encountered in the literature on energy studies and can therefore be described as a novel approach in the field.

1.6 Overview of chapters

Chapter One provides an introduction to the energy poverty and development challenges in countries such as South Africa by highlighting issues that prevail within urban and rural contexts. This chapter also defined the research aims and objectives that guided the study and provide an overview of conceptual/ theoretical and methodological approaches employed. Chapter Two details the multi-conceptual theoretical framework used in this study. Literature on rural development debates, energy poverty and the energy development nexus is reviewed in Chapter Three. Additionally, the significance of renewable and modern energy sources are emphasised in terms of serving multiple developmental goals. The literature draws on experiences in both the developing and developed worlds in terms of best practices with regards to addressing energy poverty and ensuring environmental well-being. Chapter Four provides a detailed description of the socio-economic, political and environmental conditions of Inanda and Bergville and describes the research methodologies and design of the study. Chapter Five presents analyses of primary data emanating from this study and discusses the trends observed in relation to the existing literature. Chapter Six, the final chapter, recaps the key findings of the study and provides suggestions and recommendations for future energy and rural development studies.

1.7 Conclusion

This study is informed by multiple discourses embedded in the poverty-energy-development agenda. As discussed above, key aspects such as energy poverty, sustainable development and RETs are discussed in relation to the overarching framework of energy provision in KZN, South Africa. Furthermore, this study examines household energy profiles in peri-urban and rural communities, thus facilitating a comparison of energy behaviour within these contexts. Additionally, energy poverty and household energy profiles are influenced by socio-economic factors. Given South Africa's political history, the distribution of resources, development and infrastructure has a strong spatial/ geographical legacy. Therefore, this study critically examines the differences in household energy practices and attitudes from a socio-economic and spatial perspective, so as to inform future energy implementation strategies for the poor. This chapter provided an overview of key aspects associated with the energy crisis, energy poverty and household energy practices within rural and peri-urban communities. The chapter also defined the aims and objectives that informed this study. Additionally, the chapter provides a brief overview of the selected conceptual/ theoretical frameworks and the research methodologies and philosophies that underpin the study. The chapter concludes with an outline of the subsequent chapters.

CHAPTER TWO
CONCEPTUAL FRAMEWORK

2.1 Introduction

The energy discourse during the 1970s and 1980s focused primarily on the technical and expansionist viewpoints and limited attention was paid to the provision of energy as a means of improving livelihoods in developing countries (Cherni & Hill, 2009). However, current approaches increasingly recognise the multiple benefits of securing access to energy in promoting socio-economic development in poor and remote communities (UNDP, 2004; Modi et al., 2006; Bruscher, 2009; Munien & Ahmed, 2012; Sovacool, 2013; Surendra et al., 2014; Black et al., 2015; Alkon et al., 2016; Gabriel, 2016). The conceptual frameworks adopted in this study are located within these contemporary approaches in an attempt to unpack the factors that contribute to energy profiles and security at the household level.

Conceptual/ theoretical frameworks can be described as the overarching structure that guide the critical interpretation and analysis of existing phenomena using established theories that inform all aspects of the research being carried out (Leshem & Trafford, 2007). Svinicki (2010: 5) asserts:

> a conceptual framework is an interconnected set of ideas (theories) about how a particular phenomenon functions or is related to its parts. The framework serves as the basis for understanding the causal or correlational patterns of interconnections across events, ideas, observations, concepts, knowledge, interpretations and other components of experience.

Similarly, Rudestan and Newton (1992: 6) state:

> A conceptual framework, which is simply a less developed form of a theory, consists of statements that link abstract concepts to empirical data. Theories and conceptual frameworks are developed to account for or describe abstract phenomena that occur under similar conditions.

Jabareen (2009) proposes that conceptual frameworks are outcomes of the theorisation processes and encompass ontological (knowledge of the way things are), epistemological (how things exist in reality), and methodological (how things work in reality) assumptions. Accordingly, these factors serve the following purpose:

- Provides an interpretative approach to social reality;
- Seeks to generate new interpretations of existing theories; and

- Hypothesises the relationships between concepts and provides an understanding of key roles and linkages.

Likewise, Robson (1993, cited in Lesham & Trafford, 2007: 97) state:

> Developing a conceptual framework forces you to be explicit about what you think you are doing. It also helps you to be selective; to decide which are the important features; which relationships are likely to be of importance or meaning; and hence, what data you are going to collect and analyse.

In order to capture the multiple dimensions of energy-centred rural development, a more nuanced approach to research is required. Madubansi and Shackleton (2007) state that previous approaches that failed to address the root causes of poverty and capture the immediate needs of the poor, did not bring about positive outcomes in livelihoods and simply perpetuated poverty cycles. Mirasgedis and Diakoulaki (1997) assert that approaches that focused solely on the economics and technological aspects of energy provision did little to reduce reliance on traditional energy options due to neglect of issues that allowed for the sustained use of modern energy options. The concept of sustainable development has challenged many contemporary methods to unpack the multi-dimensionality of energy-based development in an attempt to provide a more holistic approach to the general development agenda (Modi et al., 2006; Munien & Ahmed, 2012).

Energy provision has been recognised as a developmental goal, however, securing access to affordable, sustainable and reliable energy options remains a fundamental challenge in developing countries (Winkler, 2010; Surendra et al., 2014; Black et al., 2015; Bouzarovski & Petrova, 2015; Alkon et al., 2016). More recent studies indicate that understanding livelihood strategies is essential for realising the potential of energy services in poverty reduction (Sola et al., 2016; Zhang et al., 2016). Abject poverty, socio-economic inequalities and poorly structured institutional frameworks present unique scenarios in which many factors have varying degrees of overlap thus, giving rise to research based on multiple conceptual/ theoretical frameworks.

The process of contextualising concepts that inform a study is a critical aspect of research design and methodology. In relation to energy studies, the inclusion of social, cultural, psychological, political and economic paradigms indicates radical changes in existing conceptual frameworks on energy-centred development (Buran et al., 2003; Barry et al., 2009; International Energy Agency [IEA], 2011; Meyar-Niami & Vaez-Zadeh, 2012; Sovacool et al., 2012; Shaffer, 2013). Studies that centre on energy and rural development issues require multi-model conceptual approaches to disaggregate the linkages and therefore allow for a more robust representation and explanation of key concepts (Chaurey et al., 2004). This chapter reflects on three fundamental theoretical approaches which guide this study: SLA, political economy model, and the socio-psychological framework on household energy choices. The subsequent sections discuss the key concepts associated with these frameworks which forms the backdrop to understanding the chosen research phenomena, energy and society.

2.2 The Sustainable Livelihoods Approach and energy

Scoones (1998: 3) states that the term 'sustainable livelihoods' plays an integral role in development. Since energy access is equally important in facilitating socio-economic development (Buran et al., 2003), the SLA was considered a suitable theoretical framework to guide this study. According to the Development Study Group Zurich (2002), the SLA was the brainchild of Chambers who established the framework in the mid-1980s. They assert that the SLA is a tool that can improve understanding of the livelihoods of poor people and the issues that affect them. Ashley and Carney (1999) consider livelihoods as the strategies that an individual uses to achieve particular outcomes which are inclusive of available assets and access to institutional services and processes. More clarity on maintaining and sustaining livelihoods is given by Serrat (2008: 15) who defines it as:

> the capabilities, assets, and activities required for a means of living. It is deemed sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities, assets, and activities both now and in the future, while not undermining the natural resource base.

Scoones (1998) highlights that although sustainable livelihoods is a compound term, it is important to recognise that these definitions are context specific and are often negotiated within development debates. Sustainable livelihood activities are especially important in poor rural communities who have to identify and implement effective ways that support livelihoods and reduce poverty (Kaygusuz, 2011). It is therefore important to understand the nature and context of livelihood strategies adopted in poor households, especially as they relate to energy demands.

According to the International Fund for Agricultural Development (IFAD, 2007), the SLA has seven core principles which do not have fixed resolutions or prescriptive methods, but are adaptable and adjustable to different local conditions. They identify the approach to be people-centred, holistic, dynamic, display the ability to build on strengths, promote micro-macro links and encourage broad partnerships. Ashley and Carney (1999) assert that the core principles of the SLA makes it applicable to diverse development initiatives which allow for the identification of external support systems that align with people's livelihood strategies and priorities. In this regard, understanding of the following livelihood components are considered pertinent:

- the priorities that people identify;
- the different strategies they adopt in pursuit of their priorities;
- the institutions, policies and organisations that determine their access to assets/ opportunities and the returns they can derive;
- their access to social, human, physical, financial and natural capital, and their ability to put these to productive use; and
- the context in which they live, including external trends (economic, technological, demographic, etc.), shocks (natural or man-made) and seasonality.

(adapted from: Ashley & Carney, 1999: 7)

Serrat (2008) suggests that the SLA highlights the skills, social networks, access to physical and financial assets and their potential to impact livelihood outcomes. Kaygusuz (2011) states that livelihood strategies adopted by the poor may serve as indicators when examining the potential of energy in poverty reduction, given that the lack of access may also constrain the range of potential livelihood options. Additionally, affordability and use can depend on access to financial resources (for example, the ability to purchase and maintain the use of various energy sources) (van der Kroon et al., 2013). The ability to maximise positive outcomes from energy availability can therefore be linked to the asset/ resource base of a household. Access is therefore a critical factor and is described by the IFAD (2007: 1) as:

> The extent of their (household or community) access to these assets is strongly influenced by their *vulnerability context*, which takes account of trends (for example, economic, political and technological), shocks (for example, epidemics, natural disasters and civil strife) and seasonality (for example, prices, production, and employment opportunities). Access is also influenced by the prevailing social, institutional and political environment, which affects the ways in which people combine and use their assets to achieve their goals. These are their *livelihood strategies*.

Understanding the background contexts as well as opportunities and constraints remain the main concern of the SLA. This provides a framework to understand how the poor attempt to exploit opportunities in establishing sustainable livelihood options (Food and Agriculture Organisation [FAO], 2009). The SLA model uses five key aspects of rural development which include the vulnerability context, capital assets, policies and institutions, livelihood strategies and livelihood outcomes, and elucidates their inter-relations and impacts as illustrated in Figure 2.1.

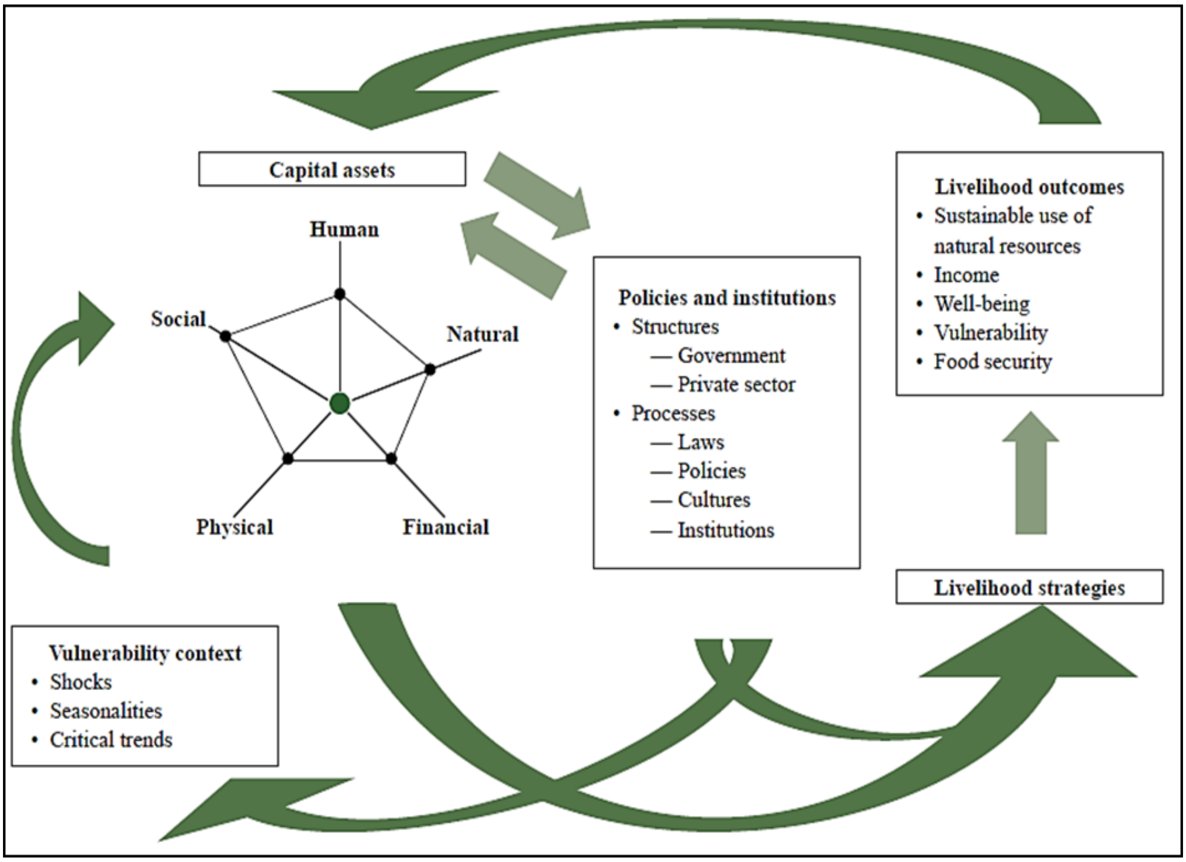

Figure 2.1: The Sustainable Livelihoods Approach model (source: Serrat, 2008: 2)

With reference to Serrat's (2008) interpretation of the SLA, the vulnerability context is a useful indicator of poverty as it reflects the multi-dimensional discourse that is inclusive of environmental, socio-economic and political influences. Adger (2007: 268) defines vulnerability as "a powerful analytical tool for describing states of susceptibility to harm, powerlessness, and marginality of both physical and social systems, and for guiding normative analysis of actions to enhance well-being through reduction of risk". Another definition by Hinkel (2011: 199), describes the concept of vulnerability as a "measure of possible future harm" that is location and context specific. Similarly, Polsky et al. (2007) state that household vulnerability and adaptation corresponds with local socio-economic and environmental characteristics. According to Adger (2007), vulnerability is based on three fundamental factors: exposure, sensitivity and adaptive capacity. In this study, vulnerability, exposure and sensitivity are defined in relation to risk of energy poverty, exposure to the impacts of indoor use of primitive and transitional fuels and the sensitivity to changes in the energy sector.

The SLA defines the vulnerability context in terms of shocks, seasonality and critical trends, and reflects the changes that occur in the external environment which are often beyond the control of the household (Serrat, 2008). Energy related studies show that poor and low income households are most at risk to the impacts of energy poverty (Chaurey et al., 2004; Buzar, 2007; Barry et al., 2009; Chang & Berdiev, 2011). Moreover, poor and low income households, in particular, lack the capacity to respond to changes in the energy sector; for example, inflation of energy sources and technology prices (shocks), inefficient supply and availability of modern energy options (seasonality), and the lack of adequate support from energy policies (critical trends) (Buzar, 2007). Policy and institutional components of the SLA comprise structures (public and private sector) and processes (laws, policies, practices and institutions) that shape the overall vulnerability context but also determine functionality of the system (Turton, 2000). Barnes et al. (2011) found that increased household income correlates with increases in energy expenditure and therefore postulated that household well-being, income and energy use are jointly determined. Similarly, Howells et al. (2005) show that the ability of households to react to changing energy prices influences overall energy efficiency. They further argue that this is mostly prevalent among poor households who show increased reliance on less efficient energy sources such as paraffin and fuelwood. Alternatively, having suitable and supportive energy or social policy may have little effect on vulnerability contexts if there is a lack of institutional presence to facilitate successful implementation of programmes that are cognisant of the above factors (Mulugetta, 2008).

In energy studies, livelihood outcomes could revolve around two scenarios: the conversion or use of capital assets to secure access to energy services, and improved access to energy services to facilitate expansion of capital assets, which may manifest as improved opportunity to engage in income generating activities (Clancy, 2003). The SLA premises that an improvement in livelihood strategies and outcomes will have a concomitant impact on capital assets that are available to the household thus, reducing household risk and vulnerability (Smit & Wandel, 2006). Turton (2000) identifies four main livelihood outcomes, prioritised by the SLA framework:

- increasing financial capital in the short-term, through the conversion of human, physical or social capital;
- increasing financial capital in the long-term through investment in human, physical or social capital;
- reducing the reliance on financial assets by developing other assets that result in direct livelihood benefits, such as home ownership; and
- reducing the draw on financial assets, suggesting that when there is no other way to generate the required amount of money to meet needs, people should trade-off through processes of prioritisation.

Central to the SLA are the capital assets that are available to the poor, which are depicted as a pentagon, to show their interrelatedness (Figure 2.1). Pretty (2003) argues that the reason for the term 'capital' is due to the concept reflecting the potential investment or depletion of these resources by the individual or household. Similarly, Serrat (2008) proposes that these assets constrain and enhance livelihood opportunities and households use these capital assets to make decisions and trade-offs that influence vulnerability and livelihood outcomes. Moreover, the SLA model postulates that the assets/ capital available to households can be grouped into five inter-related categories, namely (Serrat, 2008):

- human capital (education and skills);
- social capital (institutions, networks and leadership);
- financial capital (investments, saving and material assets);
- physical capital (infrastructure such as roads, schools and electricity grid); and
- natural capital (environmental resource base).

There is growing realisation that capital asset bases play a significant role in defining vulnerability of poor and marginalised households (Adger, 2007). Holistic attempts to reduce energy poverty and improve on access to multiple energy options for the marginalised are dependent on the ability to purchase modern energy sources and associated technologies and the capacity to make informed decisions that promote household energy security which complement existing livelihood practices (Ishihara & Pascual, 2009; Kaygusuz, 2009). It is clear from the above discussion that the SLA model foregrounds the importance of capital assets as a mechanism to support existing livelihood strategies and facilitate progression towards new and perhaps more secure livelihood strategies.

Kaygusuz (2011) states that the limitations to diversification of household livelihood options are attributed to the lack of access to energy services which impact household income generation and the potential to accumulate assets. Sovacool et al. (2012) assert that an immediate benefit of improving access to energy services is satisfying basic (lighting, improved education potential, health and communication), productive (mechanised agricultural production and income generating opportunities) and modern (cooling, heating and domestic appliances) needs. However, Khennas (2012) argues that energy provision is no stand-alone remedy to broader development needs, and stresses the importance of policy and institutional frameworks in energy provision. Access to adequate, modern and affordable energy services is largely dependent on the strength of institutional structures which highlights the need for increased governmental support and improved energy policy (Mulugetta, 2008; Knickel et al., 2009; Singh & Hiremath, 2010; Meyar-Niami & Vaez-Zadeh, 2012).

The success of rural energy provision is determined by the capabilities (skills, levels of awareness and knowledge), institutions (economic, social and political), and organisations both public and private (Mulugetta, 2008). Additionally, Kaygusuz (2011) proposes that poor households may be unable to access modern energy services, even if they were available, due to the absence of infrastructure (such as roads and communication), and lack of access to credit and markets. Development strategies that centre on livelihood structures of the poor allow for an understanding of the productive and social uses of energy and further highlight the impacts of energy deprivation on the process of capital asset accumulation (Kaygusuz, 2011). Furthermore, Ishihara and Pascual (2009) posit that electricity is the most common choice of energy among rural individuals, but is financially and physically available to a select few. Therefore, one of the major considerations in rural energy provision is cost and type of energy, as well as the availability of appropriate infrastructure which facilitate energy access to remote communities.

Mulugetta (2008) describes the provision of energy services as a challenge that moves beyond economic development and the satisfaction of basic human needs to improve social welfare. According to Henao et al. (2012), in addition to highlighting the needs of the poor, the SLA recognises the inherent human, social, physical, natural and financial assets that households possess. Additionally, capacity building in terms of the energy sector centres around operational and maintenance know-how of existing energy infrastructure, highlighting the influence of skills and technical capacities of potential energy users (Stephenson et al., 2010). Training, awareness and skills development in this regard will serve to improve on multiple capital assets available to the household (Mulugetta, 2008). Chaurey et al. (2004) show that the provision of electricity results in an improvement of human capacities and therefore has a direct impact on the local Human Development Index (HDI).

Henao et al. (2012) highlight the need to consider social, human, natural and infrastructural dimensions of energy development rather than focusing solely on the technical and economic aspects. Similarly, Cherni et al. (2007) identify the supply of technology, economic costs, social welfare impacts and environmental integrity as having equal influence in energy development debates. Titeca and Vervisch (2008) are of the opinion that the accumulation of social capital can facilitate increased participation in decision-making. Enhancing participation of marginalised groups is a vital outcome of the SLA, which brings to the fore the critical elements like gender representation in energy studies. According to Knox-Hayes et al. (2013), there is a need to encourage gender-sensitive frameworks in energy debates as women are often tasked with domestic chores and are therefore more at risk to the impacts of energy poverty. Furthermore, Meyar-Niami and Vaez-Zadeh (2012) argue that social capital itself represents a broad framework for development as it considers access to credit, service delivery and community development. Involvement in technical and financial support groups allows for the marginalised groups, particularly women, to engage in, and establish support structures outside of the household; this can encourage participation, community involvement and empowerment (Goebel et al., 2010).

One of the most recognised strengths of the SLA is its ability to systematically identify unanticipated impacts, facilitating strategic planning and advocacy within the context of rural development (Ashley & Carney, 1999; Parkinson & Ramírez, 2006). Additionally, the inclusion of local dynamics in conceptualising poverty adds value and provides a wealth of information when applying bottom-up approaches to development. Given the diverse socio-economic and political discrepancies prevalent in South Africa, models such as the SLA are highly relevant. In energy studies, more specifically, understanding local dynamics in terms of energy efficiency, access and cost can reflect on the broader energy policy needs (Abrahamse & Steg, 2009) thus, making the SLA an appropriate tool in this study.

There is no doubt that the issues discussed above unpack a number of development agendas relevant to developing countries. Similarly, securing access to energy for the poor requires multi-sectorial cohesion and consultation in the planning and implementation phases. However, the role of policy and government institutions is critical for the sustainable reduction of energy poverty. In this regard, the political economy model was deemed a suitable framework within which factors that contribute to energy security and the implementation of renewable energies could be investigated. This is elaborated on in the following section.

2.3 The political economy of energy

Emerging from Marxist, capitalist and neo-liberalist approaches, the role of politics and economics is undisputed in the development agenda as they are fundamental factors that promote growth and ultimately development itself (Cherni & Hill, 2009). Jones (2008: 378) describes political economy as “ways of capturing political, economic, social and cultural worlds as a moving spatial matrix of possibilities under capitalism”. Similarly, Matutinović (2009) states that changes in energy markets and the subsequent impacts on consumer behaviour are vital to the political economy framework, but have been overpowered by natural resource and technological constraints. Chang and Berdiev (2011) argue that energy reliability and affordability are key factors influencing production cycles and therefore, have a significant impact on growth and trade. Tanaka (2011) brings to the fore the concept of energy efficiency and describes this to be a key determinant of energy security and environmental and economic well-being. This underpins the importance of energy security in establishing strong economies, and further highlights the need for developing countries to strive towards sustaining energy security as a main driver of socio-economic development.

Khennas (2012) states that even though parts of north Africa and South Africa have the highest Gross Domestic Product (GDP) within the continent, locally there are significant differences between urban and rural, and rich and poor groups. This emphasises the importance of equitable distribution within the economy. The energy debate in South Africa can be classified into two main themes: energy inequality and energy sustainability (Brüscher, 2009; Winkler et al., 2010). The former brought on by the intergenerational effects of discrimination as a result of the apartheid regime and the latter due to the overreliance on coal-based electricity as a result of abundant coal reserves (Winkler et al., 2010). These, of course, add several complexities to energy access within South Africa and highlight the role of state institutions in formulating suitable policy and regulatory frameworks that incorporate the historical and environmental contexts. Furthermore, Brüscher (2009) describes South Africa to be a neo-liberal capitalist economy where energy remains central to production processes which influences social welfare mechanisms. However, increased privatisation, commercialisation and marketisation results in the poor being excluded from these sectors and worsening of poverty cycles.

Adger et al. (2005) define the political economy framework as cross-scale interactions between stakeholders that are guided by a hierarchy based on the distribution of power. According to Peterson (2000), power at the local level is overt and covert, or structural at higher levels. Additionally, Paul and Verdier (1996) argue that income distribution defines one's relative power which implies that different income groups experience different levels of political participation or power; for example, the poor experience lower political participation compared to the rich. Adger et al. (2005) reinforce the notion that the most powerful stakeholders are those who can afford to invest in knowledge and thus, have the most pertinent information which influences the manner in which decisions are made and trade-offs are negotiated. Ribot and Peluso (2003) aver that power is undoubtedly linked to the distribution of resources and wealth but it is also influenced by governance and culture. In order to distribute benefits to the less powerful, governance systems need to be strengthened and the poor need to be mobilised (Adger et al., 2005).

Tshuma (1999) is of the opinion that policy and improved governance systems play a central role in advancing development agendas. In terms of energy, Khennas (2012) suggests that democratic approaches to development and substantial financial resources are needed to achieve energy access. Moreover, institutions responsible for energy policy have the tendency to influence energy equality and sustainability (Khennas, 2012). Rehman et al. (2012) underscore the importance of establishing 'pro-poor' energy policies that unpack the technological and socio-economic barriers to ensure equity and reliability in energy access. Similarly, Kahrl et al. (2013) suggest that policy should focus on energy efficiency rather than economic incentives that reinforce the power imbalances within the system. Studies show that economic growth, investment and political efficacy within the public sector facilitates increased accumulation of financial and capital assets and ultimately reinvestment in energy services by households through increased purchasing power (Chaurey et al., 2004;

Madubansi & Shackleton, 2007; Nussbaumer et al., 2012; Deaton, 2016; Kakwani & Son, 2016). Furthermore, Chaurey et al. (2004) state that energy access in developing economies are compounded by the lack of sufficient government programmes and access to information and energy markets. In addition, the poor are unable to react to changing energy prices because they lack representation within the energy policy decision-making arena (Buzar, 2007; Cameron et al., 2016; Deaton, 2016). It is also evident that social welfare support falls short in addressing energy poverty, as the root causes are neglected, creating unsustainable dependencies on the state and government social aids (Madubansi & Shackleton, 2007; Khennas, 2012; Kakwani & Son, 2016). Additionally, the poor are further disadvantaged by their inability to access modern markets as a result of high interest rates, lack of infrastructure (such as roads) and limited access to information, which exacerbates the urban-rural dichotomy and deepens poverty cycles (Pandey, 2002; Sovacool, 2013; Zhang et al., 2016).

Adger et al. (2005) assert that knowledge, action and investment of resources to advance the development agenda are viable options for the poor which will lead to distributing power within the economy. Redistributing power within an economy can also be initiated through public education programmes, where investment in the creation of human capital can result in improved and sustainable economic growth (Paul & Verdier, 1996). However, this raises concerns around affordability of obtaining knowledge and skills within the economy, as many of the poor may not be able to invest factors that promote growth, and could result in a further reduction of power (Rehman et al., 2012).

Meyar-Niami and Vaez-Zadeh (2012) argue that sustainable energy policy should reflect on the national goals and must consider the limitations in order to produce meaningful outcomes, especially for the poor. Fragmented energy policy and poor integration of factors that govern energy insecurity within developing contexts do not effectively reflect the disparities between the poor and those that are financially secure (Chang & Berdiev, 2011; Tanaka, 2011; Schillebeeckx et al., 2012). Sovacool (2012) posits that global and local stakeholders play an important role in the way in which energy policy is implemented and corruption, patronage to fossil-fuel energy, and political instability encumber equitable distribution and access to modern energy services. Enhanced investment in building human capacities through improved access to information and awareness may serve multiple objectives in bridging the technological gaps among the poor, thereby promoting the implementation of modern energy options, such as renewable energy (Pandey, 2002; Pereira et al., 2011a; Rehman et al., 2012).

Additionally, maintenance and repair of RETs is one of the major causes of poor uptake and can be addressed by developing capacities. Jorgenson et al. (2012) highlight the urban-rural dichotomy in access and distribution of resources and argue for the increased decentralisation of technology and infrastructure investment that could lead to more equity in development patterns across rural and urban sectors.

Sovacool and Mukherjee (2011) propose that the main dimensions and components of energy security in relation to the political economy framework include availability, affordability, sustainability, the development of efficient technologies, and strong governance and regulatory structures. Each of these dimensions are further subdivided into various components, for example, availability is inclusive of security of supply and production, dependency and diversification (see Table 2.1).

Table 2.1: Dimensions and components of the political economy of energy (adapted from Sovacool & Mukherjee, 2011: 5345)

Dimensions	Components
Availability	Security of supply and production Dependency Diversification
Affordability	Price stability Access and equity Decentralisation
Technology Development and Efficiency	Innovation and research Safety, quality and reliability Resilience Energy efficiency Intensity Investment and employment
Environmental and Social Sustainability	Land use Water availability Societal health Environmental health Climate change
Regulation and Governance	Good governance Trade and regional inter-connectivity Competition and markets Knowledge and access to information

Infrastructure is a key driver of economic development; sustained investment in roads, water and sanitation, and information and communication technologies are vital in securing access to energy among the poor (Khennas, 2012). In this regard, increased decentralisation of power, knowledge and access to information regarding the most viable energy options is primarily dependent on improved political frameworks that prompt changes in attitudes, practices and economic activities at the grassroots level. Additionally, the supply and production of energy services alongside costs are key indicators that need to be factored into general energy debates and policy reform (Pereira et al., 2011a; Sovacool & Mukherjee, 2011; Khennas, 2012; Rehman et al., 2012).

From the discussion above, it is clear that the political economy of development is complex and interrelated and therefore, energy provision is no different. Sustained economic empowerment and income generation of the poor are strongly emphasised as key determinants in accessing improved energy services and technologies (Krupa & Burch, 2011). Given that there are multiple stakeholders within the energy sector and that sustainable energy practices are closely aligned to socio-economic and political well-being, unpacking the political economy of energy is critical. From the literature reviewed above, a model illustrating the cross-cutting nature of the political, economic and social dimensions of energy security was formulated (Figure 2.2). This political economy model for energy highlights the direct and indirect linkages that exist between the far-reaching factors that determine energy insecurity within the developing contexts more broadly, and at a household level. The model examines energy security in terms of the linkages between the political/ institutional and economic influences, whereby energy security/ insecurity can be described as a response to economic and political pressures. The latter include energy prices, energy policy, access and availability of energy infrastructure (or the lack thereof), and investment in the energy sector. Therefore, the level of energisation within a country is reflective of both economic and political frameworks that determine and impact the social dimensions. An improvement in development initiatives and energy policies will eventually lead to economic growth and consequently influence household investment in related goods and services.

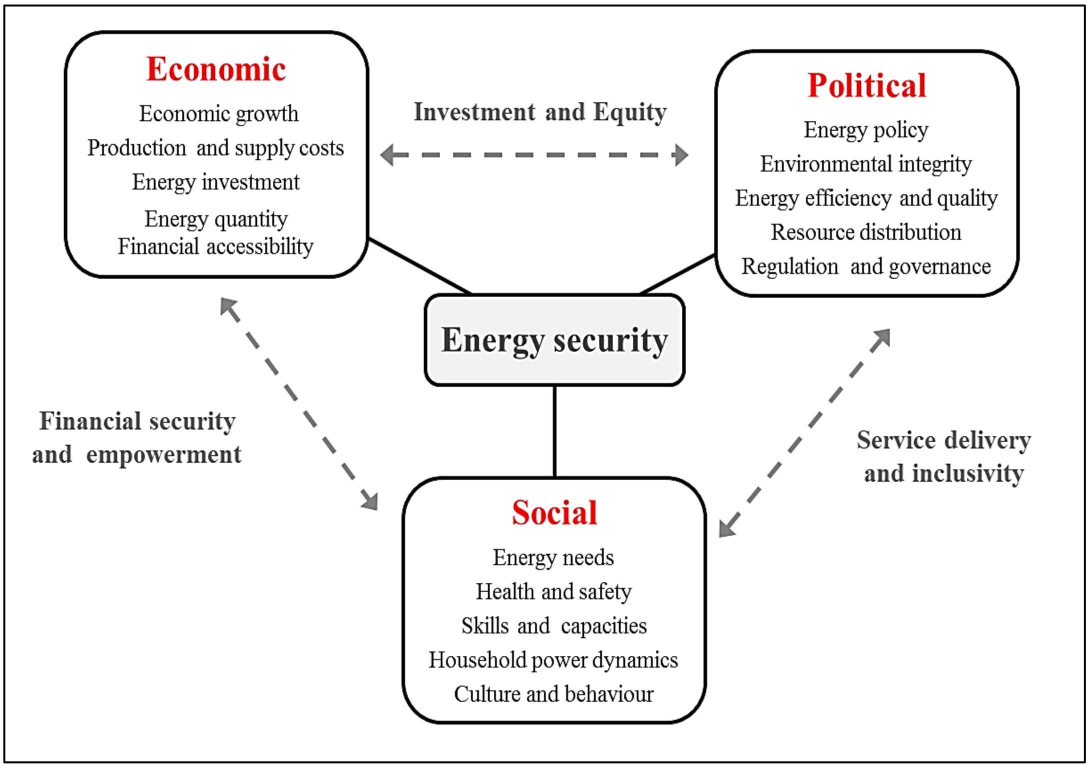

Figure 2.2: A political economy model for energy based development (Author, 2016)

Political and economic factors play significant roles in energy provision to marginalised groups. However, internal household structures determine energy choices and practices. The latter is considered equally important and can inform broader energy policy. An appreciation of issues such as fuel-switching and prioritisation of energy needs within households may reveal additional factors that determine energy insecurity. Therefore, in addition to the political economy and SLA frameworks, this study uses conceptual models defining household energy behaviours and decision-making processes, as discussed below.

2.4 Household energy decision-making processes

Chambers (1995) argues that the manner in which developers and institutions conceptualise poverty and development is different compared with more complex viewpoints of the poor, as they employ a range of strategies to maximise income, reduce risk and protect the assets they deem valuable. Understanding internal decision-making processes at the household level is important and lends itself to the development of appropriate initiatives and policies that capture the needs of the poor at a more localised level. Unpacking livelihood strategies of the poor allows for developers and governments to identify key agents of change that can be incorporated into development approaches and energy policy, thereby ensuring improved implementation (Shaffer, 2013).

Heltberg (2005) states that previous studies on household fuel choices were largely dominated by movement along the energy ladder which was primarily determined by the availability of household income. However, studies indicate that fuel choice is a more complex process, which includes factors such as quality of life (Howells et al., 2005; van der Kroon et al., 2013; Mensah & Adu, 2015; Romero-Jordán et al., 2016), culture and social constructs such as patriarchy and household power dynamics (Pachauri & Rao, 2013; Stephenson et al., 2010; Behera et al., 2015; Kastner & Stern, 2015; Deaton, 2016), psychology and sociology (Allcott & Mullainathan, 2010; Kok et al., 2011), knowledge and technological know-how (Kaplowitz et al., 2012), and energy efficiency (Gyberg & Palm, 2009).

As indicated above, energy poverty is a complex phenomenon and the rationale behind household energy preferences and choices are equally important in informing energy policy and investment opportunities. This study utilises the household energy decision-making processes as a guide to better understand the impacts of energy security. Cherni et al. (2007) state that processes of prioritisation and selection of energy options and needs can be used in energy policy design and development of relevant technologies. Furthermore, Mulugetta (2008) states that household energy choices are strengthened by non-cognitive factors such as norms, values, beliefs, ideals, process and procedures.

The inclusion of behavioural sciences in energy studies has gained academic popularity in recent years in an attempt to provide a more holistic examination of household energy practices. Keirstead (2006) uses the 'structure-agency' approach to examine behaviours, where individuals are deemed capable of engaging in the desired change (for example, sustainable energy practices) given the right structures. Structure is defined as "rules and resources, recursively implicated in the reproduction of social systems. Structure exists only as memory traces, the organic basis of human knowledgeability, and is instantiated in action" (Giddens, 1984 cited in Sewell, 1992: 5). Sewell (1992) defines agency as practices, actions and capacities which give rise to patterns and therefore, determine social structure which in turn will influence future agents. In terms of the energy agenda, reliance on electricity (agency) to service individual energy needs has overpowered perceptions, practices and policy (structure); therefore, a paradigm shift is required in both energy structure and agency in order to substantially mitigate the impacts of climate change and reduce energy poverty (Keirstead, 2006; Stephenson et al., 2010; Broomell et al., 2015; Cameron et al., 2016). Stephenson et al. (2010: 6121) state that features of the material world such as products, services, resources and lifestyles are closely linked to structure and are the "outcomes of choices people make according to their values, needs and the social context".

Kaplowitz et al. (2012) suggest that social structures and human behaviour are vital to understanding energy consumption and will therefore inform energy efficacy and conservation strategies. Wilson and Dowlatabadi (2007) use social setting and technological transformations to understand energy behaviour. Stephenson et al. (2010) note that energy behaviour is complex and influenced by multiple factors which can be unpacked using the energy culture framework (Figure 2.3).

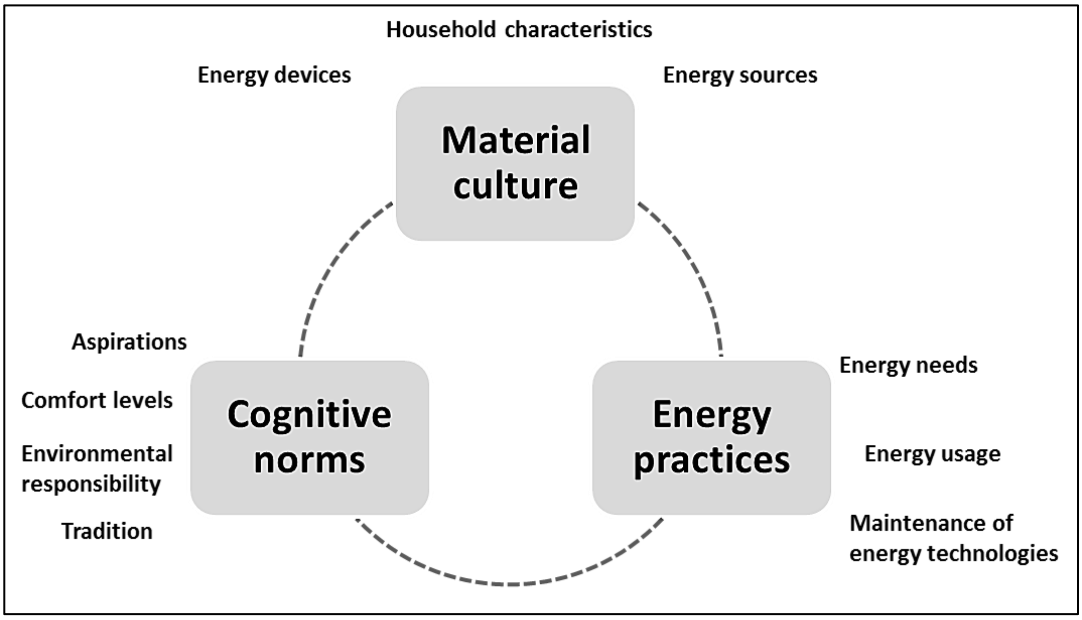

Figure 2.3: The energy cultures framework (adapted from: Stephenson et al., 2010: 6124)

The energy cultures framework uses material culture, cognitive norms and energy practices as core concepts that influence energy behaviour. Stephenson et al. (2010) define material culture to be household specific (comprising aspects such as dwelling properties, availability of energy options and devices), cognitive norms as attitudes, values and belief systems, and energy practices as an outcome of the interactions between individual and societal behaviour. Furthermore, Lutzenhiser (1993: 3) warns that energy behaviours cannot be easily simplified due to the inter-relatedness of concepts and the context specific variations that prevail and argue that previous policies such as 'just get the prices right' have done little to change energy behaviour. According to Wilson and Dowlatabadi (2007), decisions are a product of the broader social constructs such as socio-technical systems, and collective transformation processes. They further assert that awareness and attitudes alone do not alter people's energy behaviour thus, highlighting the need to examine the social contexts in which energy actions, practices and choices occur. Similarly, Allcott and Mullainathan (2010) assert that even with improved energy efficiency and access people may fail to change their energy behaviour. They go on to explain that energy behaviour is an outcome of a combination of factors and therefore suggest the aspects summarised in Table 2.2 to be important drivers of change.

Household energy choice remains a composite phenomenon and the influences of the above factors (Table 2.2) may produce different behaviours, depending on socio-economic contexts. Furthermore, energy behaviour interventions can be cost-effective and successful when implemented in larger groups (Allcott & Mullainathan, 2010). Stephenson et al. (2010) use multiple perspectives in an attempt to understand household practices in changing socio-economic and technological environments and consider the following to be essential (Stephenson et al., 2010: 6121):

- microeconomics (rational choice models, pricing, market structure);
- behavioural economics (bounded rationality, decision heuristics);
- technology adoption models (diffusion theories, cognitive dissonance, theory of planned behaviour, self-efficacy, social communication);
- social and environmental psychology (impact of information, pro-environmental attitudes, value-belief-norm characteristics, habits); and
- sociological theories (social constructs, organisational behaviour, embeddedness, socio- technical systems and the energy decision-maker's cultural and social context).

Table 2.2: Factors influencing energy behaviour (adapted from: Allcott & Mullainathan, 2010: 2-4)

Factors	Description
Psychology	The drive to adopt and purchase energy is influenced by price, demand and material culture.
Commitment devices	Human beings can be described to be procrastinators and the willingness to commit to change often occurs in the 'now', however, the actions are almost always for the 'tomorrow'.
Default options	Electricity or traditional biomass are often seen as default options, the switch to other options are often associated with additional actions and hence, the procrastination.
Social norms	Non-price drivers where an individual conforms to the behaviours and attitudes of the masses due to 'comfort in conformity' and 'wisdom of crowds'. The most popular energy option will be the most sort after.
Implementation intentions	Given that there is a noteworthy difference between intention and action, changing attitudes and perceptions are relatively easier than changing actions. Energy intervention should seek to initiate actions.
Demand	An outcome of cost and non-cost factors (for example, efficiency, safety and accessibility). This could offer some explanation for the extensive fuel-switching that occurs in poor households (for example, the use of fuelwood for cooking and heating which are seen to be more efficient).

Kok et al. (2011) proclaim that understanding the relationship between technology and human behaviour is central to changing peoples' desired energy choices, however, policy often neglects the non-financial influences on the latter, which is considered essential to successful energy policy. Smith (2007) asserts that the link between society and technology is influenced by cognitive norms and socio-economic conditions; therefore, the ability of individuals to embrace certain technologies such as solar cookers or heaters have the potential to sustain energy development trajectories. However, the adoption of technologies is non-linear and is specific to the social and institutional factors like regulation, pricing, availability and efficiency (Geels & Schot, 2007).

Energy behaviour can also be explained using the factors that prompt desired change in individuals. van der Kroon et al. (2013) propose a conceptual framework (Figure 2.4) to better understand energy behaviour at the household level. The model includes the influence of external socio-cultural and natural environments, political-institutional market environments, and internal economic systems and historical contexts (Farsi et al., 2007). Although household energy practices are characteristic of human behaviour, there are several other factors that determine energy choices (van der Kroon et al., 2013).

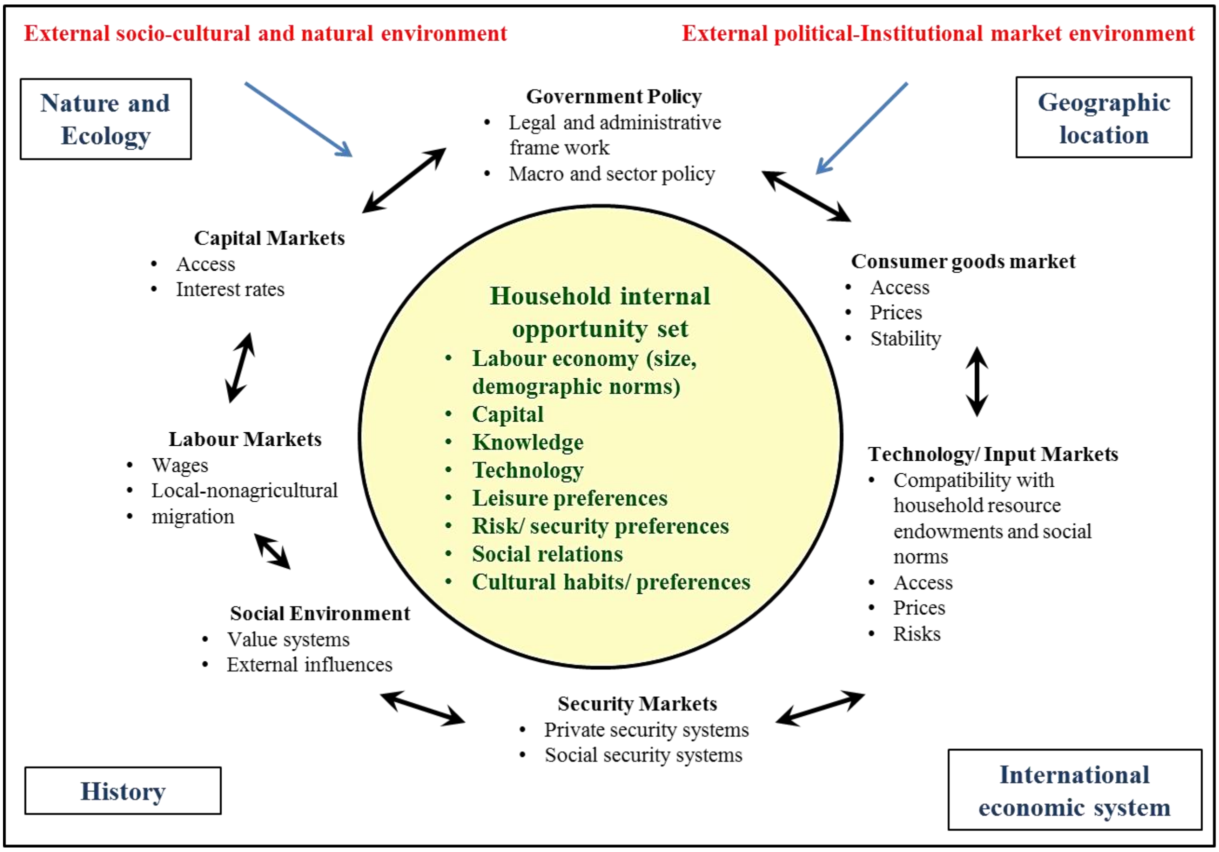

Figure 2.4: Conceptual model of household energy choice (source: van der Kroon et al., 2013: 507)

Household energy practices and energy behaviours in general are attributed to complex endogenous and exogenous processes, which are inclusive of economic, political, environmental, technical and socio-cultural factors; however, the latter may provoke behaviours that are in contradiction to what is deemed economically rational (Kowsari & Zerriffi, 2011). Similarly, individual preferences are influenced by power relations and social constructs through the process of creating common knowledge and collective action, however, power relations can result in marginalised individuals having limited representation in household decision-making processes (Ishihara & Pascual, 2009). Kok et al. (2011) suggest that human cognitive, emotional as well as social and physical environmental limitations may produce irrationality in behaviour. These perspectives on the influences of behaviour suggest that an individual's energy choices and practices may be considered irrational even under sound economic and political conditions. Furthermore, Gyberg and Palm (2009) stress the fact that there is no direct link between knowledge and human behaviour suggesting that irrationality may also be attributed to factors such as ideology and material reason.

A detailed description of the exogenous and endogenous elements of household energy choice is given in Figure 2.5 below. The model examines energy use at the household level, where causal relations between different energy uses can be captured (Kowsari & Zerriffi, 2011). Energy services, devices and carriers are considered fundamental indicators contributing to household energy consumption patterns. The model utilises features from the personal and contextual domains to describe the exogenous and endogenous elements that govern energy choices. The personal domain comprises attitudes, habits and experiences, whilst the contextual domain incorporates capabilities and external conditions.

Most of the elements featured in Figure 2.5 have been discussed earlier, however, what is noteworthy is the emphasis on energy services, carriers and devices as principal determinants of energy use. Kowsari and Zerriffi (2011) suggest that household energy choice is more dependent on the energy service than the quantity of energy that is available. The Kowsari and Zerriffi (2011) model advocates a finer inspection of the internal chains that determine household energy prioritisation. Furthermore, household fuel-switching can serve as a key indicator of prioritisation of energy at the household level. Masera et al. (2000) attribute the switch to modern energy sources to improved household income, energy costs, accessibility, and the distribution of modern energy sources. As evidenced by Kok et al. (2011), energy research has often taken a techno-centric approach with little focus on human behaviour. The growing awareness around humans as key agents of change in the energy sector is gaining momentum and begins to unpack some of the discreet chains that govern energy demand. Additionally, knowledge emerges as one of the primary factors that may improve energy behaviour, however, compared with materialistic preferences and cultures, the latter seems to provoke more noticeable behavioural changes in terms of energy practices (Stephenson et al., 2010; Mensah & Adu, 2015; Kastner & Stern, 2015).

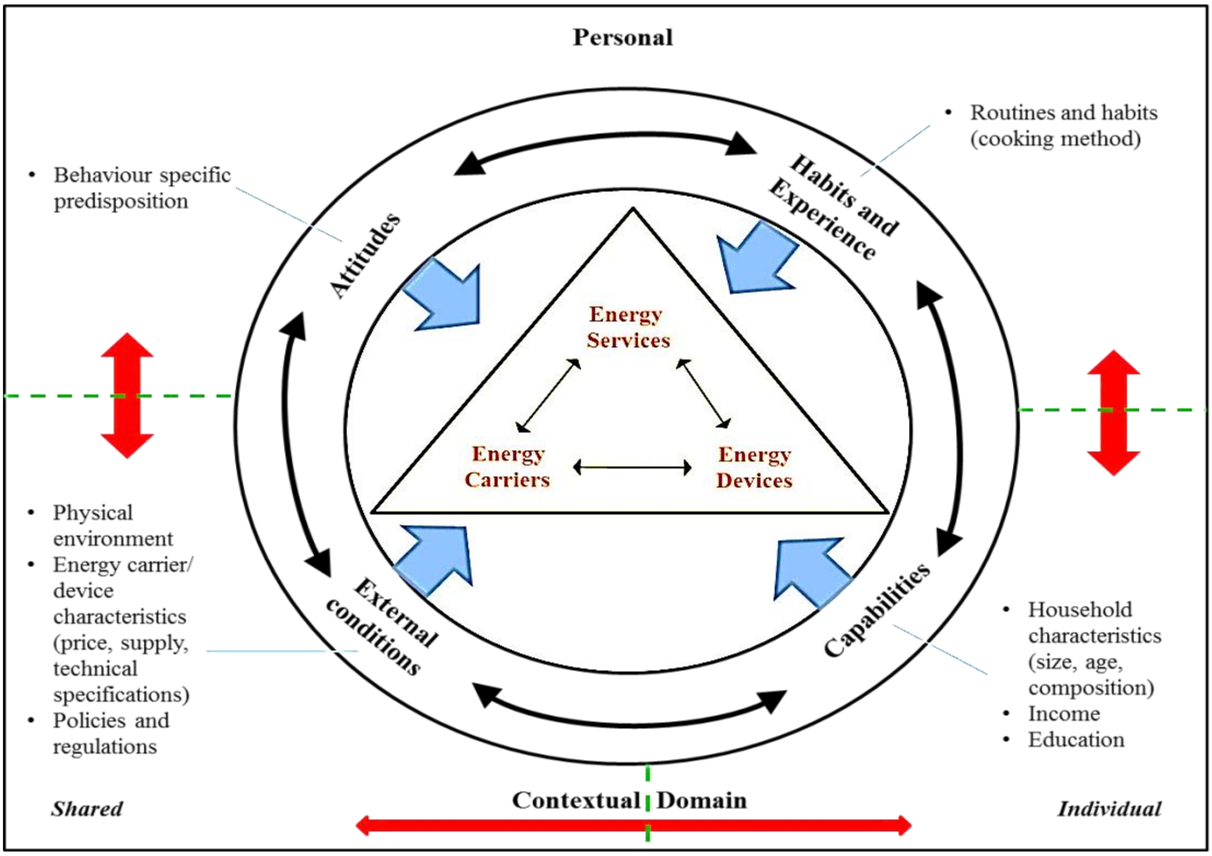

Figure 2.5: Endogenous and exogenous influences on household energy profiles (source: Kowsari & Zerriffi, 2011: 7514)

These theoretical frameworks that describe energy behaviour and practices often fail to recognise that time is a fundamental element that needs to be integrated into discussions pertaining to changing energy behaviour. Questions that need urgent answers include: how long does an individual take to acquire the knowledge and at which time does this lead to the establishment of a different consciousness that may result in radical social change? Friedrichs (2010) likens this social change to a transition to sustainable energy practices, thereby facilitating the necessary transformations within the energy sector. However, these social changes occur over relatively long periods, implying that changes in behavioural patterns can be considered long term goals. This necessitates more immediate mechanisms such as provision of clean, renewable energy technology at competitive prices for the masses, not just for the energy poor. Based on the concepts, and conceptual frameworks that have been discussed in this chapter, Figure 2.6 is a proposed conceptual model that will guide the present study.

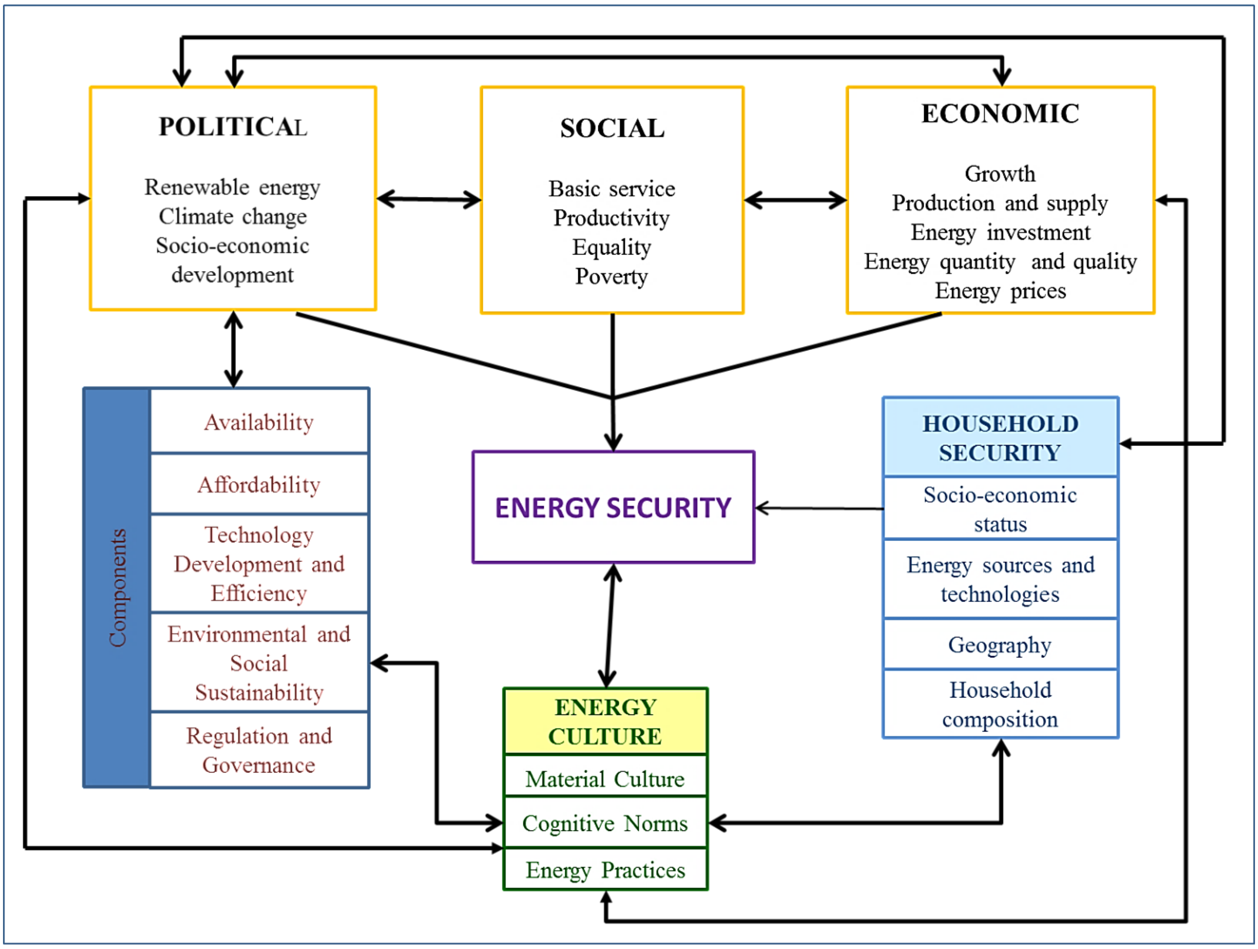

Figure 2.6: Conceptual model of this study (Author, 2016)

The conceptual model (Figure 2.6) provides an analytical framework for this study, showing the inter-relationship among political, economic and social dimensions, and household energy security. A number of elements within the political, economic and social realms are inter-related and therefore impact household energy security either positively or negatively; these impacts are considered to be context specific. Energy security at the household level will either increase or decrease depending on the strength and influence of the various factors within these three broad dimensions. The model also predicts that there is variability in household energy security along a continuum from deep rural areas to peri-urban or peri-rural areas contingent on factors from the various dimensions. The political dimensions and linkages at any level of the continuum, for example, availability and affordability, must be considered in terms of the pressure they exert on the social dimensions and its subsequent influence on household energy cultures. The chain of events that ultimately ends in household energy security does not stop here though, because energy culture is in turn shaped by endogenous and exogenous factors such as habits and attitudes that affect the use or non-use of the various forms of energy. Economic dimensions need also be considered in the events that determine energy security. The combined impact of political, social and economic dimensions will determine energy security or insecurity at the household or community level. If, for example, the country has a strong economy, the political will and governance structures, alternate energy technologies can be made available to marginalised communities at affordable prices. The opposite is also true in countries with weak economies and political institutions. Countries with weak economies will lack the resources necessary to provide any sort of energy technology, especially to the marginalised.

Energy technologies at affordable prices are not enough to satisfy the energy needs of communities. The livelihood assets that the household or community possesses are also a determining factor in obtaining energy security. Households with less livelihood assets will react differently to those who possess sufficient assets and their behaviour towards use, and attitudes towards alternate energy technologies will vary. These are some of the issues that can be discussed using the above conceptual framework and an in-depth evaluation of these issues is undertaken in the final chapter following the data analysis. As is evident from the foregoing discussion, analysing energy security at the household or community level is a complex issue. The conceptual framework presented above supports the application of the social dimensions (as defined by the SLA) of households and communities within the political-economy framework. Due to the multitude of variables in each one of the dimensions, only selected variables from each of the three major dimensions (political, economic and social) are the source of primary data for this study. These dimensions are related to household energy security within the study in order to understand whether their influence conforms or deviates from the conceptual model formulated.

2.5 Conclusion

This chapter described conceptual models such as the SLA, political economy and energy culture and behaviour frameworks to explain the multiple dimensions that need to be appreciated in order to address energy poverty and development. The shift towards more sustainable energy options has a direct influence on climate change mitigation, and has the potential to enhance socio-economic conditions. Therefore, it is considered to be a pertinent research agenda, especially in developing contexts. This study utilises multiple conceptual frameworks to guide research on household energy profiles, attitudes and perceptions. The final section proposes a conceptual model for the present study that attempts to integrate the political, social and economic dimensions that could lead to energy security or insecurity at the household or community level. The next chapter presents a review of the literature pertaining the main conceptual issues mentioned in the present chapter.

CHAPTER THREE
LITERATURE REVIEW

3.1 Introduction

The current study investigates aspects influencing the provision of modern energy services to marginalised communities within South Africa and aims to unpack the key spatial, socio-economic and technological factors that may promote or hinder the implementation of RETs. Securing access to modern energy services and options remains a complex and multi-dimensional phenomenon requiring a more integrated approach that is informed by policy, socio-economic and environmental factors. Although RETs are widely promoted and increasingly included in low-income housing projects across South Africa, few studies examine the impacts of these technologies from a livelihood perspective. Therefore, the literature reviewed in this chapter aims to improve the understanding of the multiple dimensions associated with the supply, usage and adoption of modern energy services and technologies. This chapter provides a critical overview of aspects deemed pertinent in understanding the current issues within the energy dialogue; these aspects fall into the following broad thematic areas:

- The energy discourse;
- Energy security;
- Energy poverty;
- Energy and development;
- Renewable energy: opportunities and constraints;
- Alternative and renewable energy;
- Household energy behaviours and profiles;
- Energy policy; and
- The South African energy sector.

In reviewing the literature on these themes, this chapter begins with an overview of the energy discourse which provides the context from which many of the current energy-related challenges emanate.

3.2 The energy discourse

Examining historic and present trends characterising the energy discourse is deemed important as it allows for a contextual background upon which this study is based. The importance of energy access is undisputed as an enabler of development and overall improvement of living conditions and lifestyles (IEA, 2011). Bilgen (2014: 890-891) states that energy is crucial for socio-economic growth and the enhancement of overall quality of life, and defines it as "the ability to do work and it can be found in different forms such as chemical, thermal, electricity, mechanical, gravitational, nuclear, radiant, sound and motion". However, this study focuses specifically on, "fossil (petroleum, coal, betumes, natural gas, shale oil, etc.) and renewable (alternative, biomass, hydro, wind, solar, geothermal, marine, hydrogen, etc.)" energy sources (Bilgen, 2014: 891).

It is widely accepted that access to energy facilitates economic growth and social well-being and is therefore the backbone of any economy (Kruyt et al., 2009; Johansson 2013; Akhmat et al., 2014; Surendra et al., 2014; Black et al., 2015; Löschel et al., 2015; Gabriel, 2016; Romero-Jordán et al., 2016). Belke et al. (2011) state that economic growth and industrialisation revolutionised the role of energy within emerging economies and promoted the shift to more modern energy sources. The shift to coal and oil from traditional biomass is closely related to level of development and improved energy efficiency (Bashmakov, 2007). Over the past few centuries the energy sector has undergone several changes with the most substantial being the shift from traditional biomass to fossil-fuels for the production of electric energy (Fouquet and Pearson, 2012). These slow periodic shifts experienced in the energy sector have transformed various aspects of energy production, use, storage and efficiency but most importantly culminated in the provision of modern energy services such as heating, lighting and transport (Fouquet, 2010; Solomon & Krishna, 2011).

Even though the most prominent energy shifts occurred in the late 19^{th} century, by the 21^{st} century a quarter of the global population still relied on traditional energy sources such as fuelwood to satisfy their household energy needs (Bashmakov, 2007). This suggests that even though electric energy services were available, shifts in energy practices at the household level were based on several influencing factors such as cost, efficiency, energy infrastructure, accessibility and availability (Lior, 2010). Consequently, these more efficient forms of energy were associated with higher production and extraction costs (physical and financial), thereby creating global energy markets which are intrinsically linked to resource economics (Stern, 2011). Increased industrialisation and the emergence of global markets transformed energy into a necessary commodity for trade, development and economic growth (Belke et al., 2011). Given that energy is considered an integral component of production and the backbone of development, it is unsurprising that in recent years there has been more emphasis on physical and financial accessibility to energy within emerging economies (Sovacool, 2012). Ayres et al. (2013) warn that limitations in the availability of energy may hinder economic progression, especially in developing countries.

Due to the deep-rooted links between energy and global economic markets, economic recessions exacerbate pressures on the energy sector and are often associated with increases in energy prices (Chester, 2010; Solomon & Krishna, 2011). While the change to fossil-fuel sources of energy resulted in improved efficiency and energy services (for example, mass electrification) this was also associated with a significant increase in environmental impacts, in particular, greenhouse gas (GHG) emissions (Chester, 2010). Thangavelu et al. (2015) show that even though fossil-fuels such as coal, natural gas and petroleum produce large quantities of cheap energy services, they are associated with significant volumes of GHGs. Similarly, Khan et al. (2014) state that the majority of GHG emissions originate from commercial and residential energy consumption, specifically the use of electricity for heating/ cooling, cooking and lighting purposes. Nejat et al. (2015) claim that currently buildings consume 40% of global energy, however, this is expected to escalate rapidly due to the increasing demand for housing and commercial property. A key recommendation in the literature is that attempts to transform the energy sector should include a sector-based analysis of energy needs and consumption patterns which can be used to inform sustainable energy practices and technological innovation.

In addition, there are mounting concerns that the rate at which coal and oil resources are consumed for electricity production are unsustainable (Matutinović, 2009; Lawrence et al., 2013; IEA, 2013). Lior (2010) states that despite the ecological footprint of energy, total energy consumption is said to increase rapidly over the next few decades due to population growth. Energy consumption rates therefore become an important issue within the discourse. Furthermore, increased pressure from international agencies and institutions to embrace energy sources that are less carbon intensive may result in developed economies having an unfair advantage over the developing world (IEA, 2013). In this regard, Lawrence et al. (2013) argue that total energy consumption and therefore total carbon emissions are indissolubly linked to energy inequality across different countries. This suggests that developing countries, in particular, are extremely vulnerable to changes in energy markets and escalating environmental and financial energy costs may hinder overall local level socio-economic development within these countries.

Bilgen (2014) states that given the robust relationship between energy consumption and economic growth, changes in the energy sector are likely to have multifarious impacts on developing economies, especially those aiming to address issues of energy security and climate change concerns, simultaneously. These are critical development agendas and more importantly, highlight the need for improved planning and government intervention in shifting reliance to more sustainable, cost-effective and environmentally benign energy options, such as renewable energy (IEA, 2011). In light of the concerns mentioned above, current energy studies predict the next energy transition to comprise a broader energy mix in the form of alternate and renewable energies (Kaygusuz, 2009; Munien & Ahmed 2012; Sovacool et al., 2012; Munien, 2014; Black et al., 2015; Gabriel, 2016; Zhang et al., 2016).

Analysis of the various energy sources comprising the energy sector, over the past five years, reveal that reliance on coal and oil remain unchanged, with slight increases in the contribution by renewable energy sources (IEA, 2012; 2013). Total contribution of renewable energy sources over the past five years indicate that the expected transformation away from carbon intensive energy is occurring at a relatively slow pace (International Panel for Climate Change [IPCC], 2007). The IEA (2011) state that renewable energy was projected to account for more than 40% of the total energy sources by the year 2035. Given the current energy statistics, this seems unachievable. This is disconcerting, given the much needed transformation in the energy sector. Furthermore, trends on the total GHG emissions by various economic sectors over the past nine years indicated that the energy sector contributed 26% and 31% in 2004 and 2013, respectively (Figure 3.1). This suggests that despite the increasing environmental concerns, the energy sector's contribution to global GHG emissions is increasing at notable scales (IPCC, 2007).

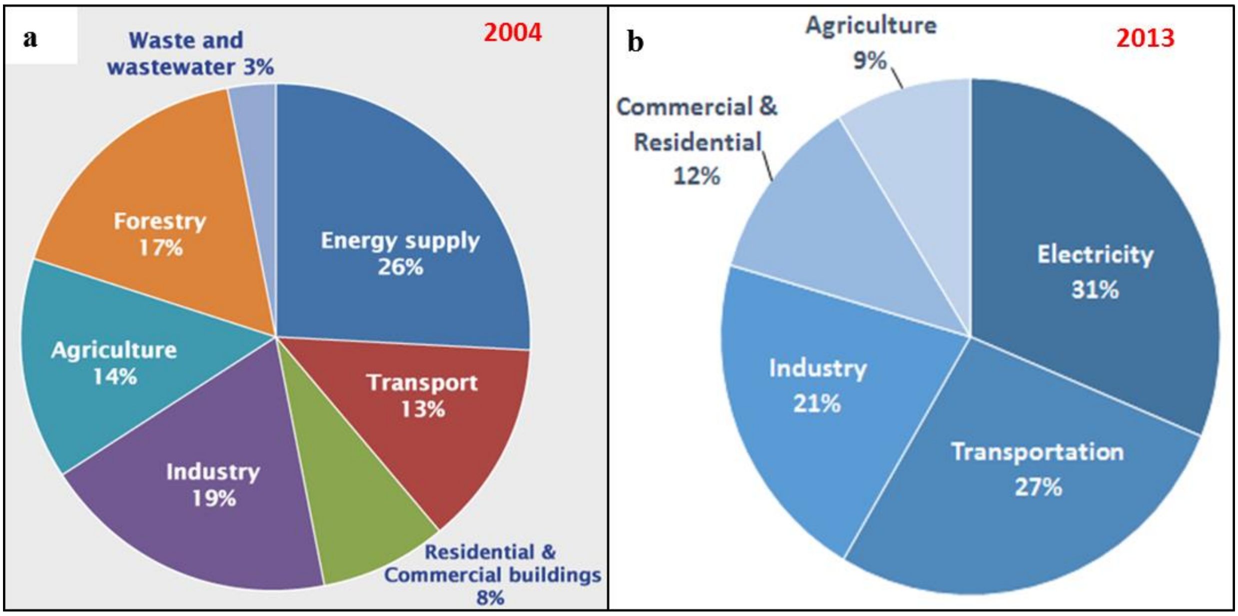

Figure 3.1: Sector-based GHG emission for the years 2004 (a) and 2013 (b) (adapted from: IPCC, 2007)

Nejat et al. (2015) state that carbon dioxide (CO_2) accounts for more than half the atmospheric GHG content and is considered the main contributor to climate change. Thangavelu et al. (2015) approximated 3.17 Gt (Gigatonnes) of CO_2 to have been emitted in 2012 with 42% of this emanating from electricity and heat generation; thus, the urgent need to switch to carbon poor alternative energy sources. Projected CO_2 emissions are expected to increase over the next 20 years, exacerbating climate change related threats (IEA, 2013). The IEA (2011) warn that even with changes in energy policy and the increase in usage of renewable energy sources over the next 15 years, CO_2 emissions are likely to remain at alarming levels. Interestingly, Nejat et al. (2015) show that energy use in the residential sector accounts for 17% of global CO_2 emissions and can therefore be considered an important sector for transformation. Additionally, energy demand within this sector is expected to increase exponentially given the current population growth rates (Nejat et al., 2015).

Harvey and Pilgrim (2011) add that residential consumption of energy may increase rapidly with greater demand for transport (particularly terrestrial and air travel) and food. Additionally, Bilgen (2014) asserts that modernisation of lifestyles through technology and globalisation will result in augmented energy demands at the household level, consequently increasing overall residential energy consumption. Even though current statistics show industrial and manufacturing sectors to be the highest energy consumers, future energy planning and transformation must also consider the residential sectors (IEA, 2013; Nejat et al., 2015). Thangavelu et al. (2015) recommend that in addition to embracing more renewable energy sources, governments should implement GHG reduction targets to address climate change related concerns. However, Akhmat et al. (2014) state that energy conservation policies will do little to alleviate energy related environmental pressure. Narrow approaches based on addressing singular components of the energy crises may not be sufficient. For example, addressing reliance on fossil-fuels alone, addresses environmental and resource concerns only and not issues such as energy affordability or security.

Lior (2010) notes energy conservation to be a vital aspect of the energy sector transformation; more specifically, improved energy efficiency, lower energy products, conservative energy lifestyles and a reduction of energy waste through recycling. Likewise, Khan et al. (2014) state that improving energy efficiency is a cost-effective way to reduce energy consumption and therefore GHG emissions. However, it should be noted that the move to renewable energy sources like solar and wind power may not necessarily equate to more energy efficiency in all countries, given the geographic variations in solar radiation levels and wind velocities. In order for renewable energy to meet current and future energy needs and provide the essential energy services, there needs to be significant developments in the capacity, storage potential and design of RETs (Fouquet, 2010). Given that total energy consumption and carbon emissions are inextricably linked, sustainable shifts in the energy sector are pivotal in climate change mitigation (Lawrence et al., 2013).

Nevertheless, transformation to sustainable energy practices remains a significant challenge especially amongst the poor in developing countries and particularly within sub-Saharan Africa and South East Asia. The slow transitions in the energy sector within these countries over the last five years, specifically, the uptake of renewable and alternate energy sources have been largely attributed to poor policy action, technological inefficiencies, and inadequate supply of energy to the user, and high costs (IEA, 2011; 2013). Sokona et al. (2012) are of the opinion that the slow transition to modern energy sources, especially among the poor exacerbates socio-economic inequalities and perpetuates risk and vulnerability. Fouquet (2010) submits that civil society may also be reluctant to commit to climate change mitigation due to the associated behavioural and technological changes. Many energy users may be unwilling to alter behaviours, especially in terms of energy conservation, reduction in consumption patterns and the switch to renewable energy (Fouquet, 2010).

Several studies have highlighted the relationship among energy, growth and climate change by focusing on economics, technological innovation and geopolitics (Winkler, 2005; Brown et al., 2008; Schaeffer et al., 2012). However, few studies champion the need for social science research to inform shifts in the energy discourse. Sovacool and Dworkin (2015) advocate for interdisciplinary energy studies that attempt to promote sustainability in the energy sector through greater cognisance of the social underpinnings. Therefore, it can be said that attempts to transform the energy sector to ensure a sustainable future are embedded in multi-dimensional approaches that not only seek to curb reliance on fossil fuels but promote radical shifts among all energy consumers towards energy conservation, and efficiency. Thangavelu et al. (2015) add that encouraging energy planning that underscores the use of renewable energy, diversity in the energy mix and GHG reductions will provide long term benefits related to energy cost and security.

The evolution of the energy discourse warrants the need to adopt trans- and interdisciplinary approaches and research. Issues such as energy security and poverty alleviation emerge as constants within the energy discourse and remain critical development needs. Kaygusuz (2009) states that the majority of the world's poor still lack access to modern energy sources and services, necessitating a redress of energy equality and access across socio-economic and geographic gradients. The next section describes differences along these gradients by providing an overview of energy security and poverty.

3.3 Energy security

According to Szabó et al. (2013), 1.6 billion people still lack access to electricity, the majority of whom reside in peri-urban and rural areas of sub-Saharan Africa and South Asia. This suggests that energy security remains a fundamental challenge within the developing world. Furthermore, 2.6 billion people still rely on traditional biomass for cooking, with sub-Saharan Africa, China and India having the highest proportions (IEA, 2013). This highlights several concerns as data for 2010 revealed that 2.5 billion people used traditional biomass globally, suggesting an overall increase in the reliance on traditional biomass (IEA, 2011). The increase in reliance on traditional biomass, although relatively minor, suggests that accessing modern energy options may be influenced by factors other than physical and financial accessibility.

Although the concept of energy security emerged during the late 1970s, to date there is no agreement on a universally accepted definition (Ang et al., 2015). Studies show that energy security is an extensive, context specific term that deals with a broad range of variables, thus making it difficult to address (Chester, 2010; Sovacool & Mukherjee, 2011; Ang et al., 2015). According to Sovacool et al. (2011: 5846), energy security is "how to equitably provide available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end users". According to Jansen and Seebregts (2010: 1655), energy security is defined as "the certainty level of enduring, uninterrupted access of the population in a defined region to affordably and competitively priced environmentally acceptable energy end-use services". Likewise, Blum and Legey (2012: 1983) state, "to ensure that an economy can reach its maximum level of welfare, it is necessary to ensure the supply and demand of adequate quantities of affordable and environmentally sustainable energy services".

Energy security therefore refers to the sustained supply of environmentally-friendly energy sources and services at a cost-effective rate. Bohi and Toman (1999, cited in Löschel et al., 2010: 1665) state that energy security refers to "the loss of economic welfare that may occur as a result of a change in the price or availability of energy". The IEA (2011: 12) define energy security as the "the welfare impact of either the physical unavailability of energy, at prices that is not competitive or overly volatile". Kruyt et al. (2009) describe energy security as an elusive term that lacks precise definition but is closely linked to security of supply of energy services and sources. Ang et al. (2015) suggest that due to energy being innately linked to all facets of life and production, the term is in constant evolution incorporating contemporary challenges such as climate change and poverty. Similarly, Chester (2010: 890) argues that energy security is intimately linked to climate change and therefore is more about managing risks; the author defines energy risk as "risk of uninterrupted, unavailable energy supplies; the risk of insufficient capacity to meet demand; the risk of unaffordable energy prices; the risk of reliance on unsustainable sources of energy".

Cherp and Jewell (2014: 415) define energy security as the "low vulnerability of vital energy systems". As suggested by the various studies above, energy security is a complex phenomenon incorporating issues of risk, welfare, affordability, energy demand and supply, and sustainability. However, permeating these debates is the consensus that energy security is a multi-dimensional issue and results in a variety of context specific symptoms. Johansson

(2013) asserts that energy is a vital commodity for the functioning of society and energy security is therefore the absence of threats to the energy system. These threats to energy security are considered to be multi-level consisting of primary, secondary and tertiary causes (Table 3.1) (Johansson, 2013). Although these threats are indicative of the prevailing socio-economic conditions, it is argued that they may not necessarily differ but simply have diverse expressions as a consequence of other externalities, for example, average population income, availability of energy sources, infrastructure, and price of energy sources, technologies and services (Jansen & Seebregts, 2010; Cherp & Jewell, 2014).

Table 3.1: Threats to and causes of energy security (Johansson, 2013: 201)

Threats	**Primary causes**	**Secondary causes**	**Tertiary causes**
Energy interruptions	Technical errors Handling errors	Lack of maintenance of energy infrastructure	Poor functioning markets Inadequate energy sector regulation
Price shocks	Weather and antagonistic events (terrorism) Supply and demand imbalances	Lack of education and awareness Lack of physical security	Political instability in energy producer and distributor countries
Long term high prices	Lack of physical resources	Lack of investment in search for alternative energy	Unsuccessful development of alternative energy sources

Nussbaumer et al. (2012) claim that energy security is a principal factor when addressing issues such as poverty, inequality, food security and climate change, and therefore is equally important in developed and developing countries. Jansen and Seebregts (2010) postulate the following to be important considerations in relation to energy security:

- Limiting reliance on fossil fuels over long-term periods will enhance security in the energy economy.
- Re-evaluating energy demand within a population may promote more efficient energy usage and provide more resilience against energy shocks.
- The use of indices that track medium and long-term changes in the availability and accessibility of energy services may reduce overall vulnerability.

Evidently, energy security is a broad polysemic term, manifesting in context specific definitions, impacts and contributors (Chester, 2010). Månsson et al. (2014) assert that the multi-dimensionality stems from stakeholders displaying different perceptions of the definition of energy security, the path to an energy secure future, and the point at which energy security is achieved. Cherp and Jewell (2014) propose that the diversity can be attributed to variation in available energy systems across the globe that in turn result in different energy related problems. They further state that policies on energy security often incorporates other contemporary challenges such as climate change and poverty which are prioritised and experienced differently across developing and developed countries. Furthermore, energy has evolved into a complex system of interconnections that are influenced by temporal and geopolitical variations which comprise objective and subjective dimensions (Johansson, 2013).

These dimensions are further influenced by the following (Johansson, 2013: 200):

- Security of supply and demand through resource availability, market performance, income stability and energy infrastructure;
- Economic and political risk which is a function of resource scarcity, over reliance on finite resources and power through energy necessities;
- Technological risks associated with skills, availability, maintenance, costs and applicability;
- Environmental risk such as climate change, pollution of air and water and threats to ecological systems, specifically biodiversity; and
- National and human security aspects which describe the ability to maintain modes of production and transport and sustain various livelihood needs, respectively.

Kruyt et al. (2009) claim that owing to the variety of contributing factors, there will always be different perspectives of energy security across the world, however, availability, accessibility, and affordability are among the key determinants. Likewise, Sovacool and Mukherjee (2011) are of the opinion that defining the factors that contribute to energy security may allow for the establishment of general frameworks that can be applicable across different contexts. Similarly, Ang et al. (2015: 1081) indicate that energy security comprises seven key themes: "energy availability, infrastructure, energy prices, societal effects, environmental impacts, energy governance and energy efficiency". By the same token, Sovacool and Mukherjee (2011) underscore the robustness of the term by examining affordability, availability, technology development and efficiency, environmental and social sustainability, and regulation and governance.

Permeating these debates is the underlying concept of vulnerability, and understanding exactly who is vulnerable to changes in the energy sector and under what conditions may provide a more nuanced approach to energy security. According to the UNDP (2014), vulnerability frameworks unpack issues such as health and economic shocks experienced by individuals or the household (Figure 3.2). In relation to energy, the loss of income or the death of bread winners or persons responsible for the accumulation of energy sources could exacerbate energy risk and insecurity (UNDP, 2014). Matutinović (2009) states that economic and political stability and constructs influence resource performance and are therefore an important indicator of physical and financial accessibility to energy. Buzar (2007) asserts that most poor households lack the capacity to respond to changes in energy markets, thus increasing vulnerability. Similarly, Pachauri and Rao (2013) highlight that women are often the most vulnerable to energy poverty due to the distribution of power, decision-making capacity within the household, and various cultural practices and household chores, such as cooking and the collection of fuelwood.

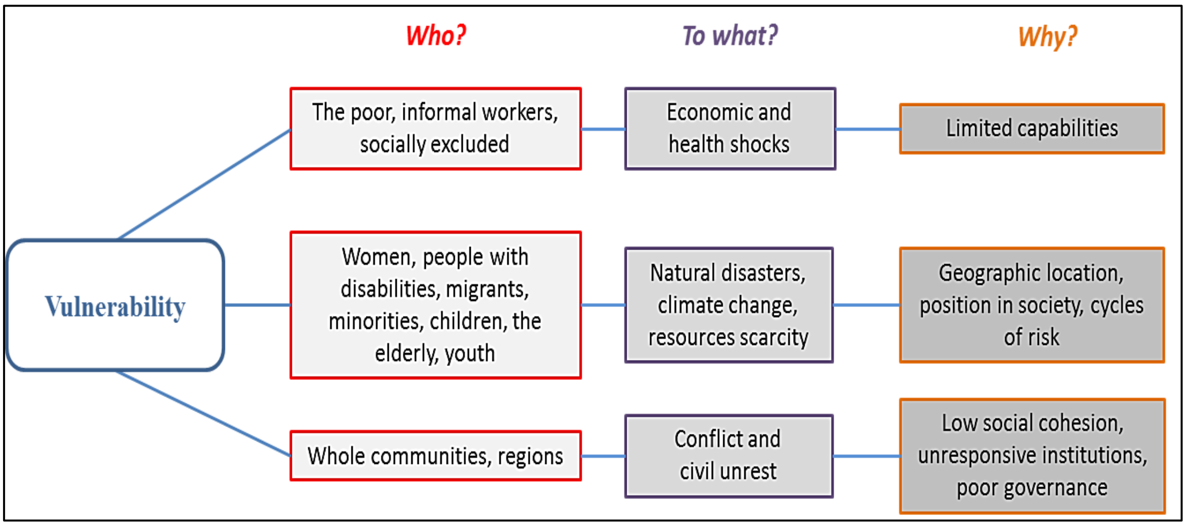

Figure 3.2 Dimensions of vulnerability (adapted from: UNDP, 2014: 19)

Chester (2010) and Kaygusuz (2011) state that energy security debates within developing countries are dominated by issues of accessibility and affordability whilst unsustainable consumption and environmental concerns remain a challenge in the developed world. Based on the diversity of definitions and the multiple expressions of energy security, there is a need to extend the scope of energy security measurements. Winzer (2012) argues that even though energy security is a key factor in current energy policy owing to its broad definitions, it is difficult to measure and evaluate progress towards energy security. Similarly, Cherp and Jewell (2014) claim that past assessments that were dominated by the political economy of energy supply did not adequately unpack the underlying socio-cultural factors contributing to energy security.

There are approximately 372 indices that measure energy security and overall performance. Some of these are listed below (Narula & Reddy, 2015: 150-151):

- Energy architecture performance index (EAPI)
- The international index of energy security risk
- Energy sustainability country index (ESCI)
- The diversity based index
- Energy security indices (ESIprice and ESIvolume)
- The willingness to pay function
- Oil vulnerability index (OVI)
- Vulnerability index
- Geopolitical energy security measure
- Economic and socio-political risk index
- Energy affinity index
- Energy sustainability index
- Aggregated energy security performance indicator (AESPI)
- Measuring short-term energy security index (MOSES)

Nonetheless, it is noted that in recent years' energy security assessments have adopted user-centric approaches that incorporate issues such as energy consumption patterns and behaviour (Sovacool & Mukherjee, 2011, Johansson, 2013; Ang et al., 2015; Day et al., 2016). Also, Sovacool and Mukherjee (2011) state that energy security is a multi-dimensional phenomenon and appraisals of it should be designed to reflect on both broad and specific issues; those authors further argue that the use of singular methods such as consumption per capita provide inadequate assessments. According to Winzer (2012), due to the all-encompassing features of and contributors to energy security, it is often measured as a factor of the source of risk, the scope of impact and the severity at which the impacts are experienced by the end-user. Narula and Reddy (2015) propose that instead of the standard metrics used to examine energy security, energy indicators provide a more holistic assessment of performance and linkages between energy price, use and economic activity.

Johansson (2013) extends this debate by advancing that approaches to and measurements of energy security differ across countries and are dependent on local energy systems and historical experiences. Other studies call for radical changes in infrastructure and technology that promote social change; for example, energy behaviour in an attempt to address energy security challenges (Ang et al., 2015; Sovacool & Dworkin, 2015; Day et al., 2016). Similarly, Winkler (2005) is of the opinion that qualitative analyses of energy needs, specifically cooking, heating, transport, production and industrial activities as well as the efficiency of energy sources and appliances at the household level provide a more robust analysis of energy security compared with overall access to energy. Furthermore, Jansen and Seebregts (2010) affirm that price and scarcity of oil and other fossil-fuels like coal, impact demand and supply of energy services and are therefore important indicators of energy security. Adding to this, energy prices are noted as critical gauges as they echo resource shortages and sustainability of energy supply and demand, and sudden energy price spikes have been noted to stifle economic growth resulting in inflation and unemployment which affect overall energy security (Löschel et al., 2010). Closely linked to price is energy availability which is related to the total quantity of energy available to meet consumer needs and the capacity to produce energy (Löschel et al., 2010).

Månsson et al. (2014) describe the following aspects to be measures of energy security:

- Resource availability which is inclusive of economic and political factors impacting supply, and physical factors such as geographic concentration of stocks and limitations on extraction rates as a consequence of climate change concerns.
- Global markets and trade comprising issues pertaining to the ability to sustain the import of energy sources, trade linkages with export countries, market related risk and foreign policy.
- Domestic markets and infrastructure: volatility of local markets, especially in terms of energy costs, investment in energy infrastructure, diversity in reliance on sources of energy, and performance and reliability of energy infrastructure.
- Economic vulnerability determined by macro- and micro- economic policy that aims to mitigate the impacts of energy price increases, resilience to market failure (for example, recessions) and the ability to respond to unplanned interruptions to the supply of energy.

Narula and Reddy (2015) argue that energy security and sustainability are complimentary terms where energy security cannot exist at the expensive of irreversible environmental damage therefore emphasising environmental impact as another important indicator. Winzer (2012) defines policy goals, sustainability and economic efficiency to be central to security assessments. Correspondingly, Bazilian et al. (2014) introduce the concept of energy governance which focuses on energy access, affordability and quality. Meyar-Niami and Vaez-Zadeh (2012) show that policy and the role of government institutions come under scrutiny and can be important indicators of energy equality and distribution. Energy equality across a population can therefore be considered a novel estimate of energy security compared with narrow measures used previously. The concept of energy equality will be discussed further in subsequent sections, particularly in relation to energy poverty and socio-economic development.

The combination of the diverse socio-economic constructs and local consumer energy needs produce significantly different energy landscapes across the globe. As a result, concepts such as energy security become increasingly difficult to define or measure. This is exacerbated by the notion that whilst energy systems are subject to insecurity threats, they also impose risk across many societies (Johansson, 2013). A critical aspect emerging from the energy security discourse is that of energy poverty which, in recent years, has become a critical development agenda, especially within developing countries (Modi et al., 2006; Kaygusuz, 2009; 2011; Ang et al., 2015; Bouzarovski & Petrova, 2015). The following section provides an overview of definitions, key concepts and approaches to energy poverty.

3.4 Energy poverty

Approximately 1.5 billion people worldwide lack access to electricity and a further 3 billion do not have access to modern energy for cooking. India, China, Indonesia, Bangladesh and Pakistan account for almost 86% of the world's biomass users (Rehman et al., 2012). From a geo-spatial perspective, energy poverty rates are disproportionally distributed across the globe with more than 95% of the world's energy poor residing in sub-Saharan Africa and Asia (Rehman et al., 2012). As suggested by several studies, the energy poverty phenomenon has deep-rooted development underpinnings and as such extends beyond the issues of access and affordability (Modi et al., 2006; Chester, 2010; Rehman et al., 2012; Bazilian et al., 2014). The concept of energy poverty emerged during the 1980s and was originally based on one's ability to afford warmth (Boardman, 1991 cited in Mayer et al., 2014: 229). Similarly, Buzar (2007) states that the inability of households to adequately heat their homes due to increases in the price of energy, during the post-socialist transformation, gave rise to the energy poverty discourse. Pereira et al. (2011a) assert that energy poverty is a derivative of poverty and is based on the principle that poverty within any society is deemed unacceptable.

Earlier works by Healy (2003, cited in Buzar, 2007: 225) aver that energy poverty conceptualisation must "aim to capture the wider elements of energy deprivation, such as social exclusion and material deprivation, as opposed to approaches based solely on home-heating expenditure or household temperature". Practical Action (2010) claim that energy poverty condemns the livelihoods and futures of many in developing countries due to the absence of modern energy services. Barnes et al. (2011) explain that energy poverty emerged as an important issue due to its direct impacts on health, education and income. Contemporary definitions of energy poverty underscore the multiple contributing factors and highlight both developing and developed world contexts in which this phenomenon is experienced (Buzar, 2007; Pachauri & Spreng, 2011; Sovacool, 2013; Bouzarovski, & Petrova, 2015; González-Eguino, 2015).

Since the 1980s the concept of energy poverty has evolved to include other aspects such as affordability, accessibility and availability of modern energy sources to meet basic needs (Buzar, 2007; Sovacool, 2013; Bouzarovski, & Petrova, 2015; González-Eguino, 2015). The IEA (2011) state that to date there is no agreement on the exact meaning of energy poverty and the term is often used interchangeably with energy access and energy vulnerability. Sovacool (2012) argues that defining energy poverty remains an onerous task due to its multiple dimensions. Nonetheless, a review of past and recent studies highlights several definitions of energy poverty (Table 3.2). It should be noted that this study examines energy poverty within the residential sector, more specifically, at the household level.

Table 3.2: Selected definitions of energy poverty

Definition	Source
"A lack of access to resources and denial of opportunities' which hampers an individual's ability to participate in the lifestyles, customs and activities which define membership of society."	Folwell (1999: 5)
"The absence of access to convenient, reliable, efficient and modern energy technologies to satisfy the basic needs that can support for human and economic development."	Parajuli (2011: 2299)
"When the amount of warmth in the home does not allow for participation in the 'lifestyles, customs and activities which define membership of society."	Buzar (2007: 225)
"The inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset."	(Gaye, 2007: 4)
"The absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development."	Masud et al. (2007: 47)
"Is when people do not have regular and safe access to electricity, consequently making intensive use of solid fuels."	Pereira et al. (2011a: 168)
"A lack of access to electricity and dependence on traditional use of biomass for cooking and heating."	Sovacool et al. (2012: 715)
"The lack of access to modern energy services. These services are defined as household access to electricity and clean cooking facilities (For example, fuels and stoves that do not cause air pollution in houses)."	IEA (2013a: 12)
"The lack of adequate modern energy for the basic needs of cooking, warmth and lighting, and essential energy services for schools, health centres and income generation."	Practical Action (2010: 2)

Barnes et al. (2011) define energy poverty as a state in which people utilise the minimum amount of energy required to sustain life. Permeating the collection of definitions highlighted in literature is the overarching recognition that energy poverty may be defined as the failure to perform everyday life tasks and practices due to the lack of affordable, accessible, modern, cost-effective, safe and environmentally-friendly energy sources. The links between energy and socio-economic well-being have been widely documented (Kanagwa & Nakata, 2007; Mayer et al., 2014; Black et al., 2015).

Practical Action (2010) argues that even though energy needs of the poor are relatively minor, access to minimum units of energy has a significant impact on their livelihoods and overall economic development. However, access to modern energy sources remains a critical challenge for developing countries. Modi et al. (2006) showed that in 2004, 2.5 billion people still relied on traditional biomass and a further 1.6 billion did not have access to electricity, all of whom can be classified as energy poor. Gross Net Product (GNP) has also been shown to be positively correlated with use of modern energy sources in several countries across Africa (Karekezi, 2002). Sovacool (2012) highlights a paradox in that even though a larger number of people have access to electricity (calculated as the percentage electrified households in a global population), a large proportion of households still live without electricity in parts of Africa and South Asia.

Accordingly, the majority of the world's poor survive on less than $2 (USD) per day, making the purchasing of modern energy services such as lighting and electric power difficult (Practical Action, 2010). Traditional biomass accounts for 70-90% of primary energy consumption within sub-Saharan Africa (Karekezi, 2002). A similar study estimates that approximately 653 million people do not have access to modern fuels in sub-Saharan Africa. A more recent report states that 1.2 billion people live on $1.25 or less per day and a further 1.5 billion people from developing countries live under poor living conditions and are deprived of basic health and educational services (UNDP, 2014). Barnes et al. (2011) indicate that the income poor proportions of society are generally considered to be energy poor, yet not all energy poor display low levels of income. In the latter case, energy poverty may be attributed to other external factors such as poor physical availability of modern energy sources (Barnes et al., 2011). Also, even though poverty rates have dropped over the last few years, approximately 800 million people are still at risk of slipping back into the poverty bracket (UNDP, 2014). In this regard, Sagar (2005) notes the lack of adequate funding to secure access to modern energy services as one of the many reasons why energy poverty remains a critical challenge in developing countries.

Modi et al. (2006) describe sub-Saharan Africa as the epicentre of the global energy crisis. Similarly, Karekzei (2002) states that in comparison to the rest of the continent, sub-Saharan Africa is plagued by lower levels of income and high levels of chronic poverty which could possibly explain the large concentration of energy poor. Buzar (2007: 238) highlights the following groups to be most at risk of energy poverty:

- Low-income households in rural and peri-urban areas of developing countries;
- Low-income households who have unemployed heads;
- Households with irregular sources of income;
- Single parent and women-headed households; and
- Households with multiple children and high dependency ratios.

This suggests that examinations of energy poverty must also consider who the vulnerable groups are or will be, rather than overemphasising why and how the phenomenon emerges. Brew-Hammond and Kemausuor (2009) assert that sub-Saharan Africa has the lowest electrification rate world-wide with only 30% of its population being electrified. However, it is argued that these statistics may be misleading as rates of electrification alone do not provide a holistic representation of energy poverty (Barnes et al., 2011). A similar study shows that even though sub-Saharan Africa displays the lowest rates of electrification, more than 1 billion people still rely on traditional biomass for cooking in East Asia (Sovacool, 2012). This underscores the complexities in acutely defining the concept of energy poverty. For example, in the United Kingdom (UK) the energy poor are classified as "households that spend more than 10% of their income on all fuels used to heat their homes to an adequate standard of warmth" (Parajuli, 2011: 2300).

Boardman (1991 cited in Mayer et al., 2014: 229) illustrates that households that spend more than 10% of their monthly income on energy, can be characterised as being energy poor. A recent study shows that even though the 10% indicator does not adequately consider household wealth and assets, it is strongly correlated with changing energy prices and can therefore be considered a useful indicator of energy poverty (Mayer et al., 2014). This definition may not be applicable in contexts where energy sources such as fuelwood are collected and not purchased. Nonetheless, the growing body of knowledge on energy poverty highlights the diverse contexts in which this phenomenon is experienced. It should be noted that previous studies have overemphasised the rurality of energy poverty, largely due to the fact that electrification was seen as the dominant solution for poor physical access to modern energy sources (Madubansi & Shackleton, 2007).

The more nuanced approaches to energy poverty begin to unpack some of these underlying factors and warrant a more critical evaluation of the contributing factors (Kaygusuz, 2009). In this regard, studies indicate that energy poverty rates are escalating within the urban areas (Practical Action, 2010; Jorgenson et al., 2010). It is argued that due to the increased rates of rural-urban migration, the poor in urban areas (specifically the peri-urban areas and slums), are fast becoming the epicentres of poverty (Jorgenson et al., 2010). The lack of access to modern energy services and the inability to sustain the use of modern fuels can be described as a symptom of energy poverty; these figures are expected to increase rapidly as a consequence of further migration and urban expansion (Jorgenson et al., 2010). Practical

Action (2010) predict that by the year 2030 almost 60% of the world's population will be living in peri-urban areas and warn that the demand for social services will overpower supply, especially in developing countries.

Clearly energy poverty represents a complex phenomenon that can manifest in various contexts and levels of severity depending on local socio-economic and political factors. Pachuri and Spreng (2011) state that energy poverty results from a combination of factors which include limited physical and financial access to energy types, lack of household income and high costs associated with specific forms of energy. Buzar (2007) states that energy poverty is linked to household energy efficiency which comprises the actual energy source and the services that the end-user derives from it. Evidently, energy poverty not only examines issues of access and availability but rather the services that one derives from the energy source. Sovacool (2012: 274) extends this debate by explaining that energy is primarily used for the following needs within the household:

- Basic needs: the provision of basic energy services such as lighting, communication, cooking and the ability to engage in educational activities and improved health and well-being.
- Productive needs: the ability to engage in income generating activities such as agriculture, water pumping for irrigation and mechanised tilling.
- Modern society needs: the ability to heat and cool households and living spaces, and the ability to use domestic appliances.

Based on the definitions of energy poverty offered above, it can be argued that the inability of households to meet any one or more basic needs determines the level of energy poverty experienced. In addition to examining energy needs, the following can be prescribed to indicate energy poverty: "electrification rates, ratio of end-use energy to total energy, and ratio of energy cost to income" (Barnes et al., 2011: 901). Buzar (2007) attributes the emergence of energy poverty to the failure of policy makers to systematically conceptualise the causes and consequences. Although defining and quantifying the severity of energy poverty remains a challenge, the impacts of energy poverty has been widely documented, as indicated in the section below.

3.4.1. Impacts of energy poverty

The majority of the world's poor experience difficulties in accessing modern energy sources and services with the most severe cases occurring within developing countries (Fullerton et al., 2008; UNDP, 2004; 2014). Energy poverty or the inability to access safe, cost-effective, and modern energy sources has been linked to several health, productivity, safety and security, empowerment and gender related impacts (Fullerton et al., 2008; Munien & Ahmed, 2012; Sovacool, 2013; Munien, 2014). Kaygusuz (2011) is of the opinion that the absence of energy increases social asymmetry and inequalities which have physical and psychological manifestations. The author further defines these as the lack of economic sustainability, increased occurrence or deepening of poverty cycles, and a disbelief in one's future or acquiring an improved quality of life. Inadequate physical and financial access to modern, safe and cost-effective energy options is an immense impediment to socio-economic development and well-being, especially for the poor in sub-Saharan Africa and South East Asia (Kaygusuz, 2011). The sections below highlight the multiple impacts of energy poverty which can occur in both developing and developed contexts. However, this study focuses specially on the impacts and experiences of energy poverty in rural and peri-urban communities within the African context.

3.4.1.1 Health

According to the World Bank (2002), the use of fuelwood in traditional cooking practices contributes to indoor air pollution (IAP) and is therefore a health hazard. For example, the use of biomass for cooking purposes results in the emission and production of carbon monoxide (CO), volatile organic compounds (VOCs), nitrous oxides (NO_x), sulphur oxides, polyorganic matter and respirable suspended particulate matter (RSPM) which impacts overall health and indoor air quality (Smith & Metha, 2003; World Health Organisation [WHO], 2006; Kim et al., 2011). Kaygusuz (2011) states that gaseous and particulate emissions from indoor smoke, (mostly generated from indoor cooking practices), reduces air quality and describes this to be a critical challenge in parts of sub-Saharan Africa and south East Asia. The WHO (2006: 8) states:

> The inefficient burning of solid fuels on an open fire or the use of traditional stoves indoors creates a dangerous cocktail of hundreds of pollutants, primarily carbon monoxide and small particles, but also nitrogen oxides, benzene, butadiene, formaldehyde, polyaromatic hydrocarbon and many other health damaging chemicals.

Another study indicates that biomass fuels, commonly used in developing countries, produce more organic pollutants such as benzene and formaldehyde, and is associated with Chronic Obstructive Pulmonary Disease (COPD) and Acute Respiratory Disease (ARI) (Smith and Metha, 2003). A similar study conducted in India suggests a correlation between the use of biomass fuels and risk of tuberculosis (Mishra et al., 1999). According to Röllin et al. (2004), health-related impacts of biomass are exacerbated by the use of low efficiency stoves, cooking techniques and energy sources. Moreover, exposure to IAP (exposure fraction or intake fraction) can be over 90 times more severe due to the total time spent indoors and the concentration levels of pollutants within confined spaces (Smith & Metha, 2003; Fullerton et al., 2008). Furthermore, research indicates that the impacts of energy poverty are disproportionately experienced across the sexes and age groups, where women and children in particular were found to be most vulnerable (Clancy et al., 2003; Denton, 2002; Munien & Ahmed, 2012). In this regard, Smith and Mehta (2003) show that exposure to IAP significantly enhanced the risk of health impacts and illness especially in women and children who tend to spend more time indoors.

A study conducted in Nepal shows that children (under the age of 5 years) were prone to suffer from ARI as a result of prolonged exposure to indoor air pollution (Parajuli, 2011). Other studies show that the use of traditional biomass in poorly ventilated spaces contributes to lung and eye diseases, miscarriages within the first trimester of pregnancy, poor maternal health, premature death of infants, and several types of cancers (Clancy et al., 2003; UNDP, 2004; Modi et al., 2006). Statistics from the WHO indicate that within developing countries 2.5 million women and children die prematurely due to exposure to fumes generated from biomass stoves (Bhide & Monroy, 2011). Likewise, households in developing countries that used 'dirty fuels' (for example biomass and kerosene) displayed higher child mortality rates compared with households that used cleaner modern forms of energy (Smith & Metha, 2003). Related studies conducted in Zimbabwe and Guatemala show that pregnant women who were exposed to indoor biomass smoke gave birth to children with significantly lower birth weight compared with women who switched to liquefied petroleum gas (LPG) or electricity (Mishra et al., 2004). Additionally, Kim et al. (2011) state that household indoor air pollution generated from the use of biomass produces both respiratory and non-respiratory illness (Figure 3.3).

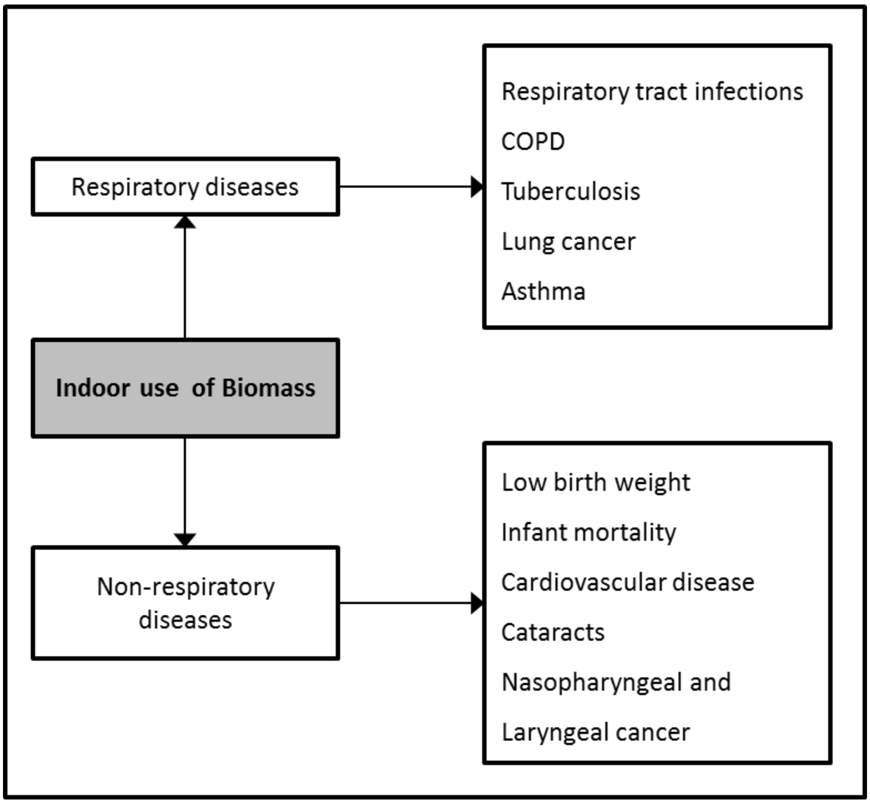

Figure 3.3: Health impacts of biomass smoke exposure (source: Kim et al., 2011: 426)

Kaygusuz (2011) asserts that these impacts are exacerbated in rural areas of South Asia and sub-Saharan Africa given their disproportionate reliance on traditional biomass. Cecelski (2000) argues that energy poverty has a distinct gender bias and due to the primary roles women play in procuring and managing energy use within the household, women remain the most vulnerable. In the absence of cost-effective and reliable energy sources at the household level, women and children endure the physical burden associated with procurement and collection of traditional fuels such as biomass (Cecelski, 2000; Biran et al., 2004; Chukuezi, 2009; Riojas-Rodríguez et al., 2013; Behera et al., 2015; Kemausuor et al., 2016). Sovacool (2012) reported indoor air pollution, injury during fuelwood collection and lack of proper medical supplies, such as vaccines due to the absence of refrigeration to be some of the main impacts of energy poverty. Once again, a distinct gender bias is noted in the nature of these impacts, given that the burden of biomass collection and use fall predominantly on women and in some cases children (Heltberg, 2005).

According to the IEA (2002), women in sub-Saharan Africa carry approximately 20 kg of fuelwood for an average 20 km per day, causing immense physical pressure which impacts overall quality of life. Sovacool (2012) is of the opinion that the collection of biomass also introduces an element of potential risk of injury; for example, walking long distances barefoot, attempting to cross rivers and busy motorways and changes in terrain and elevation. Burke and Dundas (2015) state that those tasked with accumulating fuelwood for the household face higher health and safety risks due to the heavy loads, risk of physical injuries and the total distance travelled. In addition to the health-related impacts, energy poverty contributes to other factors such as loss of productivity and opportunity for education and income generation, and safety and security issues.

3.4.1.2 Education, productivity and security

It is argued that one's productivity is proportional to one's health status and thus, the use of solid fuels such as fuelwood limits a person's economic contribution (Rao & Reddy, 2007). Heltberg (2005) shows that where household women and children spend most of their time collecting biomass or preparing animal dung as a source of energy, they are less likely to engage in activities such as education or income generation. Other studies have also shown the collection of fuelwood to be time and labour intensive, preventing women and children from engaging in activities such as education and income generating opportunities (Chukuezi, 2009; Barnes et al., 2011). Denton (2002) cites absenteeism from school and loss of productive hours to engage in educational activities to be among the many impacts of energy poverty. Furthermore, it is argued that schools that lack access to basic electricity are disadvantaged as they are unable to utilise modern technologies such as computers which limits opportunities, specifically access to information and the development of technological skills and capacities (Bridge et al., 2016). Bhide and Monroy (2011) confirm that women and children specifically are impacted by energy poverty, and estimates that a loss of 40.8 hours per household on a monthly basis due to reliance on traditional biomass. Bridge et al. (2016: 2) state that the lack of access to modern energy sources negatively impacts income through labour productivity and further argues that:

> Abundant, affordable energy defines nearly every aspect of daily work: no electric tools and machines for construction, farm work, or cottage industry; no illumination for any type of work after sunset; no cell phones to enhance communications; and no computers for acquiring information, organisation, and book keeping among other things.

Cecelski (2000) states that in the absence of electric power for activities such as irrigation, women are generally assigned these tasks which further impact their productivity and available day hours. Also, households that have access to modern energy such as electricity have showed improved levels of income, educational attainment, and agricultural and labour productivity (Bridge et al., 2016). Additionally, the lack of modern energy services such as lighting prevents after dark activities which can lead to limited participation in income generating activities, poor performance at school and reduced number of total productive hours per day (Clancy et al., 2003; Heltberg, 2005; Chukuezi, 2009; Bridge et al., 2016). Clancy et al. (2003b) show that a reduction in available productive hours results in limited capacity to diversify household income generating opportunities, limited engagement in educational and social activities, and poor performance at school, especially among female children. Similarly, Denton (2002) shows that the absence of electric power and lighting limits women's involvement in income generating opportunities due to a loss of productive hours which are used for tasks such as acquiring household fuels and water.

Additionally, the lack of electric power for processing of grains and milling of rice and other foods increases the burden on women by increasing their daily workloads (Denton, 2002). Heath (2014) argues that for women in particular, the loss of productive hours prevents them from accessing other labour opportunities which can exacerbate their vulnerability and powerlessness within the household. Casillas and Kammen (2010) assert that the impacts of energy poverty are diverse and can result in limited engagement in economic and educational activities thus preventing households from meeting their basic needs. The inability to work for extended hours in the day due to the absence of adequate lighting, poor health and the lack of basic services does not allow for adequate opportunity to engage in activities that aim to improve on the accumulation of livelihood assets, and can therefore enhance vulnerability (Modi et al., 2006; Buzar, 2007; Munien & Ahmed, 2012). Another study in Nepal showed that average literacy rates were significantly lower in districts that experienced chronic energy poverty and further argues that energy security is key in improving levels of literacy and education among the poor (Parajuli, 2011).

Burke and Dundas (2015) showed that in the Democratic Republic of Congo female labour force participation and employment were significantly correlated with biomass use; as women became active employees their reliance on traditional biomass reduced significantly. It is argued that persistent reliance on traditional biomass limits female engagement in income generating opportunities and employment, deepening gender inequality within the household. According to Barnes and Floor (1996), the use of traditional fuels for practices such as cooking and heating produce less energy per unit raw material consumed and is therefore considered inefficient, and is associated with greater opportunity costs (for example, negative impacts on health, loss of productive hours).

Table 3.3 shows the different rates of energy efficiency across the various sources and affirms that the time and labour costs associated with the use of traditional sources for daily activities are considerably higher compared with modern energy sources such as gas or electricity. As suggested by Kaygusuz (2011), the use of modern fuels such as electricity are known to have higher conversion efficiencies per unit raw energy compared with fuelwood and kerosene, thus allowing greater productivity for daily activities. Furthermore, cooking needs account for 80% of total energy consumption in rural households which contribute to the heavy reliance on collected or 'free' fuels such as fuelwood (Kaygusuz, 2011). In this regard, poor households fail to recognise the associated opportunity cost; for example, loss of productive hours, increases risk of injury and physical burden, in relation to their reliance on traditional biomass (Modi et al., 2006; Chukuezi, 2009; Parajuli, 2011; Behera et al., 2015; Burke & Dundas, 2015).

Table 3.3 Energy conversion efficiencies of fuels used for cooking and lighting (Kaygusuz, 2011: 939)

Fuel	**Efficiency**
Cooking	Conversion
Electricity	1.00
Propane/ kerosene	0.77
Fuelwood	0.15
Lighting	Luminous effect
Electricity	1.00
Candles	0.02
Kerosene	0.01

Energy poverty has also been associated with a number of safety and security issues, particularly in the case of women and children in remote and rural parts of the world. According to Denton (2002), the lack of suitable lighting creates unsafe environments for women and children in particular, due to the risk of crime and fire hazards associated with the use of candles. Furthermore, women are often blamed for the occurrence of household fires, given the distribution of domestic responsibilities, which can further jeopardise their safety (Denton, 2002).

The lack of adequate street lighting at night reduces women's safety and the ability to engage in community and educational activities (Denton, 2002). Poor involvement in social and community-based activities is believed to enhance women's powerlessness and lack of representation at the household and community level, thereby deepening their marginalisation and poverty (Munien & Ahmed, 2012). As mentioned above, it is widely established that energy poverty comprises one's ability to meet basic needs, escape poverty, reduce livelihood vulnerability through income diversification, improve on levels of basic education, and improve overall quality of life. Furthermore, given the multiple dimensions and impacts of energy poverty, energy researchers highlight a few indicators that can be used to examine the extent and nature of these impacts. These aspects are discussed in the section below.

3.4.2 Indicators of energy poverty

Pachauri and Spreng (2011) assert that attempts to reduce energy poverty are based on the general understanding and definitions of the phenomenon, however, as mentioned earlier there is still large-scale debate on an exact definition of energy poverty. Pereira et al. (2011a) state that while several studies define energy poverty in relation to accessing efficient energy sources, consumption-based variables may provide a more robust understanding of the phenomenon. Also, it has been noted that energy poverty is a measure of one's ability to satisfy basic human needs in a sustainable, safe and environmentally-friendly manner (Pereira et al., 2011a). Given that energy consumption patterns align with basic, productive and modern needs of a society, many authors have attempted to identify the minimum amount of energy necessary to fulfil these needs (Pachuri et al., 2004; Sagar, 2005; Modi et al., 2006; Barnes et al., 2011; Sovacool, 2012).

The minimum level of energy consumption is understood to be the quantity of energy required to survive by fulfilling basic lighting, cooking and heating needs (Barnes et al., 2011). As a result, the energy poverty line was established to indicate the upper and lower thresholds of what can be classified as energy poverty, which is similar to the income poverty line (Pereira et al., 2011a). It is suggested that the establishment of an energy poverty line is based on the variations in household energy demand which is a factor of income and other welfare indicators (Barnes et al., 2011). The minimum unit of energy necessary for a suitable standard of living by fulfilling basic human needs is between 50-100 kWh (Kilo Watt hour) per person, per year (Sovacool, 2012). Goldemberg (1990) argues that 500 J/s (Joules per second) of energy is required per person on a daily basis to meet minimum basic human needs. In relation to productive and modern energy needs, the minimum amount of energy required by the household is 500-100 kWh and 2000 kWh per year, respectively (Sovacool, 2012). Modi et al. (2006) state that the universally accepted minimum amount of energy required is 4 kgOE (oil equivalent). Pereira et al. (2011a) highlight that in Brazil, the minimum amount of energy required for basic needs is 9.65 GJ (Gigajoules)/ per year. These studies argue that households that have less than the specified limits can be classified as energy poor. Similarly, the severity of energy poverty can be measured by examining whether or not any of the needs are met on a daily basis.

Furthermore, it is argued that increases in income do not produce significant shifts in energy consumption for households below the energy poverty line; income-related shifts in consumption are only noted for households living above the energy poverty line (Barnes et al., 2011). Pereira et al. (2011a) state that energy poverty is more about how and when energy sources and services are utilised by the household. Sovacool (2012) argues that the non-income factors for example, living conditions, health and education, are equally important in examining the type of energy sources used for cooking practices, and can therefore be useful indicators. Madubansi and Shackleton (2007) refute the notion of measuring energy security purely from the 'access to electricity' perspective by stating that unless these attempts address the root causes such as unemployment and poverty, the total number of households living in energy poverty will remain relatively unchanged. Measuring energy poverty is a combination of examining who is energy poor, and understanding how and why they experience energy poverty (Pachauri & Spreng, 2011). Even so, attempts to reduce or eradicate energy poverty have been based on improving access to more efficient and safe energy sources. Studies argue that the notion of addressing energy poverty in isolation has led to inefficient policies and programmes which have little impact on reducing the world's energy poor (Bazilian et al., 2014). Those authors further highlight the need for more integrated approaches that aim to minimise poverty, improve levels of employment and income simultaneously.

Given that energy poverty is experienced differentially across the globe, the associated measurements are useful tools in unpacking the various contributing factors. In this regard, Pachauri and Spreng (2011) argue that measurements of energy poverty can be subjective as they are based on the minimum amount of energy required to meet basic needs, however, the definition of basic needs is still contested. Pereira et al. (2011a) show that measurements of energy poverty are based on three major notions: the portion of total household income used to acquire energy sources and/ or services; the total amount of energy consumed by the household; and physical and financial accessibility to different energy sources by the household. Barnes et al. (2011) add that amongst the low-income groups, energy consumption remains somewhat unchanged in relation to shifts in household income. Kaygusuz (2011) states that poor households spend a large portion of income on food items and therefore are unable to afford modern energy sources. Parajuli (2011) adds that energy poverty can also be examined based on energy consumption at the national level, however, this form of assessment must consider other poverty indicators such as the HDI and physical quality of life (PQLI).

According to the UNDP (2014), the HDI has been widely used to examine progress and is an integrated index based on average income, life expectancy and total schooling years. The human development report shows that sub-Saharan Africa and South Asia display the lowest levels of human development (UNDP, 2014). Similarly, the PQLI was developed as an attempt to measure the quality of life or well-being within a country which is presented as the average of basic literacy rate, infant mortality and life expectancy (calculated one year after birth) (Morrison, 1980). African countries such as Zimbabwe, Nigeria, Tanzania and Botswana ranked the lowest in the world in relation to PQLI values (Economist Magazine, 2005). This is unsurprising as these regions are also associated with the highest levels of energy poverty and vulnerability (Modi et al., 2006). As a result, in recent years there has been growing recognition that energy poverty assessments should also include an appraisal of the safety and efficiency issues associated with specific energy sources.

Another measure of energy poverty is the examination of fuel types used for basic energy needs within the household (Sovacool, 2012). Kaygusuz (2011) shows that the cost of useful energy varies across the globe, and further argues that the cost of energy services may also be important. Furthermore, it is noted that as levels of household income improves, individuals transition to more convenient and efficient sources of energy therefore, tracking changes in energy profiles can be useful in energy poverty assessments (Kaygusuz, 2011). A related study shows that improved access to energy services alone will do little to eradicate energy poverty and should be complemented by an improvement in the capacity of households to purchase these services (Parajuli, 2011). Another indicator established to define energy poverty is the ‘energy access-consumption matrix’ which examines the distribution of access to different sources of energy at the national level, and the total amount of energy consumed by households for basic needs (Pachauri et al., 2004).

It has been argued that increasing the supply of energy to poor household can reduce risk of energy poverty as well as empower households out of the energy poverty bracket (Barnes et al., 2011). Such indicators base the assessment of energy poverty on overall national performance. Whilst these are good for examining intra-country dynamics, it may provide inaccurate assessments when comparing across countries. Other measures include the Energy Development Index (EDI) which examines the total energy consumed by the commercial sector, the portion of commercially consumed energy in relation to total energy used, and the total proportion of the population that has access to electricity (IEA, 2004). Pachauri and Spreng (2011) state that the EDI allows for comparative assessments of energy development across countries, but does not permit an evaluation over time as values used in the calculations are normalised based on performance units calculated for that given year. Given that energy poverty is inextricably linked to income, poverty, health, and education, more nuanced approaches are required for the assessment of this phenomena. In light of the above arguments, it is widely accepted that accessing affordable, safe, efficient, reliable and environmentally-friendly energy services promote several livelihood opportunities and is linked to socio-economic well-being (Kaygusuz, 2011). The following section highlights some of the major findings in relation to the energy-development nexus.

3.5 Energy and Development

The importance of accessing sustainable, efficient, cost-effective and modern energy options have been well-documented, specifically in relation to socio-economic development, poverty alleviation and environmental protection; warranting the inclusion of energy issues as a fundamental aspect in approaches to development (Modi et al., 2006; Kanagawa & Nakata, 2007; Prasad, 2008; Fouquet, 2010; Lior, 2010; Nussbaumer et al., 2012; Rehman et al., 2012; Sokona et al., 2012; Szabó et al., 2013; Bridge et al., 2016). It is argued that sustainable economic growth, poverty reduction and improvements in health and levels of formal education are dependent on the regular supply of electric energy (Pereira et al., 2011a). Chaurey et al. (2004) argue that electricity is vital for both the enhancement of living standards as well as productivity and economic activities. Likewise, Kanagawa and Nakata (2007) assert that accessing modern forms of energy is among the fundamental requirements for development. Other studies argue that access to abundant, affordable and reliable energy is necessary in meeting basic needs and it enhances all aspects in relation to quality of life (Bridge et al., 2016).

Rehman et al. (2012) state that historically, access to electricity was considered the main driver of economic growth and development and is therefore subject to immense political influence and regulation. Improved access to energy has also been associated with improved accumulation of livelihood assets through the diversification of livelihood options, and the availability of more production hours in the day, previously consumed by the collection and procurement of traditional sources of energy (Cecelski, 2000; Denton, 2002; Modi et al., 2006). Gustavsson (2004), for example, showed that with better lighting services, school performance amongst children was greatly enhanced within Zambia. Kanagawa and Nakata (2007) also highlight several benefits of improving access to sustainable, cost-effective and safe energy sources and describe women and children to be the main beneficiaries (Figure 3.4). Although literature cites various linkages between energy access and poverty reduction, these relationships are complex in nature and need to be examined both quantitatively and qualitatively (Kanagawa and Nakata, 2007).

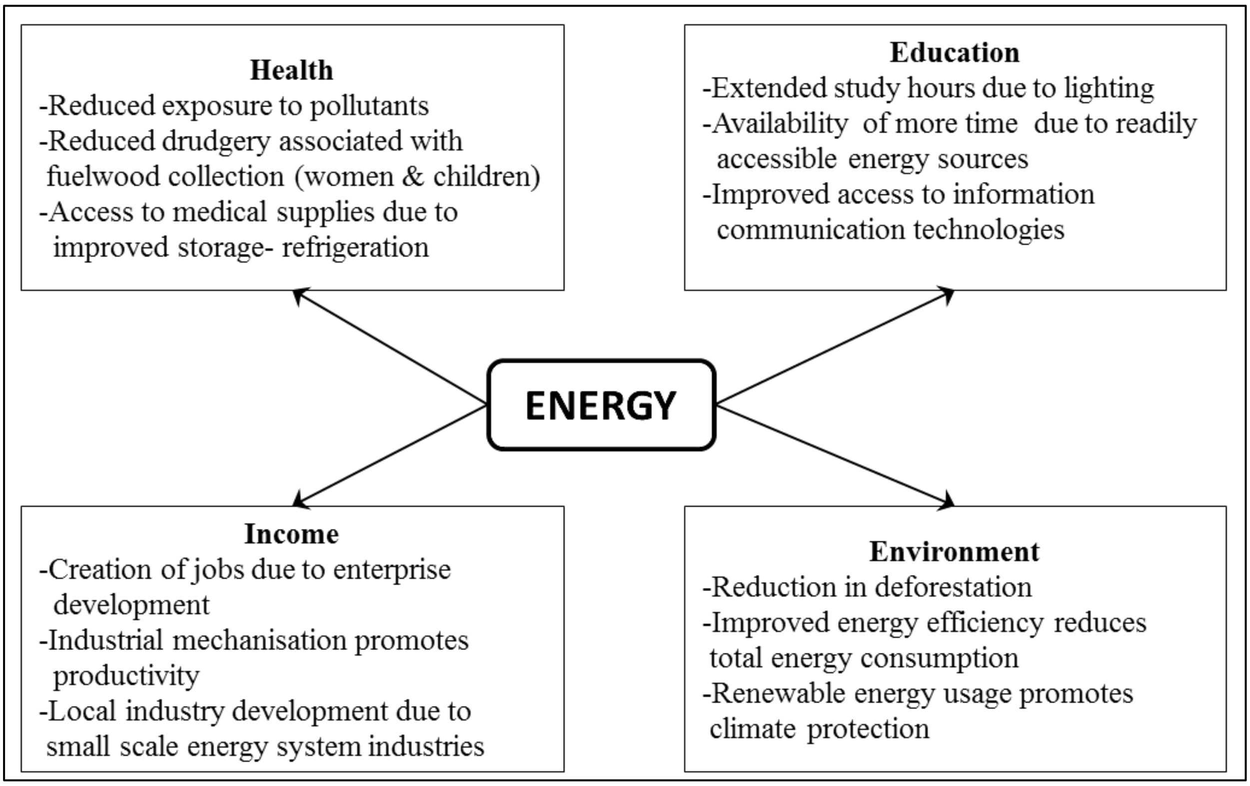

Figure 3.4: Benefits of energy (Source: Kanagawa & Nakata, 2007: 321)

It has been noted that the provision of energy services is directly linked to economic security and has the ability to promote overall social development and well-being (Sovacool, 2012). Pereira et al. (2011a) show that the introduction of electricity was closely associated within the adoption of modern cooking techniques and therefore a reduction in the use of solid fuels (such as traditional biomass), consequently reducing the risk of indoor pollution and other related respiratory diseases. Additionally, the use of modern energy sources was found to promote an improvement in living standards through the provision of services such as refrigeration, lighting, heating and cooling of living spaces and more efficient cooking appliances (Bhide & Monroy, 2011). Kanagawa and Nakata (2007) present similar findings from India where significant reductions in respiratory related illness were observed when gas stoves replaced traditional wood stoves. Barnes et al. (2011) assert that the availability of electric power and the associated energy services create vast opportunities for poor households through extended work and study time, which promote household productivity and educational achievement.

Bazilian et al. (2014) are of the opinion that access to modern energy services, for instance cooking, lighting and heating are necessary elements for an acceptable quality of life and thus should be prioritised as basic human rights. Similarly, a related study suggests a correlation between access to modern cooking energy and increased daily average of food intake (Pachauri & Spreng, 2011). Accessing cost-effective modern and reliable energy services has been noted to improve agricultural output through mechanised irrigation and processing of raw materials, facilitate the establishment of micro-industries that enhance employment opportunities for the local community, and improve level of participation in economic activities such as sewing, crafting and catering (Kaygusuz, 2011). Over the past two decades widening access to energy, more specifically access to modern sources of energy, has been central to many development initiatives within sub-Saharan Africa and South East Asia (Sokona et al., 2012).

Modi et al. (2006) argue that even though the MDGs do not overtly include energy, access to affordable, safe and modern energy services are essential for meeting all the MDGs. However, the recent SDGs highlight access to clean energy as one of the primary goals. In this regard, recent studies have also linked realisation of the SGDs to improved access to education, gender empowerment, improvements in health, and quality of life (Griggs et al., 2013; Lu et al., 2015; Chin & Jacobsson, 2016; Costanza et al., 2016; Bongaarts, 2016;

Fredman et al., 2016). Similarly, the International year for Sustainable Energy for All (SE4ALL) initiative calls for universal access to modern energy, a 40% reduction in global energy intensity, and an increase in renewable energy use to approximately 30% of total primary energy supply by the year 2030 (Sovacool, 2012: 227).

Additionally, the UN highlighted the following energy-related targets as essential in achieving the MDGs (Practical Action, 2010):

- Ensure that approximately 50% of the current traditional biomass users (cooking purposes) switch to modern fuels;
- Ensure that reliable modern energy services are accessible to the poor in urban and peri-urban areas;
- Ensure that all schools, health facilities (clinics and hospitals) and community centres are electrified; and
- Ensure that all communities in rural and urban areas have access to mechanised power.

It is firmly established that energy promotes multiple forms of development and empowerment. However, a recent study establishes that the number of people living without electricity has increased due to natural population increase rates exceeding the rate of electricity connections (Panos et al., 2016). This raises several concerns particularly in terms of meeting some of the goals prescribed in the MDGs, SDGs and the UN SE4ALL programme. The rate of electrification remains a critical challenge in developing countries. Furthermore, current reliance on fossil fuel-based energy options remains unsustainable and has a significant contribution to total carbon and GHGs. Current energy studies suggest an establishment of a nexus between energy, socio-economic development and environmental well-being, given the current concerns over the impacts of climate change and poverty (Szabó et al., 2013; Bazilian et al., 2014; Mayer et al., 2014; Bridge et al., 2016). Renewable energies are increasingly seen as viable options that address some of these issues without comprising environmental well-being. There has been significant technological advancements and innovation in relation to the application, design, capabilities and cost of residential-based alternate and renewable energy systems. The following section provides an overview of the renewable energy sector in relation to residential use and poverty alleviation.

3.6 Renewable energy: opportunities and constraints

The growing awareness around environmental and socio-economic impacts of the use of traditional and fossil-fuel based sources of energy highlight the potential role of renewable energy as a means to minimise the aforementioned impacts as well as attend to issues such as improving energy accessibility amongst the poor and low-income groups. Also, escalating climate change concerns provide the impetus for the adoption of cleaner energy technologies, and it is within this context that renewable energy sources are recognised to serve multiple benefits (Sagar, 2005). Achieving global access to modern energy services, a 40% reduction in global energy intensity and 30% increase in the use of renewable energy by the year 2030 are among the targets set by the UN in an attempt to attain global energy sustainability (Sovacool, 2012). Similarly, several international organisations and economies recognise the need to transform current energy consumption and production patterns by emphasising the shift from the use of fossil fuels to more environmentally-friendly sources such as renewable energy (Bazmi & Zahedi, 2011).

The introduction of renewable energy is rapidly increasing across the globe, however, there are major discrepancies at global and local scales in terms of security and efficiency (Chester, 2010). Trends in the energy sector reveal an emerging dualism which establishes energy security and energy efficiency as fundamental issues that underpin successful energy reform (Fouquet, 2010). Increasing concerns over climate-related impacts and carbon emissions from the energy sector has resulted in the large-scale implementation of renewable energy. According to Thirugnanasambandam et al. (2010), converting approximately 0.1% of global solar thermal energy has the potential to generate 3000 GW (Gigawatts) of power. In recent years, there has been considerable developments in renewable energy carriers and devices (particularly solar technologies), thus enhancing their application at institutional and household levels (Pinel et al., 2011; Tian & Zhao, 2013; Yettou et al., 2014). Chaurey et al. (2004) suggest the introduction of small-scale RETs for remote communities, or as short term solutions to delays in grid extensions.

According to Lemaire (2011), PV systems can serve as cost-effective and efficient alternatives for the delivery of energy services to remote households without the threat of indoor air and noise pollution, and GHG emissions. Lior (2010) states that although renewable energies can satisfy a significant portion of the global energy demand, issues such as price and accessibility present significant challenges, especially in developing countries.

Sub-Saharan Africa displays high levels of energy insecurities yet paradoxically, this region boasts the highest solar radiation intensity (Sanoh et al., 2014). Karekezi (2002) and Sanoh et al. (2014) argue that Africa shows significant potential for the use of renewable energy, however, this is severely underutilised, especially in relation to the following:

- despite the extensive coastline and fresh water resources across the continent, 7% of hydropower has been effectively harnessed;
- large-scale geothermal potential that has the ability of producing 9000 MW (Megawatts) of energy, however, only 45 MW is been utilised; and
- countries like Ghana, Zimbabwe, Kenya, Namibia and South Africa receive a daily average 5-6kWh/m^2 of solar radiation, however, photovoltaic applications are limited to specific devices and used in small decentralised or poor communities.

Solangi et al. (2011) are of the opinion that solar energy is the cleanest and most suitable renewable energy options with the least environmental implications. Furthermore, solar energy has been used extensively throughout Europe, the Americas, Asia, and Africa, making it applicable in both developed and developing contexts (Solangi et al., 2011). The introduction of small-scale renewable technologies has the potential to service basic energy needs in remote and marginalised communities, and in doing so lead to the establishment of smaller electricity grids that can service local industry and facilitate economic growth (Chaurey et al., 2004). It is stated that in order for energy programmes to be successful, they have to enhance the social value derived by end users by "defining the social value of energy, understanding how energy projects can deliver social value via discreet energy services, and designing the socio-technical arrangements of energy systems such that they deliver enhanced social value" (Miller et al., 2015: 67). Several studies advocate the use of renewable energy, especially in remote and rural settings where grid extensions remain a challenge (Bastakoti, 2003; Cherni et al., 2007; Nissing & Blottnitz, 2010; Kaygusuz, 2011; Blum & Legey, 2012; Onyeji et al., 2012; Becker & Fischer, 2013; Cherp & Jewel, 2014; Kemausuor et al., 2016). This study examines the factors influencing renewable energy implementation with special focus on solar-based technologies. There are projects across developing countries that note successful up-take and implementation of solar-based technologies within developing contexts and these are discussed in the subsequent section.

3.6.1. The use of renewable energy

Within the African continent, Kenya shows a long history of use of PV systems commencing in 1939 (Acker & Kammen, 1996). By the late 1980s most of the PV components were produced within the country, catapulting the growth of the PV industry and resulting in successful dissemination and implementation (Acker & Kammen, 1996). Kenya hosts one of the largest unsubsidised solar home systems and decentralised PV systems for rural electrification on the continent (Duke et al., 2002). The use of solar PV systems for electricity generation in Kenya supported economic and educational productivity, increased communication and connectivity (through radios, television and cellular phones), and the expansion of consumer goods markets (Jacobson, 2007). Evidence from Zambia's Lundazi District shows that although RET use among households has decreased over the years, institutional use was associated with several benefits (Mfune & Boon, 2008). For example, hospitals indicated improved refrigeration and concomitant use of vaccines; the use of solar microscopes resulted in a 30% increase in the detection of tuberculosis (TB), consequently increasing TB cure rates by 10%; and improved communication and reporting of emergencies as a result of solar radios (Mfune & Boon, 2008). Other successes of this Zambian project included enhanced student performance due to the availability of lighting and access to radio and other information technologies as learning aids, particularly television (Mfune & Boon, 2008).

Similar findings were noted in Algeria, specifically within remote rural villages, where solar PV systems improved public lighting, water pumping, telecommunications, and refrigeration (Stambouli, 2011). Furthermore, given the remoteness of some of these villages, the decentralised supply of energy services was at a significantly reduced cost due to savings on transportation and transmission (Stambouli, 2011). The application of PV systems in India show a marked increase in HDI, improved literacy rates, and indoor air quality (Chaurey & Kandpal, 2010). The use of renewable energy within the Indian context is, however, not limited to solar-based applications; biofuels and biogas are also gaining momentum, especially among rural communities (Chaurey & Kandpal, 2010). Pachuri and Spreng (2003) show that the use of renewable energy-based cookstoves and lighting facilitates growth and development through the creation of micro-enterprises and increased engagement in income generating activities, especially among women. Examples from South Africa indicate that the use of RETs improves access to basic energy services, and improves access to safe drinking water for domestic and medical purposes (Niewoudt & Mathews, 2005). Walwyn and Brent

(2015) state that the use of PV systems has improved significantly across South Africa and attributes this to the decreasing costs of the technologies.

Another example from KwaZulu-Natal, South Africa, shows that the conversion of shipping containers into micro-solar powered business centres were well received among communities, who cited the following benefits: ability to purchase goods locally compared to travelling more than 20 km previously; ability to charge their cell phones and batteries; access to printing and faxing services thereby improving overall connectivity; and the establishment of tuck shops and a sewing industry which improved income generating opportunities and access to services (Hajat et al., 2009). Barry et al. (2011) highlight benefits of solar power in Tanzania, where systems were used by local business to improve on the delivery of goods and services to local communities. In Egypt, the application of solar power is predominantly in the form of SWHs (more than 200 000 installed), and solar powdered desalinisation plants that are aimed at addressing water insecurities within the country (Bugaje, 2006). In the case of northern Ghana, PV systems secured access to extended lighting and was seen to improve performance in education among children and adults through adult-based literacy programmes; however, it had limited impact on job creation, health and gender equity (Kankam & Boon, 2009). Ahlborg and Hammar (2014) state that within rural Tanzania and Mozambique electrification rates are at approximately 5% and off-grid solutions such as PV systems have assisted in providing access to basic energy services.

Mondal et al. (2010) report that in Bangladesh 70% of rural households use traditional biomass stoves and the installation of 66 000 solar home systems have improved overall quality of life. Likewise, villages in Nepal showed a significant improvement in infant and maternal health spurred by the use of solar-based technologies for cooking (Parajuli, 2011). The island of Pangan-an in the Philippines showed a marked decrease in household reliance on kerosene advocated by the introduction of a solar power plant which feeds electricity to surrounding households (Hong & Abe, 2012). There are other countries such as China and India that display high levels of renewable energy implementation, particularly PV systems, biogas and hydro-based projects (Liming, 2009). A more recent study indicates that despite the rates of implementation of RETs, sustained use is a major obstacle within China and India (Becker & Fischer, 2013). Interestingly, China and India are described as the world's leading producers of PV and solar home systems (Becker & Fischer, 2013). This suggests that in addition to affordability and accessibility, there are other factors that govern the implementation and up-take of RETs. Understanding and informing the implementation of renewable energy and its associated technologies is one of the fundamental aspects that underpin this study. In this regard, the following section provides the context and overview of some of the recorded factors that promote or hinder implementation of RETs within the developing context and specifically among the poor.

3.6.2 Implementation of renewable energy options

The World Bank (2004) highlights that while Africa may be opportunistically positioned, the lack of infrastructure, limited human and technical capacities, poor financial and physical accessibility to RETs, and widespread poverty are major obstacles in embracing the full potential of available renewable energy resources. Likewise, Sanoh et al. (2014) argue that all countries on the African continent have excess energy resources, however, financial difficulties prevent many countries from harnessing their full energy potential. According to Chaurey and Kandpal (2010), PV systems are the most commonly used RETs within the residential sector. Furthermore, there have been several attempts to extend the application of RETs in the African context, for example, the introduction of biofuel cookstoves, ram pumps for irrigation, SWHs, and micro-hydro technologies for agricultural applications and processing (Karekezi, 2002). Lemaire (2011) states that although solar-based systems are implemented widely across developing countries, there are limited records of prolonged use due to the high start-up and maintenance costs. Based on evidence from South Africa, a fee-for-service type arrangement can sustain use of these technologies (Lemaire, 2011).

Private companies offer set-up and maintenance services for a monthly fee, however, this study warns that the monthly fee needs to be appropriately formulated based on local socio-economic conditions. Additionally, the fee-for-service approach for RET maintenance and repair must be supported by suitable energy policies and institutional frameworks (Lemaire, 2011). Energy studies assert that even though finance is not the only variable impacting implementation of RETs, it does represent a pertinent constraint across most developing countries (Chaurey & Kandpal, 2010; Parajuli, 2011; Becker & Fischer, 2013; Gabriel, 2016). Nonetheless, Chaurey et al. (2004) recommend the framework shown in Figure 3.5 for small-scale implementation of RETs in rural communities. It is argued that RETs have the potential to provide various benefits, including stimulating small industries and improvements in overall social and economic conditions at the household level. Others, such as Karekzei and Kithyoma (2002), assert that the dispersed settlement patterns across rural sub-Saharan Africa provides an ideal platform for the establishment of decentralised energy technologies.

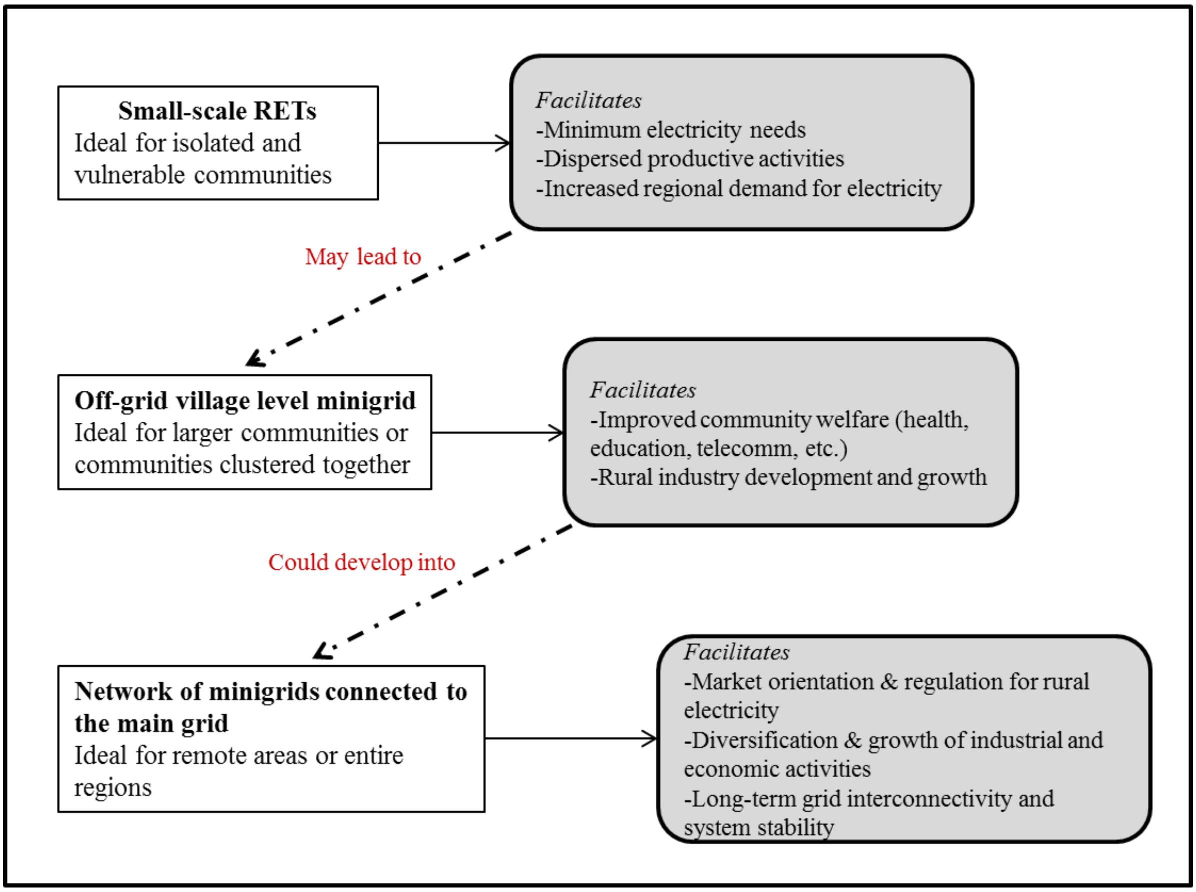

Figure 3.5: Framework for energy provision in remote rural areas (adapted from: Chaurey et al., 2004: 1704)

Ahlborg and Hammar (2014) suggest that government support through appropriate energy and development policies is key to the implementation of RETs, especially in the context of providing modern energy services to rural and poor communities. Additionally, the promotion of renewable energy and its associated products through donor support and awareness campaigns are key in shifting energy preferences away from traditional fuels such as fuelwood (Ahlborg & Hammar, 2014). It appears that the dissemination of RETs in the African context is specific to local needs and conditions. The selection of appropriate technologies is governed by RET maintenance and quality, suitability of technology to environmental and dwelling conditions, the transfer of knowledge and technical skills to users, technological capabilities that meet user needs and satisfaction, user affordability and accessibility, environmental benefits, and institutional support (Barry et al., 2011).

Bergmann et al. (2006) further argue that urban and rural communities are characteristically different which may require different RETs. In addition, government and donor agencies are cautioned against using the one-technology-fits-all approach for rural and urban communities, given the different socio-economic and environmental conditions (Bergmann et al., 2006). Duke et al. (2002) advise that due to the diversity in available RETs, users should be aware of performance and maintenance related issues before installation. Srivastava and Rehman (2006) state that decentralised solar home systems are used in remote rural villages in India and have assisted in servicing basic energy needs, however, they do not cater adequately for productive needs. In the Pagan-an case study mentioned earlier, a centralised solar power plant supplied more reliable energy at higher volumes compared with the standard household-based solar systems (Hong & Abe, 2012).

There is a need to examine the applicability and selection of RETs targeted for use by poor households, given the overreliance on home-based systems despite the fact that centralised plants display greater potential in providing reliable and more efficient energy services (Stambouli, 2011; Hong & Abe, 2012; Becker & Fischer, 2013; Jebaselvi & Paramasivam, 2013). Although centralised systems may cost more, they have the potential to offer long term solutions to energy poverty and climate change concerns because of their extended application and potential for local job creation and micro-enterprise development (Jebaselvi & Paramasivam, 2013). In this regard, Srivastava and Rehman (2006) state that there should be greater encouragement of user participation in an attempt to develop strategic partnerships for improved dissemination and implementation of RETs. Veldmann and Brinkmann (2007) show that market demonstrations, trade fairs, pilot tests and group presentations can be effective strategies to improve up-take, but warn that these should be carried out in cognisance of the different socio-cultural backgrounds. It is stated that acts of public disclosure on product quality, standards and testing, and the establishment of user support programmes may increase trust and social acceptance among users (Duke et al., 2002). Similarly, Sovacool (2012) argues that non-financial indicators such as behaviour, culture and levels of awareness are equally important for the dissemination and implementation of RETs.

Evidently, there needs to be greater consideration of the social environments when designing and implementing renewable and more efficient energy technologies. More specifically, energy carriers and technologies need to complement "knowledge and skills required to construct, operate and maintain the energy device or carrier, socio-economic conditions that enable the purchase and financing for construction, operation and maintenance, and regulatory and policy frameworks that support the development and dissemination of renewable energies and devices" (Miller et al., 2015: 68). Jacobson (2007) shows that within Kenya, television and improved telecommunication connectivity were the main drivers that promoted the use of renewable energy systems, suggesting that emphasising recreational benefits may improve up-take.

Similarly, understanding energy cultures may assist in tailoring implementation that is directly suited to the wants and needs of potential users (Stephenson et al., 2010). Pachauri and Rao (2013) assert that adopting modern energy options such as RETs is governed by household cultural practices. Verbruggen et al. (2010) are of the opinion that awareness campaigns that aim to inform and transform energy profiles and behaviours are key to the successful implementation of RETs. Mulugetta (2008) asserts that the use, implementation and maintenance of RETs require a range of technical skills and experiences, and therefore demands the need to include technical support systems for users. Chukuezi (2009) states that RETs are closely linked to increased productivity and improved health amongst women, especially in relation to adopting improved cooking and heating devices. Thus, it is suggested that the implementation of RETs, particularly cooking and heating devices, must be accompanied by appropriate skilling and capacity building programmes that target women, specifically (Munien, 2014).

In addition, social acceptance is an important factor impacting the design, transfer and up-take of RETs, however, this has been overlooked during implementation phases (Mallet, 2007; Wüstenhagen et al., 2007). Social acceptance comprises socio-political, community and market acceptance that relates specifically to supporting policy and institutional frameworks, community engagement and trust, and market performance of RETs (Wüstenhagen et al., 2007). Mallet (2007: 2790) argues that social acceptance is defined as the willingness to use and pay for RETs, which is influenced by "the processes of technology adoption; knowledge, persuasion, implementation and confirmation". Ku and Yoo (2010) show that willingness to pay for RETs is based on the combined effect of perceived affordability and economic status of users, and further argues that the amount users are willing to pay differs based on type, perceived benefits, and attitudes towards specific devices. A study conducted in Korea reveals that the prospect of increased job creation, environmental protection and a reduction in air pollution were some of the reasons why users developed favourable attitudes towards RETs and thus, displayed a willingness to pay for these technologies (Ku & Yoo, 2010).

A study in Crete indicated that willingness to pay for RETs was positively linked to household income, household size, dwelling size, awareness of climate-related issues, and energy conservation behaviours (Zografakis, et al., 2010). Contrary findings were noted in Sweden, where income and age was negatively correlated with willingness to adopt RETs (Ek, 2005). These studies highlight the importance of awareness and energy related behaviours in improving implementation of RETs. Moreover, improved awareness of environmental threats associated with energy use can evoke a change in behaviour and the adoption of RETs (Mallet, 2007). Chaurey and Kandpal (2010) aver that understanding user perceptions and attitudes towards RETs are important when examining the challenges and barriers to implementation and up-take. Using China as a case study, Yuan et al. (2011) show that public awareness of SWHs were positively correlated with level of education and income but negatively correlated with age. Additionally, the authors found that urban households displayed a greater willingness to adopt these technologies compared with rural households. This suggests that socio-demographic and geographical variables may also play a role in the implementation of RETs.

Mallet (2007) suggests that informing attitudes and perceptions may lead to changes in social norms and institutions, and may ultimately result in wide scale up-take of RETs. In this regard, establishing public-private partnerships is described as fundamental to changing perceptions and attitudes to and encouraging diffusion of RETs among the general public (Mallet, 2007). Walker et al. (2010) warn that in establishing public-private partnerships, social trust emerges as an important variable. In this regard, the nature and quality of relationships shared between communities and government bodies can potentially influence the adoption of RETs, however, these relationships are context specific and are a function of socio-political conditions (Walker et al., 2010). Additionally, it is stated that community trust builds social cohesion and a greater probability of RETs being widely accepted into that society (Walker et al., 2010).

Another study prescribes a community-based approach to the implementation of RETs, and further states that community ownership and participation in the production and use of renewable energy builds cohesion and thus more trust in the technology (Warren & McFadyen, 2010). Additionally, greater community-involvement is associated with positive psychological effects thus, eliciting positive attitudes towards the technologies used which can promote up-take (Warren & McFadyen, 2010). Likewise, Rogers et al. (2008) maintain that even though community-based strategies can improve on public acceptance of RETs, without institutional support it is doubtful that these attitudes will be taken on by the masses. Also, it is important to note that community participation is limited by divisive attitudes and perceptions, lack of resources including time, poor governmental support, and experience (Rogers et al., 2008). Furthermore, the levels of participation by community members can also assist in shaping attitudes and perceptions; manipulative and tokenistic participation may produce a negative impact (Rogers et al., 2008; Walker, 2008).

Reddy and Painully (2004) show that consumer perception and behavioural factors influence how RETs are perceived in relation to their utility, cost, and quality compared with conventional technologies. Sovacool (2009) argues that the relatively lower prices of conventional electricity over-shadow the social and environmental benefits of renewable energies; thus, consumers have a misguided perception of the actual costs associated with the generation and supply of fossil-fuel-based electricity. In this regard, improving public awareness of the impacts of energy production, especially air pollution and environmental degradation, may reduce public apathy towards the environment, enabling them to perceive and rationalise the actual costs of fossil fuels (Sovacool, 2009). Faisers and Neame (2006) posit that improved awareness of energy production and its impacts may also promote more energy efficient behaviours. Landscape values (the value awarded to different geographic spaces) also emerge as a key factor impacting energy perceptions (Rogers et al., 2008; Zografakis et al., 2010; Yuan et al., 2011). For example, the urban-rural dichotomy where one region is given preference to the dissemination of energy development initiatives can evoke public conflict and elicit negative attitudes and perceptions among certain groups (Mallet, 2007; Wüstenhagen et al., 2007; Rogers et al., 2008; Zografakis et al., 2010; Yuan et al., 2011).

Also, Sovacool (2009) states that behavioural barriers encumber social acceptance of RETs and implementation programmes must be cognisant of energy behaviours, culture and psychology. According to West et al. (2010), culture is described as the manner in which individuals view the world and can be classified into four main groups: fatalism, individualism, hierarchism and egalitarianism. According to West et al. (2010: 5742), these groups elicit specific perceptions towards RETs, for example:

- Individualistic groups display little concern for the environmental and therefore do not recognise the need for renewable energy;
- Individuals who have adopted the hierarchic philosophies acknowledge the need for renewable energy; and
- Egalitarian-based views lead to the belief that there is an urgent need for mass renewable energy for environmental protection.

Clearly, the cultural discourses produce different perceptions and attitudes towards renewable energies and technologies, however, it is probable that individuals do not fall precisely into these categories and the overlap across discourses can produce variable public perceptions (Stern, 1992; 2000; Stephenson et al., 2010; West et al., 2010). Faisers and Neame (2006) use the case study of SWHs to show that although consumers may hold certain egalitarian-based attitudes towards RETs, financial, economic and aesthetic factors dissuade them from adopting these technologies. Masini and Menichetti (2012) state that attitudes towards technological risk weigh on the probability of investing in RETs. Policies that aim to provide consumer support in relation to finance, maintenance and use can assist in promoting more favourable attitudes towards RETs, however, the role of governments and donor agencies are emphatically emphasised (Masini & Menichetti, 2012).

Faisers and Neame (2006), add that if consumers do not recognise the worth of RETs compared with their conventional energy sources, adoption of these technologies may be hindered. Moreover, in order for the public to adopt RETs they have to be knowledgeable of them; this highlights the role that media can play in improving knowledge and awareness around energy issues, environmental impacts and RETs (Faisers & Nemame, 2006). Television, radio, social media, newspapers and pamphlets can be used as effective tools for the dissemination of information, and can assist in framing RETs as marketable and attractive alternatives to consumers (Fasiers & Nemae, 2006; Munien, 2014). Rogers (1995, cited in Faisers & Neame, 2006: 1799) state that the diffusion of technology or innovation occurs in 5 stages; improving on knowledge of the technology; persuasion for adoption; making the decision to adopt; and implementing the technology and confirmation through use. These studies illustrate that the implementation of RETs is a complex process where consumers rationalise economic, financial, political, social, cultural and psychological factors and needs.

As mentioned earlier, it is important to engage potential users in the design of RETs. In this regard, the present study will inform the design and implementation of a novel solar thermal box-type cooker intended for small-scale use by examining household energy profiles as well as attitudes towards and willingness to pay for these technologies. The solar thermal cooker will be developed as part of a broader research collaborative initiative aimed at developing small scale systems for collecting and storing heat at approximately 250°C. The project also focuses on developing a range of different types of technologies based on the same principle of thermal heat storage. Solar cookers can be classified into three main categories, box-type cookers, concentrating-type cookers and non-focusing cookers, however, their application is dependent on the thermal storage efficiency, so cooking can continue during evenings and nights (Yettou et al., 2014). Some limitations of solar cookers include low cooking speeds, reduced functionality at night, winter and during rainy seasons and dangerous exposure to solar radiation, however, a few of these issues can be overcome by installing effective thermal energy storage (TES) systems (Mawire et al., 2010). Nonetheless, not all solar cookers have built-in TES systems due to the associated costs resulting in increased production costs which may not be suitable for poor or low-income households (Yettou et al., 2014).

Negi and Purohit's (2005) analyses show that non-tracking solar concentrator thermal box cookers have the potential to provide more energy efficiency for cooking through improved heat collection and storage; this can lead to a reduction in operator risks associated with exposure to high concentrations of solar radiation. Pinel et al. (2011) also suggest the use of chemical storage systems (for example, engine oil) to compensate for reduced efficacy due to seasonal changes. There is therefore evidence that innovative developments in the design of solar thermal cookers are extending their residential applications. According to Esen (2004), advances in solar thermal cookers has resulted in improved heat storage to achieve a maximum cooking temperature of 175˚C, allowing for the preparation of several foods over longer periods. Likewise, Buddhi et al. (2003) show that with improved latent heat storage late evening cooking with solar thermal cookers is possible. Furthermore, experimental studies show that there are significant improvements in solar thermal cooking devices, making them increasingly applicable for residential use (Sharma et al., 2005; Muthusivagami et al., 2010; Thirugnanasambandam et al., 2010; Pinel et al., 2011; Prasanna & Umanand, 2011; Kalogirou et al., 2016). This offers promising alternatives to households, particularly in developing countries, where energy poverty and reliance on traditional fuels present a number of health and social challenges. Pinel et al. (2011) show that the residential uses of STTs can be extended to space heating and the production of hot water which will improve overall living standards. Harmim et al. (2014) highlight affordability, enhanced energy efficiency across seasons and simplicity in operating systems to be key characteristics that will promote up-take and social acceptance of solar thermal cookers. The implementation of RETs, as defined above, is a context specific process that is impacted by several factors from diverse disciplines. The next section describes some of these challenges in detail.

3.6.3 Challenges and barriers

The literature establishes that based on studies throughout the developing context, affordability, accessibility, technological complexities, and maintenance are among the main barriers to the wide-scale implementation of RETs (Sagar, 2005; Winkler, 2007; Sebitosi & Pillay, 2008; Liming, 2009; Sovacool, 2009; Verbruggen et al., 2010; Masini & Menichetti, 2013). According to Panos et al. (2015), 590 million people lack access to electricity in sub-Saharan Africa due to outdated infrastructure which lack the capacity to generate sufficient amounts of energy. Miller et al. (2015) state that the programmes aimed at reducing energy poverty have been criticised because they fail to adequately transform the supply of energy into energy services that reduce vulnerability and overall poverty. In an attempt to achieve universal access to energy, developing countries need to support investments into maintaining and establishing suitable and reliable energy infrastructure (Panos et al., 2016).

One of the key challenges experienced within these countries is facilitating economic and social development while promoting energy security and equity, and environmental sustainability (Panos et al., 2015). According to Kaygusuz (2011), high initial set up costs of RETs is a major obstacle for implementation thus, the use of renewable energy remains low in the low-income contexts. Karekezi and Kithyoma (2002) argue that in addition to the limited affordability of RETs among the poor, conventional PV and solar-based systems can only be used for lighting and powering small appliances, thus only servicing a portion of energy needs. Furthermore, the application of certain renewable sources, for example, hydro, wind and geothermal power, is severely constrained by resource availability confining use to specific geographic regions. Moreover, environmental factors, (for example, storms, cyclones, droughts, snow and hail) and dwelling characteristics (such as roof design and material, and structural support) also emerge as factors that could influence dissemination of

RETs (Beck & Martinot, 2004; Bergmann et al., 2006; Pegels, 2010; Practical Action, 2010; Parajuli, 2011; Ahlborga & Hammar, 2014).

Bugaje (2006) shows that in Mali, solar cookers were prone to failure due to their limited energy storage capacity and are limited to outdoor use which did not support cooking activities after daylight. Similar issues relating to limited battery capacity of solar cells were recorded in Ghana (Jacobson, 2007). A study conducted in West Africa shows that even when improved cookstoves were available, women did not use them due to the following limitations in the design of the technology (Miller et al., 2015: 68):

- Size of improved cooker was too small;
- Cooker was not adaptable to pot sizes;
- Limited durability to support preparation of larger meals and water heating; and
- Time taken to heat.

Chaurey and Kandpal (2010) show that within India, maintenance of household PV systems was a major challenge and often was not successfully carried out given the limited technical capacities. In this regard, the author suggests a 'fee-for-service' type agreement with private service providers. Stambouli (2011) shows that in many rural and low-income communities the 'fee-for-service' approach was not well received as maintenance costs were not affordable to many of the households. Similar findings were noted in South Africa for SWHs, specifically (Neiuwoudt & Mathews, 2005). Mondal et al. (2010) and Hong and Abe (2012) state that the use of poor quality materials in the construction of RETs (in an attempt to reduce costs) poses severe long term costs, especially in relation to maintenance and repairs.

Limited financial and physical resources within poor communities does not support the emergence of renewable energy markets thus, there is need for energy projects to not only provide energy services but create suitable markets and social value for households, governments and other key stakeholders in an attempt to encourage investment in RETs (Practical Action, 2014). Also, factors such as top-down institutional organisation, lack of government and donor agency support, poverty, gender asymmetry, poor capacity and performance of technologies, high initial and maintenance costs, limited energy infrastructure that support the use of RETs, and cultural practices were seen as the main barriers to RET implementation in Tanzania and Mozambique (Ahlborg & Hammar, 2014).

Other challenges were noted in Nepal, where subsidies for RETs were ineffectively utilised by most poor households as they were unaware of them and more importantly some could not afford the initial set-up costs of the RET system (Parajuli, 2011). Mfune and Boon (2008) show that lack of knowledge and information on RETs among users impact negatively on implementation and uptake. Likewise, Bastakoti (2003) illustrates that when dealing with novel energy carriers and technologies, perceptions among end-users vary considerably and can be a major obstacle in adoption and implementation. This is emphasised by the findings of Mondal et al. (2010) who note that the lack of information and limited levels of awareness on RETs produce difficulties during implementation. Furthermore, a study in Bangladesh revealed that limited technical and empirical skills and knowledge of the RET among users were noted as some of the obstacles encountered during installation and implementation (Mondal et al., 2010). Miller et al. (2015) state that one of the main barriers facing developing countries in shifting reliance to renewable energy is the failure to integrate social and technical aspects into implementation programmes. Barry et al. (2011) argue that in general, the transfer of technology within the African context has been poor due the limited technical skills, human and financial resources.

Similarly, Kaygusuz (2011) is of the opinion that support for energy investment is constrained by the households' ability to pay for modern energy services, high set-up and initial costs of RETs, and the limited capacity of institutional frameworks to improve availability and accessibility of RETs at the household level. Cherni et al. (2007) are of the opinion that poor up-take and use of RETs are attributed to the lack of consultation and involvement of end-users in the planning and implementation phases. Similarly, Onyeji et al. (2012) attribute limited adoption of RETs, in the African context, to limited access, insufficient RET capacities, poor institutional and policy frameworks, and limited financial resources. These are further emphasised by Solangi et al. (2011) who cite high initial costs, limited and poorly formulated energy policy, limited levels of community awareness, and limited technical skills and knowledge to be major obstacles for the wide-scale implementation of RETs.

Other studies argue that social acceptance and knowledge of challenges faced by other RET users may elicit negative attitudes in potential users (Reddy & Painuly, 2004; Mallet, 2007; Wüstenhagen et al., 2007; Sovacool, 2009; West et al., 2010; Yuan et al., 2011). Using the case study of Maharashtra, Reddy and Painully (2004) argue that it is important to understand the nature and extent of the barriers to technologies as these discourage buy-in and long-term use. Additionally, these barriers differed across RETs, with financial barriers and the lack of technical awareness commonly associated with the adoption of solar-based technologies (Reddy & Painully, 2004). Additionally, RETs are often associated with discomfort and sacrifice rather than the realisation that required energy services can be attained through healthier, safer and more cost-effective means (Reddy & Painully, 2004). Yuan et al. (2011) argue that this is related to the limited levels of awareness and information on RETs in relation to its benefits, utility and capacities.

Venkatesh et al. (2000) assert that processes of adopting new technologies are different among the sexes; for example, the decision to adopt new technologies were closely correlated with attitudes among men, and women's choices were influenced by subjective norms and factors that control behaviour. Modi et al. (2006) state that energy projects were carried out in a gender-neutral manner which resulted in failure. Denton (2002) shows that women's involvement in agricultural activities and the dependency on traditional biomass makes them key stakeholders in the provision of energy services. Karekezi and Kithyoma (2002) assert that access to modern energy would greatly improve the practice of agriculture and the well-being of women given that women are predominately tasked with agricultural activities. Therefore, greater gender inclusivity and participation should be a key objective in future energy projects. Related studies show that RETs are often technologically complex which can dissuade users from adopting them (Sovacool, 2009). Gumede et al. (2009) show that women in rural communities face immense challenges in physically and financially accessing modern energy technologies.

Additionally, women experience challenges in accessing credit for the purchase of technology which has been attributed to limited levels of education, limited rights to land and other assets (that could be used as collateral by financial institutions), and limited power and decision-making capacity within the household (Gumede et al., 2009). According to Karekezi and Kithyoma (2002), there has been some micro-scale cognisance of the gendered nature of energy consumption, especially concerning technologies such as gasifiers, solar and biomass cookstoves; however, this is severely underrepresented at the policy level within sub-Saharan Africa. This is a major concern in countries such as South Africa that display high proportions of female-headed households (Mandhlzai, 2000 cited in Karekezi & Kithyoma, 2002: 1074).

Bridge et al. (2016) state that these limitations are symptomatic of many developing economies and are therefore some of the main challenges in transforming reliance to more sustainable, modern and efficient energy options among the poor. As mentioned earlier, simply ensuring physical and financial access to renewable energies does not always facilitate up-take warranting a deeper understanding of the factors that influence households' or individuals' energy choices. Lior (2010) argues that sustainability in the energy discourse is a consequence of improved efficiency and energy conservation which can be attained by modifying current energy profiles and behaviour. Likewise, attempts to bring about energy efficiency and conservation within the residential sector must unpack the social systems and behavioural factors that determine household energy consumption (Kaplowitz et al., 2012). This study examines energy behaviour and household fuel choices in an attempt to improve implementation and up-take of RETs at the household level. The following section describes factors that influence residential energy behaviour and profiles.

3.7 Household energy behaviour and profiles

Cherni et al. (2007) show that the processes of energy prioritisation and household energy needs are critical factors that need to be integrated into energy policy and the development of appropriate technology. Given that energy poverty remains a critical global development issue, it is important to understand the factors that influence household energy profiles and how the energy poor respond to changes in the energy sector. A key variable distinguishing the energy poor from the rich is the availability of a wide range of energy options at the household level (Pereira et al., 2011a). Barnes et al. (2011: 896) state that household energy demand is influenced by "household level factors (highest level of education attained, land and non-land assets, hygiene, preferences and the ability to afford certain types of energy), and community level factors (energy price, community infrastructure, prevailing wage structure, and commodity prices)". Notably, energy consumption at the household level is influenced by several internal and external factors.

In this regard, focus should be placed on the energy sector itself as a key driver of household energy profiles and behaviours. Changes in the energy sector have profound impacts on economies and therefore household energy profiles, for example, the concept of improved heating as a result of electric heat energy enabled the shift from biomass to electricity (Grübler, 2004). Although the transition to electricity was associated with improved energy services it came at a higher cost which meant that households that could not afford electric power continued their reliance on biomass (Friedrichs, 2010). It can be argued that the transition to modern sources of energy exacerbates the gap between the rich and poor and is associated with the emergence of the energy poverty phenomena (Buzar, 2007). The differential energy consumption patterns experienced across the world, as a result of physical and financial accessibility, led to energy being positioned as a valuable commodity in world trade markets and is fundamentally linked to the functioning of both developed and developing economies (Friedrichs, 2010). Bashmakov (2007) argues that shifts in the energy sector are periodic events termed energy transitions, and are facilitated by three primary laws:

- The law of long term energy costs to income stability;
- The law of improving energy quality; and
- The law of growing energy productivity.

Similar studies conducted by Allen (2009) and Mulugetta (2008) argue that price is an important factor that determines overall energy transitions within a country. Likewise, Fouquet and Pearson (2012) argue that the type of energy service, energy efficiency and technological developments are key drivers of energy transitions. Fouquet and Pearson (2012) are of the opinion that during periods of energy transition there are notable increases in consumption which is linked to decreases in prices of energy carriers and the associated technologies. As processes and implementation become more streamlined the costs associated with the 'new' sources of energy decrease rapidly, creating more competitive markets and thus more room for uptake by consumers (Fouquet, 2010). Correspondingly, Asafu-Adjaye (2000) shows that economic growth is associated with higher demand and consumption of energy as a result of increased total income amongst the population.

Moreover, Fouquet and Pearson (2012) show that energy transitions are likely to occur when the cost of energy services are cheaper than the energy source itself. These studies indicate that the price of specific sources of energy and their associated services are fundamental in facilitating energy transitions which could be useful in extending the use of alternative and renewable energies. Furthermore, Bashmakov's (2007) third law of energy transition relates specifically to energy productivity, suggesting that the rate of uptake of new and/ or modern sources of energy is linked to the recognition of enhanced energy services and benefits to consumers. For example, electricity provided enhanced services such as lighting and increased total productive hours per day thus, the shift to electric power from traditional biomass was relatively rapid (Belke et al., 2011). Kaygusuz (2009) supports this by explaining that accessing modern forms of energy such as electricity is associated with increased productivity at the household level and the resultant impacts are apparent within the first hour of using electric power.

In an attempt to unpack household energy behaviours and practices, the ladder of fuel preferences (commonly referred to as the energy ladder), was established to explain household transition to modern sources of energy for cooking purposes (Leach, 1986; Hosier & Dowd, 1987; Davis, 1998). According to Hosier and Dowd (1987), households adopt a neoclassical consumer approach to energy selection and transition to more sophisticated energy services and sources as their income increases. The energy ladder model proposes an energy hierarchy and assumes that an increase in income will result in households ascending the energy ladder and thus the transition from traditional to modern, more efficient energy sources (Figure 3.6) (Davis, 1998; Masera et al., 2000). van der Kroon et al. (2013) categorise these energy sources into three groups: primitive (fuelwood, agricultural and animal waste), transitional (charcoal, kerosene and coal) and advanced (electricity, LPG, biofuels). It is stated that energy sources higher up on the hierarchy (energy ladder) are considered to be more efficient and expensive but are less labour intensive and produce less pollution, and are therefore awarded higher social status by households (Masera et al., 2000). Additionally, the upward movement along the ladder is not limited to factors such as concern for health and improved energy efficiency but can be based on the household's need to attain a higher social status (Masera et al., 2000).

Heltberg (2004) argues that households ascend the energy ladder in three phases:

- Phase one: use of traditional/ primitive, for example dung and fuelwood.
- Phase two: an increase in household income will result in the adoption of transitional fuels such as kerosene
- Phase three: strengthening of household prosperity and income security will result in the complete switch to advanced fuels like electricity.

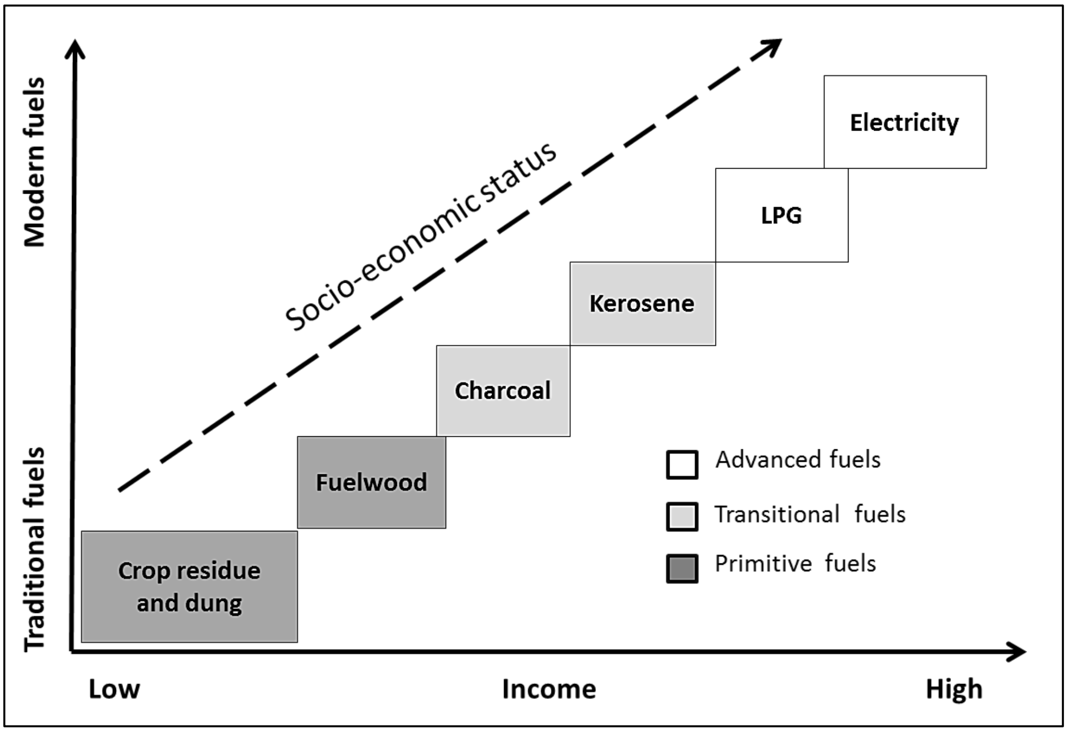

Figure 3.6: The energy ladder model (adapted from: van der Kroon et al., 2013: 505)

Sovacool (2012) explains that even though energy ladders are fundamentally flawed they can be useful in describing the differences between rich and poor energy users. Given that household energy profiles are inextricably linked to income, energy consumption patterns and behaviours are varying alongside household income, as illustrated in Table 3.4 (Madubansi & Shackleton, 2007; Kowsari & Zerriffi, 2011; Sovacool, 2012; Sola et al., 2016; Zhang et al., 2016). Sovacool (2012) shows that household energy profiles within developed countries show heavy reliance on modern energy sources across income groups whilst households in developing countries show continued reliance on traditional sources, even when levels of income improve. A possible explanation for this is that the cost per unit energy for poor households, particularly in developing countries, is comparatively higher for activities such as cooking and heating since they are limited to inefficient energy sources and appliances (for example, open pit cooking). This suggests that an improvement in household income may not necessarily lead to the purchase of modern sources of energy (Sovacool, 2012).

Table 3.4: Horizontal household energy ladder (adapted from: Sovacool, 2012: 273)

Energy service	Developing countries			Developed countries
	Low-income	Middle-income	High-income	
Cooking	Wood, charcoal, agricultural residues and dung	Wood, agricultural residues, coal, kerosene and biogas	Wood, kerosene, biogas, LPG, natural gas and electricity	Electricity and natural gas
Lighting	Candles, kerosene (sometimes none)	Kerosene and electricity	Electricity	Electricity
Heating	Wood, agricultural residues and dung	Wood and agricultural residues	Wood, coal and electricity	Oil, natural gas and/ or electricity
Other appliances	None	Electricity, batteries	Electricity	Electricity

The failure of the energy ladder model in describing the impacts of other related factors that may bring about change in household energy profiles suggests that the impact of income may be overpowered by other variables (Sovacool & Muhkerjee, 2011). Masera et al. (2000) argue that the use of the energy ladder in rural contexts is problematic given that most biomass in developing countries is collected not purchased and the energy model assumes income to be monetary in nature. Another limitation is that the energy ladder model assumes that the transition to modern fuels is linear in nature and that a complete shift to the more modern fuel occurs; however, energy choices are a complex outcome of multiple factors (Pachauri, 2004; Howells et al., 2005; Gyberg & Palm, 2009; Allcott & Mullainathan, 2010; Kok et al., 2011; Kastner & Stern, 2015; Mensah & Adu, 2015; Romero-Jordán et al., 2016). Sovacool (2012) warns that energy ladders are flawed because they do not capture the complexities of household energy consumption and are based on the premise that movement on the energy ladder is by default upwards. Similarly, Heltberg (2004) explains that even though energy ladder models acknowledge the impact of income, their failure is to inadequately consider the possibility of a downward shift, and posits a complete fuel-switch which assumes that traditional and modern sources of energy are not used concurrently by the household.

Fuel-switching is the shift from traditional solid (biomass and animal dung) energy sources to modern non-solid (electricity, LPG and oil) sources of energy and is defined along three categories (Heltberg, 2004: 879):

- No switching - only solid sources of energy are used;

- Partial switching - both solid and non-solid sources are used; and
- Full switching - only non-solid sources are used.

Even though a complete switch can be noted in some households most poor households in developing countries are considered partial switchers or hybrid energy users (Masera et al., 2000; van der Kroon et al., 2013). This suggests that attempts to transition low-income households to more modern sources should not be limited to physical and financial accessibility but should also consider the factors influencing household energy preferences/ choices. An improvement in levels of education is positively correlated with the likelihood of a complete fuel switch whereas increases in household size enhances the probability of partial switching (Heltberg, 2004; Kastner & Stern, 2015; Romero-Jordán et al., 2016). In this regard, recent studies indicate that contrary to the assumptions of the energy ladder model, most low, to middle income households continue their use of solid fuels even though modern fuels are available (Masera et al., 2000; Heltberg, 2004; Goldemberg, 2007; Kowasari & Zerriffi, 2011; Taylor et al. 2011; Sola et al., 2016; Zhang et al., 2016). These studies postulate a modified energy ladder (Figure 3.7), in an attempt to explain the practice of fuel switching.

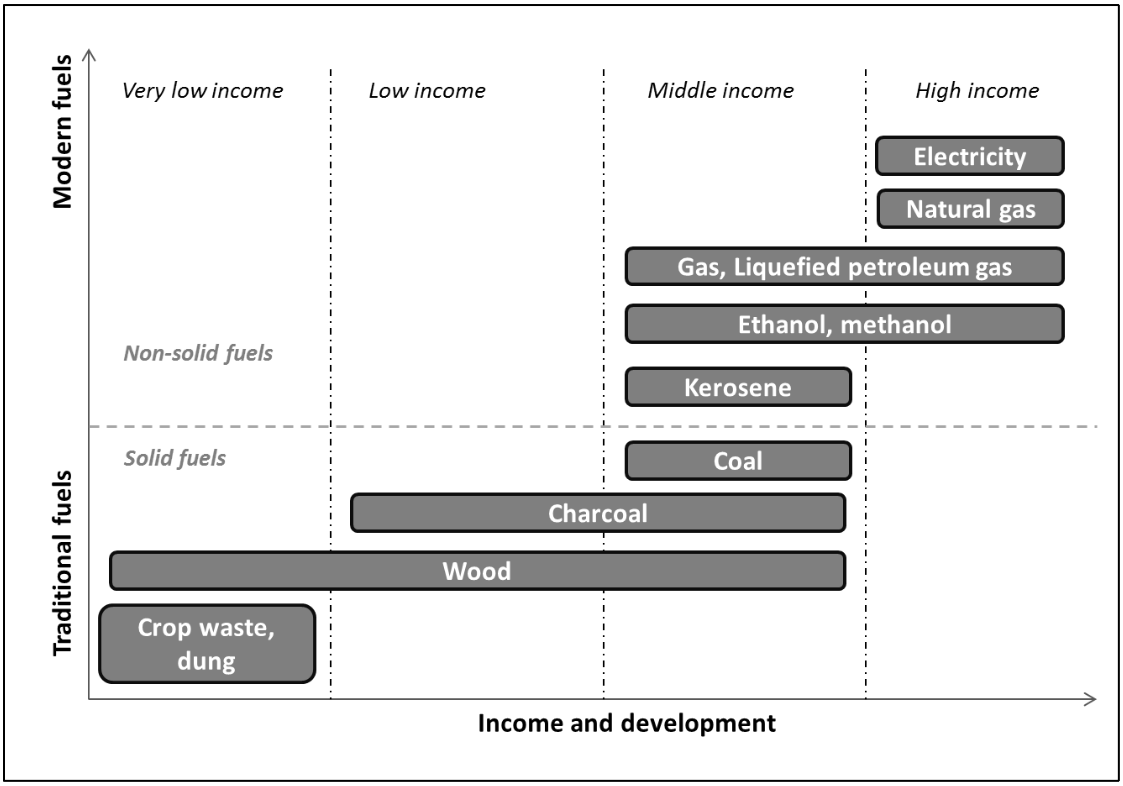

Figure 3.7: Modified energy ladder (adapted from: WHO, 2006: 9)

It must be said though that energy ladders do not adequately highlight individuality and the effect of culture which are described as key factors influencing household fuel choices (Kowsari & Zerriffi, 2011). A study conducted in Mexico proposes that the cultural and historic contexts provide important perspectives when examining energy behaviour and transitions, and attribute fuel switching to the following factors (Masera et al., 2000: 2084):

- The cost and accessibility of energy sources and stove types;
- The technical characteristics of cookstoves and cooking practices;
- Cultural preferences; and
- Impacts on health.

According to Heltberg (2004), partial fuel-switching is the most common transition in household energy profiles and is extensive in countries such as Guatemala, South Africa and Brazil where energy hybridisation is seen across income groups. Bhide and Monroy (2011) assert that electricity does not completely replace biomass and the shift towards modern energy sources is dependent on availability, affordability and cultural practices, and therefore by definition does not imply a smooth linear progression along the energy ladder. Similar studies conducted in China showed that rural households continued their reliance on biomass and only a few wealthy households engaged in a complete fuel switch, with increased income (Peng et al., 2010). Interestingly, low-income households still chose traditional energy sources for cooking and heating even though more efficient forms of energy were available, and the complete transition to modern fuels for these purposes was only noted amongst upper income households (Heltberg, 2004; Bhide & Monroy, 2011; Kastner & Stern, 2015; Mensah & Adu, 2015). Goldemberg (2007) posits that fuelwood remains a popular choice amongst low-income households, especially in rural areas, because it is rarely purchased and can provide a variety of energy services (cooking, heating and lighting). Likewise, Taylor et al. (2011) show that even though households in Guatemala owned gas cookstoves, the majority continued to use biomass as their main source of energy for cooking. Behera et al. (2015) show that in Bangladesh households continued their reliance on fuelwood (attributed to limited provision of alternate sources and/ or the abundant supply of solid fuels), even though levels of income increased.

Similarly, Röllin et al. (2004) show that access to modern energy services reduce reliance on traditional biomass, however, electricity use was still complimented with fuelwood. Similar findings in Zimbabwe support the argument that energy ladders fall short in explaining sustained reliance on traditional energy sources even when modern options are available

(Campbell et al., 2003). Several studies conclude that most households, with the exception of some in the high income categories, do not engage in a complete fuel switch and continue to use fuels lower on the energy ladder as additional sources of energy (Masera et al., 2000; Heltberg, 2004; Kowasari & Zerriffi, 2011; van der Kroon et al., 2013; Sola et al., 2016). The recognition that these households are partial fuel switchers suggests that energy ladders are unable to depict the robustness of household energy choices and practices.

Nonetheless, energy ladders effectively describe the transition from traditional to modern energy sources as a consequence of increased household income. In response to the above limitations a modified energy/ fuel stack model is proposed to investigate household energy choices (Masera et al., 2000; Heltberg, 2004, 2005; Gyberg & Palm, 2009; van der Kroon et al., 2013; Romero-Jordán et al., 2016). The energy stack model uses the energy hierarchy but acknowledges that households may be partial fuel switchers and energy sources from different categories may be used concurrently, even with increases in income (Figure 3.8). Included in the energy stack model below, is the energy services dimension which is also known to influence household energy choice. Heltberg (2004) states that fuel stacking is a dominant practice in rural regions within developing countries, however, in some of the poorer countries, particularly South East Asia and sub-Saharan Africa, it is practiced by the majority of the population.

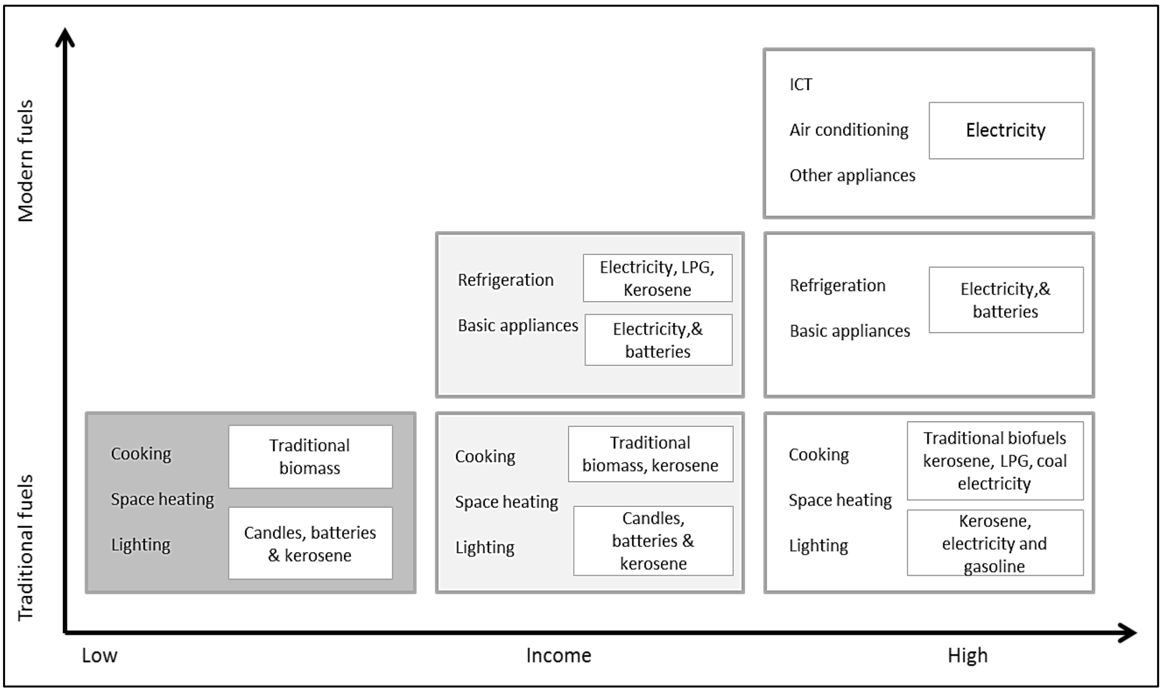

Figure 3.8: Energy stack model (adapted from: Kowsari & Zerriffi, 2011: 7509)

Furthermore, it is argued that the manner in which households consume energy and engage in fuel-switching is not unidirectional, and is linked to aspects such as energy prices (Hosier & Dowd, 1987; Davis, 1998), availability of energy carriers and services (van der Kroon et al., 2013), the rate of technology transfer, adoption and innovation (Wilson et al., 2007), culture (Stephenson et al., 2010), psychology (Keirstead, 2006; Allcott & Mullainathan, 2010), and political frameworks (Meyar-Niami & Vaez-Zadeh, 2012). Energy behaviours are a more complex and context specific result of energy market characteristics, internal household dynamics, culture and psychology (Stephenson et al., 2010; Fan et al., 2011; Kowsari & Zerriffi, 2011; Bilgen, 2014). Kowsari and Zerriffi (2011) assert that household energy profiles and behaviours are influenced independently by endogenous and exogenous factors, however, the combination of both these factors may also have a profound impact. Similarly, Pereira et al. (2011a) state that household choice of energy sources and services is a consequence of cost, security in supply, efficiency and availability. Likewise, Keirstead (2006) asserts that economics, psychology, anthropology and technological innovation are some of the main factors impacting household energy choices.

It is argued that the examination of household energy profiles should also include an understanding of the factors that influence human behaviour and psychology, given that energy choices are an outcome of cognitive, social and behavioural processes (Keirstead, 2006; Kowasari & Zerriffi, 2011; van der Kroon et al., 2013). However, household energy behaviours are multi-dimensional and can manifest in a variety of outcomes, making it difficult to understand, map and explain (Stephenson et al., 2010). As explained in Chapter 2, energy behaviours are difficult to simplify due to the inter-relatedness of concepts and varying socio-economic contexts (Wilson & Dowlatabadi, 2007; Lutzenhiser, 1993). As indicated in Table 3.5, several factors impact on household energy profiles, however, some studies identify political structures and governance to produce context specific energy outcomes at the household level (Madubansi & Shackelton, 2007). This is echoed by Meyer-Naimi and Vaez-Zadeh's (2012) assertions that policy frameworks are key in facilitating the transition towards sustainable energy economies by providing a legal and administrative platform for energy accessibility, affordability and efficiency at the household level.

Table 3.5: Factors influencing household energy choice (Kowsari & Zerriffi, 2011: 7509)

Categories	Factors
Internal characteristics	
Economic	Household income, expenditure, assets
Non-economic	Household size, gender, age, composition, education
Behavioural and cultural	Preferences, practices, lifestyle, social status, ethnicity
External conditions	
Physical environment	Geographic location, climatic conditions
Policies	Energy policy, subsidies, market and trade policies
Energy supply factors	Affordability, availability, accessibility, reliability of energy sources
Energy device characteristics	Conversion efficiency, cost and payment method, complexity of operation

Given the recent concerns over climate change and the impacts of energy poverty, there is a need to shift reliance to more sustainable energy sources, particularly in the developing contexts where these impacts are more severe. However, Kaplowitz et al. (2012) state that focus should be placed on modifying human behaviour rather than the overreliance on technology-based interventions to provide solutions to environmental challenges. Similarly, the IPCC (2007) calls for sustainable lifestyle shifts towards energy efficient practices, and states that behavioural changes can have a significant impact. In light of the multiple dimensions governing household energy choice and energy behaviour, there is need to integrate drivers of human behaviour in energy planning and policy. Additionally, it is important to understand the factors that influence energy behaviour at the household level in an attempt to transition to more sustainable energy options.

According to van der Kroon et al. (2013: 507), household energy choices are a result of the nature of household employment, available capital, knowledge, access to technology, energy needs, social relations, culture, risk/ security preferences, and desired levels of comfort and leisure. Kowasari and Zerriffi (2011) are of the opinion that household size and composition, income, level of education, availability and affordability of energy sources and technologies, energy needs, culture, and social norms have causal and reciprocal links to energy choices. Heltberg (2005) states that within poor communities, larger households and those with a greater number of females are more likely to continue their use of fuelwood because it is considered to have lower opportunity costs (collected rather than purchased, greater number of people in the household to take up the responsibility). A similar study conducted in Swedish households reveals that energy behaviour is influenced by the awareness and knowledge of specific energy sources, the quality and cost of derived energy services, and the availability, affordability and efficiency of related technologies, for example, solar geysers (Gyberg & Palm, 2009).

Farsi et al. (2007) state that the type of energy used and the duration of use were related to level of household income, however, household characteristics, security of supply, culture, social norms, distance to source of supply of energy, and individual preferences influenced household energy behaviour. In related studies across urban and rural communities within developing countries, households that exhibited higher levels of education chose cleaner and more efficient fuels, possibly attributed to the awareness of associated health impacts, convenience and fuel efficiency (Heltberg, 2004; Peng et al., 2010; van der Kroon et al., 2013). Behera et al. (2015) show that level of education of the household head is positively related to preference for cleaner fuels and attributes this to a greater awareness of the impacts associated with the use of traditional fuels. Reddy and Srinivas (2009) argue that households with a higher level of education have a greater tendency to choose more efficient and cleaner fuels in an attempt to save time and reduce the negative impacts on health. The lack of knowledge and failure to cognise their own energy impact was seen as a barrier that prevented households from engaging in sustainable energy practices (Abrahamse & Steg, 2009; Kaplowitz et al., 2012; Mensah & Adu, 2015). Similarly, values and attitudes, for example eco-centrism, are likely to bring about altruism and concern for the environment and increase the likelihood of adopting sustainable energy options and energy conservation behaviour (Stern, 1992; Kaplowitz et al., 2012).

Knight and Rosa (2012) assert that households with fewer members chose more modern energy sources, whereas larger households exhibited a heavy reliance on biomass and engaged in extensive fuel stacking. Pandey and Chaubal (2011) assert that in rural India, household size and use of fuelwood is positively correlated given the higher demands for energy services in larger households. Mayer et al. (2014) indicate that among the low-income groups, households with children and those displaying a heavy reliance on social welfare were more likely to experience more severe impacts of energy poverty. Additionally, Behera et al. (2015) show that household labour supply in relation to the total number of males, females and children is often seen as an opportunity for fuelwood collection thus, reliance on solid fuels is notably higher. Furthermore, it is argued that gender plays a significant role in influencing household fuel preferences; for example, female-headed low-income households display extensive reliance on fuelwood which is considered to be a ‘free’ source. However, amongst middle to upper income households women show a greater preference for cleaner fuels over fuelwood, given their involvement in cooking (Israel, 2002; Behera et al., 2015).

Heltberg (2005) describes affordability of household energy technologies to be a major obstacle for low-income households since the poor spend a disproportionately higher percentage of their income on energy. Whilst issues such as cost, accessibility, availability and efficiency can be dealt with from a political economy perspective, the deeper issues of up-take and adoption at the household level remain a critical challenge. Wilson and Dowlatabadi (2007) state that the adoption of new technologies or energy sources is based on situational factors such as lack of resources (for example, income and applicable appliances to compliment new sources of energy) and poor physical accessibility to these technologies or sources of energy. von Borgstede et al. (2013) state that people display a greater probability of adopting environmentally-friendly behaviours when opportunity costs are at the lowest. Allcott and Mullainathan (2010) posit that changing behaviours may be more successful if it applies to the mass population rather than specific groups. Furthermore, interventions that align with social norms may influence the behaviour of an individual for the following reasons (Allcott & Mullainathan, 2010: 1204):

- People conform to others because they believe in a wisdom of crowds;
- The belief that others took action because they had more and/ or different information on the benefits; and
- The appeal of social approbation or inner comfort from conformity.

Kok et al. (2011) argue that cognitive norms such as the level of concern one displays for themselves or toward others is key in adopting responsible behaviours and may eventually lead to more conservative energy practices. Permeating the various studies listed above is the acknowledgment that human behaviour is seen to influence energy consumption and therefore is an important variable to consider in energy planning. Furthermore, it is argued that there is a need to modify energy behaviour of populations and not just select groups (for example, the poor) in and attempt to shift towards greater energy efficiency and sustainability. In this regard, a number of studies assert that energy policy can be used as effective tools to bring about the desired shifts in energy behaviour. The next section investigates these aspects in detail and provides an overview of existing energy policies in relation to reducing energy poverty and shifting reliance to more sustainable forms of energy.

3.8 Energy policy

Energy policy plays a pivotal role in directing suitable resources for the establishment and generation of sustainable energy options, especially those that favour the needs of poor and marginalised groups. Even though the literature shows a vast number of top-down and bottom-up energy policy models, many are not applicable to the developing contexts. For example, they fail to consider the historical socio-economic dynamics of the country, the long term issues of equity in the distribution of energy services, potential barriers that prevent households in their upward progression along energy ladders, and limitations in the diffusion of various energy technologies among the poor (Pandey, 2002). Practical Action (2010) state that existing policies and institutional frameworks rarely respond to the needs and capacities of the poor, especially in relation to affordability and the transfer of energy technologies.

Likewise, efficiency, sustainability and security of supply have been noted to be fundamental factors underpinning successful energy planning and policy in developing countries (Jansen & Seebregts, 2010; Tanaka, 2011; Winzer, 2012; Johansson, 2013). According to Johansson (2013), securing the supply of energy is multi-faceted given the volatility experienced in global energy markets which often overlap with environmental, foreign exchange and business and trade policy. Jansen and Seebregts (2010) argue that securing energy supply to the poor is also about developing long-term resilience to energy price increases and changes, all of which are deemed important elements of energy policy. Lior (2010) indicates that energy policy must include both long- and short- term measures that promote sustainable energy practices through increased efficiency and a notable reduction in reliance on fossil-fuels.

Similarly, Buzar (2007) states that most governments have failed to develop adequate policy frameworks for improving energy efficiency or residential energy sources, particularly those available to low-income households and suggests a need to develop and implement policies across various governance structures that aim to address domestic energy deprivation. Likewise, it is noted that harmonisation and improved communication between the different government sectors are necessary for effective delivery of energy services and technologies that aim to reduce energy poverty (Parajuli, 2011). Also, research indicates that energy policy has been dominated by economic-based approaches and has failed to recognise the role of non-price factors such as poverty, levels of awareness and knowledge, and the socio-physiological factors influencing energy behaviour (Allcott & Mullinathan, 2010; Kok et al., 2011; van der Kroon et al., 2013). Wilson and Dowlatabadi (2007) are of the opinion that attitudes and levels of awareness alone do not change energy behaviour; a more complex relationship exists between these factors and the broader social constructs (for example, level of economic well-being and household power dynamics) from which they emanate, and these aspects ought to feature more prominently in energy planning and policy.

Equally, culture, values and social norms play pertinent roles in shaping household energy choices and practices, warranting the need to steer away from energy policy with a strong emphasis on the financial and economic metrics and indicators alone (Stephenson et al., 2010). The World Bank (2004) state that energy policy discussions should be a dynamic process that responds to characteristics and changes at the household level and energy markets at the national level. Additionally, the value of reliable, current and continuous quantitative and qualitative data from these sectors is deemed vital to establishing suitable energy policies that are relevant to the contexts of individual countries (World Bank, 2004). According to Barnes et al. (2011), understanding basic household energy requirements are vital for policy mediation and may reflect on some of the underlying aspects that contribute to energy poverty and unsustainable energy practices.

Given that energy policy is dominated by economic-based factors, there is a tendency to view energy subsidies as a viable solution to improve affordability among the poor (World Bank, 2004; Heltberg, 2005; Schaeffer, et al., 2012; Szabó et al., 2013). It is argued that energy subsidies are considered soft measures and require significant capital and administrative investments which can result in the depletion of public funds that could have been channelled to the construction and maintenance of energy infrastructure in poor communities (Heltberg, 2005). The poor remain unconnected to main energy grids and are therefore unable to reap the benefits of energy subsidies and may never do so, due to the counter financial drain caused by these subsidies (Heltberg, 2005). Bhattacharyya (2006) showed that energy policies that aim to improve rates of electrification alone remain inadequate as they fail to recognise the deeper issues of development and income generation that sustain long term use of electricity. Similarly, Farsi et al. (2007) suggest policies that aim to improve levels of education, gender empowerment and socio-economic development to encourage more efficient and sustainable energy use. Heltberg (2005) shows that the poor spend a disproportionately larger share of their income on energy thus, basic energy services such as cooking and lighting are associated with higher costs.

Even though electricity may be physically available to poor households, reliance and use is ultimately dependent on household income security and ability to purchase these fuels; this is compounded by the escalating opportunity costs of modern energy services (Bazillian et al., 2014). In this regard, there is a need for energy policy to focus on aspects that cause energy vulnerability (for example, poverty and lack of income) in order to promote greater energy security (Madubansi & Shackelton, 2007). Similarly, it is argued that reducing energy poverty should be based on understanding the role that energy plays in enabling sustainable livelihoods through improved health, education, agriculture, income and job creation, rather than the focus on supply of energy services and the associated technologies (Kaygusuz, 2011). Energy policy should therefore embrace holistic and multi-level action towards the root causes of poverty as opposed to addressing the symptoms manifesting as energy poverty.

Additionally, in the drive toward an energy secure society, it should be noted that the upward movement along energy ladders suggests that household-based GHG emissions would increase significantly, thus policies aiming to improve energy access should also consider the environmental implications of prescribed sources (Sagar, 2005). Szabó et al. (2013) is of the opinion that energy policy should not exclusively focus on electrification to address energy poverty due to the associated climate change and environmental pollution concerns but should advocate the use of a broader energy mix to meet household needs and reduce environmental impacts; more specifically, a suitable mix of small-scale RETs. Furthermore, the focus on climate change mitigation and energy security has propelled the shift towards alternate energy and energy conservation technologies (Brown & Huntington, 2008). Renewable and alternate energy sources have been widely used to address issues of energy security, sustainability and poverty (Prasad, 2008; Bhide & Monroy, 2011; Kaygusuz, 2011; Sovacool, 2012). Arguably, the implementation and use of RETs in poor contexts has been met with a number of challenges; specifically, application, storage and efficiency as well as availability of suitable technologies that meet household energy needs (Schaeffer et al., 2012; Sokona et al., 2012; Cherp & Jewell, 2014; Harmim et al., 2014). Szabó et al. (2013) assert that energy policy should reflect on these issues when advocating the use of RETs and aim to improve the service by strengthening private partnerships. For example, within developing countries service delivery to rural and remote communities are severely constrained by a lack of resources; encouraging private sector partnerships may shift some of this burden, especially in relation to implementation and follow-up maintenance.

Africa holds significant potential in terms of renewable energy, with some of the highest levels of solar radiation in the world, however, due to limited resources and institutional capacities these reserves remains relatively untapped (Kaygusuz, 2009). The adoption and implementation of RETs may be alternatives to fossil-fuel energy, however, these technologies alone are unsustainable unless accompanied by effective follow-up servicing and maintenance support, in which case energy policy should make allowances for the short- and long- term opportunity costs in promoting a particular energy carrier (Chaurey et al., 2004). Furthermore, the provision of RETs (for example, solar cookers) may assist in meeting some basic needs, however, they do not adequately address other productive and modern energy needs necessary for overall improvement of living standards and quality of life (Chaurey et al., 2004; Sokona et al., 2012).

Similarly, Brown and Huntington (2008) warn that energy policy should not over-prescribe or focus on a single type of renewable energy or technology as this can hinder research and development of future technologies and energy carriers. According to Panos et al. (2016), the quality of public management and implementation of economic and social structural changes, through improved institutional efficiency and a reduction in levels of corruption, can produce significant improvements in overall energy access. Furthermore, the pursuit of suitable renewable energy options should remain transparent, objective and free of corruption to gain public confidence and improve levels of trust and uptake (Brown & Huntington, 2008). According to Onyeji et al. (2012), in sub-Saharan countries the effectiveness of governments is strongly related to levels of electrification, however, lack of political will, effort, and high levels of corruption are the main factors preventing scaling up of rural electrification.

More recently, the concept of governance and justice has featured more prominently in energy policy debates (Bazillian et al., 2014; Sovacool & Dworkin, 2015). The concept of energy justice reflects on the moral and ethical considerations of energy access across a population highlighting issues of equity, representation, basic human needs, and the moral implications of individuals' energy behaviours (Sovacool & Dworkin, 2015). It is argued that energy policy aiming to address both climate change concerns and energy security for the poor should consider energy justice as a founding principle given the emergence of the dualism of climate change and energy poverty in developing countries (Pandey, 2002; Sovacool & Dworkin, 2015). Similarly, energy governance involves three main dimensions: politics (stakeholders and the power dynamics that develop between them); polity (rules, hierarchy and institutional settings); and policy (instruments used to achieve perceived outcomes and energy goals) (Bazillian et al., 2014).

Energy security can be described as the outcome of complex linkages between the above dimensions. In relation to the poor, policy often assumes that addressing energy access alone is a viable solution with little consideration for the politics and polity dimensions (Bazillian et al., 2014). For example, it is argued that access, affordability and quality of energy are deemed equally important for energy security (Nussbaumer et al., 2012). Sovacool and Dworkin (2015) aver that institutional corruption and misuse of power among the stakeholders do little to improve the environment necessary for the establishment of objective and relevant energy policies. Furthermore, existing energy policy fails to adequately unpack the power relations between stakeholders, particularly how energy poverty is experienced across the different socio-economic and demographic groups (Goebel et al., 2010).

Similarly, failure to include the gendered aspects of energy poverty in policy masks more serious issues of empowerment and representation at household and national levels (Goebel et al, 2010; Arora-Jonsson, 2011; Kaygusuz, 2011). Modi et al. (2006) state that energy needs, preferences and technical know-how are often overlooked in energy planning and policy resulting in insufficient solutions and remedies to energy issues (Modi et al, 2006). The UNDP (2004) posit that whilst there were several projects and policies that aim to energise the poor, many are 'gender-blind' and do little to change the current energy security status quo. Inadequate coverage of the role of women in energy and climate change mitigation can have serious impacts on livelihoods and may increase women's vulnerabilities (Alston, 2013). Knox-Hayes et al. (2013) suggest the need to promote gender sensitive frameworks that provide suitable coverage of the gendered experiences of energy poverty and climate change. Goebel et al. (2010) establish that women play important roles in changing practices and behaviour at the household level, making gender a critical aspect of energy planning and policy. Kok et al. (2011) propose that technology and behaviour are key aspects influencing household energy choices; therefore, future energy policy should consider both financial and non-financial facets.

According to Munien (2014), women carry a notable portion of the burden in securing energy for household use thus, holistic and multi-disciplinary policies for energy security will greatly improve the livelihoods and experiences of women, especially among poor households.

Evidently, there have been radical changes in energy policy and a notable shift from the usual economic and financial based models used in energy planning and policy. Past energy policies had the tendency to focus on the provision of energy sources with poor understanding of issues surrounding affordability, efficiency, sustainability and the lived experiences of energy poverty, particularly along gendered lines. The studies above warrant the need for more nuanced approaches to formulating energy policy which involve multi-level and transdisciplinary approaches that reflect on long term energy security, efficiency and sustainability.

Energy security, poverty and consumption patterns are context and site specific, given that they are influenced by several external and internal factors. For example, South Africa displays diverse socio-economic landscapes as a result of previous discriminatory political practices, inequitable distribution and access to resources and services, and wide-scale poverty. In addition, South Africa is among the world's leading producers of coal-based electricity, however, the country is plagued by varying levels of energy poverty and increased concerns over climate change given its mega biodiversity status. The following section provides an overview of the South African energy sector which will serve as the backdrop to the research design, data collection and analysis methods used in this study.

3.9 The South African energy sector

South Africa houses 90% of the African continent's economically viable coal resources, and produces more than 50% of the continent's electricity, making it Africa's leading producer of electricity (Karekezi, 2002; Odhiambo, 2009). Most of the electricity produced in South Africa is coal-based (90%) with smaller portions (10%) from nuclear and hydro-power (Department of Energy [DoE], 2014). In comparison, the rest of Africa produces electricity from multiple sources such as hydro (38.9%), oil (33.5%), gas (27.1%) and geothermal (0.5%), however, these are in relatively smaller quantities (Karekezi, 2002). South Africa produces approximately 239 tWh (terawatt hours) of coal-based electricity and is ranked 7th in the world (IEA, 2014). The public utility energy and parastatal, ESKOM (Electricity Supply Commission), is the main producer of the country's energy which is regulated by the National Energy Regulator of South Africa (NERSA).

Even though South Africa is the leading producer of coal-based electricity on the African continent, current rates of electrification are approximately only 85% at the national level; however, these differ significantly across the nine provinces given the different socio-economic conditions (SSA, 2013). For example, in Limpopo, Eastern Cape and KwaZulu-Natal rates of electrification range between 74-80% (SSA, 2013). Additionally, the impacts of apartheid have produced notably diverse socio-economic conditions that add to the complexities of addressing energy security across these provinces (Gaunt, 2005; Bekker et al., 2008). The overall energy market of South Africa is unlike other developing economies comprising the industrial sectors, residential sector and the transport sector (ranked in order of demand) (Winkler, 2005). Further to this, Pollet et al. (2015) state that the current electricity blackouts, high energy tariffs and underinvestment in energy infrastructure deepen insecurity.

According to Gaunt (2005), electrification in South Africa was spurred by three distinct objectives: first economic development followed by socio-economic development, and more recently, social objectives, for example, ethics and human rights. Studies argue that electricity provision is not only key to economic growth but also vital in improving living standards of previously disadvantaged groups (Spalding-Fecher & Matibe, 2003). Similarly, Brüscher (2009) highlights energy inequality and sustainability to be the two main pillars of the South African energy debate, with the former addressing historic inequalities and energy access in rural and remote communities, and the latter reflecting on the environmental and economic issues. Several studies indicate that attempts to redress past inequalities through socio-economic development and improved access to basic services such as the energy, water and sanitation are priority agendas (Winkler 2007; Bekker et al., 2008; Sebitosi & Pillay, 2008). In an attempt to promote the provision of electricity to poor households, a poverty tariff was introduced where households receive 50kWh of free electricity per month (Winkler, 2007).

Even though the country has made significant progress in promoting energy access, rapid rural-urban migration, growing concerns over GHG emissions, escalating energy costs, and lack of or outdated energy infrastructure present major challenges within the energy sector (Davis, 1998; Thom, 2000; Gaunt, 2005; Bekker et al., 2008; Menyah & Wolde-Rufael, 2010; Pegels, 2010; Walwyn & Brent, 2015). Recent census data shows that overall reliance on solid fuels has decreased since 2001 for cooking, lighting and heating activities, however, most households have not yet made the complete switch to modern energy sources such as electricity (Table 3.6) (SSA, 2011). As indicated in Table 3.5, South Africa showed significant growth in energy access between the years 2001 and 2011, particularly in terms of a reduction in the reliance on traditional fuels. Interestingly, even though electricity grids have been extended to more than 80% of the population, most low-income South Africans can be classified as hybrid energy users who engage in extensive fuel switching (Davis, 1998; Thom, 2000; Madubansi & Shackelton, 2007). This process of fuel switching, as described earlier, can be classified as a symptom of energy insecurity and vulnerability. Furthermore, Bekker et al. (2008) warn that even though rates of electrification have increased significantly within the country, the lack of data on disconnections, and illegal and informal connections does not allow for a comprehensive understanding of energy issues within the residential sector.

Table 3.6: Percentage energy consumption patterns for basic needs in South Africa from 2001 to 2011 (SSA, 2011)

Activity	Year	Electricity	Gas	Paraffin	Wood	Coal	Solar	Animal dung	Candles
Heating	2001	49.9	1.2	14.3	24.2	6.3	0.1	0.7	-
	2011	58.8	2.5	8.5	15.3	2.0	0.3	0.3	-
Cooking	2001	52.2	2.6	21	20.1	2.7	0.2	1.0	-
	2011	73.9	3.5	8.5	12.5	0.7	0.2	0.3	-
Lighting	2001	70.2	0.3	6.6	-	-	0.2	-	22.4
	2011	84.7	0.2	3.0	-	-	0.4	-	11.4

A similar study reveals that low to middle income households that were electrified for more than two years continued their reliance on dry cell batteries for radios and candles for lighting (Thom, 2000). Another study revealed that most electrified low-income households in South Africa compliment their use of electricity with two additional fuels; mainly, fuelwood and paraffin (Davis & Ward, 1995 cited in Thom, 2000: 41). Furthermore, two studies revealed that as household income increased, low-income households switched from collected to purchased sources of energy (for example, kerosene), however, collected sources now served as complimentary rather than primary energy sources (Davis, 1998; Pereira et al., 2011b).

Energy hybridisation is symptomatic of the inability to afford prolonged use of modern, safe and reliable sources of energy (van der Kroon et al., 2013). Thus, even though South Africa produces significant volumes of electricity and has extended electricity grids to most of the country, trends in electricity consumption patterns reveal that modern sources of energy are still financially inaccessible to many poor and low-income households (Winkler, 2007;

Bekker et al., 2008; Sebitosi & Pillay, 2008; Pereira et al., 2011b). Ziramba (2008) shows that South African residential electricity demand shares an inelastic relationship with energy price and household income, where increases in household income did not yield significant increases in electricity demand, and energy price increases did not discourage residential electricity consumption.

The DoE (2013a) showed that 47% of South Africans spend more than 10% of their monthly income on energy sources. According to definitions of energy poverty given earlier, this suggests that these households can be characterised as energy poor. Further inspection revealed that KZN, the province in which this study is located, has an average energy poverty rate of 45% (DoE, 2012). This is alarming, given the vast developments in electrification rates and grid extensions over the last decade. This suggests that energy poverty remediation is not just about electricity grid extensions and improvements in the supply of energy to households but is also influenced by household-level dynamics such as poverty, unemployment, level of income, and energy behaviour. Moreover, even though South Africa has showed significant growth in the supply of energy to households, specifically electricity, energy efficiency remains a critical challenge within the country.

Inglesi-Lotz and Pouris (2012) assert that efforts to improve energy efficiency through the alignment of energy behaviour with social, economic and environmental goals are central in the global race towards achieving sustainability in the energy sector. The World Energy Council (WEC, 2008: 9) defines energy efficiency as the "reduction of energy use or the related energy services which can be achieved through technological changes or improved organisation and management within the economic sector". Oikonomou et al. (2009) state that improving energy use can only be achieved through improving the efficiency of energy sources used by consumers and adopting more conservative energy behaviours. Similarly, Sebitosi (2008) underscores improvements in energy efficiency as the most effective and financially viable approach to meeting MDGs and SDGs. South Africa has three centralised electricity hubs and transmits electricity over a distance of 1000 km which is associated with high transportation costs and investment in related energy infrastructure (Sebitosi, 2008; DoE, 2012). Energy efficiency remains a challenge in South Africa due to historically low energy prices, overreliance on coal-based electricity and the lack of suitable energy policies (Ingelsi-Lotz & Pouris, 2012). Also, South Africa is characterised as having large-scale socio-economic and geographic (topographic and climatic conditions) diversity, resulting in a combination of informal, traditional and formal type dwellings. According to the DoE (2015a), this presents a challenge when promoting energy efficiency as thermal efficiency across these dwellings types differ significantly. As Buzar (2007) explains, thermal comfort experienced by the household (through internal and space heating, and physical conditions of the dwelling) is directly linked to the lived experiences of energy poverty.

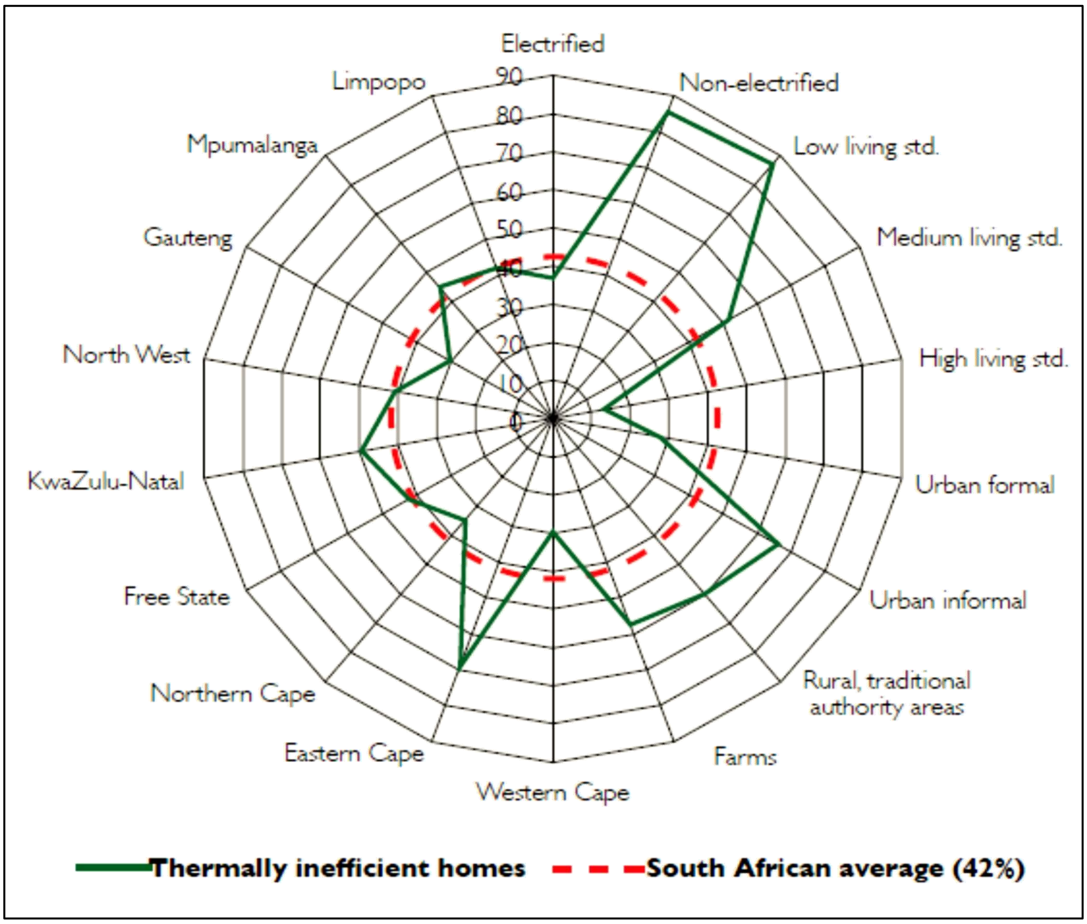

Figure 3.9: South African household thermal efficiencies (DoE, 2015a: 64)

In relation to South Africa, 42% of homes within the country are classified as thermally inefficient (DoE, 2015b). However, these statistics are location and dwelling specific with traditional (78%) and informal type dwellings (86%) showing significantly higher levels of inefficiency compared to formal dwelling types (32%) (Figure 3.9) (DoE, 2015b). As indicated in Table 3.6 and Figure 3.9, evidently South Africa displays poor rates of energy efficiency at the household level with the least efficiency being recorded amongst poor households. As mentioned earlier, it is important to establish that the symptoms and impacts associated with energy poverty are most commonly experienced by the world's poor, and more recent studies have shown that this is no longer confined to rural areas. The growing number of urban poor, (particularly in developing countries like South Africa), add to the complexities of sustainably transforming energy sectors as well as addressing energy security.

Sebitosi (2008) advances that although attempts to achieve energy efficiency within the South African context are underpinned by strong policy, the following strategies may be useful:

- Changing energy behaviours of consumers;
- Adopting energy efficient appliances;
- Promoting the use of low carbon technologies; and
- Up-scaling the distribution and use of renewable energy options.

Inglesi-Lotz and Pouris (2012) argue that a differential pricing scheme may assist in promoting energy efficiency amongst users and warn that blanket energy price increases experienced in South Africa may do little to improve energy conservation and may have negative impacts on overall industrial growth. Although the South African government acknowledges the issues with energy efficiency and have made several attempts to address the problem, what is inherently lacking in these strategies are specific human capacity development targets (Sebitosi, 2008). Odhiambo (2009) established a causal relationship between energy consumption and economic growth in South Africa and proposes an expansion of the electricity infrastructure to address future needs. Undoubtedly, the South African energy sector is expected to grow to meet the various development goals, however, there is a need to channel this growth to align with the principles of sustainability. Energy is fundamentally linked to socio-economic development thus, it is recommended that efforts to address the various challenges within the South Africa energy sector also consider adopting strategies that aim to provide benefits across the social, environmental and economic sectors. In this regard, there is consensus among energy researchers that renewable energies can offer several benefits in relation to energy efficiency, access and affordability within South Africa (Winkler, 2007; Sebitosi, 2008; Pegels, 2010; Krupa & Burch, 2011; Becker & Fischer, 2013; Baker 2015).

As a result of growing pressure from international agencies such as the UN and the International Renewable Energy Agency (IREA) there has been large scale investment in renewable energy by the South Africa government (DoE, 2014). Currently, a total of 1 827

MWhs (Megawatt hours) of energy was connected to the grid through various renewable energy projects, however, given that the country produces almost 300 TWhs (Terawatt hours) of energy per annum (DoE, 2014), fossil-fuel based energy still dominates the market. Menyah and Wolder-Rufael (2010) suggest that because South Africa is a developing economy and energy is pivotal to economic growth, reductions in reliance on coal-based energy will occur at a slower pace. Krupa and Burch (2011) assert that the traditional energy systems of South Africa have perpetuated systems of marginalisation, poverty and environmental threat thus, renewable energy can provide a valuable footing towards sustainable development.

According to Winkler (2005), renewable energy options hold significant potential in the South African context for the following reasons:

- Renewable energy technologies are exceedingly suitable for off-grid applications that align with the country's development agendas which aim to provide affordable energy services to all households and compliment the drive to ensure 100% electrification rates amongst households;
- Promote sustainable attempts at restructuring the fossil-fuel intensive energy sector; and
- Ensure environmental integrity, directly through the reduction in GHG emissions and climate change mitigation.

The national energy regulatory body, NERSA (2014), states that renewable energy potential in South Africa exceeds the current electricity generation production capacity by more than 6 000% and include energy derived from solar, wind, bagasse, wood, hydro, and agricultural-based sources. For example, the Northern Cape receives some of the highest levels of solar radiation in the world and can therefore be used to address both emissions and energy supply issues impacting the country (Pegels, 2010). According to Fluri (2009) South Africa has the potential to generate approximately 545 GWs of solar thermal energy, and areas surrounding the Cape Provinces and Free State are best suited for the application of large-scale solar concentrating power plants. The majority of the country is well suited to support the wide-scale production of solar and solar thermal energy as it receives between 4.5 to 6.5 kWh/m^2 per day, as illustrated in Figure 3.10 (Pollet et al., 2015). Also, Zawliska and Brooks (2011) assert that cities that display large growth rates, for example, Durban, have significant potential and motivation for the adoption of solar-based RETs.

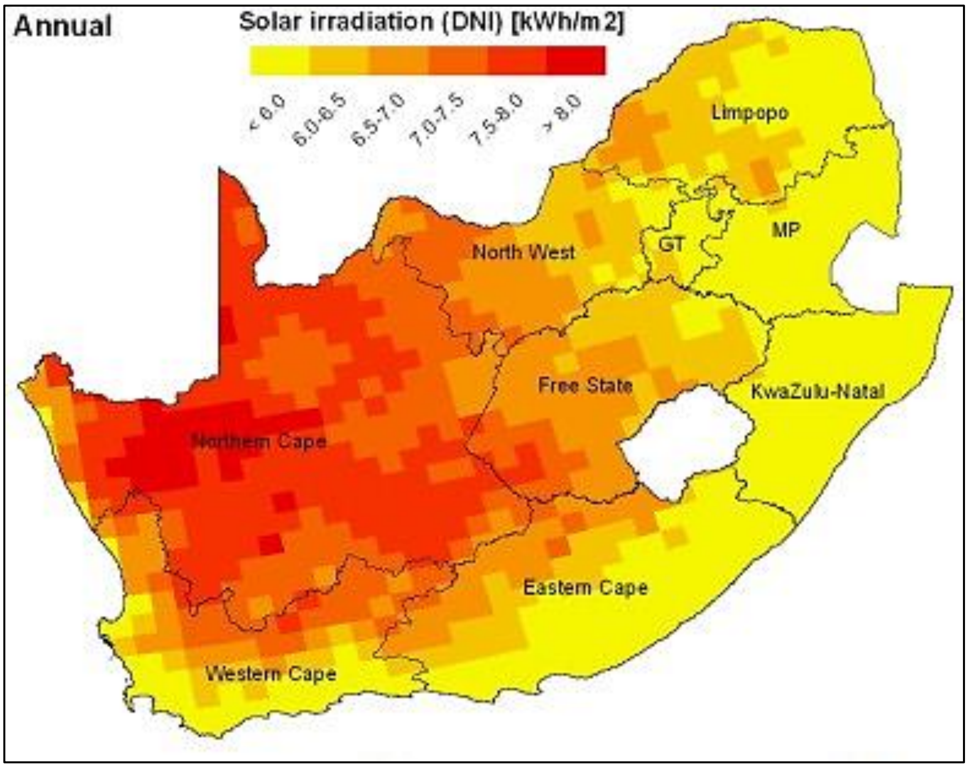

Figure 3.10: Average solar radiation levels across South Africa (source: Fluri, 2009: 5076)

In light of the provinces receiving different levels of solar radiation throughout the year, it is suggested that solar technology implementation compliment the levels of radiation received. For example, areas of higher intensities should be serviced with smaller panels while regions with lower levels of radiation ought to be serviced with larger panels to increase energy capture (Munzhedzi & Sebitosi, 2009). Accordingly, this will result in a reduction of national RET based expenditure and these funds could be used to extend implementation across a broader population (Munzhedzi & Sebitosi, 2009). Pollet et al. (2015) show that since 2013 most large-scale construction projects have focused on renewable energy programmes in an attempt to establish a green-based economy within the manufacturing sector. Some of the largest renewable energy projects in the country are the Renewable Energy Independent Power Producer Programme (REIPPP), Renewable Energy and Energy Efficiency Partnership (REEEP), and the National Solar Water Heater Programme (NSWHP) which prioritises poor and low-income households (DoE, 2015a). According to Nieuwoudt and Mathews (2005), accessible hygienic and safe water is a critical concern among many rural and poor South Africans, which could explain the decision to subsidise and implement SWHs to most low-income and rural households as part of the renewable energy scale-up programme. Traditionally, hot water is predominately attained through the use of fuelwood in rural areas and paraffin in peri-urban areas, both of which have several negative impacts. Thus, renewable energy options that aim to provide water heating services are a key priority for the poor in South Africa (Nieuwoudt & Mathews, 2005).

Through the REIPP programme, South Africa aims to purchase 2 400 MW of renewable energy from independent power producers (IPPs) which has led to investments in several RETs such as wind, solar-based systems, PV systems, solar thermal energy systems, the use of biomass and biogas, and small hydro-based systems (Pollet et al. 2015). In an attempt to extend the supply and use of renewable energy, South Africa is one of 12 countries that form the Southern African Power Pool (SAPP) (Pollet et al., 2015). Also, there are smaller renewable energy projects, for example, the Bethlehem hydro project and the Darling wind farm that add approximately 14 GW of energy to the grid (Msimanga & Sebitosi, 2014). Currently, South Africa has a total of 1 149 photovoltaic power plants and 200 solar thermal plants (DoE, 2014). A major critique of the REIPP is the high initial costs and limited capacity for the integration of small-scale energy producers (Msimanga & Sebitosi, 2014).

De Groot et al. (2013) show that small-scale solar-based systems may be a cheaper alternative compared with larger parks due to high running and transmission costs. Pegels (2010) and Msimanga and Sebitosi (2014) caution that IPPs may face difficulty in accessing the energy market given the dominance of ESKOM. Similarly, Sebitosi and Pillay (2008) recommend that IPPs from the public and private sector be awarded equal opportunity to compete in the renewable energy market in an attempt to establish a national renewable energy economy. According to Sebitosi and Pillay (2008), the increased competition among renewable energy service providers may improve energy efficiency, accessibility and affordability of RETs, given that the energy parastatal has been experiencing several backlogs in the delivery and implementation of wide-scale renewable energy services. Studies show that the implementation of renewable energy sources, at the household level, is negatively impacted by the large coal resource base, intergenerational poverty, and deprivation of access to basic services as a result of the political history (Bekker et al., 2008; Pegels, 2010). Tsikata and Sebitosi (2010) assert that the cheap and abundant supply of coal-based electricity can be viewed as a major obstacle as it is currently more expensive to produce renewable energy.

Krupa and Burch (2011) argue that even though renewable energy is linked to long term environmental sustainability and sustainable development, historically, South African energy policies have not promoted the use of RETs effectively. Similarly, Bekker et al. (2008) assert that funding of modern energy infrastructure and establishing a suitable tariff system remains a major challenge to the South Africa energy sector. Correspondingly, Tsikata and Sebitosi (2010) warn that South Africa may be facing high import costs for RETs and suggest a more localised approach which involves the transfer and development of skills through the establishment of locally produced RETs that are best suited to community needs. Sebitosi and Pillay (2008) argue that the lack of reliable energy data to inform energy policy and planning can be viewed as a major obstacle in the shift towards renewable energy options. Pollet et al. (2015) state that national government responses to energy issues forms part of their ‘5-Point Energy Plan’ which aims to explore energy security through off-grid renewable energy solutions such as hydrogen energy, oil, natural gas and gas-to-power technologies.

Gaunt (2005) states that PV systems have been commonly used for small-scale decentralised electrification needs, however, these have proven to be more expensive than grid extensions, making them financially unfeasible for developing countries such as South Africa. Winkler et al. (2009) postulate that the cost of renewable technology may be relatively expensive when first introduced, however, as production and learning processes are optimised, and as overall buy-in from energy users increases these costs are significantly reduced. In this regard, introducing feed-in-tariffs (FITs) (payment for the generation of renewable energy that is fed back into local and national grids) may be a useful incentive that promotes the uptake of RETs, however, the success of this strategy is dependent on the negotiated rate (Becker & Fischer, 2013). Baker (2015) raises concerns over the financing of RETs and states that because more than half the current investment is actually debt, success of these systems is paramount, especially in relation to the political economy of the country. According to Walwyn and Brent (2015), even though the REIPPP has seen unprecedented success since its inception, there has to be greater effort in advancing some of the socio-economic targets, particularly the transfer of technology and establishing local manufacturing bases for the RETs. Those authors add that RETs have significant potential in creating local-level employment, especially in relation to manufacturing, implementation and maintenance of these technologies.

Despite the large-scale investment in RETs and level of economic activity compared with the rest of Africa, the country is not the best performer in terms of renewable energy on the continent (Nakumuryango & Inglesi-Lotz, 2016). This is attributed to the relatively higher implementation and maintenance costs of producing renewable electricity and energy compared with coal-based electricity (Nakumuryango & Inglesi-Lotz, 2016). Others, for example, Govender (2013) show that SWHs lack proper maintenance plans and follow-up at the household level thus resulting in poor community perceptions and attitudes towards these devices. Additionally, a recent study showed that many low-income households prefer not to use SWHs due to the strong association with poverty or being poor, and poor functionality during winter (Maharaj, 2014). Lemaire (2011) states that PV systems are often abandoned a few years after installation, mainly due to maintenance and repair issues, theft, and limited capacity of the device to meet existing energy demand. In an attempt to improve on the uptake and use of these RETs, it is suggested that proper installation, warranties and guarantees should be an integral aspect of implementation (Tsikata & Sebitosi, 2010). A similar study within South Africa revealed that failure to operate and repair installed RETs were the main challenges facing communities (Bikam & Mulaudzi, 2006). Additionally, even though some users initially received RETs positively (during the implementation phases), once they realised the difference (after use), in functionality and capacity compared to a standard grid connection, these devices were met with dissonance (Bikam & Mulaudzi, 2006).

Sebitosi (2008) is of the opinion that government agencies should be seen putting into practice their interventions to promote public sensitisation and awareness, particularly for RETs that have been perceived poorly. Conversely, Wamukonya (2007, cited in Lemaire, 2011: 278) is of the opinion that due to the costs associated with solar systems, they are not an absolute solution to energy security but can play a vital role, in the short-term, in providing access to the remote and marginalised. Moreover, it is argued that while the environmental benefits of renewable energy are well understood, further research needs to be conducted in terms of the associated impacts on economic activity and growth within the country (Nakumuryango & Inglesi-Lotz, 2016). It is argued that suitable subsidies or financing options for RETs must be available to the public in an attempt to improve on uptake (Lemaire, 2011). Winkler (2007) states that a combination of policies are required to action sustainable shifts in the energy sector and argues that South African energy policies should aim to improve energy efficiency in the industrial sectors, encourage more efficiently designed commercial buildings, promote the use of clean and more efficient fuels at the household level, increase production of biofuels, increase reliance on renewable energy sources in relation to the national energy mix, increase imports of hydro-based power and natural gas, and consider possible taxation on the generation of coal-based electricity.

Solar-based home systems ought to be installed based on specific energy needs and consumption patterns thus, the practice of 'one size fits all' will not be suitable for large-scale implementation plans (Lemaire, 2011). Hajat et al. (2009) show that even with the limitations of small-scale solar systems, these devices did provide small businesses with services that were previously inaccessible, for example, communication, faxing, cell-phone charging, extended lighting, and resulted in income saving due to reduced travel to urban centres to purchase electricity. Bikam and Mulaudzi (2006) suggest that culture, human capacities and level of income of potential users are key factors that should be considered during the planning and implementation phases. More importantly, it is suggested that users are made aware of the differences in function and capacities of RETs during the planning stages (Bikam & Mulaudzi, 2006). Several studies warrant training and skilling of local community members, especially in relation to repairs, maintenance and implementation; this will assist in strengthening sustainability but also stimulate employment and human capacity development through small-scale local renewable energy industries (Hajat et al., 2009; Lemaire, 2011, Sovacool, 2012; Msimanga & Sebitosi, 2014).

South Africa displays high levels of socio-economic and environmental diversity, which no doubt adds complexity to national-level energy planning and local-level implementation. As mentioned earlier, even though some energy programmes have been introduced across the socio-economic gradient, much of the failures arise due to limited rates of up-take by the target population, poor implementation, limited resources, limited levels of awareness of renewable energy sources and technologies, limited knowledge of the impacts associated with the use of solid-fuels, lack of long-term monitoring and evaluation programmes, cultural differences, and various resource constraints.

3.10 Conclusion

This chapter provided a detailed description of the energy discourse, energy security and vulnerability and its associated impacts, and the role of energy in promoting socio-economic development and gendered empowerment. In addition, an overview of the role of renewable and alternate energies was provided by examining the potential opportunities and constraints of implementing these options within developing contexts. Factors influencing household energy behaviours were also discussed. The literature presented in this chapter provides the status quo for data analyses and concluding remarks emanating from this study. The chapter concluded with a discussion of current energy policies and an overview of the South African energy sector.

CHAPTER FOUR
DESCRIPTION OF STUDY AREA AND RESEARCH METHODOLOGY

4.1 Introduction

The following chapter details the description of the study areas (Inanda and Bergville) and research methodologies utilised in this study. Specific information regarding the environmental and socio-economic characteristics of Inanda and Bergville are listed, to provide the context for the comparisons made in the analysis of the data. In addition, a brief discussion on the research design, its philosophical underpinnings as well as an overview of methodological approaches used in this study are provided. Furthermore, this chapter discusses the background and motivation for the various techniques and tools employed as part of the data collection and analyses undertaken in this study.

4.2 Description of study area

The province of KZN is located on the eastern coast of South Africa and displays large scale socio-economic and environmental diversity. The province is approximately 94 361 km^2 (7.7% of South Africa's total area) and houses an estimated 10.3 million people (19.8% of the total population) (SSA, 2012a). In terms of housing, approximately 71.9% of residents live in formal dwellings, 19% reside in traditional type housing and 8.3% live in informal dwellings (SSA, 2012a). IsiZulu and English are the two principal languages, with 13.2% of the population utilising English as their main language (SSA, 2011). KwaZulu-Natal comprises 12 district municipalities which are further sub-divided into 55 local municipal areas. This study focuses on two communities, one located within the eThekwini Metropolitan Municipality and the other in the Okhahlamba Local Municipality (Figure 4.1). The Okhahlamba region is classified as being predominantly rural whilst Inanda is considered peri-urban. The latter community is located on the periphery of eThekwini (Durban) central within the eThekwini Municipality (the economic hub for KZN), whilst the Bergville community falls within the Okhahlamba Municipality and is located in western KZN (Figure 4.1).

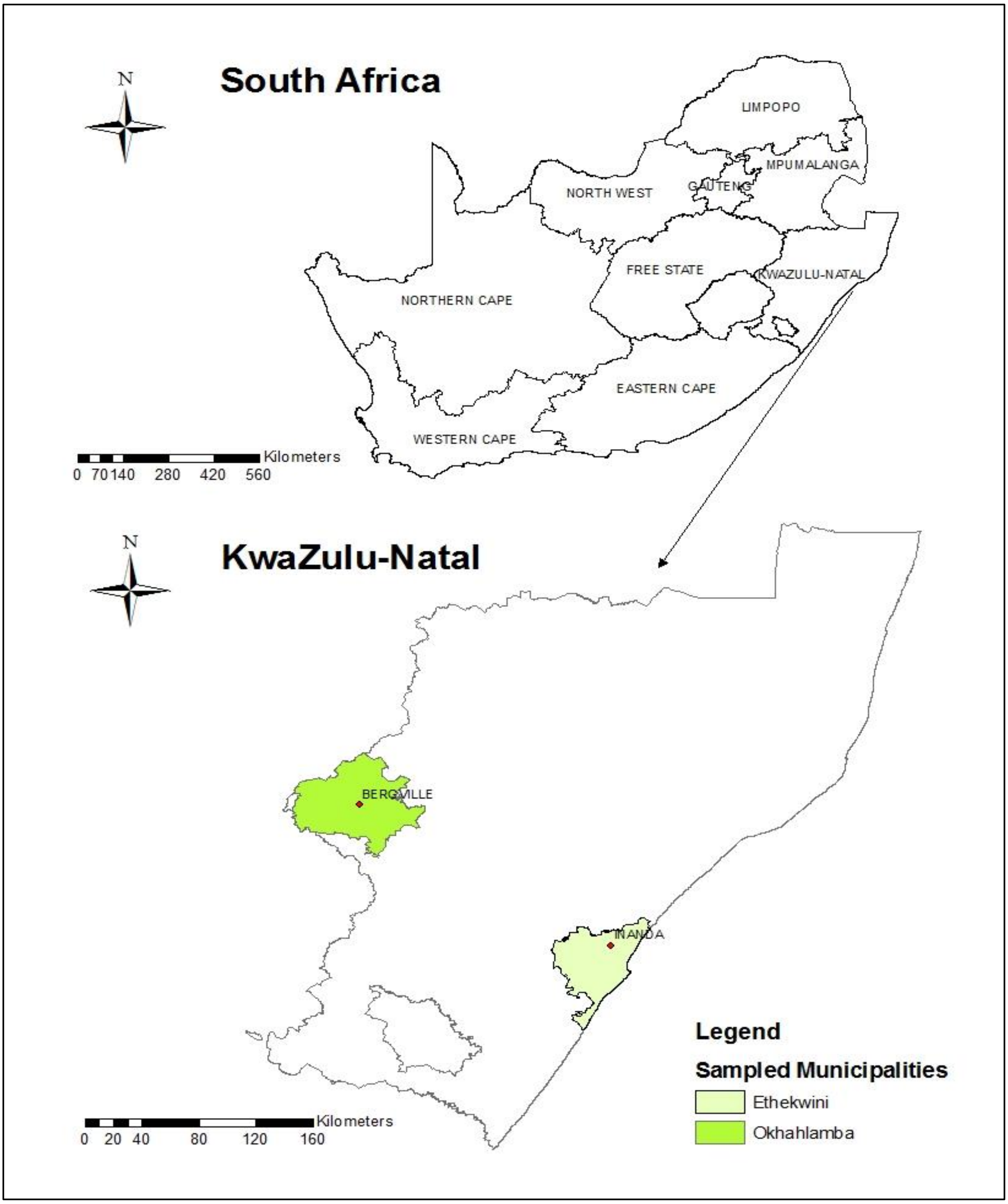

Figure 4.1: Location of Bergville and Inanda communities with the province of KZN (Author, 2016)

KwaZulu-Natal is considered to be one of South Africa's major tourist destinations and is characterised by both urban and rural settlement types. The province has amongst the highest growth rates within the country with an average household income of R83 050 per annum (SSA, 2012b). However, this average does not reflect the diverse levels of household incomes within the province adequately. Rapid rates of rural-urban migration and the presence of settlements along the urban periphery and in remote rural areas have resulted in stark socio-economic and demographic inequalities across the province. The present study compares the energy profiles of rural (Bergville) and peri-urban (Inanda) households in an attempt to improve knowledge on and an understanding of, energy practices among the poor.

4.2.1 Inanda

Inanda is located in the northern region of the eThekwini Metropolitan Municipality, approximately 25 km North-east of eThekwini's city centre (DPLG, 2007). The total population is around 153 106 individuals that are distributed across an area of 24.5 km^2 with an average density of 6 258/km^2 (SSA, 2012c). According to Khan (2007), Inanda is one of the largest settlements of low-income residential areas in South Africa. Furthermore, Inanda is further divided into 31 townships which are characterised by uneven population distributions with Newtown A being considered the most densely populated (Figure 4.2) (DPLG, 2007).

4.2.1.1 Climate conditions

Average monthly temperatures in Inanda range from 10.9°C during the winter and 27.4°C in summer, July and December, respectively (eThekwini Municipality, 2013). Rainfall is experienced throughout the year (78.3 mm average) with January receiving the highest recorded rainfall (131 mm) while the lowest precipitation is received during June (29 mm) (eThekwini Municipality, 2013). Wind direction varies considerably throughout the year, due to the undulating terrain (eThekwini Municipality, 2013).

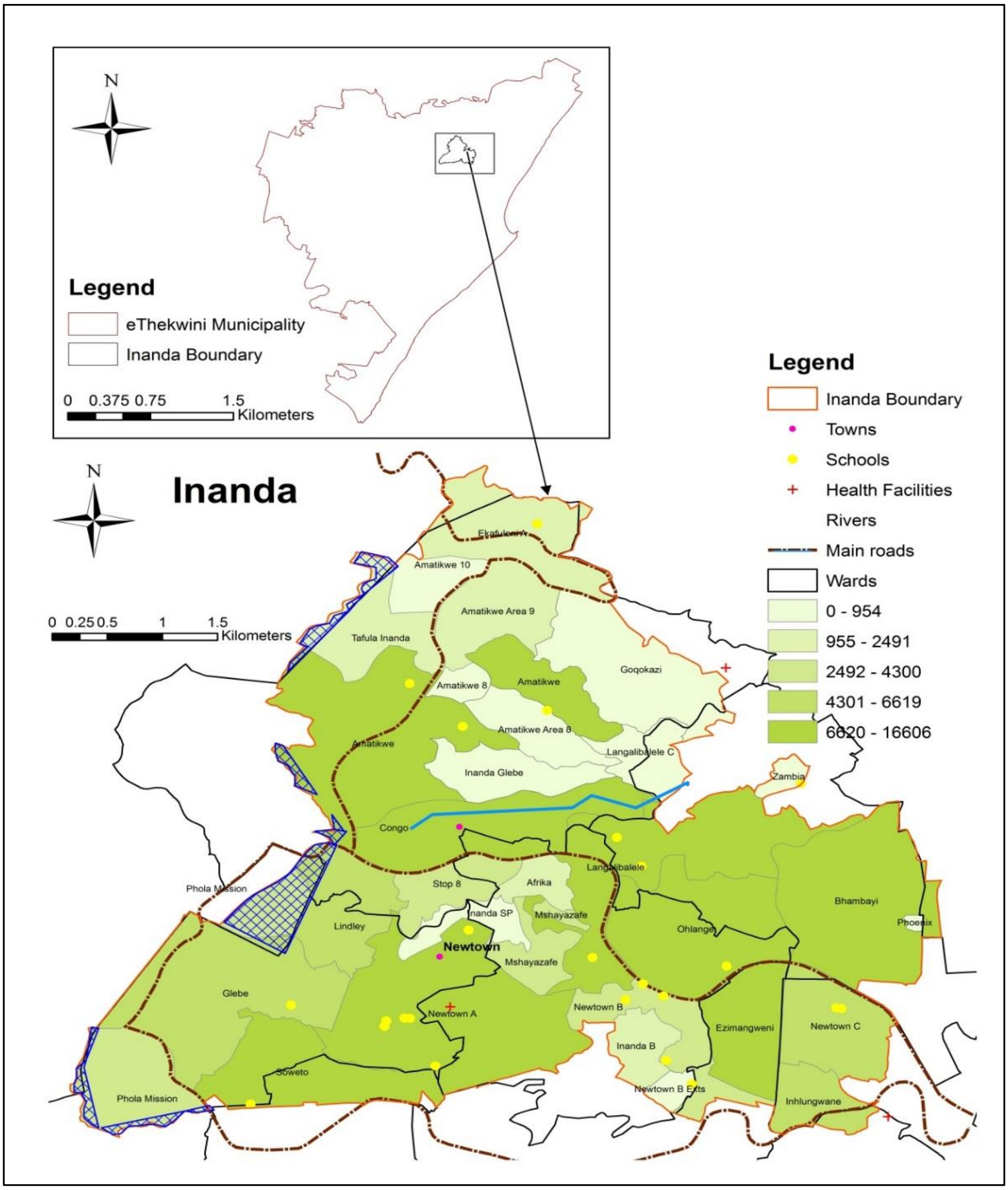

Figure 4.2: Main features and population density of Inanda (Author, 2016)

4.2.1.2 Socio-economic characteristics

According to the DPLG (2007), Inanda was established in the 1800s to house African and Indian communities that were forcibly removed from the Cato Manor region. According to the previous racial classification, 99.7% of residents are African, with smaller clusters of Coloured (0.2%) and Indian (0.1%) residents (SSA, 2011). The region comprises formal (52%), informal (43%) and traditional (5%) type dwellings, with the highest informal dwellings located in the Bhambayi township (DPLG, 2007) (Figure 4.3c). Unsurprisingly, rates of employment are considerably low resulting in 43.1% of individuals being unemployed and 33% economically inactive (DPLG, 2007). The low levels of employment can, in part, be attributed to the overall low levels of education, with 22% of residents having completed secondary level schooling (DPLG, 2007). Furthermore, Inanda is described as a low-income community with high levels of poverty; the average household income is considerably lower than that of the eThekwini Municipality (R112 830 per annum) but higher than the provincial mean (R83 050 per annum) (SSA, 2012c).

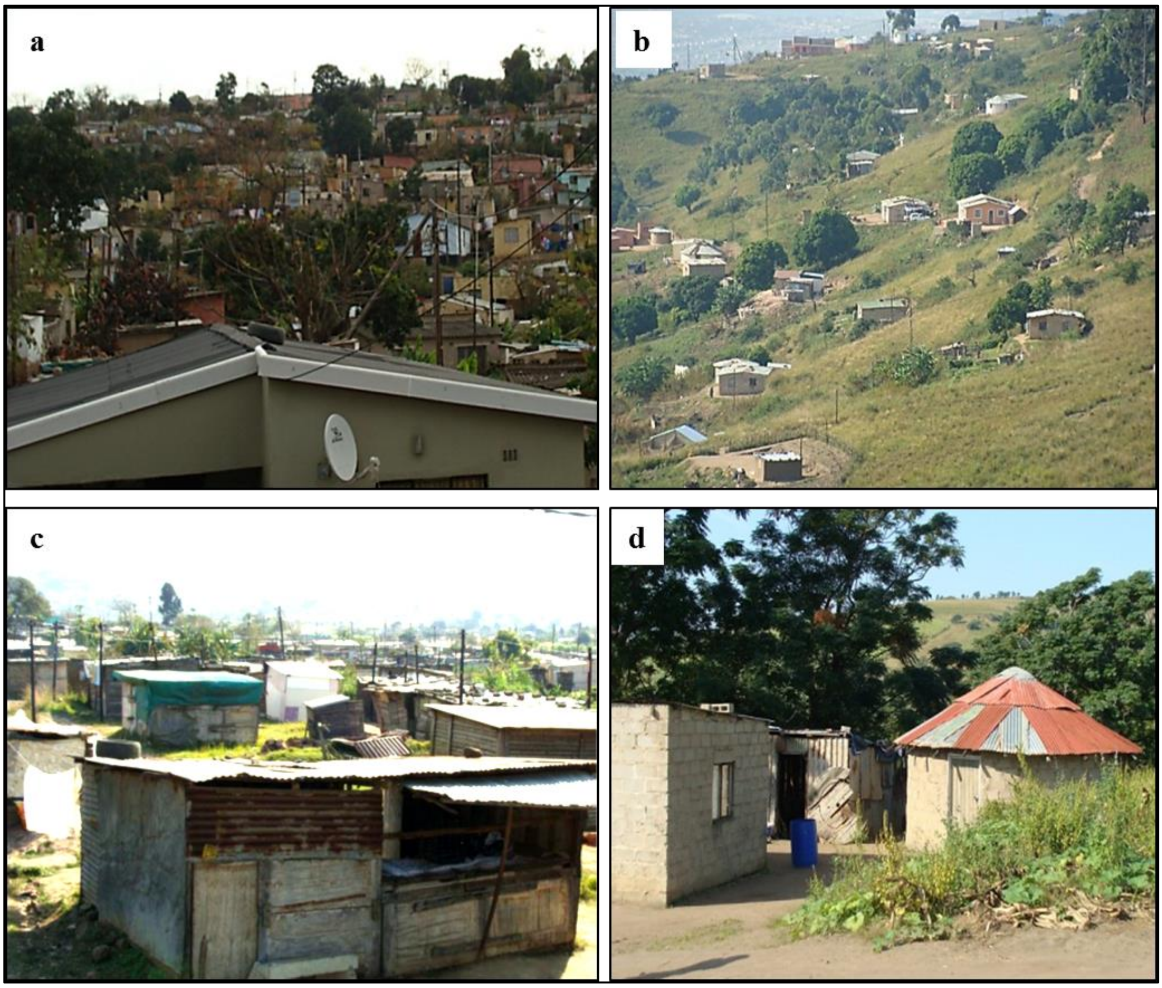

Figure 4.3: Variations in density (a & b) and dwelling type (c & d) among households in Inanda (Author, 2014)

As mentioned earlier, population density differs across the Inanda community; the gentler terrain is characterised by higher densities (Figure 4.3a), compared to locations that are more remote and those with steeper terrains (Figure 4.3b). Additionally, there are differences in dwelling types; most dwellings are formal brick structures (Figure 4.3d), however, there are some informal structures as well (Figure 4.3c). These differences may present challenges when establishing suitable renewable energy strategies. Furthermore, this highlights the community level differences in socio-economic and environmental conditions, which are often overlooked in energy planning and policy debates.

In 2001, the South African Government initiated the Urban Renewal Programme (URP) and the Integrated Sustainable Rural Development Programme (ISRDP) to address under-development in the most severely impoverished urban and rural communities. Alexandra, Galeshewe, Mitchell's Plain, Khayelitsha, Motherwell, Mdantsane, Inanda, Ntuzuma and KwaMashu were identified as the key nodes (DPLG, 2007). As a result of the geographic proximity between Inanda, Ntuzuma and KwaMashu, and the overlap of wards and township boundaries, the region was categorised as the Inanda, Ntuzuma and KwaMashu (INK) development node (DPLG, 2007). Subsequently, the INK node has been recognised as one of five pilot areas for Area-based Management (ABM) (DPLG, 2007). The ABM programme was designed to implement municipal Integrated Development Plans (IDPs) at the sub-municipal level by integrating civil society, government and private sectors. Despite these attempts, the INK region is among the most impoverished communities within the Municipality (eThekwini Municipality, 2013).

Housing in KwaMashu and Ntuzuma is predominantly formal, whilst Inanda exhibits the highest concentrations of informal housing, limited service delivery and is experiencing severe government housing backlogs (DPLG, 2007). Additionally, the socio-economic issues are exacerbated by high unemployment rates, low levels of education and limited household incomes (DPLG, 2007). Hemson (2003) states that poverty within Inanda is unevenly distributed, however, with the highest levels being confined to zones that have high levels of informal settlements, such as Bhambayi, and zones located furthest away from major roads. Despite the three development programmes initiated in the region, economic activities are lacking which could be attributed to the low levels of education and skills available at the household level. Consequently, Inanda has a mixed economy comprising both formal and informal structures where most of the income is derived from retail and small business; however, there is a significant dependency on social grants and remittances to sustain households (DPLG, 2007). Additionally, the presence of heritage and historical sites such as the Inanda Dam, John Langalibalele Dube and Mahatma Ghandi sites encourage tourism-related economic activities.

In terms of service delivery, DPLG (2007) estimate that 30% of the population lack piped water, electricity and sanitation at the household level. Furthermore, due to the increased presence of informal dwellings, the lack of access to basic domestic services could be more severe than estimated. Inanda is characterised by a young population. Furthermore, the HIV infection rate within the INK region is approximately 39%, which is regarded as the highest rate of infection in the country (DPLG, 2007).

4.2.2 Bergville region

The Bergville community is located within the Okhahlamba Municipality, along the western region of KZN. The Okhahlamba Municipality comprises private commercial farms and several small-holder settlements, which are managed by the local municipality and the Amazizi and Amangwane traditional authorities (Okhahlamba Municipality, 2013). Bergville is the economic and administrative hub of the Okhahlamba Municipality and comprises approximately seven small-holder settlements with a total population of 151 441, in 2 6674 households (SSA, 2011). According to Mthembu (2011), the population is unevenly distributed across the area with Amangwane being the most populous (Figure 4.4). The following sections provide a description of the environmental and socio-economic characteristics of Bergville.

4.2.2.1. Climatic conditions

Climatic conditions in Bergville varies throughout the year, with maximum temperatures exceeding 27.9°C during the summer months (November to February) and a minimum of -1°C during the winter months (May-July) (Okhahlamba Municipality, 2013). The region receives adequate rainfall throughout the year with an annual average of 643 mm (Mthembu, 2011).

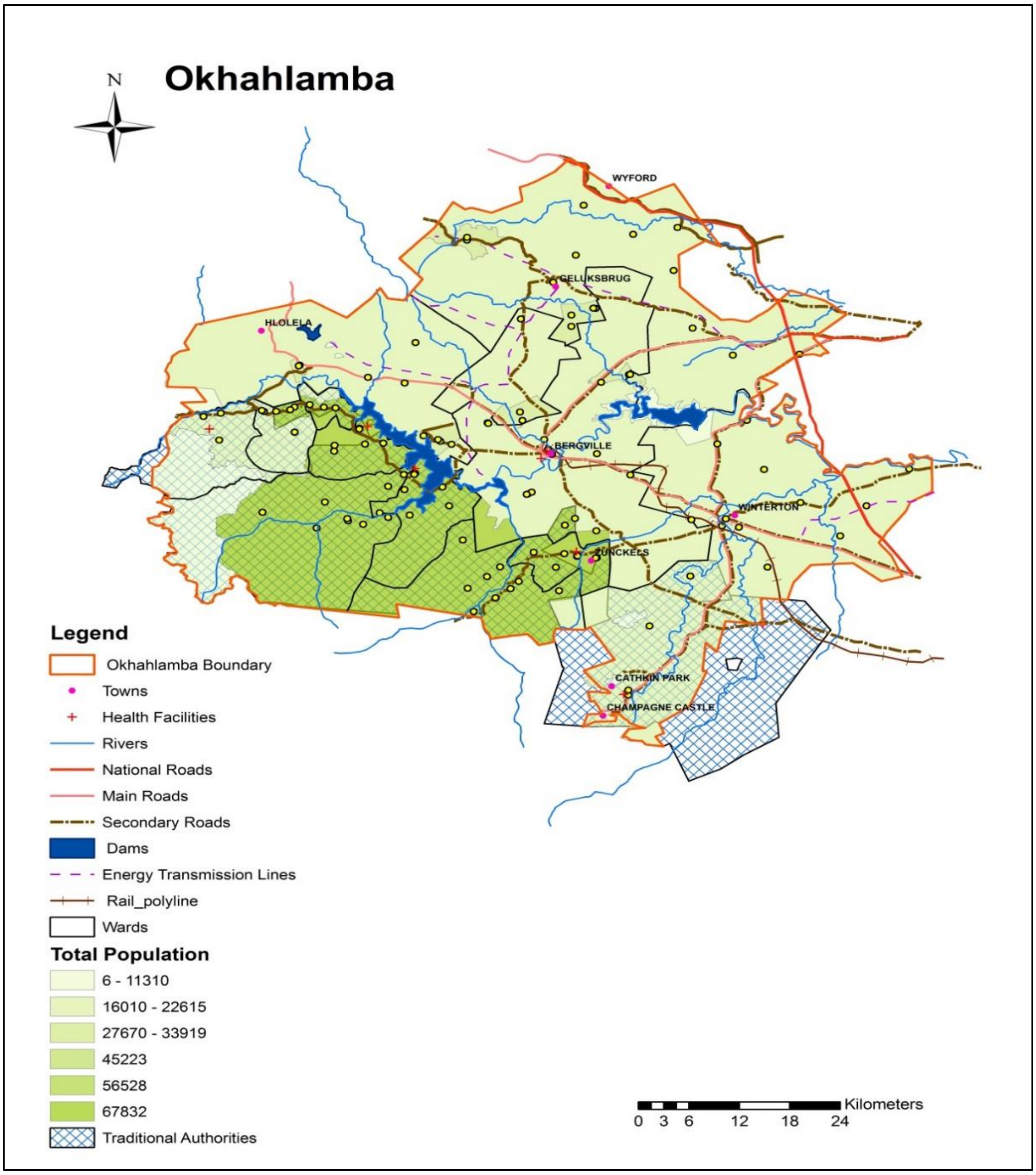

Figure 4.4: Main features and population density of Bergville (Author, 2016)

4.2.2.2. Socio-economic characteristics

The communities within Bergville can be described as having a youthful population, the majority of which are within the 30-40 year age category (Okhahlamba Municipality, 2013). In terms of the historical racial composition, 97.5 % are African with smaller proportions being White (1%), Indian (1%) and Asian (0.5%) (SSA, 2011). There are more females (57%) than males in Bergville, with 38% of the population not having any formal education; 22% and 21% have some level of primary and secondary education, respectively (SSA, 2011). A small proportion of the population (10%) have completed secondary education

(Okhahlamba Municipality, 2010). According to SSA (2011), the average unemployment rate in Bergville is 43.1%, however, this is slightly higher among the younger population groups (52.3%). Additionally, Mthembu (2011) describes Bergville as having limited levels of formal skills and high levels of unemployment. In terms of housing services and infrastructure, 41% of dwellings are formal brick structures, 3% are informal structures and the vast majority (56%) are traditional dwellings (Figure 4.5). According to Mthembu (2011), these characteristics highlight persistent poverty within the community, since housing is a basic need which contributes to the improvement of life and enables sustainable livelihood practices. Given the socio-economic, geographic and dwelling characteristics, Bergville is described as a rural community (Mthembu, 2011; SSA, 2011).

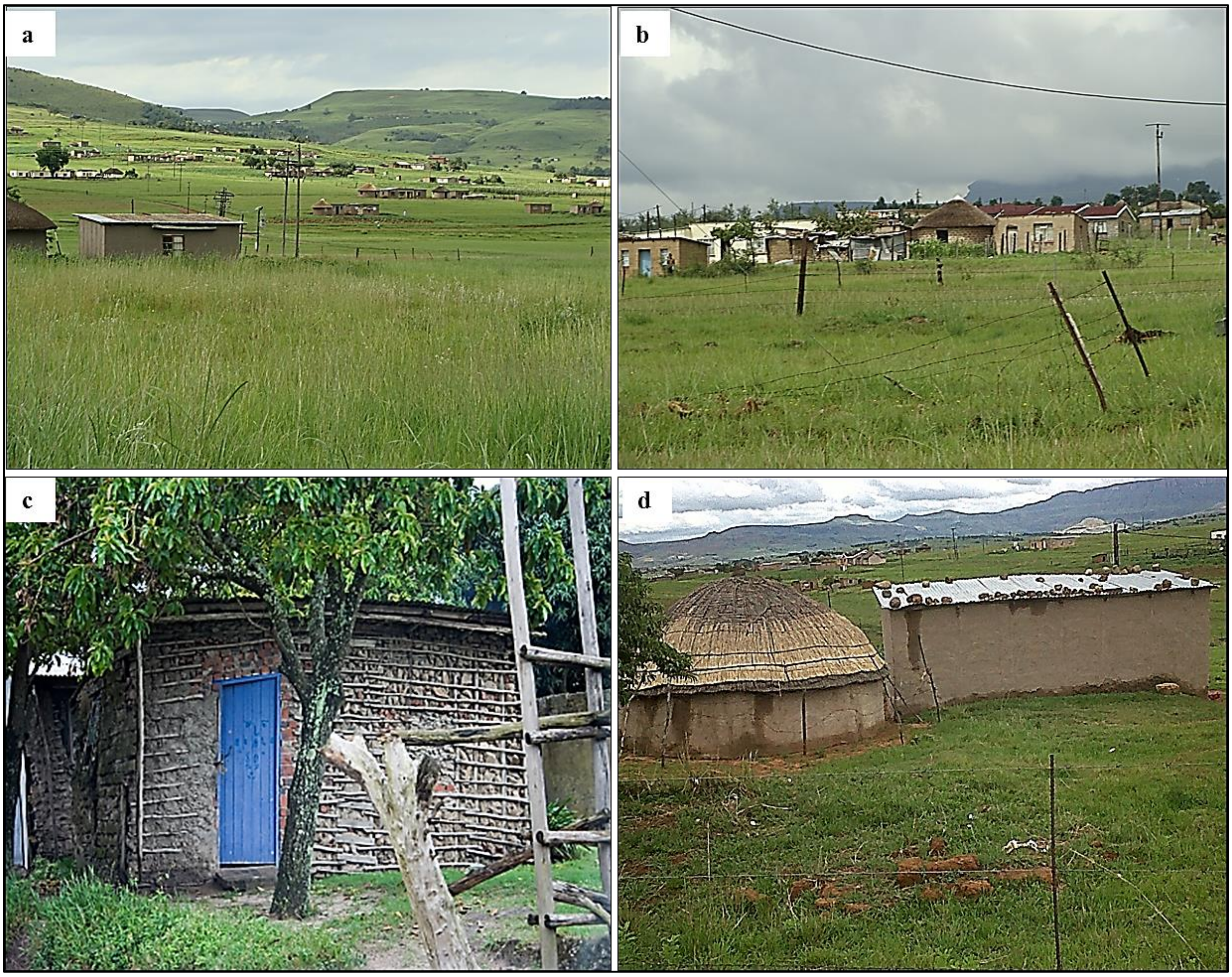

Figure 4.5: Variations in density (a & b) and dwelling type (c & d) among households in Bergville (Author, 2016)

As mentioned earlier, dwellings in Bergville vary in terms of structure and density. A few of the smaller settlements display high densities and these are generally located closer to the main business hubs and central business district (Figure 4.5b). The more densely populated areas also show a higher percentage of formal brick type dwellings. The outlying and more remote settlements in Bergville are sparsely populated (Figure 4.5a) and consist predominantly of traditional dwellings constructed with mud, stones and wood, and thatched roofs (Figure 4.5c). The differences in dwelling type, and more specifically the poor structural stability associated with tradition dwelling structures and roofs may present a challenge for the implementation RETs such as SWHs and PV panels, which require stable platforms for installation. Physical household characteristics, in these contexts become pertinent factors that contribute to the up-take and implementation of RETs.

Commercial and subsistence farming practices are the main activities which is supported by the local soils, relatively gentle terrain (south east to north east regions), and sufficient amounts of rainfall throughout the year (SSA, 2011; Okhahlamba Municipality, 2013). Bergville is considered the economic and administrative hub and has been identified as the primary node for development under the Spatial Developmental Framework (SDF) (Okhahlamba Municipality, 2013). Land resources within Bergville are owned and managed on a freehold basis, under the Ingonyama Trust and private sectors, however, a major challenge impeding development in the area is attributed to 90% of land being gazetted for land restitution (Okhahlamba Municipality, 2013).

In relation to energy provision and use, most households have a formal supply of electricity; however, there are some remote settlements that lack energy infrastructure (Okhahlamba Municipality, 2013). Statistics South Africa (2011) revealed that although electricity is the main source of supplied energy, households still rely on fuelwood for cooking and heating, and candles for lighting needs. This suggests that extensive energy hybridisation occurs within Bergville, however, there has been a notable reduction in household reliance on fuelwood and candles between 2001 and 2011 (Okhahlamba Municipality, 2013). Other commonly used sources of energy are paraffin and animal dung which have also been associated with a decline since 2001 (Okhahlamba Municipality, 2013). The Okhahlamba Municipality (2013) highlights plans to introduce SWHs, solar and biogas cookers in their development plans, and argue that these will assist in improving efficiency and safety within households.

4.3 Research design

4.3.1 Methodology

Research methodologies can be described as frameworks that guide the overall processes of collecting, analysing and interpreting data on specific phenomena. Leedy and Ormond (2010) state that methodologies are systematic approaches that govern the overall processes and more importantly, the choice of research tools selected. Greene (2007) defines research methodologies as the strategic approach defined by the researcher to address research questions. Similarly, Avison and Fitzgerald (1995: 63) define research methodologies as "a collection of procedures, techniques, tools and documentation aids, but a methodology is more than merely a collection of these things. It is usually based on some philosophical paradigm; otherwise it is merely a method, like a recipe". Leedy and Ormond (2010) state that research begins with the process of inquiry which stimulates chain reactions that lead to the selection of various tools to provide more insight on particular phenomena. These processes and the initial stages of inquiry are embedded in one or more philosophical understandings of specific phenomena (Leedy & Ormond, 2010).

The systematic processes of data collection and analysis in any research endeavour is key to the development of knowledge, however, it is the philosophical slant that determines which knowledge should be accepted or rejected (Leedy & Ormond, 2010). This study investigates the socio-economic, political and spatial dimensions that define household energy access, profiles, behaviours and practices. Based on the multi-model conceptual frameworks of this study, an array of techniques were utilised to examine the energy-poverty-development nexus within rural and peri-urban communities. The sections that follow provide a detailed description of and motivation for the chosen research design, methodological approaches and tools. Additionally, the philosophical paradigms that guided the research and methodology used are also described.

4.3.2 Research philosophy and approach

Several studies highlight the importance of research paradigms in determining the processes and tools associated with any research endeavour (Naslund, 2002; Bryman & Bell, 2007; Saunders et al., 2007). Research design involves an overview of the philosophical underpinnings that guide the systematic processes of the research endeavour, from inception, to data collection and interpretation (Saunders et al., 2007). The design of this research comprises interpretive positivist and phenomenological philosophies, in an attempt to understand and explain the causal relationships that exist between household energy profiles and the prevailing socio-economic, environmental and political factors. According to Mason (2000), a researcher's ontological and epistemological position will guide the research and the methodology utilised. In order to demonstrate the entire research process, Chao (2010: 5) draws on the work of Saunders et al. (2007) who use a model referred to as the 'research onion' (Figure 4.6).

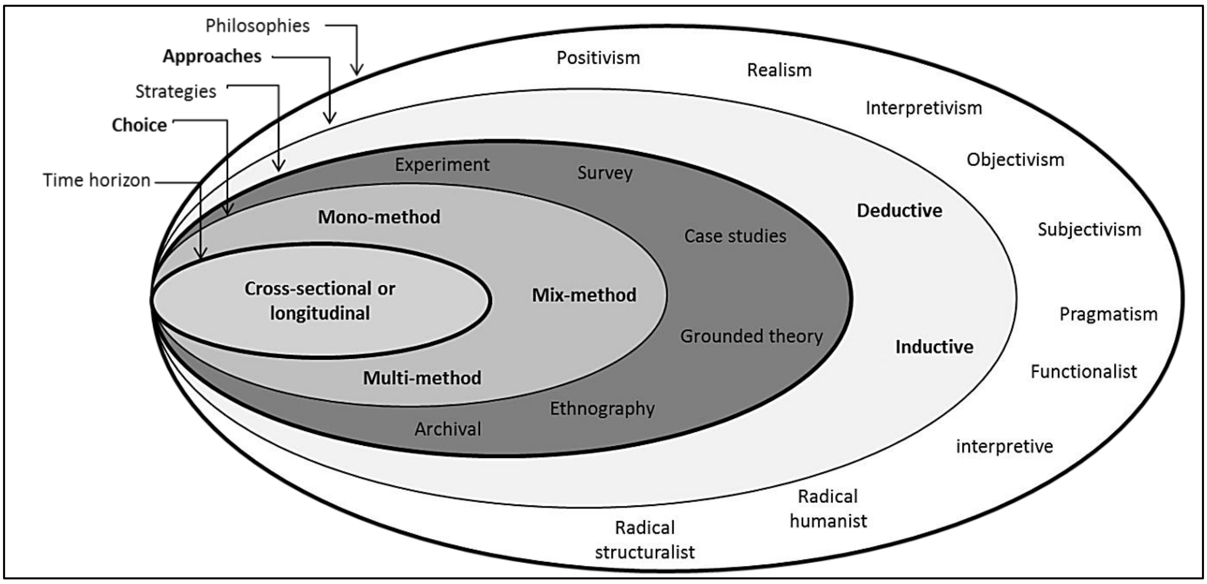

Figure 4.6: The research onion model **(s**ource: Saunders et al., 2007: 32)

From an ontological perspective, it can be argued that reality is socially constructed and can have various meanings, thus mono-methodologies often fail to capture these complexities (Rodela et al., 2012). According to Rodela et al. (2012), the main aim of any research agenda is to unpack these realities and capture as many meanings as possible. In terms of the present research, a mixed method approach was adopted and includes the following:

- Positivistic, phenomenological and an interpretivist philosophical approach that was both inductive and deductive;
- Survey and case study strategy; and
- Mixed method, (specifically, triangulation).

Furthermore, this study uses a cross-sectional, comparative approach to examine energy profiles in rural and peri-urban contexts. These concepts are discussed in detail in subsequent sections below.

4.3.2.1 Mixed methods

Combining qualitative and quantitative methods offers the advantage of offsetting biases, utilising the strengths of each and compensating for their weaknesses (Greene, 2008). The reason for using mixed methods is that they provide insights which cannot be obtained from using one method alone (Johnson & Turner, 2003). Creswell (2003) identifies six mixed method designs and his views on these are summarised in Table 4.1.

Table 4.1: Mixed method designs (adapted from: Creswell, 2003)

Design	Focus	Theory	Data collection, analysis, evaluation
Sequential explanatory	Qualitative data used to enhance and complement quantitative findings; explaining relationships between variables.	No particular theoretical framework	Quantitative data collected and analysed first; integration of quantitative and qualitative data in evaluation.
Sequential exploratory	Quantitative data used to enhance and complement qualitative findings.	No particular theoretical framework	Qualitative data collected first and then quantitative; quantitative results used to complement and extend qualitative findings
Sequential transformative	Quantitative or qualitative data used to ensure views and perspectives of a diverse range of participants is represented to get a better understanding of a process.	Method determines theoretical perspective	Collecting either quantitative or qualitative first; data from quantitative and qualitative survey analysed separately and integrated in interpretation.
Concurrent triangulation	Cross-validating, corroborating findings from single study.	No particular theoretical framework	Quantitative and qualitative data collected together; data are analysed separately and integrated in interpretation.
Concurrent nested design	Embedding one kind of data into the other when studying different levels or units of an organisation.	No particular theoretical framework	Quantitative and qualitative data collected concurrently and analysed together and mixed; various strategies used such as developing typologies or transforming into narratives.
Concurrent transformative	Using quantitative or qualitative data together.	Clearly defined theoretical perspective guiding methodology	Quantitative and qualitative data collected concurrently and analysed together and mixed.

In terms of Creswell's (2003) design methods, the approach adopted in this study can be described as concurrent triangulation which uses both qualitative and quantitative data sources. The use of quantitative and qualitative data sources provided a more holistic understanding of household energy preferences, choices and behaviours. As mentioned in Chapter 2 the use of the political economy and household energy behaviour conceptual frameworks in the conceptual model for this study, imply that there are multiple determinants of energy profiles, especially within marginalised households. The use of both quantitative and qualitative techniques highlights the experiences, values, processes as well as trends and relationships between variables. Shaffer (2013) highlights the extensive history of mixed method approaches in poverty and development research, especially in developing studies. Each of these approaches adds new perspectives to the research processes and warrants the need for more detailed methodologies in understanding specific phenomena.

Several studies highlight the increasing importance of mixed methods and triangulation as a means of investigating phenomena that are influenced by multiple factors, and have the potential to manifest differentially across socio-economic and geographic gradients (Amaratunga et al., 2002; Creswell, 2003; Johnson et al., 2007; Denscombe, 2008). This study therefore embraces the call to examine social and technologically related topic using this methodological approach (Pachuari et al., 2004; Mulugetta, 2008; Mondal et al., 2010; Rehman et al., 2012). The study of solar energy in the context of socio-economic and spatial characteristics provides an opportunity to explore the use of multiple methods.

4.3.2.2 Quantitative and qualitative (Q^2) methods

Qualitative research provides knowledge of how the world is constructed and it aims to provide a deeper understanding of social phenomena (McLeod, 2001; Silverman, 2001). Denzin and Lincoln (2005) suggest that qualitative research is a process where experiences and perceptions on various phenomena are interpreted in their natural settings, so as to understand and extract the value and meaning people attach to specific phenomena. Similarly, Creswell and Clark (2007) assert that qualitative methods and its causal philosophies are essential in understanding personal and social issues. Tavallaei and Talib (2010) posit that qualitative methods are relevant to studies where issues such as gender, race, and socio-economic status are important variables. Petty et al. (2012) argue that research findings generated from qualitative studies are context specific and therefore prevent generalisation. As highlighted in Chapter 2, energy behaviour, needs and prioritisation are influenced by factors such as values, beliefs, culture and materialistic wants, which highlights the role of the individual. The qualitative methods used in this study, include focus group discussions, open-ended questions in the survey instrument and participatory mapping to understand household energy use, behaviour and needs. Additionally, validation of data trends and relationships are executed by adopting the relevant quantitative approaches, which are discussed in detail below.

Quantitative research methods display empirical and positivistic characteristics and provide insight on the facts or causality of social phenomena (Carr, 1994; Hussey & Hussey, 1997; Sheppard, 2001). More simply, quantitative processes measure and examine patterns and relationships within data. Sheppard (2001) iterates that quantitative approaches and spatial statistical analyses add rigour and enhance the practice of geographic research. Bryman and Bell (2007) are of the opinion that qualitative research influences intellectual traditions whereas quantitative research determines what should be accepted as knowledge. Thomson (2008) states that the differences between these approaches are subtle and while quantitative research involves measuring components of a particular phenomenon, qualitative research is more about understanding the entire model. However, Saunders et al. (2007) equate the difference between qualitative and quantitative techniques to the presence or absence of numeric data. According to Kumar (2005), quantitative methods highlight the extent of the issue whereas qualitative methods explore the nature of the issue. In adopting a mixed methodological approach, this study uses triangulation to investigate and understand the main research phenomena and concepts, highlighted in Chapter 2.

4.3.2.3 Triangulation

The progression from positivism to phenomenological paradigms resulted in the coalescing of different research methods and techniques within a single study which adopts, as indicated by the triangulation approach, and represents the middle-ground to the divergent viewpoint as discussed above (Hussey & Hussey, 1997). Mangan et al. (2004) assert that triangulation provides empirical support to theory and reduces likely bias and flaws due to solitary method approaches. The triangulation approach employs different data collection techniques and is considered best to complement the case study approach, as the latter requires information from multiple sources (Mangan et al., 2004; Saunders et al., 2007). There are four types of triangulation: data triangulation (data collected from different sources or at different times), investigator triangulation (multiple investigators in the research process), methodological triangulation (the use of quantitative and qualitative techniques in the research process), and theory triangulation (the use of multiple theories to explain a phenomenon) (Easterby-Smith et al., 1997). This study uses data and theory triangulation to address the research questions, aims and objectives.

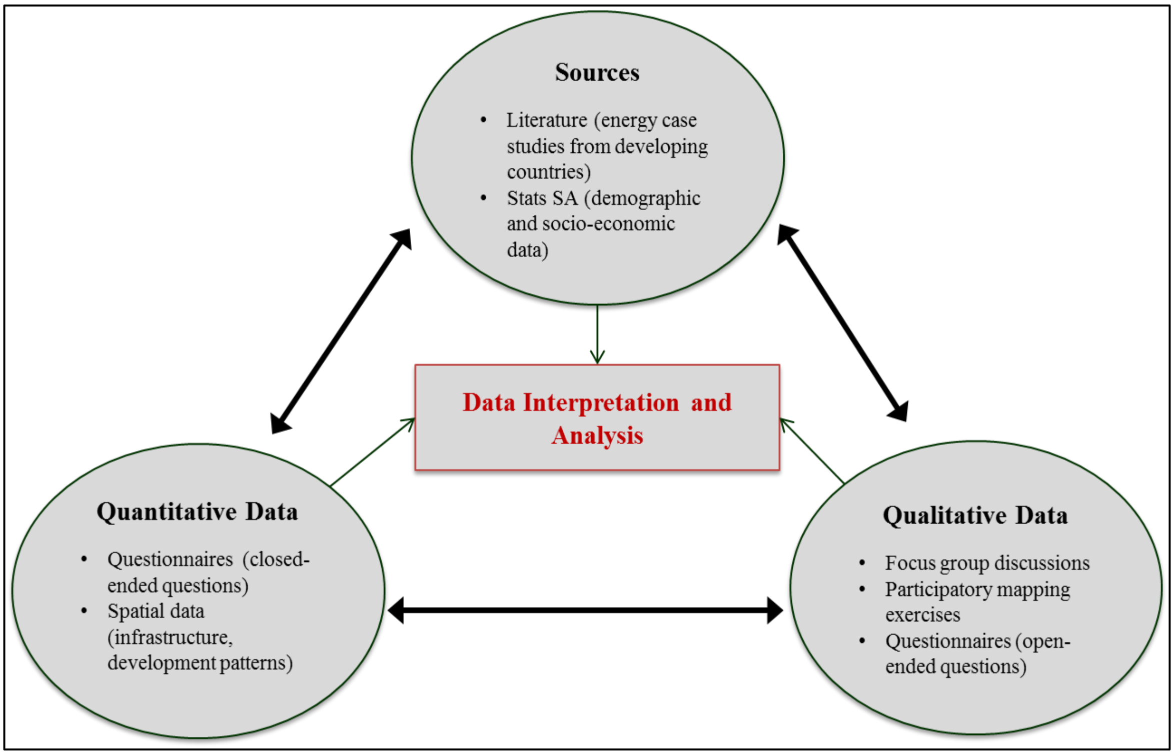

Figure 4.7: Triangulation approach of this study (Author, 2015)

4.3.2.4 Case study approach

The case study methodology emanates from human and social sciences and falls within the cluster of evaluative research tools (Creswell, 2007). Robson (2002) asserts that the case study approach utilises multiple sources of information to empirically examine phenomena within the real life context. Stake (2005: 10) defines a case study as “the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances”. Welch et al. (2011) argue that the use of case studies can allow one to draw on causality and contextualisation processes which allow the researcher to generate knowledge about particular phenomena. Similarly, Jävensivu and Törnroos (2010) state that case studies include aspects of ontology, epistemology and methodology. Yin (2003) proposes that the most applicable use of the case study approach would involve complimenting the process by the use of both quantitative and qualitative techniques for data collection. Stake (2005) emphasises the necessity for the chosen case study to incorporate the typical experiences and realities of other cases, within the broader context, in this case marginalised households. Furthermore, South Africa displays diverse socio-economic landscapes, thus case studies for this study were purposively chosen to provide a more holistic understanding of energy use, practices and behaviours in both rural and peri-urban settings: Bergville and Inanda, respectively.

4.4. Research questions

This study applied multiple theories from the discipline of Geography, ranging from positivist, interpretivist and phenomenological paradigms and as well as quantitative and qualitative data collection techniques to examine household characteristics, attitudes and perceptions, and how these influence energy behaviour. In addition to informing the overall approach adopted in this study, the multiple theories guided the interpretation and analysis of data obtained to advance the research questions and objectives. Guided by the above philosophies and the research aims and objectives outlined in Chapter One, this study addresses the following research questions:

- What are the energy profiles of households within rural and peri-urban communities?
- Is there any correlation between the socio-economic and demographic characteristics and energy profiles of households within these communities?
- Do the energy needs differ between rural and peri-urban households, and what are the main determining factors?
- What are household preferences, awareness and attitudes towards traditional and modern energy sources?
- What are the key concerns, at the household level, for the introduction and implementation of renewable energy sources?
- What are the likely impacts of renewable energy options on livelihood practices?
- Which energy sources are households most likely to use to enhance and sustain livelihoods?
- What are the spatial patterns of energy use, behaviour and choice?
- What are the implications of future energy demands on energy policy, implementation, type, supply and cost?

4.5 Data collection tools and processes

Both primary and secondary data was used in this research and were obtained by quantitative and qualitative techniques. As mentioned earlier, any research endeavour is not devoid of the philosophical and theoretical underpinnings. Therefore, secondary data included an overview of existing literature on energy and rural development, a review of related case studies as well as South African energy policies. Primary data was collected using survey instruments, focus group discussions and spatial mapping techniques. These are discussed in detail in the subsequent sections.

4.5.1 Questionnaire surveys

Questionnaires are the most commonly used quantitative tool that extracts information vital to the research (Babbie & Mouton, 2003). According to Maylor and Blackmon (2005), surveys are useful techniques in obtaining data on opinions, behaviours, and/ or attitudes from a variety of respondents. Malhotra (2006) states that questionnaires comprise a formal set of questions aimed at extracting respondent perceptions, experiences and attitudes towards specific phenomena. Questionnaire surveys are carried out by selecting a sample that adequately represents the entire population or a target group within the population, for example, small-scale farmers (Chu et al., 2009). The survey instrument has a variety of designs ranging from structured to unstructured and can include open and/ or close-ended questions. The design of the survey instrument is dependent on the research objectives and the phenomenon itself. Close-ended questions may lack flexibility for the respondent, however, they produce consistency in data and can be easily coded and captured (De Vaus, 2002; Marshall, 2005). Open-ended questions on the other hand, produce more detailed data but are associated with issues of inconsistencies and difficulties in interpretation and summarising for coding purposes (Kumar, 2011).

The survey instrument used in this study included a combination of open- and close- ended questions (Appendix A). De Vaus (2002) warns against the sterility of questionnaires as a quantitative tool but assert their value in providing factual, descriptive and insightful information on the target population. Marshall (2005) highlights language and interpretation as some of the main limitations in utilising questionnaires, and warns that the researcher should always be cognisant of the fact that respondent's interpretation of the questions may not always align with the researcher's objective or intention. Additionally, adequate planning in the design and administration phases is crucial in reducing poor response rates and unreliable data (Marshall, 2005). O'Sullivan et al. (2006) state that accurate data profiling of household energy use, demographics and awareness is necessary for the transition to more sustainable energy sources, but is lacking within energy debates.

In the light of the above, this study used the following themes in the research instrument to understand household energy behaviour:

- Socio-demographic profile;
- Household energy profile;
- Perceptions and attitudes towards various energy sources;
- Awareness and perceptions of solar and solar thermal energies; and
- Energy conservation practices.

Demographic variables such as age, income, employment status and current household livelihood strategies provided the context in which energy behaviour and perceptions were examined in section A of the research instrument. Additionally, this section profiled the willingness of households to engage in other livelihood activities and the main barriers that they encountered. Section B of the instrument, examined main energy sources used in the household with the emphasis on basic energy needs which when identified from the literature include cooking, heating and lighting activities. Key issues such as total usage, accessibility, affordability (start-up and current usage costs), previously used sources and main reasons for their choice were profiled. This was followed by an examination of awareness and attitudes towards commonly used energy sources.

Section C outlined respondent perceptions of renewable energy, main sources of information, preferences, and willingness to use and pay for renewable energy sources (start-up and monthly usage costs). Furthermore, respondents' perceptions on the maintenance and up-keep of RETs were defined. This section then focuses specifically on solar thermal energy and cookers, where costs and perceptions were detailed. The survey concluded by examining awareness around climate change and specific energy conservation practices. Lastly, respondents compiled a list of the main community needs and issues.

4.5.2 Focus group discussions

According to Bryman (2008), focus group discussions are systematically designed to examine the ways in which participants interpret, perceive and collectively act in relation to the subject under study, which may unpack issues not addressed by the survey instrument. Focus group discussions are qualitative data collection methods that comprise semi-structured and structured dialogues and activities with approximately 8-15 purposively chosen individuals from the sample population (Rubin & Babbie, 2005). Other studies suggest that focus group discussions create permissive environments which allow for enhanced interaction between participants and the researcher, thereby stimulating multiple in-depth discussions, which enrich information collected by the surveys (De Vos et al., 2005). Likewise, reinforced assurance in confidentiality, anonymity and ethical considerations are important in creating environments where participants feel safe and comfortable to interact and converse (Barnett & Breakwell, 2001; Denscombe, 2007). However, De Vos et al. (2005) warn against facilitator bias, which can hinder the flow of information from all participants within the group. According to Curry et al. (2009), focus group discussions are structured activities that allow participants to engage on several aspects related to the research phenomena. A focus group discussion explores the differences in experience and perspective between the individuals to highlight factors that determine people's behaviour and opinions (Curry et al., 2009).

Focus group discussions were carried out in Bergville and Inanda to compliment primary data obtained from the survey. Resource mapping, ranking and prioritisation exercises were part of the focus group discussions and were used to afford participants an opportunity to identify and examine energy use, services and needs. One focus group session was conducted in each of the communities by facilitators who were conversant in both English and isiZulu. Each focus group was approximately 3-4 hours in length which allowed participants to engage and communicate with ease. The Inanda focus group comprised 12 individuals (5 males and 7 females) who collectively represented residents (8), local councillors (2) and individuals from a private organisation (2) tasked with installing solar-water heaters within the community. The councillors and the informants from the private company were purposively selected whilst the community members were chosen by way of referrals from the councillors.

The Bergville focus group comprised 11 participants (four males and seven females), that were from the local community (8), local council (2) and private organisations (1) that facilitated the implementation of solar energy (solar-water heaters and photovoltaic panels) in the community. A similar technique used for the selection of the focus group in the Inanda area was used for the Bergville focus group. In addition to group interviews, ranking, option-assessment charts and participatory mapping exercises were conducted to allow for a more robust understanding of local perspectives on energy, development needs and future implementation plans of renewable energy sources. The schedule for the focus group sessions is included in Appendix B, the main thematic areas covered during the focus group discussions included the following:

- Main energy sources and their challenges;
- Identification of most vulnerable and resilient households;
- Ranking and priority assessments of current and preferred energy needs and sources;
- Main household and community needs and challenges;
- Identification of energy priority areas; and
- Identification of suitable areas for the implementation of RETs.

Additionally, the focus group probed key trends emanating from survey data, specifically, the main reasons for energy related practices, preferences, attitudes and perceptions. These issues were re-visited during the focus group discussions to include any details that may have been overlooked by the field survey. Also, this provided an opportunity to examine the deeper-rooted decision-making processes that govern energy choice and practices within the communities.

4.5.3 Participatory mapping

A further exercise during the focus group discussions involved the creation of baseline maps that allowed participants to highlight important socio-economic and environmental factors/ features that shape their energy practices, as well as depict potential areas of concern for the implementation of RETs. Brown (2012) describes PGIS as a method that aims to incorporate public knowledge and perceptions in planning and decision-making processes that have spatial implications. Voss et al. (2004) show that spatial planning problems that impact on large groups of people, for example energy access or energy poverty, require multidisciplinary approaches and describe PGIS as suitable tools that successfully highlight the geographic variations. Others, such as Simão et al. (2009) state that spatial planning is a complex issue that involves multiple stakeholders, thus the use of Participatory GIS mapping (PGIS) streamlines the process of collating multiple viewpoints on a specific phenomenon. Similarly, in the context of this study, PGIS offered a unique avenue for examining spatial variations in relation to the following:

- Areas that used the most and least amount of energy and its primary purpose (for example, residential, municipal, industrial or commercial);
- Most and least impoverished areas;
- Areas that are most in need of energy;
- Areas that currently use solar energy; and

- Environmental factors that will constrain and enable the use of solar energy.

4.5.4 Sampling framework

Sample size is vital in quantitative research, and whilst it is not possible to sample the entire population due to time and logistical limitations, a statistically representative sample is recommended for precision and accurate estimates with limited random error (Mason et al., 2000; Sverke, 2007). Similarly, Leedy (1993) asserts that sampling is a process whereby a subset of a large population is selected to represent the entire group using appropriate sampling techniques. Additionally, Patton (2002) highlights that the larger the sample the greater the statistical power of obtaining significant results. Communities were purposefully selected to represent different contexts within South Africa. The focus on peri-urban and rural communities permits a comparative analysis of different spatial, energy and social contexts. Very few studies provide a comparative basis to assess whether peri-urban and rural communities are significantly different in relation to household level energy security and vulnerability, behaviour, preferences, and attitudes and perceptions.

4.5.4.1 Household surveys

A multi-stage spatial sampling approach was designed to obtain data for the household survey, starting with a random selection of Enumerator Areas (EAs) from the 2001 Census within the selected sites (Inanda and Bergville). The EAs are similar to wards and are used to collect census data as well as for voting purposes; they are comparable in terms of household numbers. Following a random selection of households for interviews, quantitative surveys, focus group discussions and PGIS techniques attempted to achieve objectives 2-4 and in part, objectives 1 and 5 (see Chapter 1, section 1.3) within the selected communities. The sampling design for the proposed study consists of three sampling stages:

- Selection of EAs;
- Selection of households within EAs; and
- Selection of suitable locations for the installation of RETs based on communities' preferences and spatial suitability (for example, terrain, slope and accessibility).

The sample design arrived at is 400 households per site, thus, a total of 800 households comprised the quantitative component for the two communities studied. Since both communities have less than 100 000 households, 400 is a statistically significant sample size (at the 95% level of confidence) (Isaac & Michael, 1981). Random sample points were identified using the conditional point random sampling module of Hawthorn's tool (Version 3.27 extension for ArcGIS 9+). This tool uses proportionality and geographic spread to identify random points. These were selected by EA weighting and sub-setting according to household/ settlement density using the GIS sampling tool mentioned above. Twenty random points were generated for each community. The second stage of sampling involved the selection of 400 households from the 20 random points. The 20 closest households to the random point were surveyed. The geographic spread and randomness of the data collection criteria allowed for adequate representation of the study populations (Figures 4.8 and 4.9). As mentioned earlier, the two communities selected represent different geographic contexts, rural and peri-urban.

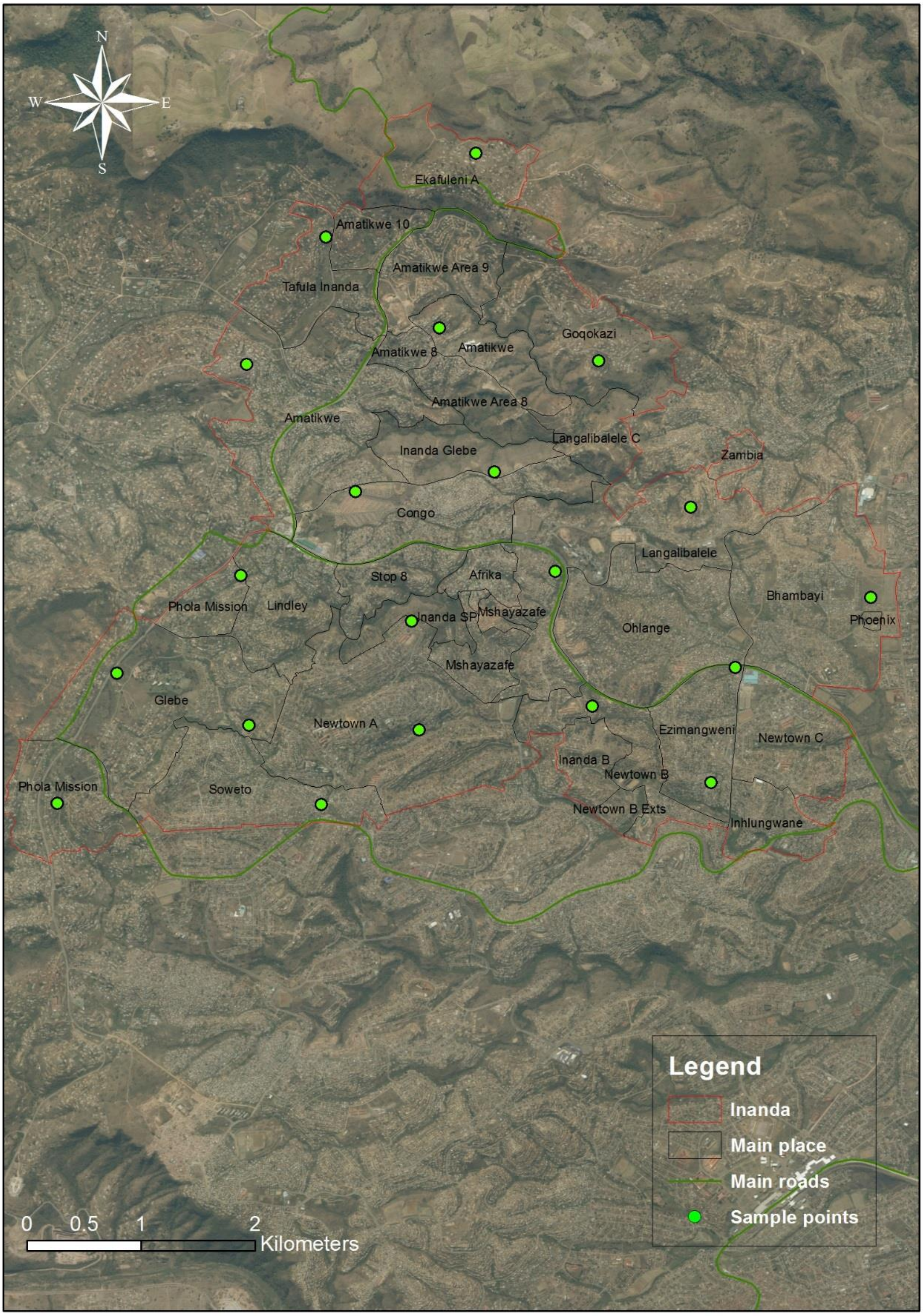

Figure 4.8: Random sampling points generated for Inanda (Author, 2016)

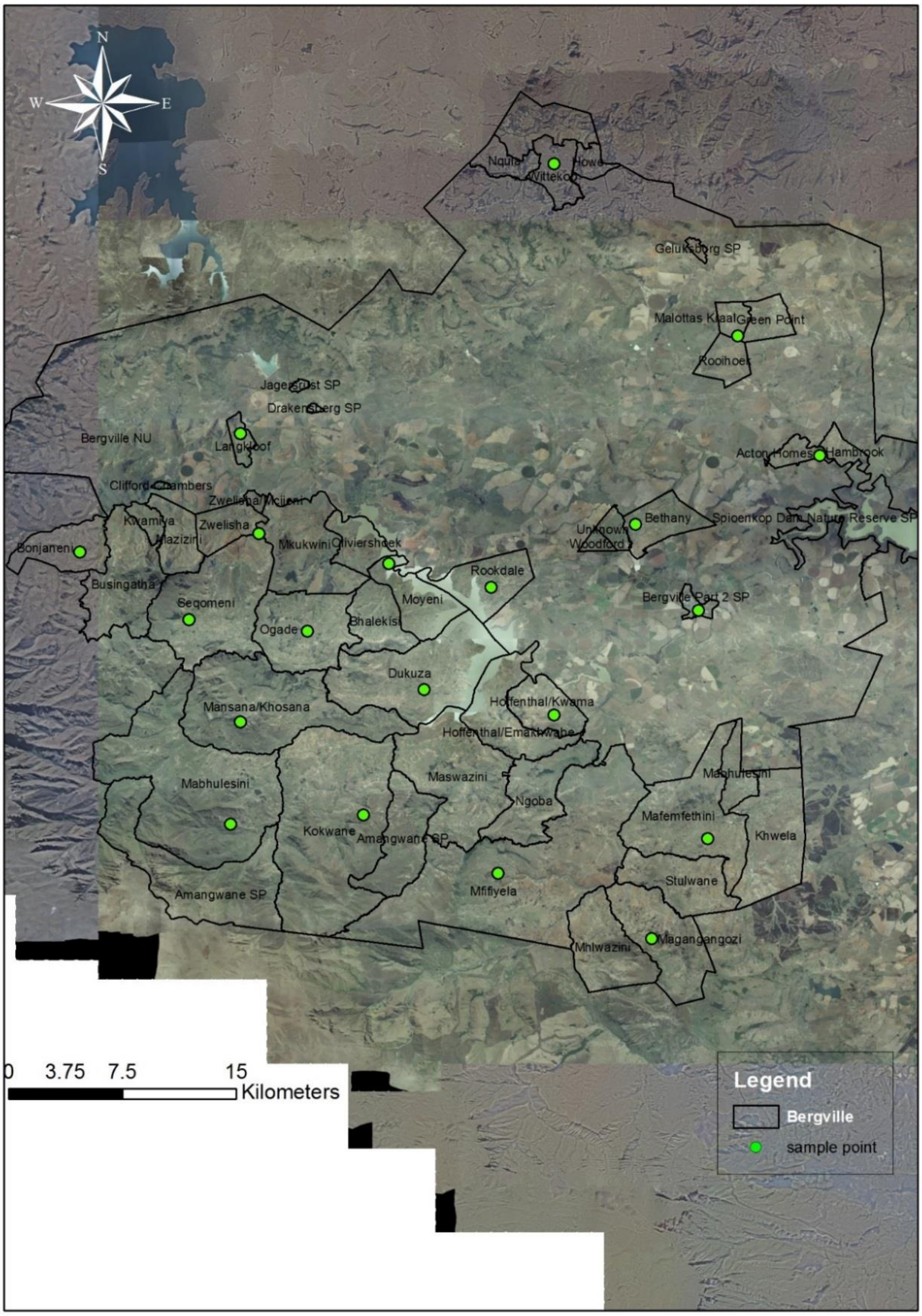

Figure 4.9: Random sampling points generated for Bergville (Author, 2016)

Four hundred household surveys were administered in each community, comprising a total of 800 surveys for this study. Sixty households in communities neighbouring Inanda and Bergville were chosen to pilot the surveys, approximately one month prior to data collection.

The pre-tests revealed that households were able to understand the questions and respond appropriately. However, questions that proved to be unclear or ambiguous during the piloting exercise were either omitted or rephrased depending on their relevance to research questions and objectives of this study. Moreover, based on the level of detail and responses obtained from the piloting exercise, a few open-ended questions were restructured to close-ended questions to facilitate easier capture of responses for the fieldworkers and data inputters.

Marshall (2005) foregrounds the importance of minimising comprehension errors during the interview process, emphasising the importance of language and coherent communication between the respondent and interviewer. The survey instrument used in this study was designed in English, however, respondents from the communities sampled were primarily isiZulu and English speaking. Thus, field assistants conversant in IsiZulu and English were employed to conduct the interviews. Field assistants underwent training to avoid communication and interpretation errors when conducting the interviews. Data was collected over a period of three weeks in each community by 10-12 fieldworkers. Each survey was pre-processed on site to check for completeness and consistency, thereby reducing errors in the interpretation stages. Survey data was later captured using the Statistical Package for Social Sciences (SPSS, IBM Version 23) software. Incomplete surveys were not included in the study.

4.5.4.2 Focus group discussions

Community members were purposively chosen to represent diversity in age, gender, income category and level of education. The literature presented in Chapter 2, lists these variables as some of the major factors that influence household energy practices and decisions. Focus group discussions were conducted post survey to scrutinise key trends and relationships that emerged from survey data. Ranking of energy options that best suited the needs of the households were prioritised, with the aid of option assessment charts and matrices, to compliment data obtained from the surveys. Focus group discussions were conducted by a facilitator (conversant in both English and IsiZulu), and notes were taken by two scribes to reduce error in interpretation and translation. The entire discussion was conducted over two sessions, the latter comprising the various mapping activities, and was between 3-4 hours in duration with each activity taking between 15-20 minutes.

4.6 Reflexivity and positionality

Reflexivity is a process carried out by the researcher whereby he/she reflects on preconceived values or actions, feelings and conflicts (Parahoo, 1997; Holloway & Wheeler, 2002). I explored my personal experiences and feeling regarding those aspects that might influence the study and was cognisant of these aspects to achieve some degree of objectivity (Burns and Grove, 2003). This experience made me more aware of possible biases and preconceived ideas that I may have had in my position as an outsider. This brings into question the concept of 'positionality' when conducting the qualitative aspects of my research, especially, the focus group discussions and participatory mapping. Chacko (2004:52) defines positionality as "…aspects of identity in terms of race, class, gender, caste, sexuality and other attributes that are markers of relational positions in society, rather than intrinsic qualities". As indicated, the population in both Inanda and Bergville are almost exclusively African. My position as a South African Indian, conducting research in predominantly African communities, in a country that was historically racially divided, made me an outsider as explained by Mullings (1999) and Ganga and Scott (2006). Also, I am not fluent in isiZulu (the local language), and therefore was unable to personally facilitate the focus group discussions. However, I was introduced by the facilitators, this exercise seemed to gain the trust of those present which led to a smooth transition to the focus group discussions. Furthermore, it emerged during the discussions that all focus group respondents were bilingual (spoke both English and isiZulu), hence I took the lead in explaining the mapping exercises since this is my area of expertise.

4.7 Data analysis

According to De Vos et al. (2002) and Kitchin (2013), data analysis is a process of applying order, structure and meaning to data. Mouton and Marais (1996) assert that the systematic processes of identifying, isolating and examining individual variables that make-up complex structures is commonly referred to as data analysis. Data obtained in this study was analysed thematically using quantitative and qualitative techniques in three stages:

- Descriptive analyses (description of data trends and relationships, with the use of descriptive statistics were applicable);
- Statistical analyses (inferential statistics to compare and quantify trends and relationships between Inanda and Bergville, as well as statistical modelling to predict future patterns and energy demands); and

- Spatial analyses (to depict spatial patterns and differences in energy needs, behaviour and usage).

Demographic and energy variables were cross-tabulated in relation to community name to compare main trends. Cross-tabulations were further examined using a combination of the *z*-test and Pearson's chi-square test of independence to establish significant differences between communities. In this study, socio-economic characteristics and location (community name) were identified as independent variables. In addition, socio-economic variables were used as a basis to compare and contrast perceptions between sample communities. Descriptive and inferential statistics were utilised to describe data trends. All numeric data was tested for normality using the Kolmogorov-Smirnov test. All numeric data that was non-parametric and subjected to the Mann-Whitney U tests to test for differences between communities and the Spearman's rank correlation was used to test for relationships between selected variables. Furthermore, Cronbach's Alpha statistic was used to test reliability of data collected using Likert scales. Spatial analyses and maps were generated using the ESRI ArcGIS software (Version 10.3), to show spatial patterns, relationships and differences between communities.

4.8 Conclusion

This chapter began with a detailed description and comparison of the sampled communities, Inanda and Bergville. This was followed by an in-depth description of research methodologies used in this study as well as the key philosophical and theoretical backgrounds to the research design. The multiple theoretical frameworks adopted in this study played a significant role in the manner in which the data was collected and analysed and advocated the use of case studies, and data and theory triangulation methods. In addition, both quantitative and qualitative methods were utilised to address the research questions and objectives, specifically pertaining to household energy profiles as well as their attitudes, perceptions and behaviours. The different methodological approaches drawing from both qualitative and quantitative paradigms were discussed in detail along with their application in the present study. In addition, an overview of the sampling framework, data collection tools and processes were included in this chapter.

CHAPTER FIVE
DATA DESCRIPTION AND ANALYSIS

5.1 Introduction

It is argued that improving levels of sustainability within the energy sector can drive socio-economic and environmental well-being, particularly in relation to energy poverty and climate change mitigation. The literature emphasises the role of renewable energy sources and technologies in delivering these social and environmental benefits, however, there are several aspects, discussed in Chapters 2 and 3 that underpin the successful up-take, implementation and sustained use of renewable energy options. In this regard, socio-demographic contexts, energy needs, preferences, awareness and attitudes are recognised as fundamental factors impacting renewable energy use, especially among low-income groups. This Chapter presents and discusses results obtained in this research endeavour which examines the factors that impact energy behaviours and consumption patterns within peri-urban and rural communities. This study adopted a mixed methodological, comparative case study approach to highlight and examine potential differences and similarities in household energy profiles and behaviours within peri-urban and rural contexts.

The theoretical frameworks that guided this study highlight multiple socio-economic and spatio-locational specific factors that influence household energy practices. Thus, this study compares household energy profiles across an urban-rural gradient. Primary data (from questionnaires and focus group discussions) was obtained from the Bergville (rural) and Inanda (peri-urban) communities in an attempt to highlight and better understand the factors that may augment or encumber the implementation of renewable energy, and to examine the potential use for, and inform the design of, a prototype solar thermal box cooker. Results obtained from the surveys are presented in contingency tables, while findings from focus group discussions are integrated into the data description. All data obtained in this study are discussed in relation to the literature according to the following key thematic areas:

- Socio-demographic profile of respondents and households;
- Household energy profiles;
- Energy consumption patterns;
- Simulated energy indicators;
- Household energy preferences;

- Household energy conservation practices;
- Climate change and energy related perceptions; and
- Household attitudes and perceptions towards solar thermal energy and technologies.

A total of 818 face-to-face interviews were conducted in Inanda (n=408) and Bergville (n=410), collectively. All completed surveys were examined for missing and inconsistent responses, resulting in a 97.8% response rate and a final sample size of 800 surveys. In addressing the research questions and objectives that framed this study, descriptive and inferential statistical analyses were conducted, specifically tests for significant differences between Bergville and Inanda. Chi-square tests were carried out on count (frequency) data while the results are presented in percentages and in contingency tables to show differences and/ or similarities between populations.

5.2 Socio-demographic profile of respondents and households

Given the multi-dimensional nature of energy studies, socio-demographic variables are described as key factors that shape attitudes and behaviours. The importance of unpacking the socio-demographic contexts of research phenomena in the social and geographical studies cannot be over-stated. Similarly, factors such as age, sex and level of income have been noted to influence energy practices and preferences at the household level. For example, research indicates that energy security and vulnerability assessments need to be understood in relation to socio-economic contexts (Sovacool & Mukherjee, 2011; Ang et al., 2015). Respondents were profiled in relation to their age, sex, level of education, employment status and occupation, while households were profiled based on household size, gender-based composition, livelihood strategies and total monthly income which were obtained during the face-to-face interviews. Both Inanda and Bergville populations were profiled in respect of their socio-economic and demographic characteristics and these results are discussed below.

5.2.1 Respondent profile

Respondent ages ranged from 19 to 85 years for Bergville and 18 to 88 years in Inanda. Results show that in both Inanda and Bergville, the 26-35 year age cohort showed the highest proportion of respondents, 27.7% and 24.8%, respectively. This was closely followed by the 36-45 year groups in Inanda (20.8%) and Bergville (17.7%) (Table 5.1). There was an almost equal distribution of respondents across the 46-55 year (11% in Inanda and 15.3% in Bergville) and 56-65 year (12.5% in Inanda and 14.3% in Bergville) age cohorts within each community. In relation to the overall population, respondents older than 66 years old were a minority in both communities, however, there was a higher portion of respondents older than 66 years in Bergville (13.5%) compared to Inanda (5.4%).

Table 5.1: Age categories of respondents (in %)

Age categories (in years)	Inanda (n=400)	Bergville (n=400)
18-25	20.8	15
26-35	27.7	24.8
36-45	23.3	17.7
46-55	11	15.3
56-65	12.5	14.3
66-75	5.4	13.5
Average age	**39.3**	**44.1**

Unsurprisingly, Bergville showed a higher proportion of respondents over the age of 46 years indicating a mature population. Inanda on the other hand, can be described as a youthful population evidenced by the majority of respondents (71.8%) being between the ages of 18-45 years old. A lower proportion of respondents (57.5%) were between the ages 18-45 years in Bergville. The differences in respondent age categories across communities is further emphasised in the average age with respondents from Inanda being younger (average age of 39.3 years) compared to Bergville (44.1 years). Mean age differed significantly between communities (p<0.0001; Mann-Whitney U test). According to SSA (2011), the majority of the population in KZN, (the province in which this study is located), are younger than 35 years. It is evident that Inanda displayed a larger proportion of respondents in the 26-35 year and 36-45 year age cohort, compared to Bergville. The age distribution results obtained in this study are expected and may reflect issues such as increased rural-urban migration trends, particularly among the younger age groups. Mulcahy and Kollamparabil (2016) show that economically active groups within South Africa, (particularly the younger age groups), migrate toward urban centres, however, cost of living, availability of housing and transport remains a challenge. The movement of economically active groups into urban and peri-urban centres such as Inanda, in search of improved socio-economic opportunities could explain why respondents in Bergville (a rural community) were significantly older. The differences in age groups across rural and urban centres may present future challenges in relation to human and social capital required for the establishment of decentralised bottom-up approaches to local economic development.

In relation to sex, 65.3% and 73.3% of respondents were female in Inanda and Bergville, respectively (Figure 5.1). Male respondents comprised the minority of the sample population in Bergville (26.8%) and Inanda (34.8%). Chi-square test revealed that gender did not differ significantly across communities (p=0.09). Once again, the impacts of rural-urban migration patterns could explain the higher portion of females within rural communities. Also, the higher proportions of females compared to males could have been a consequence of the sampling approach adopted in this study, where all interviews were conducted between working hours (10 am to 4 pm, Monday to Friday). The results are in keeping with research conducted in other developing countries which show that rural areas have an aging population compared with urban and peri-urban areas (He & Ye, 2014). As Jorgenson et al. (2010) indicate, this is the result of continued migration of the more youthful population.

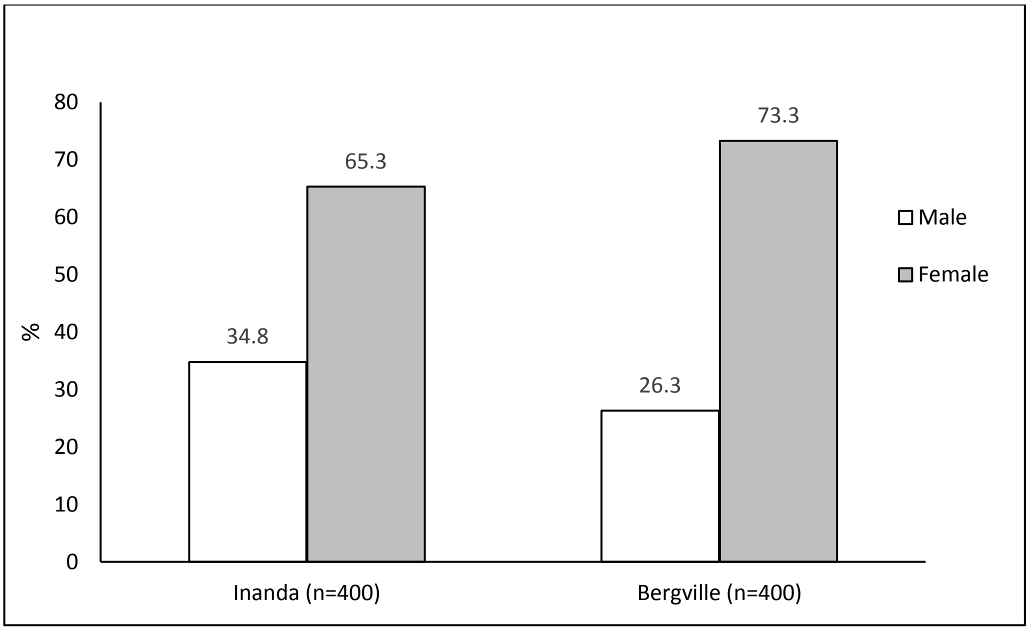

Figure 5.1: Sex of respondents (in %)

Nonetheless, these results align, in part, to census data which shows that within Bergville and Inanda there are between 10-15% more females than males (SSA, 2011). More importantly, community-based statistics reveal that 47.7% of households within Inanda and 63.2% in Bergville are female-headed (SSA, 2011). This raises several concerns in relation to energy profiles and vulnerabilities as many studies show that female-headed households display a greater reliance on traditional energy sources and are generally more vulnerable to the impacts of energy poverty (Israel, 2002; Behera et al., 2015).

Likewise, Heltberg (2004) shows that level of education can also impact energy consumption and behaviours, specifically improved levels of education was associated with a greater reliance on modern fuels. A higher proportion of respondents from Inanda (96.2%) possessed some level of formal education compared to their Bergville counterparts (76.6%), as illustrated in Table 5.2. For example, the majority of respondents from Inanda (66.8%) had some secondary school level education (32.8% partial and 34% complete), compared to 46.3% of respondents in Bergville (27% partial and 19.3% complete). Also, 10.1% of respondents from Inanda completed tertiary level education compared to 2.5% in Bergville. Evidently, respondents from Inanda did possess higher levels of education compared to Bergville. Chi-square tests show significant differences in respondent levels of education between communities ($p<0.0001$). The z-test indicates that there was a significantly higher proportion of respondents in Bergville who did not possess formal education, and who completed partial primary level schooling. However, there were significantly more respondents from Inanda who completed secondary and tertiary level education. Results from Inanda align with the provincial level data which shows that 31.2% of individuals in KZN have completed secondary level schooling (SSA, 2011).

Census data shows that 9.1% of individuals living in KZN have had tertiary level education with an overall 10.8% literacy rate within the province (SSA, 2011). The results obtained in this study are disconcerting as it proposes that Bergville is severely underperforming in relation to access to basic education with 23.5% of respondents indicating that they had no formal education compared to 4.1% in Inanda. Given the ageing population, this may simply be a consequence of apartheid. Chi-square tests revealed that male respondents displayed significantly higher levels of formal education compared to females ($p=0.018$). In addition, female respondents from Inanda displayed higher levels of education compared to female respondents from Bergville. Moreover, these results highlight the stark differences between rural and urban literacy rates which are often hidden when examining national and regional averages.

Table 5.2: Level of education (in %)

Level of education	Inanda (n=400)	Bergville (n=400)
No formal education*	4.1	23.5
Partial primary*	10	16.3
Primary completed	8.8	10.5
Partial secondary-Grade 10	32.8	27
Secondary completed*	34	19.3
Tertiary *	10.1	2.5
Adult-based education (ABED)	0.5	1

*column proportions are significantly different when compared between communities, within categories: *z*-test

Barnes et al. (2001) show that level of education influences household energy demand and attitudes towards specific energy carriers. Similarly, Walker et al. (2010) argue that levels of education are intrinsically linked to levels of awareness and technical capacities, which are described as important issues impacting renewable energy implementation and use. Furthermore, access to education emerged as a key theme during the focus group discussion in Bergville, where participants highlighted broadening access to secondary level education as a key community need. Participants also shared that the poor levels of secondary level education could be a result of the limited number of secondary schools being available in the community, and that secondary schools are generally located further from the community. Access to basic primary and secondary level education are some of the many concerns highlighted by the sustainable development goals, especially in response to poverty alleviation (Waage et al., 2015).

Table 5.3: Respondent employment status (in %)

Status	Inanda (n=400)	Bergville (n=400)
Employed*	25	12.3
Unemployed*	44.5	58
Self-employed	7.3	4.8
Retired*	13.8	22.8
Medically bordered*	2	-
Student*	7.5	2.3

*column proportions are significantly different when compared between communities, within categories: *z*-test

According to Kowasari and Zerriffi (2011), socio-economic conditions, particularly employment status, is an important variable that impacts household energy consumption especially given the direct links to energy affordability and accessibility. In terms of levels of employment, some respondents from Inanda (25%) and Bergville (12.3%) indicated that they were currently engaged in full-time employment (Table 5.3). A higher proportion of respondents indicated that they were unemployed in both communities (44.5% in Inanda and

58% in Bergville). Although unemployment rates were high in both communities, Bergville showed a significantly higher proportion of unemployed respondents. The levels of unemployment noted in this study were higher than the community-based averages revealed in Census data (43.4% in Bergville and 43.1% in Inanda) (SSA, 2011). Compared to the national (24.9%) and provincial (33%) averages, communities in this study display disconcerting levels of unemployment. Also, the results above indicate that unemployment levels may have increased since 2011, particularly in Bergville (more than 10%). Unsurprisingly, given the age distribution of respondents, a significantly higher proportion of Bergville respondents (22.8%) indicated that they were retired compared to Inanda (13.8%). Further testing revealed that, a significantly higher proportion of respondents from Bergville were unemployed, or retired compared to Inanda (Table 5.3).

These results support the trends noted in relation to levels of education and support the claims that Bergville may be experiencing higher levels of socio-economic vulnerabilities. The differences in levels of employment between Bergville and Inanda reflect the rural-urban discrepancies in the availability of employment opportunities (SSA, 2011). In addition, rural-urban migration could explain the higher proportions of retired and aged in Bergville compared to Inanda. Further tests revealed that a significantly higher proportion of female respondents were either unemployed or retired, compared to their male counterparts ($p<0.0001$; chi-square test). Limited levels of employment among women could also be symptomatic of the limited levels of formal education characterising this group.

These results resonate with assertions made in the literature that highlight women to be more vulnerable (Denton, 2002; Suguna, 2011; Sandhya, 2015), and in this case show higher levels of dependency within poor and low-income communities. Also, results obtained from Inanda are concerning given the age distribution of respondents. More specifically, Inanda displays a higher proportion of youthful respondents and the high level of unemployment implies that a large proportion of the population may be economically inactive. This does present a number of challenges and is not uncommon among most developing countries that experience limited employment opportunities for the economically active proportions of the population, and is an indicator of the broader economic and political challenges experienced within most parts of sub-Saharan Africa. Another aspect deemed important in profiling socio-economic characteristics of study populations is occupational status.

An examination of respondents' monthly income (Table 5.4) shows that most of the respondents from Inanda (41.3%) stated an income between R1 001 to R3 000, followed by 22.5% indicating no income, 20.4% receiving less than R1 000, and 11% between R3 001 and R5 000. Smaller proportions indicated an income between R5 001-R7 001 (2.3%), R7 001-R9 000 (1.3%), and greater than R9001 per month. The majority of respondents from Bergville (56.2%) noted a monthly income between R1 000 and R3 000, followed by 36.3% who stated an income under R1 000. A smaller group earned more than R3 000 per month (2.2%). Respondents in Inanda indicated a higher average monthly income (R1 750.38) compared to Bergville (R1 405.28). It is important to note that the range of respondent incomes were considerably broader for Inanda with a minimum of R0 and a maximum of R19 000 (R2 264.98 Standard Deviation [SD]). The income range was much narrower for respondents in Bergville who indicated a minimum of R0 and a maximum of R6 000 per month (R9 16.04 SD).

Table 5.4: Respondent monthly income (in %)

Income categories	Inanda (n=400)	Bergville (n=400)
None	22.5	5.3
< R1000	20.4	36.3
R1001-R3000	41.3	56.2
R3001-R5000	11	1.6
R5001-7000	2.3	0.6
R7001-R9000	1.3	-
>R9001	1.7	-
Average monthly income	R1750.38	R1405.28

These trends infer that income potential within Bergville is lower than in Inanda. Interestingly, even though levels of unemployment were higher in Bergville compared to Inanda, with only 5.3% of respondents indicating that they did not receive a monthly income. This was probed during the focus group discussions, and participants shared that they received state grants in the form of old age and child care pensions, remittances from family members and sold surplus agricultural produce as a source of income. These aspects are discussed in detail in relation to additional sources of income (Table 5.7). In general, the average incomes noted in Inanda and Bergville were lower than the provincial average (R6920.83) (SSA, 2012b), highlighting noteworthy discrepancies across income groups, more specifically inequity in the distribution of income across the province. These findings support the argument that energy access and the implementation of renewable energy options must be cognisant of the local level nuances of income levels (Kaygusuz, 2011).

Furthermore, results highlight that local level community profiling is required given the differences when compared to national and regional socio-economic data trends.

Parajuli (2011) underscores the importance of ensuring that households display the ability to function in current energy markets and respond to changes in energy prices through improved purchasing power. The author also argues that the inability of households to respond to increases in the cost of modern energy sources threatens their overall security, and households that lack the access to adequate financial assets may revert to collected or cheaper, more traditional forms of energy. Sovacool and Mukherjee (2011) assert that physical and financial accessibility are critical factors underpinning energy security within developing countries, and attempts to improve access to modern sources of energy should focus on strengthening household income streams. Similar studies acknowledge the importance of household characteristics such as size, gender distribution and monthly income in examining energy practices (Kowsari & Zerriffi, 2011; van der Kroon et al., 2013). Household profiles are discussed in the next section.

5.2.2 Household profile

It is argued that the study of energy behaviours and practices should be complimented by an understanding of household variables such as size which have been documented to influence reliance on specific energy sources (Zogarafakis et al., 2010; Pandey & Chaubal, 2011). Household size was taken as the number of individuals that have repeatedly eaten from the same pot over the last three months. Household profiles across sample populations varied in relation to household size, income streams and gender distribution. For example, the majority of respondents from Inanda (56.2%) stated that the household consisted of approximately 3-5 individuals (Table 5.5). This was followed by 6-9 (33.2%), 1-2 (5.8%) and 10-12 (3.8%) persons per household. Similar trends were noted in Bergville, with most respondents stating a household size of 3-5 (42.1%) and 6-9 (40.9%) individuals. An almost equal proportion of respondents from Bergville documented household sizes of 1-2 (7.4%) and 10-12 (7.6%) persons. A minority of respondents indicated a household size of 13-15 people in Inanda (0.8%) and Bergville (2.3%).

Table 5.5: Household size (n=400; in %)

Number of persons	Inanda (n=400)	Bergville (n=400)
1-2	5.8	7.4
3-5	56.2	42.1
6-9	33.2	40.9
10-12	3.8	7.6
13-15	0.8	2.3
Average household size	**5.2**	**5.9**

There was a slight difference in average household sizes in Inanda (5.2 persons) and Bergville (5.9 persons). It is important to note that for both communities, household sizes were slightly higher than the community averages reflected in Census data (household size of 4 in Inanda and 5 in Bergville, SSA, 2011). A finer inspection of these results revealed that the sizes of households ranged from 1 to 19 persons in Bergville and 1 to 13 persons in Inanda. The diversity in household sizes highlighted by respondents is noteworthy and suggests that even within local communities, household level dynamics may differ considerably.

Gender distribution among households was also examined, and the results show that there were generally more females than males in Bergville and Inanda (Table 5.6). Results reveal that the majority of households in Inanda had between 1-2 males (55%) and 3-5 females (51.3%), with smaller groups of households indicating a composition of 3-5 males (39.3%) and 1-2 females (41.3%). Similar trends were noted among Bergville households, with 3-5 females (51%) and males (49%). Forty-three percent of Bergville households had between 1-2 males and 38.3% between 1-2 females.

Table 5.6: Total number of males and females in household (in %)

Sex	No of persons	Inanda (n=400)	Bergville (n=400)
Males	None	3.8	2.3
	1-2	55	43
	3-5	39.3	49
	6-9	2.1	5.6
Average		2.4	2.8
Females	None	2.5	0.3
	1-2	41.3	38.3
	3-5	51.3	51
	6-9	5.1	10.6
Average		2.9	3.2

Bergville households showed an almost equal distribution in the average number of males (3) and females (3) within the household. There were more males (2) than females (3) within households in Inanda. Mann-Whitney U tests revealed that the distribution of total number of males ($p<0.0001$) and females ($p=0.019$), in the household, are significantly different between communities. Literature shows that within poor communities, households with a higher number of females tend to rely more heavily on collected energy sources, such as fuelwood (Heltberg, 2005). Behera et al. (2015) show that the supply of labour within the household, particularly females, is often seen as an opportunity for fuelwood collection thus, reliance on solid fuels is notably higher. Modi et al. (2006) show that women generally bear the bulk of the burden associated with fuelwood collection as household heads fail to recognise the impacts of their energy choices. In this regard, levels of energy affordability experienced at the household levels play a key role in facilitating access to cleaner, sustainable and more efficient sources of energy. Total monthly household income was captured for all sampled households in Bergville and Inanda. These results are presented in Table 5.7 below.

Table 5.7: Monthly household income (in %)

Categories	**Inanda (n=400)**	**Bergville (n=400)**
None	2.8	4
< 1000	12.7	24.7
1001-3000	48.1	62.2
3001-5000	21	8.7
5001-7000	9.1	1.8
7001-9000	3	0.8
> 9001-15000	3.4	-
Average household income	R3109.25	R1841.38

Inanda households displayed a higher average household income (R3 131.39) compared to Bergville (R1 883.33). The majority of households in Bergville (62.2%) stated that household income was between R1 000 to R3 000 per month, this was followed by 24.7% who indicated less than R1 000 per month. Smaller proportion of households from Bergville stated no income (4%), between R5 000-R7 000 (1.8%) and R 7000 to R9 000 per month (0.8%). Household incomes varied across a broader range in Inanda (R0-R32 000), with most households (48.1%) earning an income between R1000 to R3 000 per month.

Twenty-one percent of Inanda households earned between R3 000 to R5 000, 12.7% less than R1000 and 9.1% noted R5 001-R7 000. Almost equal portions earned no income (2.8%), between R7 000- R9 000 (3%) and more than R9 000 per month (3.4%). Analysis of variance testing between communities revealed a significant difference in the levels of household income between Bergville and Inanda ($p<0.0001$) with the latter displaying a higher average income. Madubansi and Shackleton (2007) argue that securing access to modern sources of energy among poor communities is dependent on the ability of that household to financially access the source and, more importantly, the ability to sustain its use throughout the year.

Further inspection of mean incomes for households and respondents reveal stark differences across the Bergville and Inanda populations (Figure 5.2). Results presented in Figure 5.2, show that the mean household income within Inanda and Bergville were considerably lower than the provincial average. Results show that households in Inanda and Bergville are underperforming in relation to others within the province, however, there is large-scale differences in the levels of household income within the province, and provincial averages do not adequately reflect the conditions of the poorest groups. It should be noted that SD values for household income in Inanda (R3256.00) and Bergville (R1247.54) displayed a noteworthy difference, suggesting a more pronounced difference between the upper and lower income percentiles in Inanda.

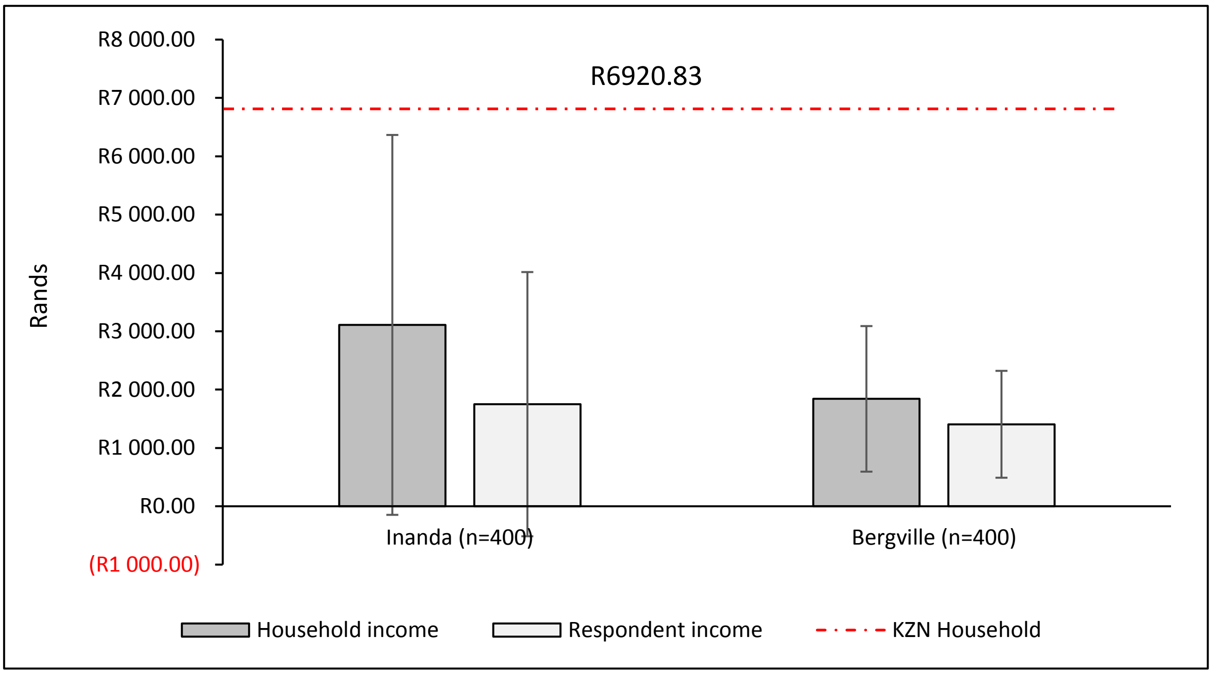

Figure 5.2 Mean incomes for household and respondent

These results show that household income alone may not be a robust enough index to understand energy affordability and/ or consumption within these communities. An examination of household income in relation to household size (purchasing power parity) shows a monthly average spend of R626.28 per person in Inanda and R313.89 in Bergville. Overall levels of household income in Bergville are disconcerting given the UN accepted income threshold of $1.25 per day for low-income communities to meet basic human needs (±R430, when converted to Rands per month). The findings obtained in this study propose that the use of composite socio-economic indices, for example, household income and size, may be more applicable to examine socio-economic conditions, vulnerabilities and access to energy in low-income communities within South Africa.

Heltberg (2004) shows that within the low-income context, households that are larger in size have the tendency to switch between fuels down the energy ladder. Sovacool (2012) shows that in some cases, even though levels of household income improve, there is a continued reliance on traditional energy sources. Similarly, Allcot and Mullainathan (2010) and Kowsari and Zerriffi (2011) highlight household size, age, composition, income and levels of education as the main contextual factors influencing energy practices. Barnes et al. (2011) argue that while all low-income groups may be characterised as energy poor, not all energy poor have low-incomes. This emphasises earlier assertions that household energy affordability and use is a result of complex interrelationships between multiple variables, and examining socio-economic variables such as income in isolation may not provide adequate and relevant information to inform implementation or energy policy.

In an attempt to examine livelihood security, the survey highlighted the various sources of household income. These results are presented in Table 5.8. This study reveals that most households in Bergville (56.3%) and Inanda (53.8%) stated that state child support grants were a source of monthly income. Respondents in Inanda indicated remittances (21%), none (10.5%), and sales from a tuck shop (4.8%) as sources of income. Similar trends were noted in Bergville, for example, 15.5% of respondents noted remittances as an additional source of income, and 9.8% of respondents stated that they had no additional source of household income. Smaller groups of respondents indicated sale of agricultural produce in Bergville (2.9%) and Inanda (1.4%). The results indicate a disturbingly high level of state dependency as a source of monthly income in both communities (80.2% in Inanda and 85.4% in Bergville).

More importantly, fewer households in Inanda (20%) and Bergville (11.8%) indicated employment as a source of household income. These data trends indicated a lack of income generating livelihood options, limited income security, a lack of access to employment, and alarmingly high levels of underemployment among the economically active groups within these communities. Moreover, the results highlight critical levels of dependencies among both communities. Census data notes a 54.3% and 63.2% dependency ratio for Inanda and Bergville, respectively (SSA, 2011). These trends underscore an alarmingly high reliance on state grants, which could be indicating dependency and a burden on the developmental states in low-income communities across South Africa.

Table 5.8: Additional source of household income (Multiple responses, in %)

Status		Inanda (n=400)	Bergville (n=400)
None		10.5	9.8
Employment		20	11.8
Remittances		21	15.5
Old age pension	State grants	20.8	25.8
Child grant	State grants	53.8	56.3
Disability	State grants	5.6	3.3
Sale of agricultural produce		1.4	2.9
Tuck shop		4.8	-

In an attempt to better understand livelihood structures, this study probed livelihood practices among respondents listed in Table 5.9. Data obtained shows that there is limited diversity in livelihood practices within Inanda and Bergville households. Alarmingly, more than 50% of the respondents did not engage in any activity that supported the accumulation of livelihood assets. Respondents in Bergville noted crafting (9.7%) and small business (3.8%). Bergville respondents showed a tendency to engage in subsistence-based activities, for example, crop production (25%) and livestock rearing (4.8%); whereas Inanda respondents engaged in income generating activities such as small business (12.3%), construction (7.8%), and hairdressing and beauty services (7.6%).

Table 5.9: Activities that currently take place on the property (Multiple responses, in %)

Activities	Inanda (n=400)	Bergville (n=400)
None	52.8	55.2
Crafting	11.4	9.7
Construction/ building	8.4	5
Hairdressing/ beauty care	7.6	4.9
Business/ spaza shop	12.3	8
Traditional medicine	0.3	0.1
Crop production	11.3	18.1
Catering/ cooking	1.3	0.8
Livestock rearing	2.5	3.7
Child/ elderly/ sick care	1.8	0.9

Overall, respondents' engagement in livelihood activities was limited in both communities. This has serious consequences on sustainability and resilience of livelihoods. The lack of engagement in livelihood-based activities could imply that households in poor communities, whether rural or urban, do not have access to adequate livelihood supporting options. Additionally, these trends could be attributed to the limited levels of formal skills and training displayed by respondents from both communities. According to Serrat (2008), diversification of livelihood options, particularly the participation in income generating activities assists in the accumulation of livelihood assets, which promotes household resilience to shocks. Respondents were probed on their willingness to engage in other activities. Results show that the majority of respondents from Bergville (83.9%) and Inanda (84%) indicated a willingness to engage in other livelihood activities.

These respondents also specified the main type of activity they are willing to take up (Table 5.10). Evidently, a significantly higher proportion of respondents from Inanda (74.7%) indicated a willingness to take-up income generating activities. Smaller percentages from Bergville noted income generating activities (45%). A higher percentage of Bergville respondents would like to engage in agricultural (39.9%), and educational activities (13.9%) compared to Inanda respondents (12.2% and 5.9%, respectively).

Table 5.10: Main activity respondent willing to engage in (in %)

Main activity	Inanda (n=336)	Bergville (n=331)
Income generating	74.7	45
Agricultural	12.2	39.9
Education	5.9	13.9
Entertainment/ leisure	7.1	1.2

Respondents were asked to highlight the main factors that prevented them from engaging in the above activities (Table 5.11). Also, during the focus group discussions participants shared that access to employment opportunities and formal education was a challenge within their communities. Other community challenges highlighted by the participants included access to in-house sanitation, the lack of indoor supply of water, crime and the increasing cost of living. In this regard, the type of activity respondents were willing to engage in could reflect broader community challenges perceived by the respondents. More than 50% of respondents from both communities (55.6% in Bergville and 54.1% in Inanda) indicated that the main factor constraining their involvement in the above activities is the lack of resources. This was followed closely by lack of skills (32.4% in Inanda and 28.1% in Bergville), time constraints (20.5% in Inanda and 13.3% in Bergville) and lack of infrastructure (17.9% in Inanda and 19.9% in Bergville). It is interesting to note that the minority of respondents from both populations perceived access to energy as a major factor constraining their involvement in the above activities (5.4% in Inanda and 0.6% in Bergville).

Table 5.11: Factors preventing respondent from engaging in these activities (Multiple responses, in %)

Reasons	**Inanda (n=336)**	**Bergville (n=331)**
Access to energy	5.4	0.6
Insufficient time	20.5	13.3
Lack of skills	32.4	28.1
Lack of infrastructure	17.9	19.9
Lack of resources	55.6	54.1

An overall assessment of socio-economic and demographic contexts show that both Bergville and Inanda can be characterised as displaying high levels of vulnerability, especially in relation to the limited individual and household incomes, lack of skills and training, poor levels of education and low levels of employment. Furthermore, heavy reliance on state aid in the form of child support, disability grants and pensions may contribute to increased dependency among the low-income households and may stifle local-level innovation and development.

Some studies argue that even though modern sources of energy may be available to the household, use is dependent on income security and vulnerability (Madubansi & Shackelton, 2007; Bazillian et al., 2014). The increased socio-economic vulnerability displayed by the study populations could have an impact on household energy profiles, specifically access to and use of modern, safe and cleaner energy sources. The combined effect of socio-economic variables on energy consumption patterns within low-income contexts cannot be overstated. More so, given the site specific nuances highlighted in the literature, energy profiles and behaviours remain complex research phenomena. This study examined energy profiles of households in both communities, in an attempt to understand and highlight key factors specific to the South African context. These findings are discussed in the section below.

5.2.3 Community needs and challenges

During the Inanda focus group discussion participants listed main community needs to include employment opportunities, the supply of in-house sanitation and water, more schools and houses. Also, focus group participants highlighted crime, lack of formal skills and employment for the youth, and poverty as main community challenges. Furthermore, as part of the participatory mapping exercises, participants identified areas they perceived to be the poorest and most in need of socio-economic development (Figure 5.3). Main reasons for their choice included lack of services and formal housing, presence of informal settlements, number of children and senior citizens, and overall income. Participant from Bergville listed in-house water and flush toilets, hospitals and clinics, secondary schools, employment opportunities, formal houses, and roads as their main needs. Moreover, the lack of domestic services, transportation services for scholars and the aged, and the lack of available medicines at clinics were the main community challenges highlighted by participants.

The areas deemed poorest and most in need of socio-economic development are depicted in Figure 5.4 below. Additionally, focus group participants shared that these areas were deemed most vulnerable due to the high levels of unemployment, high proportions of elderly residents and children, and limited road accessibility. The map shows that these areas are located along the outer regions of Inanda and along steeper terrain. Focus group participants highlighted Tafula Inanda, Ekafuleni A, Amatikwe Area 9, Amatikwe 8, Goqokazi, Inanda Glebe, Langgalibalele C, Zambia, Afrika, Inanda SP, Bhambayi, Inanda B, Phola Mission, Lindley and Glebe as the poorest regions in Inanda.

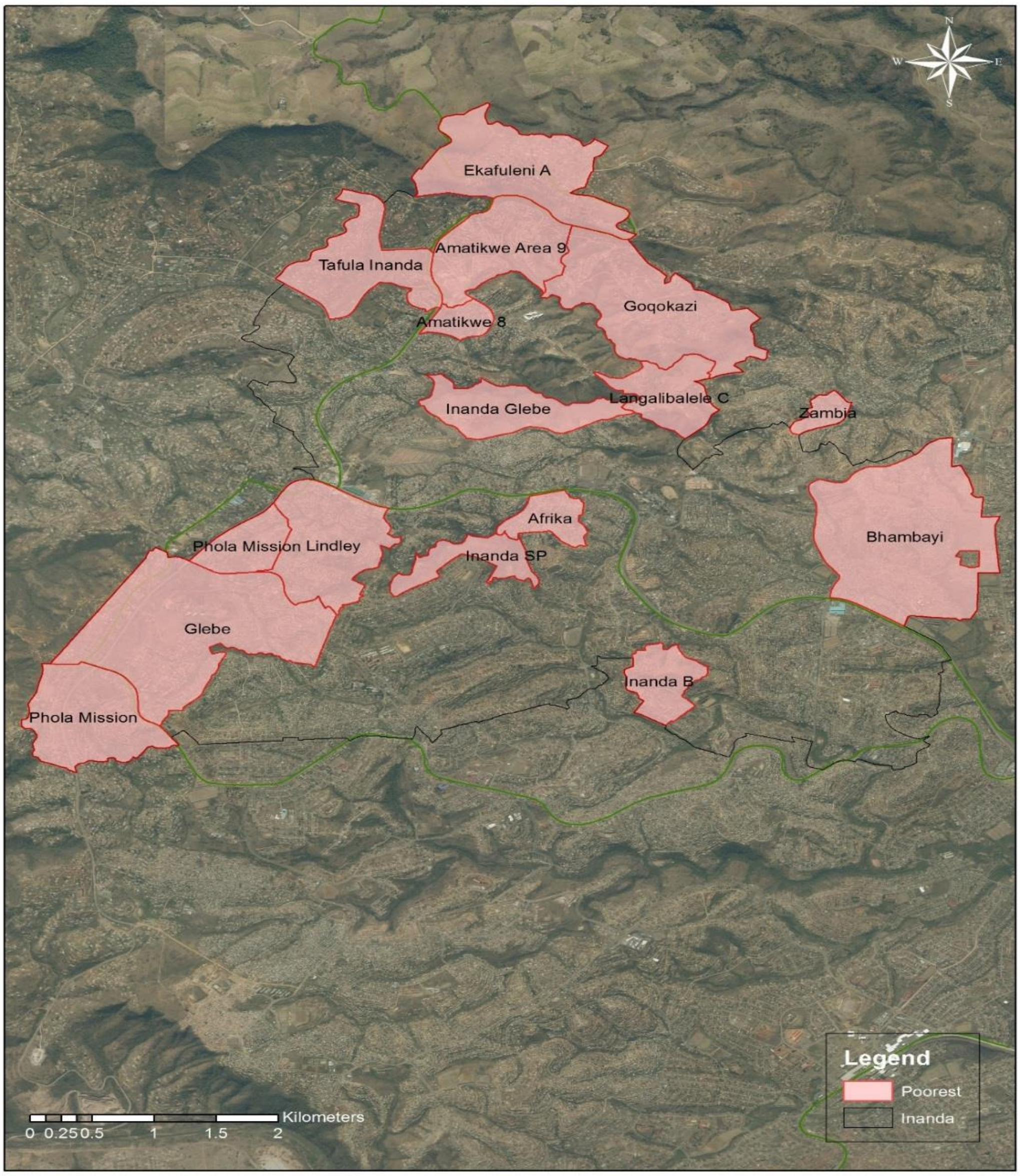

Figure: 5.3: Participants' perceptions of the poorest areas in Inanda (Author, 2016)

A similar exercise was undertaken during the Bergville focus groups discussions and the results are illustrated in Figure 5.4. Participants from Bergville identified Mkukwini, Seqomeni, Ogade, Mansana, Hoffenthal, Ngoba, Maswazini, Stulwane, Rooihoek and Mhlwazini as the poorest regions within their community. They also, added that these areas were selected due to the lack of service, poor road access, the lack of connection to national energy grids, and a high proportion of fuelwood users. With the exception of Rooihoek, these areas were located along the south western boundary of Bergville. The areas identified were also located away from the Bergville CBD.

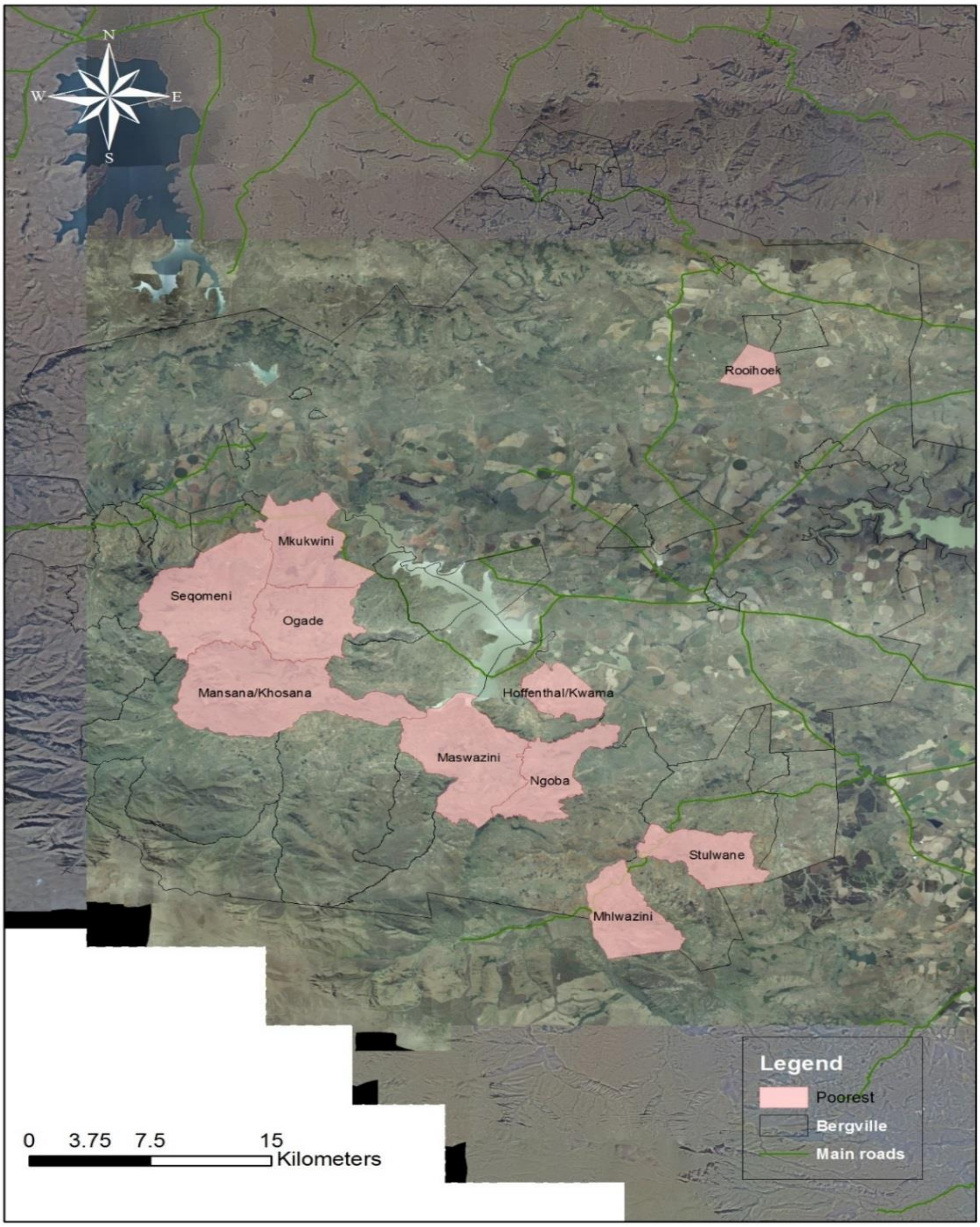

Figure 5.4: Participants' perceptions of the poorest areas in Bergville (Author, 2016)

In comparison, both groups of participants highlighted access to basic services, education and employment as main community-based needs. This demonstrates that poor communities such as Bergville and Inanda have difficulties accessing services to meet their daily needs, for example, water and sanitation, which becomes a serious concern for achieving basic human rights. More importantly, the spatial distribution of these areas suggest that even within communities, the most marginalised are located away from central nodes and therefore, may experience increased difficulty in accessing basic services and opportunities. In this regard, there is a need to critically evaluate the nodal-based development approaches adopted in South Africa, as opportunities and services may still be inaccessible to the marginalised portions of society located away from these nodes, specifically, in the more remote areas. The following section provides an overview of household energy profiles which describe sources of energy used by the households and the main household energy needs.

5.3 Household energy profiles

Energy studies indicate that household energy profiles and behaviours are a complex multi-dimensional process that is influenced by culture and social constructs, endogenous socio-economic contexts, quality of life indicators, household power dynamics and gender-based empowerment and levels of awareness, knowledge and skills (Howells et al., 2005; Gyberg & Palm, 2009; Allcott & Mullainathan, 2010; Stephenson et al., 2010; Kok et al., 2011; Kaplowitz et al., 2012; Pachauri & Rao, 2013; van der Kroon et al., 2013). It is argued that energy planning and policy must be conceptualised in relation to the above factors. The World Bank (2006) underscores the importance of accessing reliable, continuous and current energy data in energy planning and policy decision-making processes. Similarly, it is stated that energy policy and implementation discussions ought to be a dynamic process that can adequately reflects changes across all levels (World Bank, 2001; Lior, 2010; Johannsson, 2013; Szabó et al., 2013). Barnes et al. (2011) assert that understanding basic household energy requirements are vital to policy mediation and should therefore reflect on some of the underlying aspects that contribute to energy poverty and unsustainable energy practices.

5.3.1 Main sources of energy

The primary survey data shows that the majority of households in Bergville (88.3%) and Inanda (99%) had access to grid-based electricity connections (Table 5.12). A minority of households (11.7%) in Bergville did not have access to the electricity grids. The large-scale electrification programmes has resulted in an electrification rate of more than 80% across South Africa (SSA, 2011). Buzar (2007) states that the concept of energy poverty has expanded beyond physical accessibility to modern sources, and reflects issues of affordability, efficiency and the ability to meet basic and productive needs.

Table 5.12: Access to electricity (in %)

Community	Yes	No
Inanda (n=400)	99	1
Bergville (n=400)	88.3	11.7

Studies show that securing physical access to electricity and other modern sources of energy may not necessarily alleviate the impacts of energy poverty or improve on energy security at the household level, as many of these could still be financially unattainable to users (Campbell et al., 2003; Röllin et al., 2004; Nussbaumer et al., 2012; Sovacool, 2012). In this regard, it is important to examine specific trends in the energy consumption patterns, especially, in relation to meeting basic needs. Table 5.13 presents the main energy sources used by respondents for cooking, lighting and heating services.

Table 5.13: Main energy sources used for basic needs (cooking, heating and lighting, in %)

Activity	Source	Inanda (n=400)	Bergville (n=400)
Cooking $p<0.0001$	Electricity*	94.3	78.8
	Fuelwood*	0.8	12.5
	Gas	1.8	-
	Paraffin*	3.3	8.8
Lighting $p<0.0001$	Electricity*	98.5	84.8
	Fuelwood	0.3	0.8
	Paraffin	0.3	1.3
	Candles*	1	13.3
Heating $p<0.0001$	Electricity*	96.8	67
	Fuelwood*	0.3	23
	Gas	0.8	0.3
	Paraffin*	1.5	9.8
	Solar	0.8	-

*column proportions are significantly different when compared between communities, within categories: *z*-test; *p*-values based on results of a chi-square test

Respondents listed electricity, fuelwood, gas, paraffin, candles and solar as the main energy sources used for basic cooking, lighting and heating activities. There was an overall higher reliance on electricity within Inanda compared to Bergville. The majority of respondents in Inanda used electricity for cooking (94.3%), lighting (98.5%) and heating (96.8%). Smaller proportions of respondents from Bergville use electricity for cooking (78.8%), heating (67%) and lighting (84.8%). Smaller groups of Inanda respondents indicated fuelwood (0.8%), gas (1.8%) and paraffin (3.3%) as their main sources of energy for cooking. The minority of respondents from Inanda, used solar energy for heating (0.8%). Further discussions revealed that this referred to SWHs specifically.

It is interesting to note that even though more than 88% of respondents from Bergville had access to electricity, a noteworthy portion of respondents used fuelwood as their main source for cooking (12.5%) and heating (23%). Chi-square tests revealed significant differences in the use of specific energy sources for cooking, lighting and heating ($p<0.0001$), more specifically, a higher proportion of respondents used electricity for these activities compared to Bergville, while respondents from Bergville showed a significantly higher reliance on fuelwood, paraffin and candles for these activities (Table 5.13). The results show that the choice of main sources of energy differs between Inanda and Bergville respondents. For example, Bergville respondents showed more diversity in their choice of main energy sources for basic activities, whereas Inanda respondents mostly used electricity. Furthermore, there was more variation in the type of main sources used for cooking and heating activities. Moreover, Bergville respondents showed a higher reliance on primitive (fuelwood) and transitional (paraffin) energy sources.

These results support the argument that having physical access to modern sources of energy may not shift reliance from traditional and transitional fuels such as fuelwood and paraffin (Röllin et al., 2004). This is particularly evident among Bergville respondents who have access to electricity but used other types as their main sources. Studies show that low-income or poor households have a broader energy mix, comprising mostly primitive and transitional fuels (Masera et al., 2000; Pachauri et al., 2004; Kaygusuz, 2011; Sovacool, 2012; van der Kroon et al., 2013). In relation to the energy ladder and stack models, it can be said that Bergville displays higher levels of energy insecurity, evidenced by a higher reliance on primitive and transitional sources compared to Inanda. Also, the differences displayed between Bergville and Inanda populations in relation to the main sources of energy raises concerns over the quality of energy services available to households. For example, the efficiency ratio and luminous effect of electricity is considerably higher than that of candles, paraffin and fuelwood (Kaygusuz, 2011).

This study reveals that the Bergville households may be experiencing higher levels of energy inefficiencies and a lower quality of energy services compared to respondents in Inanda which can impact overall productivity and quality of life. Bazilian et al. (2014) argue that energy quality is equally important in addressing access and affordability issues. Energy efficiency remains a challenge in the South African context, particularly among low-income and rural communities (DoE, 2014). Denton (2002) and Chukuezi (2009) state that the lack or the poor quality of lighting services reduces the number of productive hours available per day to engage in educational and income-generating activities. Also, poorly lit streets and corridors pose a health and safety risk, particularly for women and children (Denton, 2002). According to Cecelski (2000), the use of inefficient energy sources could increase overall energy consumption placing more burden on those responsible for attaining/ collecting these sources.

5.3.2 Additional sources of energy

Kowsari and Zerriffi (2011) assert that households experiencing higher levels of energy insecurities often supplement the use of main sources with additional fuels, specifically, when they perceive threats to the supply and availability of main energy sources. The reliance of households on additional sources of energy that supplement their main sources was examined. Thom (2000) and Madubansi and Shackleton (2007) show that most low-income households in South Africa engage in extensive fuel-switching practices and often compliment the use of electricity with paraffin, candles and fuelwood to service their energy needs.

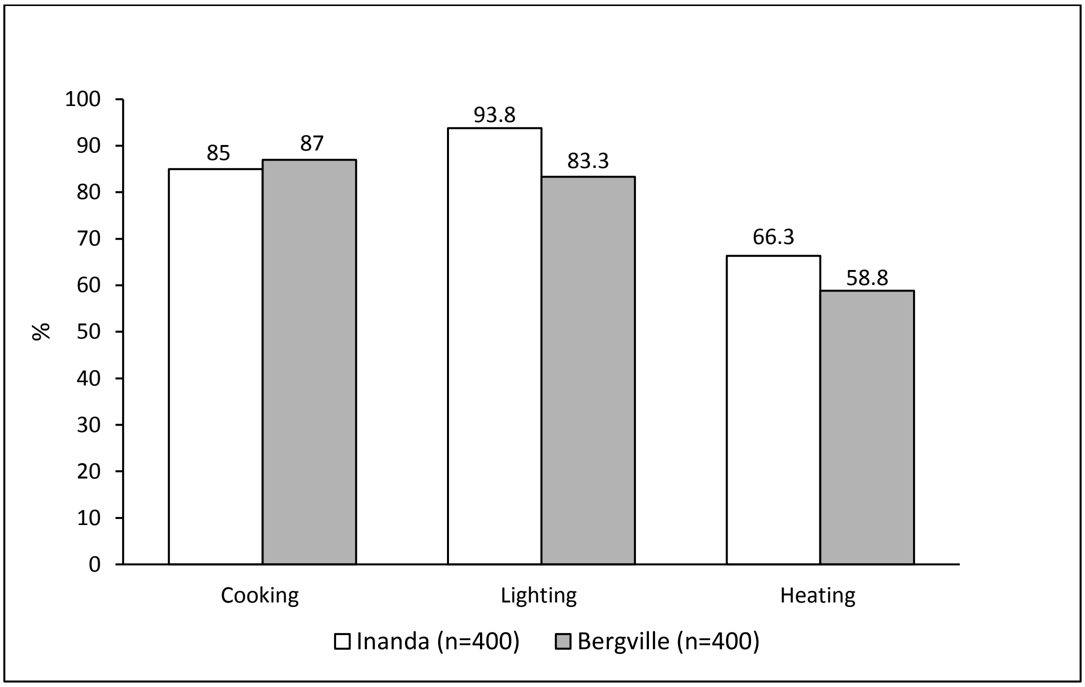

Figure 5.5: Use of additional energy sources for basic needs

The results indicate that more than 85% of all respondents use additional sources of energy to supplement the main sources highlighted above. Figure 5.5 shows the percentage of respondents noting additional sources for specific activities. Results show that the majority of respondents from Bergville and Inanda indicated additional sources for cooking and lighting activities. Interestingly, results indicate that 66.3% of respondents in Inanda and slightly fewer (58.8%) from Bergville used additional energy sources to supplement their heating needs. This trend was probed during the focus group discussions, where participants from both Inanda and Bergville indicated that the concept of heating was generally understood as the practice of heating water and sometimes food. These findings are consistent with the national energy consumption patterns, which highlight that approximately 60% of domestic energy is consumed for heating purposes within South African households (SSA, 2011).

Surprisingly, the concept of space heating did not emerge during either of the focus group discussions, thus, the concept of heating was probed further, specifically on how dwellings were heated during colder months. Some participants from Bergville shared that the family would sleep in the kitchen area (usually a thatched structure/ enclosure separate to the main dwelling, rondavels in most cases) and participants from Inanda indicated that (when electricity was available) small heating devices, for example, heaters were used. Other participants stated they "use more blankets". It is possible, that in this study space heating was not a prioritised energy need. This is unsurprising, given that just under half (47%) of South African households are classified as thermally inefficient (DoE, 2014). These findings raise concerns in relation to the overall quality of life and the lived experiences of energy poverty among respondents in both Inanda and Bergville. According to Buzar (2007), the ability of households to maintain a comfortable indoor temperature is one of the fundamental indicators of energy poverty.

Results suggest that respondents may be unaware that they are, in some respects, energy impoverished. With the exception of cooking activities, slightly lower percentages of respondents indicated additional sources for lighting and heating. These results show that for both communities, respondents use multiple sources of energy to meet their basic energy needs. Most households have access to electricity, however, other sources are required to meet basic energy needs. Secondly, respondent households from Bergville and Inanda engage in fuel-switching for basic needs implying increased energy vulnerability and insecurities. Thirdly, physical access to modern sources of energy such as electricity may not guarantee use.

Parajuli (2011) argues that households and individuals that are unable to meet their basic needs with modern, safe, environmentally-friendly and reliable energy sources can be classified as energy poor. According to Gaye (2007), energy poverty is described as the inability to cook with modern cooking fuels and the absence of electric lighting. The results show that more than 85% of respondents indicated the use of additional fuels to meet their cooking and lighting needs, showing that most respondents from Inanda and Bergville are hybrid users of energy. The energy stack and ladder models infer that reliance on specific types of fuels also reflects energy related vulnerabilities and can be used as an indicator of energy poverty. Hybrid energy users listed electricity, fuelwood, paraffin, gas, candles, dung and solar as additional sources used for basic needs (Table 5.14).

Table 5.14: Disaggregated consumption of additional source for basic energy needs (in %)

Activity	Source	Inanda (n=340)	Bergville (n=348)
Cooking *p*<0.0001	Electricity	3.8	6.6
	Fuelwood*	13.8	45.9
	Paraffin*	61.8	35.1
	Gas*	21.1	6
	Dung	-	7.1
Lighting *p*<0.0001	**Source**	**Inanda (n=375)**	**Bergville (n=333)**
	Candles*	95.5	87.4
	Paraffin	4.5	5.7
	Fuelwood	-	4.5
	Solar	0.3	-
	Dung	-	3.3
Heating *p*<0.0001	**Source**	**Inanda (n=265)**	**Bergville (n=235)**
	Electricity*	1.5	8.5
	Fuelwood*	18.3	50.6
	Gas*	20	3.8
	Paraffin*	57.9	35.3
	Solar	3	-
	Dung	-	2.1

*column proportions are significantly different when compared between communities, within categories: *z*-test; *p*-values based on results of a chi-square test

More than 61% of the respondents from Inanda used paraffin as an additional cooking fuel. The use of paraffin as an additional cooking fuel was significantly lower among Bergville respondents (35.1%). Within Inanda, hybrid energy users indicated fuelwood (13.8%) and gas (21.1%) as an additional energy source. Interestingly, a smaller proportion of these respondents from Inanda (3.8%) and Bergville (6.6%) indicated that electricity was used as an additional source for cooking practices. Approximately 45% of this group of respondents noted fuelwood as an additional cooking fuel within Bergville. Dung was only used in

Bergville to supplement cooking fuels. Similarly, solar energy, in the form of SWHs, was only used in Inanda as an additional heating fuel. These responses show that the presence/ availability of options at the local level usually influences the type of energy used by households. Specifically, as a rural community, Bergville residents keep cattle which make cow dung available. In Inanda, the eThekwini Municipality has actively promoted and supported the use of SWHs in low-income homes.

In relation to lighting, most users of additional energy used candles (87.4% in Bergville and 95.5% in Inanda). Furthermore, hybrid users of energy displayed a higher diversity in their choice of additional heating fuels in both communities. Fuelwood (50.6%) and paraffin (57.9%) were the most commonly used additional heating fuel in Bergville and Inanda, respectively. Smaller proportions from Inanda noted gas (20%) and fuelwood (18.3%) as additional heating fuels. Paraffin (35.3%) was noted as the second most used additional source of energy for heating purposes by Bergville respondents. These results are disconcerting, especially when examining respondent uses of additional sources of energy for cooking and heating practices. During the Bergville focus group discussions, participants stated that fuelwood is often used for:

- Cooking steam bread, meat, beans and samp (traditional meal consisting of dried beans and maize kernels that are boiled);
- During functions, for example, weddings, funerals and prayer ceremonies;
- To heat water; and
- To provide heat during the colder winter months.

It can be argued that use of specific energy sources for cooking practices are rationalised based on meal preparation time and the volume of meals being prepared. The manner in which respondents use specific sources of energy could also reflect on how they conceptualise associated costs. The belief that fuelwood may be cheaper or have lower costs suggests that respondents may not consider the health and time implications associated with the use of paraffin and fuelwood. Moreover, this highlights how energy choices are made within households and, more importantly, how use is rationalised for specific activities based on needs, wants and costs. Behera et al. (2015) and Israel (2002) explain that for activities that have higher energy requirements or are deemed less important, low-income households often prefer sources that are perceived to be cheaper or ‘free’. Perceptions of energy sources are examined later in subsequent sections.

Chi-square tests reveal significant differences between Bergville and Inanda respondents in relation to their choice of additional fuels used for cooking (p=0.002), lighting (p<0.0001) and heating needs (p<0.0001). Data trends reveal that respondents from Inanda displayed a higher reliance on transitional fuels such as paraffin, while the use of primitive fuels such as fuelwood and dung dominated in Bergville (Table 5.14). Goldemberg (2000) posits that fuelwood remains a popular choice amongst low-income households, especially in rural areas, because it is rarely purchased and can service a variety of energy needs (cooking, heating and lighting).

When examined in relation to the energy ladder model, results on reliance on additional sources of energy infer that respondents from Inanda may be located higher up on the energy hierarchy while their Bergville counterparts appear to be located along lower ranks. According to van der Kroon et al. (2013) and Sovacool (2012), within developing countries households experiencing limited levels of income display an overreliance on primitive fuels compared to low and middle income households that prefer a combination of transitional and modern sources. Furthermore, the availability of household income can enhance the capacity and ability to purchase and afford modern sources of energy. In relation to the energy ladder, it can be argued that surveyed households from Bergville experienced higher levels of energy insecurity and poverty compared to Inanda. Fouquet and Pearson (2012) show that the transition to modern energy options is likely to occur when these sources are affordable to households.

Sovacool and Muhkerjee (2011) warn that a fundamental critique of the energy ladder model is that it does not adequately consider the impacts of other related variables and overemphasises the role of income. Masera et al. (2000) caution against the use of energy ladders in the rural context because most primitive fuels like dung and fuelwood are collected and not purchased. Other scholars argue that the transition to modern sources of energy is not linear or discrete (hybrid energy users), especially among the lower income quintiles thus, it could be influenced by multiple factors (Howells et al., 2005; Gyberg & Palm, 2009; Allcott & Mullainathan, 2010; Kok et al., 2011). Similarly, energy ladders may consider the upward migration along the energy hierarchy, however, poor households, in particular, can experience downward shifts along the model (Heltberg, 2004). In this regard, models such the energy stack can be more useful in examining household energy consumption (Fan et al., 2011; Kowsari & Zerriffi, 2011). Nonetheless, the assertions that socio-economic variables, for example, income, may influence energy consumption patterns were further examined and tested using chi-square tests. For example, the distribution of main and additional sources of energy used were examined in relation to age, sex, household income, level of education and employment and household size. These results are presented in Table 5.15. These variables were deemed important and highlighted by the theoretical underpinnings and literature used in this study (Chapters 2 and 3).

Table 5.15: Result of chi-square tests between main sources of energy and socio-economic variables on household energy (C-cooking; H-heating; L-lighting)

	Inanda			Bergville		
Main source of energy	**C**	**H**	**L**	**C**	**H**	**L**
Age	0.372	0.117	0.99	0.880	0.866	0.786
Sex	0.029	0.839	0.208	0.042	0.050	0.901
Level of education	0.348	0.051	0.996	0.431	0.617	0.249
Employment status	0.616	0.386	0.994	0.693	0.805	0.999
Household size	0.02	0.459	0.992	0.040	0.102	0.574
Household income	0.103	0.211	1.00	0.144	0.835	<0.0001
Additional source of energy	**C**	**H**	**L**	**C**	**H**	**L**
Age	0.740	0613	0.877	0.833	0.996	0.978
Sex	0.420	0.410	0.057	0.811	0.738	0.892
Level of education	0.03	<0.0001	<0.0001	0.878	0.342	0.504
Employment status	0.001	0.005	<0.0001	0.809	0.189	0.667
Household size	<0.0001	0.011	0.601	0.045	0.010	0.299
Household income	0.184	0.227	0.302	0.338	0.001	1.000

Values represent *p*-values and are highlighted where significant

Chi-square tests reveal that sex and household size had a significant influence on the choice of main energy source used for cooking in both communities. This is expected since women play a greater role in cooking activities, given the gendered distribution of domestic roles and responsibilities within the household (Cecelski, 2000; Modi et al., 2006; Munien & Ahmed, 2012; Pachauri & Rao, 2013). Furthermore, larger households require more energy to meet their basic needs, which is evidenced in the cooking activities, specifically (Table 5.15). Based on these results, it can be argued that sex and household size are important determinants of household main energy choices for cooking activities. Rahut et al. (2016) show that female-headed households were more likely to choose cleaner energy options, given the choice. Whilst Kowsari and Zerriffi, (2011) show that among low-income groups, larger households preferred the cheaper traditional sources such as fuelwood and kerosene.

Interestingly, the results for Bergville results highlighted household income as a key factor influencing choice in relation to main source of fuel for lighting. During the focus group discussions in Bergville, participants revealed that lighting was not considered a priority energy need. The lack of prioritisation of lighting services among Bergville participants could explain the limited levels of formal education and income generating activities. Access to improved levels of lighting encourages participation and performance in educational and income generating options (Denton, 2002). These aspects are probed further in relation to energy needs and preferences. Results show stark differences in the factors that influence the choice of additional sources of energy for basic activities between sample populations. For example, level of education and employment status influenced choice of additional fuels for cooking, heating and lighting in Inanda, however, this was not the case in Bergville.

Bergville displayed significantly lower levels of education and employment indicating high levels of vulnerability across this population. The similarities displayed by Bergville respondents in their socio-economic profiles could have masked the influence of education and level of employment on choice of energy. Furthermore, these findings highlight the links between livelihood structures, more specifically the availability of capital assets such as income, and energy consumption and use within low-income and poor communities. Henao et al. (2012) propose that energy consumption is impacted by the human, social, physical, natural and financial assets that households possess. Kaygusuz (2011) states that livelihood strategies adopted by the poor may reflect their energy poverty status, where the lack of access and affordability of modern, safe, efficient and reliable energy sources constrain involvement in specific livelihood options. Additionally, affordability is directly linked to the ability to purchase and maintain the use of various energy sources (van der Kroon et al., 2013).

Household size emerged as a key factor influencing choice of additional sources of energy for cooking and heating practices. For heating activities, specifically, results from Bergville indicated that household size influenced the type of additional sources used to meet heating requirements. This is unsurprising, as studies indicate that cooking and heating practices within the household are the most energy intensive and account for 80% of total household energy consumptions (Kaygusuz, 2011). These results show that cooking and heating needs may be prioritised by both populations. Similarly, studies show that energy demand is based on three main factors: material culture (which include household size and energy devices), cognitive norms (for example, level of comfort and tradition), and cost (financial and physical) (Allcot & Mullainathan, 2010; Stephenson et al., 2010).

It can be argued that energy prioritisation in relation to needs is influenced by household size and this was evident in both communities. Bergville households were significantly larger and displayed a higher reliance on fuelwood. These results show that an increase in household size could have resulted in an increased reliance on traditional sources that may have been perceived to be cheaper or free. A more robust analysis of the use of fuelwood is provided in latter sections. Stephenson et al. (2010) describe energy needs as an important factor influencing the choice of household fuels. Similarly, studies on endogenous factors influencing household energy profiles highlight household size, gender distribution, and availability and security of household income as important contextual factors influencing selection and use of fuel types (Kowsari & Zerriffi, 2011).

Furthermore, Agarwal (1997) highlights the importance of intra-household dynamics in understanding household decision-making, and adds that it is a complex outcome of bargaining power which impacts labour divisions and access to resources within the household. Given that choice of main and additional energy sources differed in relation to intra-household characteristics, this study highlights differentiated impacts in relation to decision-making and use of different energy sources within the household. Specifically, as discussed later, gender differences are prevalent.

5.3.3 Household energy needs

Day et al. (2016) argue that energy and well-being are intricately linked, and access to modern, reliable and safe energy enhances the overall quality of life. Likewise, Sovacool (2012) asserts that improving the quality of life experienced by households is also about meeting basic, productive and modern energy needs. In addition to basic needs, listed above, respondents shared other energy needs within the household, as seen in Table 5.16.

Table 5.16: Other household activities that require energy (excluding lighting, heating and cooking) (Multiple responses, in %)

Activities	**Inanda (n=400)**	**Bergville (n=400)**
None	4.8	8.0
Crafting	5.5	2.3
Crop production	3.5	9.3
Sewing	4.5	2.8
Reading	22.5	16.8
Entertainment	64.8	77.8
Education	11	7
Businesses	10.3	1.3
Communication	76.5	54.8

Both populations displayed differences in household activities that required energy. For example, the majority of respondents from Bergville (77.8%) indicated entertainment purposes while most respondents from Inanda (76.5%) stated communication needs. It is interesting to note that in Bergville a distinctly lower percentage of respondents (54.8%) indicated communication needs. Results highlight that engagement in reading and educational activities is lower among the Bergville population. These trends emphasise earlier findings on the levels of education displayed by respondents from this community. Bastakoti (2003) and Cherni et al. (2007) show that improved access to electricity facilitates the use of devices such as cell phones, faxes and other communication devices. During the Bergville focus group discussion, participants noted that even though they have access to cell phones, use is limited by the availability of household electricity which is reserved for basic needs. Access to improved communication may be a challenge for the Bergville population.

Overall, respondents from both communities noted communication, entertainment and reading as the main activities requiring energy. Other activities highlighted by respondents included crafting, crop production, education, business and sewing. Respondents also highlighted the sources of energy used for the above activities as shown in Table 5.17. Electricity was mainly used by both communities to service the above energy needs. Smaller proportions from Inanda (6%) and Bergville (16.8%) indicated fuelwood.

Table 5.17: Main source of energy for other household activities (excluding lighting, heating and cooking) (in %)

Main sources	**Inanda (n=400)**	**Bergville (n=400)**
Electricity	94	83.5
Fuelwood	6	16.8

During the focus group discussions, participants were asked to explain some of the reasons and uses of fuelwood. Bergville participants shared that community members, particularly males would often gather for social meetings and events and during these gatherings fuelwood was used for fire and heat. This could explain why entertainment emerged as a popular household energy need among Bergville respondents. Participants from Inanda stated that some households sell cooked goods as a source of income and fuelwood was sometimes used, especially when cooking larger volumes of ‘phutu and ‘pap’ (traditional African meals) that require high temperatures and the boiling of water.

van der Kroon et al. (2013) call for the examination of previously used sources of energy as an indicator of performance in relation to energy stack and ladder models. The changes in household energy profiles can also be viewed as indicators of energy vulnerability and security (Casillas & Kammen, 2010; Cherp & Jewell, 2014; UNDP, 2014; Narula & Reddy, 2015). Respondents indicated the sources of energy used previously (Table 5.18), and the reasons why this source is no longer in use (Table 5.19). With the exception of candles, similar trends were noted among both populations. Interestingly, 2.8% of the respondents from Bergville indicated that they no longer used electricity.

Data was further disaggregated to reveal that of these 11 respondents 81.8% indicated that electricity became too expensive for use. More respondents from Inanda (19.8%) than Bergville (12%) indicated that they no longer used paraffin. A higher percentage from Inanda (8.5%) indicated that they no longer used candles, compared to their Bergville counterparts (1.8%).

Table 5.18: Energy sources used previously (Multiple responses, in %)

Energy sources	**Inanda (n=400)**	**Bergville (n=400)**
No response	58	69.3
Electricity	-	2.8
Fuelwood	9	5
Gas	9	5.3
Paraffin	19.8	12
Charcoal/ coal	1.3-	2.3
Candles	8.5	1.8
Dung	-	3
Car battery	2.8	1.3
Solar	-	0.5

Possible reasons for these changes are highlighted below. Cost of energy source emerged as the main reason among Bergville respondents (30.1%), with inconvenience the main reason among respondents in Inanda (30.4%). Twenty percent of respondents indicated connection to the main electricity grid as a reason. Other reasons highlighted by respondents include safety concerns, inaccessibility of sources and demands on their time. These results suggest that there are different energy concerns between populations, with affordability having a greater impact in Bergville, compared to respondents from Inanda who cited convenience of use. Lower average household income could explain the concerns over energy affordability in Bergville.

Table 5.19: Main reason why energy source is no longer in use (Multiple responses, in %)

Main reasons	**Inanda (n=168)**	**Bergville (n=123)**
Energy source no longer available/ accessible	16.1	22
Too expensive	14.9	30.1
Inconvenient to use	30.4	18.7
Too time consuming	22	8.9
Electricity installed within the household	15.4	20.4
Unsafe to use	6.1	2.4

Understanding energy needs of a population is important for energy planning and policies, however, examining how needs are prioritised becomes even more important, especially when examining energy choices and practices among the poor. Using pairwise ranking matrices, this study examined how energy needs (based on the literature) are proritised among Inanda and Bergville respondents as seen in Table 5.20 and Table 5.21, respectively. The ranking matrices were formulated during the focus group discussions.

Table 5.20: Ranking matrix showing the prioritisation of energy needs in Inanda

Needs	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Frequency**	**Rank**
A-Cooking		A	A	A	A	A	A	A	A	8	1
B-Lighting			C	D	E	B	B	B	I	3	5
C-Heating				D	E	C	G	H	I	2	7
D-Communication					E	D	D	D	I	5	4
E-Education						E	E	E	I	6	3
F-Agriculture							G	H	I	0	9
G-Entertainment								H	I	2	7
H-Use of appliances									I	3	5
I-Income generation										7	2

Participants from Inanda ranked cooking as the most important household energy need. This was followed by income generation, which could reflect broader community and household level challenges. Education was the 3rd most prioritised energy need, with communication at rank 4. Rank 5 was shared by use of appliances and lighting. According to Sovacool (2012), these are described as basic and modern energy needs. Contrary to the literature, heating was underscored by participants and shared the 7th rank with entertainment. Agriculture was the least prioritised energy need at rank 9, and participants agreed that this was not possible due to space limitations within the community.

Similar results were highlighted by participants from Bergville, who scored cooking with the highest priority. Education, agriculture and income generation were ranked at 2, and as with Inanda, this could reflect the broader household and community needs. Also, the importance attached to income generating activities implies that both groups deemed this to be a critical concern among their community. The use of appliances was ranked 5, followed by communication at 6, and surprisingly, heating at rank 7. More importantly, lighting was underscored at rank 8, with entertainment as the least prioritised energy need.

Table 5.21: Ranking matrix showing the prioritisation of energy needs in Bergville

Needs	A	B	C	D	E	F	G	H	I	Frequency	Rank
A-Cooking		A	A	A	A	A	A	A	A	8	1
B-Lighting			C	D	E	F	B	H	I	1	8
C- Heating				D	E	F	C	H	I	2	7
D-Communication					E	F	D	H	I	3	6
E-Education						E	E	E	I	6	2
F-Agriculture							F	F	F	6	2
G-Entertainment								H	I	0	9
H-Use of appliances									I	4	5
I-Income generation										6	2

With the exception of cooking, the ranks assigned to individual energy needs may also illustrate broader household needs, for example, income generating and educational uses of energy were ranked highly by both groups. Interestingly, lighting and heating were underscored, suggesting that lighting and heating may be overlooked in relation to productive and modern energy needs. These results echo participant reflections on community needs and challenges presented earlier. Furthermore, studies show that energy prioritisation among the poor is influenced by demography, household socio-economic characteristics, geography, and structural and thermal characteristics of dwellings (Pauchauri, 2004; Kastner & Stern, 2015; Mensah & Adu, 2015; Romero-Jordán et al., 2016).

During the participatory mapping exercises, focus group participants identified areas that they perceived to be most in need of energy. These areas are illustrated in Figure 5.6 and Figure 5.7. Participants from Inanda stated that these areas had a higher proportion of children, individuals were very poor and could not afford to buy electricity, and had many informal dwellings. Participants from Bergville indicated that the areas presented in Figure 5.7, were the few regions that were not connected to the electricity grid, and housed some of the poorest families in Bergville.

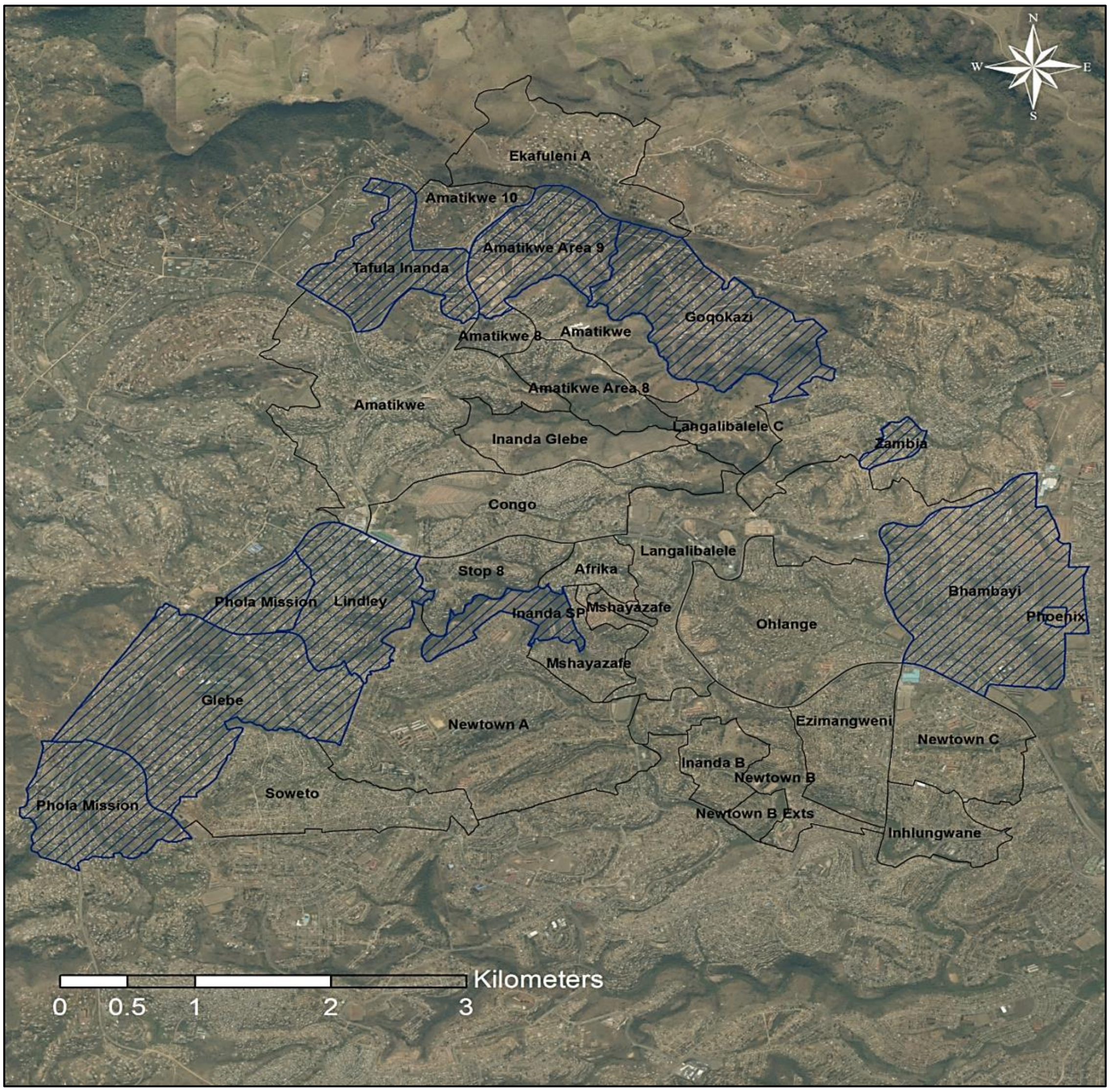

Figure 5.6: Participants' perceptions of energy priority areas in Inanda (Author, 2016)

Participants' perceptions of the most vulnerable areas show that these, with the exception of a few, are mainly located along the peripheral regions of each community. Within Inanda, these areas were predominantly along the steeper regions of the community. Similar trends were noted in Bergville, especially for areas such as Ngoba, Mkukwini and Ogade. Also, participants from Bergville shared that access was a critical challenge within these areas, as there were no formal roads. Terrain and road access have been noted to hinder the implementation of RETs in remote and rural communities (Kougias et al., 2016). Furthermore, this does present a challenge in the South African context given the history of inequity in access to basic services (Winkler, 2007; Bekker et al., 2008; Sebitosi & Pillay, 2008). Furthermore, the differences in settlement patterns and densities between Inanda and Bergville warrant the need for context and geographic specific implementation for RETs.

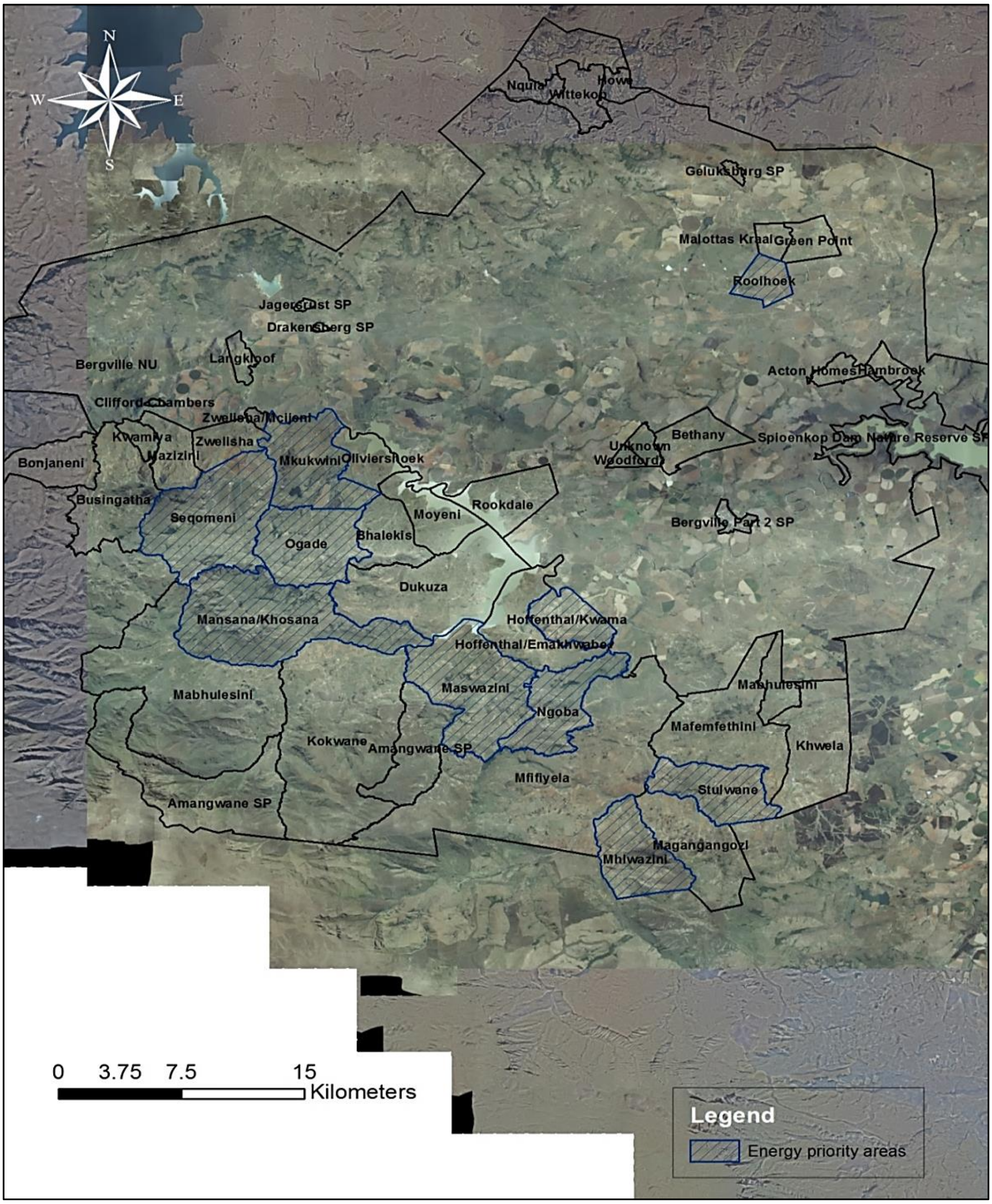

Figure 5.7: Participants' perceptions of energy priority areas in Bergville (Author, 2016)

In addition to the types of energy used at the household level, it is argued that the average energy consumption patterns can be used as indicators of energy vulnerability, poverty and insecurity (Sovacool & Mukherjee, 2011, Johansson, 2013; Ang et al., 2015). Furthermore, several studies warrant the need for continuous and current household energy data for future development planning and the formulation of appropriate energy policy (World Bank, 2001; Sebitosi & Pillay, 2008; Barnes et al., 2011; Pollet et al., 2015).

5.4 Energy consumption patterns

5.4.1 Monthly and daily energy consumption

During the piloting of the survey, it was noted that households within low-income communities rely on a broad mix of energy sources for their needs. Some sources are used intermittently whilst others are used on a more regular basis. Moreover, survey questions addressing main sources of energy used, fail to adequately highlight energy sources that are used during periods of stress, (for example, lack of income to purchase main source). In this regard, the selection and consumption of supplementary sources can assist in explaining energy behaviour. This study examined both daily and monthly energy consumption at the household level (Figure 5.8).

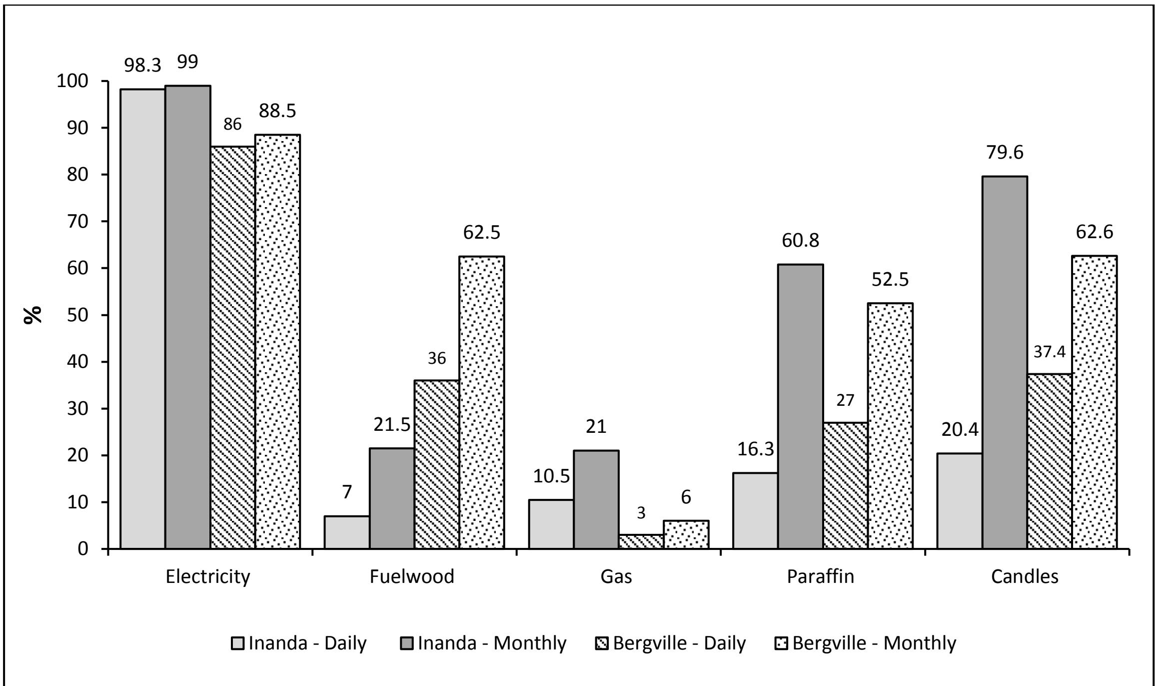

Figure 5.8: Household energy use in Inanda (n=400) and Bergville (n=400), (in %)

The majority of respondents in Inanda stated that they used electricity (98.3%) followed by candles (20%), paraffin (16.3%), gas (10.5%) and fuelwood (7%) on a daily basis. Bergville respondents showed more variation in their daily reliance with 86% using electricity, followed by candles (37.3%), fuelwood (36%) and paraffin (27%). Interestingly, even though some respondents did not use the sources listed below on a daily basis, many did indicate monthly use. Thirty-six percent of the respondents from Bergville indicated that they used fuelwood on a daily basis, however, 62.5% of respondents from Bergville used this source on a monthly basis. Likewise, among Bergville respondents, the daily use of candles was noted to be 37.4% yet the monthly use was 62.6%. Similar trends were highlighted among Inanda respondents, especially in relation to use of paraffin (16.3% daily and 60.8% monthly) and candles (20.4% daily and 79.6% monthly). Use of fuelwood, candles and paraffin showed the largest variation between daily and monthly (>50%) consumption for both populations.

It is evident that the practice of fuel-switching is more apparent when examining monthly energy consumption patterns. A comparison between daily and monthly consumption indicates the broader energy mix among respondents from both communities. However, results show that more respondents from Bergville consumed primitive (dung and fuelwood) and transitional fuels (candles) compared to their Inanda counterparts. As mentioned earlier, these trends suggest higher levels of energy poverty and vulnerabilities among Bergville respondents. Moreover, this study shows that daily energy consumption patterns may not reveal shifts in energy practices during the course of the month and therefore, does not adequately unpack household energy behaviours. Even though most respondents had access to electricity, the monthly use of additional sources of energy was noteworthy. This could be an indicator that affordability of electricity among respondents, whether in Bergville or Inanda is a critical concern.

Barnes et al. (2011) state that among low-income households energy use is influenced by the availability of income hence, a higher level of fuel-switching is expected when households can no longer purchase sources such as electricity. According to Jansen and Seebregts (2010), households that experience an interrupted supply of acceptable, safe and affordable energy services are deemed to be energy poor. The extensive fuel-switching practices suggest that respondents may also be experiencing disruptions in the quality and quantity of energy services they derive from these sources. For example, the switch to candles for lighting services is associated with poor luminosity which limits the number of productive hours available daily for educational and income generating activities (Clancy et al., 2003; Heath, 2014; Kaygusuz, 2011). Additionally, studies highlight that the lack of suitable lighting poses several safety risks, especially for women and children (Chukuezi, 2009; Denton, 2002).

Moreover, the extensive use of paraffin and fuelwood is another issue of concern for both populations. This study probed this issue further by examining household cooking practices.

5.4.2 Household cooking practices

Table 5.22 shows that more than 98% of respondents from Inanda (98.5%) and Bergville (98.3%) prepare their meals indoors. Given respondents' choice in energy sources, both populations are at risk to the impacts of indoor air pollution. In terms of methods of cooking, most respondents (>80%) prepared their meals on a stove top, however, 42.3% of respondents from Bergville indicated that they also prepare their meals over a fire (Table 5.23).

Table 5.22: Main area used for household cooking activities (in %)

Area	**Inanda (n=400)**	**Bergville (n=400)**
Indoors	98.5	98.3
Outdoors	1.5	1.3

Table 5.23: Method of cooking (Multiple responses, in %)

Cooking method	**Inanda (n=400)**	**Bergville (n=400)**
Stove top	98.3	81.5
Fire top	1.8	42.3

Focus group participants from Inanda indicated that most households in the community have a two plate electric stove, however, some have a paraffin stove which is used indoors. Participants from the Bergville discussions indicated slightly different cooking practices in the community. Participants stated that cooking is usually carried out in the rondavels (a thatched structure usually made with mud, stones and logs). This was usually separate from the main dwelling household (Figure 5.9). This is considered a sacred space and sometimes women and children sleep in this structure. In addition, participants from Bergville explained that cooking with fuelwood on open fires was a norm among households in the community. Both groups of participants highlighted cost of electricity, convenience, cultural practices and the fact that paraffin and fuelwood could serve multiple purposes (for example, cooking and heating) as the main reasons for their choice in cooking fuels.

Figure 5.9: Rondavel structures used for cooking in Bergville (Author, 2016)

The monthly results above indicate that more than 50% of respondents use one or both of these sources on a monthly basis. For example, respondents from Bergville indicated that they use both fuelwood (62.5%) and paraffin (52.5%) on a monthly basis (Figure 5.8). Respondents' reliance on paraffin and fuelwood for cooking and heating practices is problematic, given that these sources have been described to cause poor indoor air quality, several respiratory illnesses and cardiac conditions (Mishra et al., 1999; Smith & Metha, 2003; WHO, 2006; Kim et al., 2011). Furthermore, the use of these fuels within confined spaces or indoors on a regular basis results in exposure to harmful carbon monoxide and particulate matter therefore increasing health risks and reducing overall quality of life (Khan et al., 2014). Howells et al. (2005) assert that the lack of energy efficiency and its impacts (specifically, indoor pollution) associated with the use of current sources such as kerosene and fuelwood has a casual effect on the household's ability to react to changing energy prices.

This study also probed the various methods that fuelwood was obtained by the household (Table 5.24). Results show that 47.7% of respondents from Inanda who used fuelwood purchased this source on a monthly basis. This was followed by 33.7% of respondents indicating that they collected this resource and 18.6% stating that they purchased and collected this source for monthly use within Inanda. A higher proportion of respondents from Bergville who indicated that they used fuelwood (49.2%) stated that they collected their monthly fuelwood supply while 16% stated that fuelwood was purchased and 34.8% noted that this source was purchased and collected by members of the household.

Table 5.24: Methods by which fuelwood is obtained (in %)

Method	Inanda (n=86)	Bergville (n=250)
Purchased	47.7	16
Collected	33.7	49.2
Purchased and collected	18.6	34.8

Unsurprisingly, a larger proportion of respondents from Bergville collected fuelwood. This could be explained as an outcome of the limited household incomes within Bergville or attributed to a lack of vendors of fuelwood. Focus group participants from Bergville elaborated that over the years households generally collect fuelwood because it is considered free and one does not need to pay for this source. They also stated that in recent times, more households have to purchase fuelwood due to the restricted access to woodlots which sometimes occur on private property, and that forests and trees are becoming increasingly scarce within the community. Participants from Inanda shared that woodlots and forests are mainly located along the outskirts of the community where only a select few have access and more importantly, the collection of fuelwood is not well received due to the strong links to poverty. Two participants from Inanda stated that the collection of fuelwood is not safe, hence, most households purchase their monthly supply.

The results shown above align with earlier assertions that respondents from Bergville may be experiencing higher levels of economic vulnerability, especially in relation to the ability to purchase energy sources, resulting in certain sources being financially unattainable and could explain the higher reliance (compared to Inanda) on sources they perceived to be free. It can be argued that the impacts of income on energy practices are more pronounced within Bergville. Furthermore, especially in the case of Bergville, culture and tradition seem to dictate much of the respondents' energy practices. For example, the historic practice of cooking in a separate dwelling and the collection of monthly fuelwood supply is perpetuated in relation to current energy practices. van der Kroon et al. (2013) state that household cultural practices and preferences are important endogenous factors that influence energy choices.

Similarly, Kowsari and Zerriffi (2011) highlight household routine (for example, in cooking practices), size, income and level of education as key factors that influence energy profiles. These results suggest that in addition to income, culture and routine could also be important determinants of household energy practices and preferences. However, it is of concern that participants from Bergville perceived fuelwood to be free. This suggests that other costs, such as time and physical burden as well as environmental sustainability implications may be overpowered by financial costs. Studies show that households displaying a reliance on traditional biomass do not recognise the impacts of fuelwood collection, especially in relation to the loss of productive hours, increased risk of injury and physical burden (Modi et al., 2006; Chukuezi, 2009; Parajuli, 2011; Burke & Dundas, 2015).

Table 5.25 lists the persons responsible for the collection of fuelwood within the household. Results show that for both communities, women are mostly tasked with responsibility (69% in Bergville and 53.3% in Inanda). An almost equal proportion of respondents from both communities (20% in Inanda and 16.7% in Bergville) stated that all members of the household or males only have this responsibility. Women are disproportionately burdened with the responsibility of accumulating primitive sources of energy and, due to the domestic responsibilities, are also the most at risk of the health impacts associated with their use (Helberg, 2005; Modi et al., 2006; Parajuli, 2011; Munien & Ahmed, 2012; Munien, 2014; Behera et al., 2015; Burke & Dundas, 2015).

Table 5.25: Person/s responsible for collecting fuelwood (in %)

Group	Inanda (n=45)	Bergville (n=210)
Everybody	26.7	14.3
Females only	53.3	69
Males only	20	16.7

Focus group participants from Bergville established that individuals who collect fuelwood have to now travel further distances due to the scarcity of woodlots, forests and older trees in general. Respondents provided actual distance travelled to collect fuelwood on a monthly basis as seen in Table 5.26.

Table 5.26: Daily distance travelled to obtain fuelwood (in %)

Distance	Inanda (n=45)	Bergville (n=210)
Don't know	6.7	7.6
<1 km	48.9	12.9
1-3 km	26.7	18.1
3-5 km	17.8	24.8
5-8 km	-	36.7

Most respondents from Inanda who collected fuelwood (48.9%) travelled less than 1 km per day. Smaller proportions stated that they travelled between 1-3 km (26.7%) and 3-5 km (17.8%) per day. Respondents who collected fuelwood in Bergville travelled further distances compared to the Inanda counterparts. This is surprising since it is generally assumed that natural resources (including trees) are more abundant in rural rather than per-urban areas, where population densities and the built environment are greater. Approximately 36.7% of this group of respondents travelled between 5-8 km per day followed by 24.8% who travelled between 3-5 km. Almost equal proportion of respondents from Bergville (7.6%) and Inanda (6.7%) were unaware of the distances they travelled to acquire this source.

Figure 5.10: Women carrying their collected bundles of fuelwood in Bergville (Author, 2016)

Figure 5.10 was captured during one of the site visits to Bergville, and highlights the physical burden women experience in acquiring traditional biomass. Studies conducted in sub-Saharan Africa show that women carry approximately 20 kg of fuelwood for an average 20 km per day causing immense physical pressure which impacts on their overall quality of life (IEA, 2002; Modi et al., 2006; Riojas-Rodríguez et al., 2013; Kemausuor et al., 2016). Similarly, Brian et al. (2004) show that in some countries women carry almost half their body weight of fuelwood. This study shows that household energy consumption, more specifically use of fuelwood places an immense burden on women in particular. As a result, women in Bergville may be experiencing increased risk due to the impacts associated with the use and collection of this energy source. More importantly, given that women are primarily tasked with cooking, these impacts include physical burden and health-related stresses. Also, this study shows that women in Bergville, tasked with the collection and use of fuelwood, may be experiencing the impacts of energy poverty more intensely compared to males and respondents in Inanda. This resonates with earlier findings that show the impacts of socio-economic and energy related stresses to be more severe in Bergville.

5.*4.3 Household energy use*

In addition to the type of energy sources used, studies show that the total amount of energy consumption can be used as an indicator of energy insecurity experienced by the household (Goldemberg, 1990; Modi et al., 2006; Barnes et al., 2011; Pereira et al., 2011a; Sovacool, 2012). This study examined frequency and total hours of use for specific energy sources (Tables 5.27 and 5.28, respectively). During the piloting, it was noted that individuals surveyed were unable to provide the actual quantities of energy sources consumed. Further discussions revealed that electricity within low-income communities of South Africa have a meter-based electricity system. Households purchase electricity tokens/ vouchers from services providers or electricity vendors and load the credits onto the household system. This could have been the reason why individuals participating in the pilot study could not provide an estimate of electricity usage in kw/h units. This study used frequency of use, duration of use and price to estimate approximate consumption of specific energy sources.

Respondents from Inanda used electricity more frequently per day compared to Bergville. Electricity was the only source used four or more times a day, with a significantly lower proportion of respondents from Bergville (11.3%) indicating electricity usage at this frequency compared to Inanda (26%). Most respondents from Bergville (43%) and Inanda (36.3%) used electricity twice daily. Fuelwood was used more frequently by respondents from Bergville, with most indicating use twice daily (22.8%). Fewer respondents from Bergville indicated once (6.8%) and thrice daily (6.6%). Respondents from Inanda who used fuelwood, mainly did so once daily (5.5%). Other energy sources such as paraffin were also used daily, by respondents from both communities. An equal percentages of respondents (9.8%) from both populations used paraffin once daily. A significantly higher proportion of respondents from Bergville used paraffin twice (12%) and thrice daily (4.8%) compared to their Inanda counterparts. However, it was clear that respondents from Inanda used paraffin more frequently per day.

Table 5.27: Frequency of use for specific energy sources (in %)

Source	Frequency/ day	Inanda (n=400)	Bergville (n=400)
Electricity $p < 0.0001$	Source not used *	1	11.5
	Not used daily	0.8	2
	Once	14.3	14.5
	Twice*	36.3	43
	Thrice	21.8	17.8
	4 times*	26	11.3
Fuelwood $p < 0.0001$	Source not used *	78.5	37.5
	Not used daily*	14.5	26.5
	Once	5.5	6.8
	Twice*	1	22.8
	Thrice*	0.6	6.6
Gas $p = 0.013$	Source not used *	79	94
	Not used daily*	10.5	3
	Once*	3	0.8
	Twice*	6.3	1.8
	Thrice	0.5	0.3
	4 times	0.8	0.3
Paraffin $p < 0.0001$	Source not used	39.3	47.5
	Not used daily*	44.5	25.5
	Once	9.8	9.8
	Twice*	3.5	12
	Thrice*	1.8	4.8
	4 times	1.3	0.5
Candles $p < 0.0001$	Source not used	10.3	14
	Not used daily*	69.3	48.8
	Once *	16.8	27.3
	Twice*	2.5	8.3
	Thrice	1.3	1.8

*column proportions are significantly different when compared between communities, within categories: *z*-test; *p*-values based on results of a chi-square test

Given that most cooking activities took place indoors, the use of fuels such as paraffin and fuelwood within confined spaces raises concern over health and indoor air quality in both communities. The use of primitive and transitional fuels for indoor cooking purposes leads to the emission and production of CO, VOCs, NO_x, sulphur oxides, RSPM, and polyorganic matter, which negatively impact health and indoor air quality (Smith & Metha, 2003; Röllin et al., 2004; WHO, 2006; Kim et al., 2011). Kaygusuz (2011) is of the opinion that gaseous and particulate emissions from indoor smoke are a critical challenge in sub-Saharan Africa and south East Asia. Moreover, based on data trends thus far, it can be said that respondents in Bergville display higher levels of risk. Also, in comparison to socio-economic backgrounds of respondents, it is further argued that respondents from Bergville may have limited capacity to respond to these health impacts.

Although the use of gas was limited in both communities, most respondents who indicated that they did use this source, did so twice daily (6.3% in Inanda and 1.8% in Bergville). A minority of respondents from Bergville (9.8%) and Inanda (1.8%) indicated that they used dung and solar, respectively. All respondents that used dung on a daily basis (2.5%) did so once per day. All daily solar energy users (1.8%) did so twice daily. Candles were the second most commonly used source in both communities, albeit on a monthly basis. In terms of daily use, a higher proportion of respondents from Bergville (27.3%) used candles once compared to Inanda (16.8%). Smaller groups in both communities indicated that candles were used twice daily. The daily use of candles among Bergville respondents (37.2%) could suggest that lighting services are not prioritised. Moreover, increased daily reliance on candles within Bergville once again highlights the differences in the quality of energy services experienced within the study populations.

Chi-square tests reveal that all energy sources, used on a daily basis, were consumed at significantly different frequencies between populations (Table 5.27). Electricity and gas were used by a higher proportion and more frequently by respondents from Inanda. Bergville respondents consumed more candles, fuelwood and paraffin on a daily basis. Overall, respondents from Inanda showed a higher frequency of use of modern sources, such as electricity and gas, while there was a greater reliance on primitive and transitional fuels in Bergville. Furthermore, results demonstrate that the practice of fuel-switching is more pronounced among Bergville respondents as indicated earlier. A closer inspection of daily use patterns suggests that Bergville respondents may have to use sources like fuelwood, paraffin and candles more frequently due to their low efficiencies. Kaygusuz (2011) shows that transitional and primitive fuels are less efficient compared to modern sources such as electricity. Therefore, households displaying a higher reliance on transitional and primitive sources tend to use more energy to attain basic energy services.

A reliance on less efficient energy sources suggests that the quality of energy services may be different between Bergville and Inanda, with the latter having access to improved quality of energy services attributed to the more frequent use of electricity. Increased reliance on less efficient fuels in Bergville is unsurprising, as more than 40% of rural households in South Africa are considered energy inefficient (DoE, 2014). In addition, the more frequent use of modern sources of energy such as electricity among respondents from Inanda suggests that Bergville respondents can be considered more energy poor. Given the differences in household income between communities, affordability may be a key factor constraining use of modern sources of energy within Bergville, and the rural context more broadly.

A more detailed examination of daily energy consumption is presented in Table 5.28, which lists total duration of use per energy source. Results show that electricity was mainly consumed for 3-5 hours per day in both Bergville (60%) and Inanda (47.8%). Within Inanda, smaller groups indicated use between 1-3 hours (19.3%), 5-8 hours (16.8%) and more than 8 hours (12%) per day. Almost equal proportions of Bergville respondents stated that they used electricity for 1-3 hours (12.3%) and 5-8 hours (12%) per day. Overall, respondents from Inanda consumed electricity for approximately 43 minutes more per day compared to their Bergville counterparts. Further calculations reveal that on average respondents from Inanda consume electricity for 4.19 hours per day, while Bergville respondents consume this source for a shorter duration, 3.46 hours per day.

However, daily use of fuelwood among Inanda respondents was low when used with respondents doing so for 1-3 hours per day (4.8%). A higher proportion of respondents from Bergville used fuelwood daily, with almost equal proportions stating 1-3 hours (18.5%) and 3-5 hours (17.8%) of use. Average use per population indicates that respondents from Inanda consumed fuelwood for 2.03 hours per day compared to Bergville respondents who used this source for 2.8 hours per day. Overall, respondents from Bergville consumed fuelwood for approximately 48 minutes longer than their Inanda counterparts. This is unsurprising, given earlier data trends which showed a higher reliance on fuelwood in Bergville. Furthermore, fuelwood is a commonly used energy source for cooking within Bergville suggesting that, in comparison to respondents from Inanda, exposure to harmful emissions from indoor use of fuelwood is a major concern.

Table 5.28: Daily duration of use for specific energy sources (in %)

Source	Duration of daily use (Hours/day)	Inanda (n=400)	Bergville (n=400)
Electricity *p* <0.0001	Source not used	1	11.5
	Not used daily	0.8	1.8
	<1 hour *	2.5	0.5
	1-3 hours	19.3	12.3
	3-5 hours *	47.8	60
	5-8 hours *	16.8	12
	>8 hours *	12	1.8
	Average hours/day	**4.19**	**3.46**
Fuelwood *p* <0.0001	Source not used	78.5	37.5
	Not used daily	14.5	26.5
	<1 hour*	1.3	-
	1-3 hours*	4.8	18.5
	3-5 hours*	1.1	17.8
	Average hours/day	**2.03**	**2.8**
Gas *p* =0.023	Source not used	79	94
	Not used daily	10.5	3
	<1 hour	1.3	-
	1-3 hours*	7.6	1.5
	3-5 hours	1.8	1.5
	Average hours/day	**2.13**	**1.42**
Paraffin *p* =0.010	Source not used	39.3	47.5
	Not used daily	44.5	25.5
	1-3 hours	13	18.5
	3-5 hours*	3.3	8.5
	Average hours/day	**2.71**	**2.35**
Candles *p* <0.0001	Source not used	10.3	14
	Not used daily	69.3	48.7
	1-3 hours*	16.5	11.5
	3-5 hours*	4	25.8
	Average hours/day	**2.19**	**3.19**

*column proportions are significantly different when compared between communities, within categories: *z*-test; *p*-values based on results of a chi-square test

Paraffin was commonly used by both communities, with respondents from Inanda stating an average daily consumption of 2.71 hours and respondents from Bergville displaying an average use of 2.35 hours per day. More specifically, respondents indicated that this source was mainly used for 1-3 hours in Inanda (13%) and Bergville (18.5%). As mentioned earlier, the use of fuels such as paraffin and fuelwood indoors poses several health risks and in this instance, results show that respondents from Inanda maybe more susceptible. However, it must be noted that that more respondents from Bergville used paraffin and therefore a larger proportion of Bergville respondents are a risk of the impacts of indoor use of paraffin and fuelwood compared to their Inanda counterparts. Pachuri and Spreng (2011) show that the impacts associated with indoor use of fuelwood and paraffin are most prevalent among low-income rural communities. Furthermore, these results demonstrate that the impacts of energy poverty, specifically the use of unsafe fuels, are more severe among respondents from Bergville.

Similar trends were noted in term of the use of candles, for example, a higher proportion of respondents from Bergville (25.8%) indicated that they used candles for 3-5 hours per day, compared to Inanda (4%). Bergville respondents displayed a higher daily average consumption of candles (3.19 hours). Average consumption of candles in Inanda was 2.19 hours per day. Gas was mainly used for 1-3 hours per day by respondents from Inanda (7.6%), while 1.5% of respondents from Bergville used this source for 1-3 hours and 3-5 hours per day. Average duration of consumption of gas was 2.13 hours in Inanda and 1.42 hours in Bergville. These trends raise concern over the quality of lighting services received by respondents using candles on a daily basis for their basic needs. Additionally, unattended candles have been related to fires and therefore increased risk (Denton, 2002).

None of the respondents who used SETs could provide an estimate of use for the day. Focus group participants from the Inanda shared that solar energy was mainly used in the form of SWHs. They also explained that it was difficult to provide an estimate of usage as they understood very little about how the system actually functioned. One participant stated that the SWH may heat throughout the day, but the use of hot water is limited to specific times during the day and therefore an estimate in hours was difficult. Likewise in Bergville, 4.1% of respondents indicated that they used dung as a source of energy only when the main source was no longer available with an average use of 1.64 hours per day. Smaller percentages of respondents stated that use varied between 3-4 hours (1.4%), 2-3 hours (1.3%) and 1-2 hours (1.2%) per day.

Chi-square tests reveal that daily consumption of electricity, fuelwood, paraffin, gas and candles differed significantly between Inanda and Bergville respondents (Table 5.28). With the exception of fuelwood and candles, respondents from Inanda displayed a higher consumption of energy sources. More importantly, respondents from Inanda showed a more frequent and higher consumption of sources such as electricity and gas. While more respondents from Bergville not only used primitive and transitional sources, these sources were consumed more frequently and for longer periods. Overall, respondents from Inanda displayed a more frequent and greater consumption of more modern purchased sources, while Bergville showed a higher and more frequent consumption of primitive and transitional fuels.

In relation to the energy stack and ladder models, respondents from Inanda are located higher up on the energy hierarchy, suggesting higher levels of energy security. The extensive fuel-switching and reliance on energy sources lower on the energy hierarchy demonstrates that respondents from Bergville experience increased energy related risk and insecurity. Data trends show that respondents from Bergville experience higher levels of energy poverty. Furthermore, this highlights the differences noted across South Africa, where the impacts of energy poverty are most severe among poor rural communities (Sebitosi & Pillay, 2008; DoE, 2014). Studies note similar trends of energy poverty across most of sub-Saharan Africa (Rehman et al., 2012; Sovacool, 2013). According to Pereira et al. (2011a) the lack of access to electricity resulting in the use of solid fuels such as fuelwood is a form of energy poverty.

Moreover, the increased practice of fuel-switching among respondents from Bergville suggests that energy affordability may be a major challenge for households within the community. This is further emphasised by the lower household incomes noted among these respondents compared to their Inanda counterparts. Månsson et al. (2014) describe energy security to be directly linked to affordability and ability to purchase modern fuels. Likewise, Mayer et al. (2014) state that household well-being is influenced by the ability to purchase modern fuels. Other studies show that total household energy expenditure can also be used as an indicator of energy security and vulnerability (Bekker et al., 2008; Ziramba, 2008; Johansson, 2013; Cherp & Jewell, 2014). The following sections discuss household energy expenditure in both populations

5.4.4 Household energy expenditure

Respondents specified monthly expenses for energy sources used by the household as shown in Table 5.29. It was clear that electricity, fuelwood, paraffin, gas and candles were purchased monthly by both populations. In relation to electricity, most respondents from Inanda (55%) and Bergville (46.3%) paid between R100-R300 per month. Interestingly, a higher proportion of Bergville respondents (38.5%) paid less than R100 per month for electricity. A significantly higher proportion from Inanda indicated monthly electricity costs ranging from R300-R500. More respondents from Inanda (6.8%) stated that they paid more than R500 per month for this source. Overall, respondents from Inanda showed higher average electricity costs (R280.98) compared to Bergville (R145.14).

In relation to household use of gas, similar trends were noted where respondents from Inanda displayed a higher monthly expenditure for gas (R229.76) compared to Bergville (R113.04). A higher percentage of respondents from Bergville (31.8%) purchased fuelwood; this is unsurprising given the extensive reliance on this source within the population. More specifically, 17% paid less than R100 per month for fuelwood. Respondents from Inanda indicated almost similar monthly expenses for fuelwood. Bergville respondents noted a considerably higher monthly fuelwood expenditure (R118.04) compared to Inanda (R46.19).

Table 5.29: Monthly household spend for specific energy sources (in %)

Source	Monthly costs	Inanda (n=400)	Bergville (n=400)
Electricity $p<0.0001$	Source not used	1	11.5
	<R100*	10.3	38.5
	R101-R300*	55	46.3
	R301-R500	27	2.8
	R501-R700*	3.5	0.8
	>R700*	3.3	0.3
	Average monthly expenditure	**R280.98**	**R145.14**
Fuelwood $p=0.029$	Source not used	78.5	37.5
	Collected only*	7.3	30.7
	<R100*	5.3	17
	R101-R300	5.8	12.3
	R301-R500	3.3	2.5
	Average monthly expenditure	**R46.19**	**R118.04**
Gas $p=0.08$	Source not used	79	94
	<R100	4.5	3.8
	R101-R300*	9.3	1.8
	R301-R500*	7.3	0.3
	Average monthly expenditure	**R229.76**	**R113.04**
Paraffin $p<0.0001$	Source not used	39.3	47.5
	Don't know*	1	6
	<R100*	45.5	33.7
	R101-R300*	14.3	9
	R301-R500	-	3.8
	Average monthly expenditure	**R72.92**	**R78.50**
Candles $p<0.0001$	Source not used	10.3	14
	Don't know	-	4.9
	<R100	75	77.8
	R101-R300*	14.8	5.5
	Average monthly expenditure	**R60.17**	**R49.84**

*column proportions are significantly different when compared between communities, within categories: *z*-test; *p*-values based on results of a chi-square test

It is interesting to note that respondents in Bergville spent almost similar amounts on electricity and fuelwood. This could reflect a more complex issue relating to household energy preferences. This issue was examined further during the focus group discussion in Bergville. Participants stated that fuelwood was used for cooking and heating and many households did not own an electric geyser hence water was primarily heated over fires. Two participants felt that it was cheaper to purchase fuelwood compared to purchasing an electric geyser. Four participants stated that geysers may not be suitable to all households in Bergville since some homes are traditional dwellings and may not be able to support a geyser structurally. According to Kowsari and Zerriffi (2011), access to modern household appliances and energy devices influences energy needs and therefore impacts energy profiles. In this regard, physical dwelling structure characteristics could influence energy profiles. The DoE (2014) shows that traditional and informal dwellings display lower levels of energy efficiencies compared to formal brick structures. Furthermore, the structural characteristics of traditional dwellings in Bergville may pose a challenge for the implementation of RETs, such as solar or PV panels. Beck and Martinot (2004) and Ahlborga and Hammar (2014) show that roof design, dwelling structural stability and materials used for construction emerged as important factors influencing the implementation of renewable energy within poor communities. Moreover, increased expenditure on fuelwood by Bergville respondents could also reflect cultural practices and traditions. Earlier results shows that cooking practices and the use of fuelwood has a strong cultural influence, suggesting that culture may have a noteworthy influence on how energy choices are rationalised. According to Stephenson et al. (2010) and Day et al. (2016), energy choices are a complex outcome of culture, household profile and affordability.

Higher proportions of respondents from Inanda (45.5%) and Bergville (33.7%) spent less that R100 per month on paraffin. Overall, respondents from Bergville showed a slightly higher (R78.50) monthly spend on paraffin compared to Inanda (R72.92). The majority of respondents from Bergville and Inanda spent less that R100 per month on candles, however, respondents from Inanda showed a higher mean monthly spend on candles (R60.17) compared to Bergville (R49.84). Dung was only used in Bergville and respondents who did so paid an average of R31.25 for this source per month. With the exception of fuelwood and paraffin, respondents from Inanda have higher monthly energy expenditures. Chi-square tests reveal significant differences between populations in terms of the amount respondents spent on energy sources on a monthly basis. This is somewhat expected given the differences in household incomes between communities. Bergville households displayed higher socio-economic stresses and therefore the lack of expenditure on energy sources could be a consequence of limited household income, or the fact that a larger proportion of respondents collected some of the household energy sources.

5.5 Simulated energy indicators

As mentioned earlier, respondents could not provide actual estimates of household electricity consumption therefore this study uses price to simulate electricity consumption in kWh units. This was based on two assumptions: all households paid the same cost per unit electricity and the nature of electricity supply was the same across populations. In this regard, all households surveyed used electricity on a prepaid basis. This is common practice within South Africa where households in low-income communities have a pre-installed prepaid electricity meter. Additionally, the price of domestic energy within South Africa is regulated by NERSA, and according the DoE (2013b), the price of domestic energy at the time of data collection was approximately R0.8705/kWh.

Table 5.30: Disaggregated electricity consumption (in kWh, with SD) (*p*-values for Mann-Whitney U tests)

Indicator	Inanda (n=394)	Bergville (n=354)	*p*-values
Mean monthly household electricity consumption[a]	242.15±180.24	111.86±91.23	<0.0001
Mean monthly electricity consumption per person[b]	52.42±38.94	22.2 ±21.85	0.014
Mean annual electricity consumption per person[c]	629.14±467.34	266.47 ±262.26	0.02

[a]based on monthly household expenditure; [b]ased on household size; [c]based on a 12 month period.

On average, households in Bergville consumed 111.81kWh of electricity per month (Table 5.30). This was significantly higher among Inanda households who consumed an average of 242.15kwh of electricity per month (Man-Whitney U test, $p<0.0001$). Electricity consumption per household member also differed significantly between communities, with household members in Inanda consuming 52.42kWh compared to 22.20kWh in Bergville. Results show a significantly higher electricity consumption per person per month in Inanda compared to Bergville ($p=0.014$, Mann-Whitney U test). Additionally, household members from Inanda consume 629.14kWh/per person/year, which was significantly higher than the Bergville estimate of 266.47kwh/year ($p=0.02$, Mann-Whitney U test). This reinforces earlier assertions that modern energy sources like electricity may be financially unattainable to many Bergville respondents, suggesting that affordability is a critical concern within this community.

Sovacool (2012) report between 50-100kWh, 500-1000kWh, and 2000kWh of electricity are required per person per year to meet basic, productive and modern energy needs, respectively. In comparison to the assertions made by Sovacool (2012), results of this study suggest that individuals in Inanda consume suitable amounts of electricity to meet both basic and productive energy needs, while individuals in Bergville consume amounts that only allows for basic energy needs to be serviced. Furthermore, overall trends suggest that household members in both Inanda and Bergville did not consume adequate electric power to meet their modern energy needs. However, it should be noted that SD values were very high, suggesting differences in electricity consumption patterns within communities. These findings resonate with earlier assertions which claim that even within communities, energy consumption patterns show large-scale variability. Nonetheless, it is evident that households within Bergville experience higher levels of energy insecurity compared to their Inanda counterparts.

Moreover, in an attempt to unpack household energy consumption, the following energy use indicators were simulated to provide a more robust understanding of household energy practices. The results of these simulations are presented in Table 5.31, and discussed in the subsequent sections. The simulation of energy indicators, more specifically energy consumption, was examined in relation to the following characteristics:

- household size;
- household income;
- household expenditure on energy sources;
- proportion household income spent on energy per month;
- monthly energy expenditure per household member;
- proportion monthly energy expenditure used to purchase primitive (fuelwood and dung) and transitional (paraffin) fuels; and
- proportion monthly energy expenditure used to purchase modern fuels (electricity and gas).

Table 5.31: Cross-sectional evaluation of monthly energy expenditure

Estimate	Inanda	Bergville	*p*-value*
Monthly energy expenditure[a]	R426.85 ±261.4	R303.36 ±174.9	<0.0001
Proportion household income spent on energy	24.8% ±39.5	25.9% ±27.1	0.182
Energy spend per capita[b]	R93.09 ±62.2	R61.52 ±45.6	<0.0001
Proportion household income spent on primitive and transitional fuels	3.4% ±8.1	11.1% ±16.4	<0.0001
Proportion household income spent on modern fuels	17.8% ±28.9	10.9% ±13.8	<0.0001

[a]Mean based on total household energy expenditure
[b]Calculated as monthly energy expenditure/ household size
*Mann-Whitney U test

Household monthly energy expenditure differed significantly between populations, with Inanda having a significantly higher average monthly spend (R426.85). Additionally, households in Inanda spent more on energy per capita (individual) (R93.09) compared to Bergville (R61.52). More importantly, households in Bergville spent a slightly higher proportion of their income on energy (25.9%) compared to households in Inanda (24.8%). Mann-Whitney U tests revealed that the proportion of household income spent on energy did not differ significantly between communities. A comparison of SD values illustrates that even within communities there are noteworthy differences in household energy expenditure. For example, results show that SD values are similar to, and often exceed mean values.

According to Mayer et al. (2014) and Parajuli (2011), households that spend more than 10% of their income on energy are deemed energy poor. Results show that both groups of households can be classified as energy poor. Other studies claim that examination of specific energy sources can also be used as an indicator of energy poverty (Hosier & Dowd, 1987; Leach, 1986; Davis, 1998; Sola et al., 2016; Zhang et al., 2016). This study examined the proportion of household income used to purchase modern, primitive, and transitional fuels and shows that households from Inanda spent 3.4% of their household income on primitive and transitional fuels, while households in Bergville spend a significantly higher proportion of their income on these fuels (11.1%, $p<0.0001$). Also, households in Bergville spent a significantly lower portion of their income on modern fuels (10.9%) compared to Inanda (17.8%) ($p<0.0001$).

Furthermore, this study indicates that poorer households, such as those in Bergville, spend more of their income on primitive and transitional fuels, even when electricity is available.

This demonstrates that affordability of modern sources of energy remains a critical challenge to most poor households within the country. These estimates were correlated with household characteristics, in an attempt to highlight factors that influence household energy practices within communities (Table 5.32).

Table 5.32: Results of Spearman's correlation analysis (HI-household income; HS-Household size)

Variables	Values	Inanda		Bergville	
		HI	HS	HI	HS
Monthly energy expenditure	r^2	0.298**	0.213**	0.085	0.088
	p	<0.0001	<0.0001	0.089	0.080
Energy expenditure per capita	r^2	0.201**	-0.483**	-0.059	-0.530**
	p	<0.0001	<0.0001	0.235	<0.0001
Proportion of household income spent on energy	r^2	-0.742**	0.031	-0.682**	-0.68
	p	<0.0001	0.530	<0.0001	0.172
Proportion of household income primitive and transitional fuels	r^2	-0.284**	-0.125*	-0.158**	0.041
	p	<0.0001	0.012	0.002	0.410
Proportion of household income spent on modern fuels	r^2	0.377**	0.241**	0.171**	0.098
	p	<0.0001	<0.0001	0.001	0.05

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level
p values are highlighted were significant

Spearman's correlation tests revealed that a significant positive relationship emerged between energy expenditure and household income and household size among Inanda households, illustrating that households increased their energy expenditure as household size and income increased. It is interesting to note that neither household size nor income had an impact on monthly energy expenditure among Bergville households. Results from Bergville resonate with Barnes et al. (2011) who show that among very poor groups, increases in household income has no major impact on energy consumption. Furthermore, these data trends agree with the literature that show that within communities that experience chronic socio-economic vulnerability and poverty, improvements in household income will have little influence on energy consumption (Barnes et al., 2011; Kaygusuz, 2011).

Average energy spend per capita shared a significant negative relationship with household size for both populations. These trends show that larger households spent less per person on energy. This is expected as several studies show that purchasing power parity among low-income households is constrained by the overall lack of incomes (Majumder et al., 2015; Cameroon et al., 2016; Deaton, 2016; Kakwani & Son, 2016). The growth in household size, if not complimented with improved household income could result in modern sources of energy becoming increasingly unattainable in both Inanda and Bergville. These results support Madubansi and Shackleton's (2007) assertions that most poor households in South Africa lack the capacity to respond to energy prices thus, the use of modern energy sources such as electricity are not sustained throughout the month.

Results of the correlation tests show a strong negative relationship between household income and proportion of income spent on energy in both Inanda (-0.742, $p<0.0001$) and Bergville (-0.682; $p<0.0001$). This demonstrates that households with higher incomes spent a smaller proportion on energy, which could have several positive spin-offs. For example, investment in education, improved health and the accumulation of other livelihood assets. Moreover, among Inanda households, increases in household income and size resulted in a decrease in expenditure on primitive and transitional fuels, suggesting a reduced reliance on these sources among larger households and those with higher incomes. Within Bergville, increases in household income resulted in reduced expenditure on primitive and transitional fuels, however, household size had no impact on the above variable. It is important to note that most users of fuelwood, collected this source which is not accounted for in household energy expense. Behera et al. (2015) show that among the poor, there is an increased reliance on collected sources such as fuelwood with increases in household size.

Lastly, household income was positively correlated with the proportion spent on modern fuels in both populations ($p<0.0001$), demonstrating that households with higher incomes spent a higher proportion on sources such as gas and electricity. However, although household size and proportion spent on modern energy sources shared a significant relationship, contrasting trends were noted between Inanda and Bergville. Within Inanda, increases in household size resulted in a higher proportion of household income being spent on modern sources of energy, while results from Bergville did not yield a significant correlation between household size and the amount spent on modern energy sources. It can be argued that increased demand for energy among chronically poor households results in a downward movement along the energy ladders. These results underscore the findings in the literature that indicate that energy use and practices are an outcome of household socio-economic conditions. Furthermore, the dissimilarities between communities, confirmed by results of the correlations, illustrate energy consumption differences along rural urban gradients.

Day et al. (2016) and Kastner and Stern (2015) show that energy consumption is influenced by household preferences and perceptions of specific energy sources. Furthermore, the urban-rural dichotomy in access and distribution of income and other financial resources could lead to more equity in energy consumption (Jorgenson et al., 2010). In this regard, the role of energy policy and interventions are emphasised in securing access to modern energy sources among the poor. Meyar-Naimi and Vaez-Zadeh (2012) argue that sustainable energy policy should reflect on the national development goals that prioritise the poor. Appropriate pricing strategies could provide meaningful shifts in making energy sources such as electricity more financially accessible to the poor (Månsson et al., 2014). Also, fragmented energy policy that fail to include the factors influencing energy insecurity do not effectively reflect the disparities in energy affordability between the rich and poor (Chang & Berdiev, 2011; Tanaka, 2011; Schillebeeckx et al., 2012). Literature establishes that energy use is an outcome of both household and broader socio-economic and political factors thus, the role of government institutions is emphasised in creating suitable options for the poor to access modern, reliable and safe sources of energy.

The energy related theoretical frameworks guiding this study show that household energy use is also influenced by culture and personal preferences. The next section presents specific reasons for household energy choices obtained from the survey. The discussion of respondents' energy choices are complemented by results from the focus groups, specifically participants' views on the main challenges associated with each of the listed energy sources.

5.6 Household energy preferences

The survey probed the reason for households' selection of specific fuel types. According to current energy studies, the selection of household energy sources is influenced by energy needs, affordability, accessibility, household characteristics, and factors such as cultural practices and perceptions towards specific energy sources (van der Kroon et al., 2013; Kastner & Stern, 2015; Day et al., 2016). Results are presented in relation to main sources used by households.

5.6.1 Electricity

The majority of households that used electricity within Bergville (52.6%) and Inanda (46.5%) indicated convenience as the reason for their energy choice. A minority of respondents (1.8%

in Inanda and 0.9% in Bergville) indicated that their decision to use electricity was influenced by cost. Almost equal proportions of households attributed their use to electricity being easily accessible (29.5% in Inanda and 20% in Bergville) and the only option available (29.8% in Inanda and 23.1% in Bergville). Furthermore, a few respondents (10.6% in Inanda and 6.3% in Bergville) attributed their choice to the energy source being efficient.

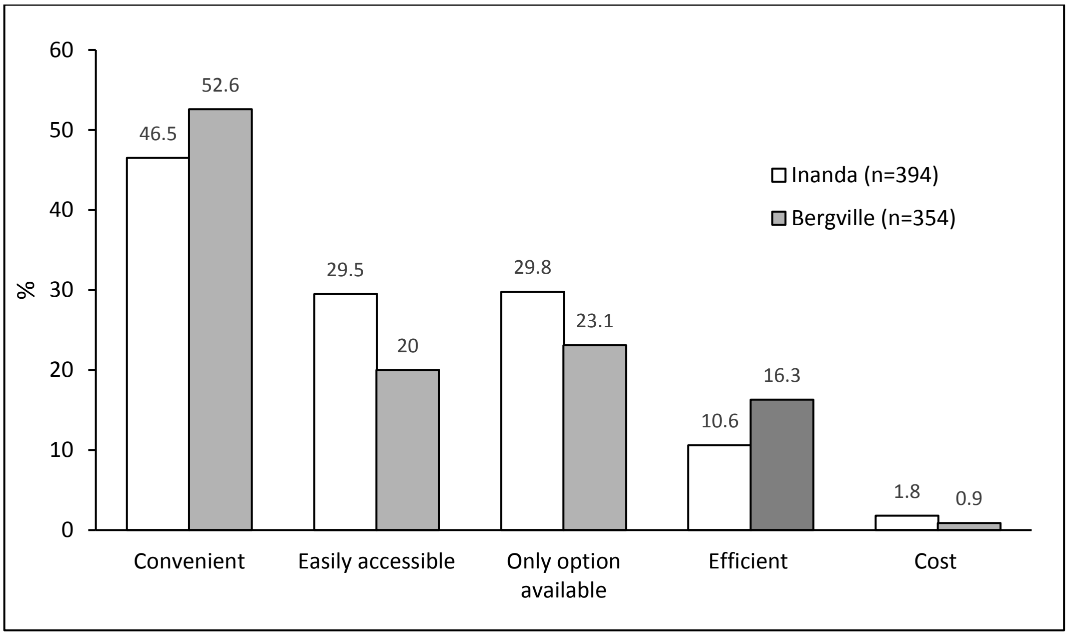

Figure 5.11: Reason for household use of electricity (Multiple responses)

Focus group participants listed cost, load shedding and illegal connections as the main challenges associated with the use of electricity. Illegal electrical connections are a major problem within South Africa, specifically among the lower income settlements where poverty remains high. Studies show that increased energy prices, population growth and significant back-logs in service delivery within poor and peri-urban areas result in an increase in illegal connections (Karekezi, 2002; Karekezi & Majoro, 2002; Bekker et al., 2008). These connections also pose several health risks, especially among children due to exposed wires and risk of electrocution (Smith, 2004).

5.6.2 Fuelwood

Reasons forwarded for reliance on fuelwood differed between communities, with most respondents from Bergville (48.8%) stating that fuelwood was their only option (Table 5.33). Amongst Bergville fuelwood users, 18% noted that the source was easily accessible, and smaller proportions noted convenience (16.4%) and cost (14%) as their reasons. Within

Inanda, 34.9% of households using fuelwood did so because they felt this source was easily accessible. Smaller proportions of this group from Inanda indicated convenience (20.9%) and that fuelwood was the only option available to them (17.4%). Most respondents (34.7%) stated that fuelwood was easily accessible. A further 5% of the respondents identified cost as their reason. A key finding emanating this study is that within Bergville, reliance on fuelwood was mainly attributed to households displaying limited physical and financial access to suitable alternatives. Furthermore, this could explain the increased reliance on fuelwood within Bergville compared to Inanda.

Table 5.33: Reasons for household use of fuelwood (Multiple responses, in %)

Reasons	**Inanda (n=86)**	**Bergville (n=250)**
Convenient	20.9	16.4
Easily accessible	34.9	18
Only option available	17.4	48.8
More efficient	5.8	9.2
Cost	5	14
Safe to use	2.3	-

It is interesting to note that a few respondents (5.8% in Inanda and 9.2% in Bergville) stated that fuelwood was more efficient. During the focus group discussions this was specifically related to cooking in relation to the intensity of the heat generated as well as the taste of the food. A few respondents (2.3%) in Bergville stated that fuelwood was safe to use which is contrary to the literature which highlights the negative health and safety concerns in relation to the use of fuelwood.

These health considerations were noted by focus groups participants as well. The main challenges highlighted by focus group participants include scarcity of forests and woodlots; household members are required to travel longer distances to collect fuelwood, and that the smoke causes a burning sensation in eyes and coughs among children. Five female participants from Bergville shared that the collection of fuelwood is becoming increasingly dangerous because of the electric fences around private farms and the risk of assault. These findings resonate with the literature which shows that women and children are disproportionately disadvantaged by the use of primitive fuels such as fuelwood.

5.6.3 Gas

Among Inanda users, the main reasons for the use of gas were easy access (22.9%), convenience (19%) and efficiency (18.1%) of the source (Table 5.34). Main reasons forwarded by households that used gas in Bergville, were that gas was their only option (33.3%), it was easily accessible (33.3%) and convenience (23.8%). Other reasons were efficiency (18.1% in Inanda and 19% in Bergville) and cost (14.5% in Inanda and 9.5% in Bergville). It is important to note that in comparison to Inanda, the number of households using gas in Bergville was significantly lower (p=0.026; Chi-square test). Both groups of focus group participants noted that the price of gas was a major concern for them. Participants from Bergville stated that gas is not easily available in the community and one would have to travel to the main town to purchase this source. Two participants stated that the lack of transportation is also a factor impacting household selection of energy sources.

Table 5.34: Reasons for household use of gas (Multiple responses, in %)

Reasons	Inanda (n=84)	Bergville (n=24)
Did not disclose	13.1	-
Convenient	19	23.8
Easily accessible	22.9	33.3
Only option available	15.7	33.3
Efficient	18.1	19
Cost	14.5	9.5

5.6.4 Paraffin

Paraffin was used extensively by both populations and the main reasons are illustrated in Figure 5.12. The majority of paraffin users in Inanda (50.8%) noted easy access as the main reason for their choice. This was followed by 26.9% stating that paraffin was their only option and 14.5% who stated that their decision to use paraffin was based on price. Results were slightly different among Bergville users with 43.3% indicating that they did not have another option available to them, and 25.7% noting easy accessibility as their reason. Among paraffin users in both populations, cost (14.5% in Inanda and 20.5% in Bergville), convenience (15.3% in Inanda and 10% in Bergville) and efficiency (9.5% in Inanda and 8.6% in Bergville) were noted as main reasons for their choice.

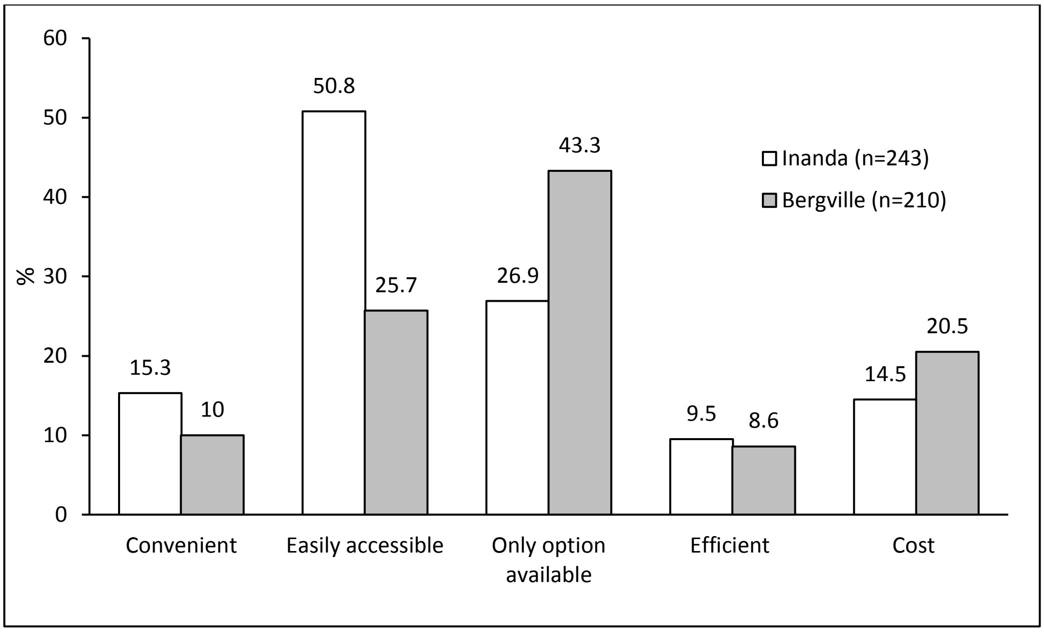

Figure 5.12: Reason for household use of paraffin (Multiple responses, in %)

This is unsurprising as paraffin and fuelwood are relatively cheaper compared to electricity and gas within the country. Focus group participants highlighted safety concerns, health issues and price as the main challenges associated with the use of paraffin. Four participants from Inanda stated that the use of paraffin induces a cough and causes eyes to become red and scratchy. The impacts of paraffin use may be intensified within Inanda due to the high density (6 258/km^2) compared to Bergville (430/km^2). Extensive use of paraffin also raises concern over air quality within these areas.

5.6.5 Candles

Candles were the second most utilised energy sources by both groups of households. The majority of households using candles (28.7% in Inanda and 57% in Bergville) stated that the main reason for their selection was that they did not have another option available to them for lighting services (Table 5.35). This is surprising given that 88.5% of households had access to electricity. Likewise, households stated convenience (22.2% in Inanda and 12.2% in Bergville) and cost (22.7% in Inanda and 19.5% in Bergville) as their main reason for use of candles. These results could suggest many households could not afford to purchase or sustain their use of electricity for all their energy needs, specifically lighting. This finding resonates with the ranks assigned to specific household energy needs during the focus group discussions.

Table 5.35: Reason for household use of candles (Multiple responses, in %)

Reasons	Inanda (n=359)	Bergville (n=344)
Convenient	22.2	12.2
Easily accessible	37.3	18
Only option available	28.7	57
Cost	22.7	19.5

Focus group participants from both Inanda and Bergville indicated that their main challenge with the use of candles is the risk of fires within the households. Participants from Bergville indicated that most households have thatched roofs which are very flammable, while participants from Inanda expressed concern over the ease at which fires could spread given the density. Three female participants from Bergville stated that the use of candles are ineffective and poses threats to them especially at night when using ablution and toilet facilities which are generally located several metres away from the main dwelling. Once again, the results suggest a strong gender bias in the experiences of energy poverty, especially among the Bergville population.

5.6.6 Dung

Dung was only used by a select few household from Bergville. Higher proportions of households stated the following reasons: dung was easily accessible (38.5%), was their only option (35.9%) and that it was cheap (28.2%), as seen in Table 5.36. Other reasons were convenience (12.8%) and efficiency (2.8%). Cattle rearing was a common livelihood practice among Bergville households and could explain the availability of this source. Focus group participants from Bergville stated that the odour was a main challenge associated with the use of this source.

Table 5.36: Reason for household use of dung (Multiple responses, in %)

Reasons	Bergville (n=39)
Convenient	12.8
Easily accessible	38.5
Only option available	35.9
Efficient	2.6
Cost	28.2

As mentioned earlier, 98.5% of households in Inanda and 88.5% of households in Bergville had access to electricity. The fact that many households noted 'only option available' as the main reason for their choice in other energy sources suggests that financial accessibility to energy sources such as electricity and gas is a critical issue within both communities. This study establishes that the lack of affordability and availability of modern energy sources, although more pronounced in Bergville, is attributed to limited household income and larger household sizes. More importantly, these findings suggest that energy planning and programmes anticipated for these communities should also target socio-economic goals, such as job creation and income generating opportunities.

Energy preferences were discussed during the focus group discussions, where participants elaborated on their energy choices. Pairwise ranking tables were used to examine preferences for specific energy sources. Participants from Inanda ranked electricity as their most preferred source of energy as illustrated in Table 5.37. This was followed by gas at rank 2 and paraffin at rank 3. Fuelwood and dung were underscored at ranks 5 and 6, respectively. These preferences were not reflected in household energy profiles. For example, even though participants preferred gas over paraffin, the latter was used more extensively by households. Similarly, even though the majority of households did not use solar, this source was preferred over fuelwood and dung. This again reinforces affordability and accessibility as key influencing variables, rather than household preference.

Table 5.37: Ranking matrix showing energy preferences in Inanda

Source	**E**	**F**	**P**	**G**	**S**	**D**	**Frequency**	**Rank**
Electricity		E	E	E	E	E	5	1
Fuelwood			P	G	S	F	1	5
Paraffin				G	P	P	3	3
Gas					G	G	4	2
Solar						S	2	4
Dung							0	6

With the exception of electricity, participants from Bergville displayed slightly different preferences as seen in Table 5.38. For example, fuelwood was ranked 2nd compared to Inanda participants who preferred gas. Paraffin, solar and dung received equal scores and was ranked 3rd. Gas was the least preferred energy source and was ranked 6th. It is interesting to note that fuelwood was preferred over most energy sources, except for electricity. Unlike Inanda, the scoring of specific energy sources was closely aligned to existing energy profiles. Even though solar was not used by the community, it was preferred over paraffin and gas. Moreover, with the exception of electricity, participants from Bergville preferred primitive fuels such as fuelwood and dung. Participants elaborated that these sources were often collected and therefore preferred.

Table 5.38: Ranking matrix showing energy preferences in Bergville

Source	E	F	P	G	S	D	Frequency	Rank
Electricity		E	E	E	E	E	5	1
Fuelwood			F	F	F	F	4	2
Paraffin				P	S	P	2	3
Gas					S	D	0	6
Solar						D	2	3
Dung							2	3

Participants' preferences for electricity do not align with monthly energy consumption patterns. This could be attributed to the lack of affordability, given the limited incomes or poor accessibility. The latter is evidenced in respondents' perceptions of gas and fuelwood. Results show that preferences or specific fuels may be overpowered by availability and affordability.

5.7 Household energy conservation practices

Given the concern surrounding current energy consumption rates and the associated environmental impacts across the globe, many studies advocate energy conservation practices as a means to improve efficiency (Khan et al., 2014; Sovacool et al., 2015; Thangavelu et al., 2015). West et al. (2010) state that individuals displaying greater concern for the environment are more likely to adopt RETs. In light of this, this study examined household energy conservation practices (Figure 5.13).

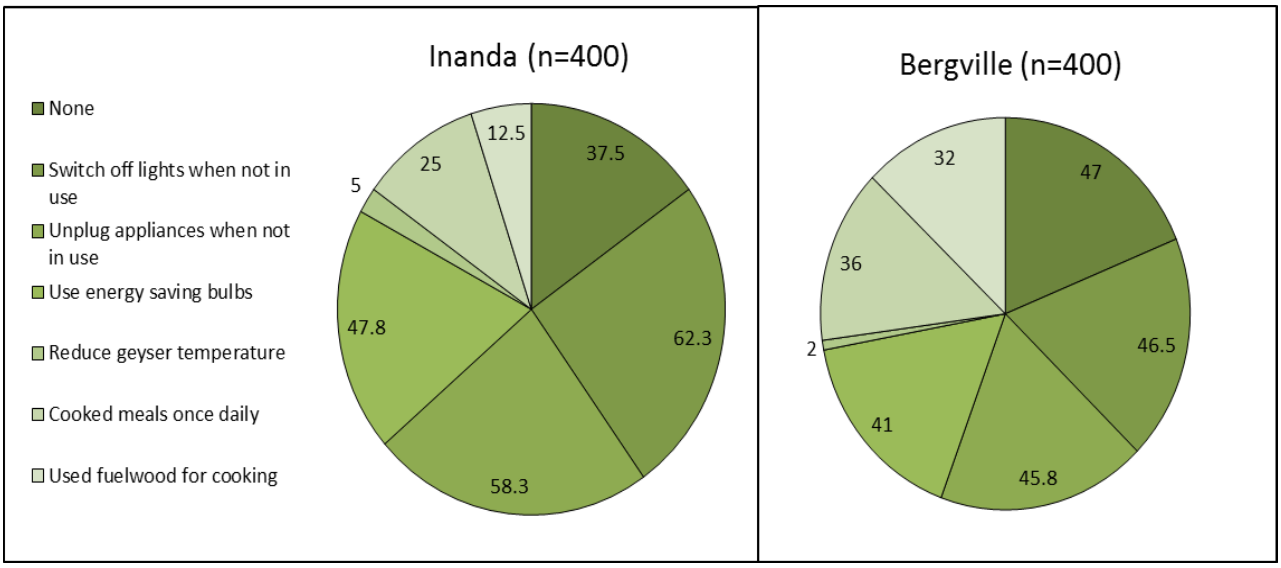

Figure 5.13: Household energy conservation practices (Multiple responses, in %)

Noteworthy proportions of respondents from Inanda (37.5%) and Bergville (47%) indicated that they did not engage in energy conservation practices. The majority of respondents from Inanda (62.3%) and 46.5% of respondents from Bergville stated that they switch off lights when not in use. This was followed by 58.3% and 45.8% of respondents from Inanda and Bergville, respectively, indicating that they conserve energy by unplugging appliances when not in use. Noteworthy proportions from Inanda (47.8%) and Bergville (41%) indicated the use of energy saving bulbs as a means to conserve household energy. It is interesting to note that 25% of Inanda respondents and 36% from Bergville cooked meals once daily in an effort to conserve energy.

Gaye (2007) argues that energy poverty is the inability to cook meals with modern energy sources. This study shows that households changed their cooking practices due to their inability to attain sufficient energy to suit their basic needs. The minority of respondents from both Inanda (5%) and Bergville (2%) stated that they save energy by reducing the geyser temperature. This finding is unsurprising as participants from the focus group discussions shared that many households within the communities do not have geysers. More importantly, the results above show that a noteworthy proportion of households in Inanda and Bergville can be classified as conservative energy users.

In response to the wide-scale disruptions to the supply of electricity experienced within South Africa, specifically load shedding, targeted campaigns have been introduced to build public awareness and encourage more efficient use and conservation of electricity. Energy price and household affordability is noted to influence household consumption (Stephenson et al., 2010; Kowsari & Zerriffi, 2011; Kastner & Stern 2015). However, it can be argued that these campaigns may have also played a role in how energy was consumed by respondents. According to Khennas (2012), Rehman et al. (2012) and Meyar-Naimi and Vaez-Zadeh (2012), public policy and programmes can have a significant impact on household energy practices. Kok et al. (2011) argue that cognitive norms such as the level of concern one displays for themselves or toward others is key in adopting responsible behaviours and may eventually lead to more conservative energy practices. Permeating these studies is a general consensus that human behaviour is seen to influence energy consumption and preferences and is, therefore, an important variable to consider in energy planning and policy.

Energy behaviour studies are increasingly used to inform energy policy. Chapter 2 of this study, through the energy related theoretical frameworks reviewed, demonstrates that energy behaviour can also be influenced by individual perceptions and attitudes towards specific energy sources. The following section presents and discusses perceptions of and preferences for specific renewable energy sources in the context of climate change issues.

5.8 Climate change and energy related perceptions

West et al. (2010) show that individuals' cultural views of the world (for example, fatalistic, individualistic, hierarchist and egalitarian viewpoints) elicit specific perceptions of energy sources. Similarly, Faisers and Neame (2006) postulate that improved awareness of energy production and its environmental impacts may also promote specific attitudes and perceptions. Other studies show that energy related perceptions should be examined against the backdrop of overall environmental awareness (Mallet, 2007; Walker et al., 2010). This study examined awareness and perceptions of climate change as well as current and renewable energy sources.

5.8.1 Climate change

Results show that the majority of respondents from Inanda (62.5%) and Bergville (53%) were familiar with the term climate change as seen in Figure 5.14. Chi-square tests show that significantly higher proportions of males were familiar with the term compared to females (p=0.028). Additionally, most respondents who were familiar with the term climate change displayed higher levels of formal education (p=0.003; chi-square test). A higher proportion of respondents (21.5% in Inanda and 10.5% in Bergville) noted climate change to be a change in weather patterns. Other respondents displayed the perception that climate change is associated with the occurrence of more rains and storm events (13.5% in Inanda and 23% in Bergville), higher temperatures (11.8% in Inanda and 5.8% in Bergville), a change in time and duration of seasons (6% in Inanda and 8.3% in Bergville) and a change in weather due to pollution (4.8% in Inanda and 5.8% in Bergville).

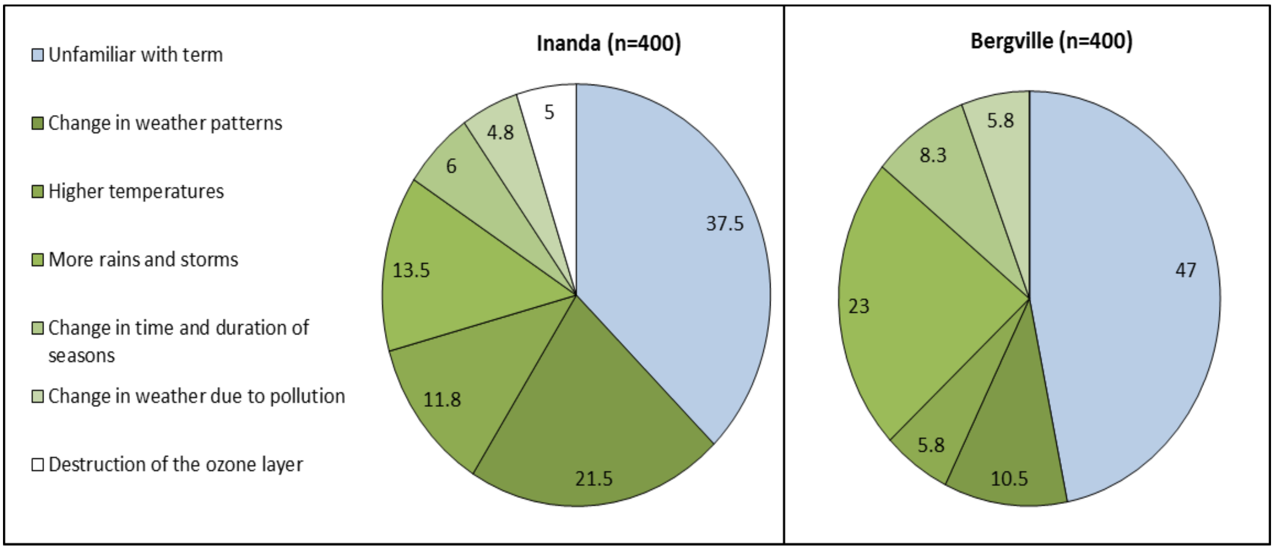

Figure 5.14: Awareness and perceptions of climate change (in %)

Respondents' perceptions of the term align closely to the scientific definitions listed by the IPCC (2007; 2012). Results suggest that despite the differences in levels of formal education, a noteworthy proportion of respondents from both communities displayed an accurate understanding of climate change. Furthermore, it can be said that perceptions of climate change were based on their experiences of environmental change, more specially the amount of rainfall, frequency of storm events and variations in seasons. Broomell et al. (2015) show that the nature of personal experiences of climate change influences local knowledge and may also bring about pro-environmental behaviours. Similarly, Pearce et al. (2015) show that ecological knowledge is derived from experiences. Cheng and Wu (2015) state that understanding of environmental phenomena is directly related to experiences and perceptions of risk. In this study, respondents generally displayed negative perceptions towards climate change. This can be used as a tool to promote the use of more environmentally-friendly options such as renewable energy.

The survey probed on perceptions of main energy sources used by the households, by examining levels of agreement with specific statements. The results are presented thematically in relation to electricity, fuelwood, paraffin, gas and candles. The statements were identified based on key trends emanating the literature, and previous studies on energy related perceptions. The reliability of the Likert scales used (in this study) to examine respondent level of agreement with specific statements were tested by using Cronbach's Alpha reliability statistics.

Table 5.39: Results of the Cronbach's reliability statistics for specific energy sources (n=6)

Energy sources	Inanda	Bergville
Electricity	0.723	0.735
Fuelwood	0.853	0.732
Paraffin	0.712	0.816
Gas	0.753	0.765
Candles	0.733	0.742

The results of this test as illustrated in Table 5.39 and show that for all categories, reliability values were greater than 0.7 which is described as the limit for acceptable reliability. Tests reveal adequate reliability, showing that the scale used to measure level of agreement is reliable. Respondent level of agreement and mean values are presented in tables below. This study used a 5-point Likert scale with the following options: Strongly disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly agree (5).

5.8.2 Electricity

Respondents from Bergville and Inanda displayed similar perceptions of fuelwood. More than 60% (61% in Inanda and 66% in Bergville) strongly agreed with the statement electricity is expensive (Table 5.40). A further 20.5% of respondents in Inanda and 26.3% in Bergville agreed with the statement. Financial inaccessibility to electricity among respondents is further evidenced in their energy behaviour, specifically fuel-switching which was noted as a common practice in both communities. The results obtained in this study highlight concerns, especially in the South Africa context where electricity prices have increased by more than 25% (DoE, 2014).

Table 5.40: Level of agreement with specific statements on electricity (in %)

Statements	Inanda (n=400)						Bergville (n=400)					
	1	2	3	4	5	Mean	1	2	3	4	5	Mean
Is expensive	3.3	4	1	30.8	61	4.86	3	3.5	7.3	20.3	66	4.69
Is bad for health	76.8	6	4.3	5.3	8.3	1.14	40	23.8	12.5	7	16.8	1.36
Is unreliable	20.5	23	14.8	16.3	26.3	3.16	28	23	16.1	5	28	3.61
Causes environmental pollution	41	30	5.8	20.1	4	1.24	39	31	18.1	4.8	7.3	1.38
Inefficient	66.3	15	5.5	7	6.8	1.26	52.8	13.3	12.1	6	16	1.27
Is inaccessible	4	3.5	9	35.3	48.3	4.36	6.5	5	12.8	19	56.8	4.15

(1- Strongly disagree, 2- Disagree, 3-Neutral; 4-Agree; 5-Strongly agree)

Unless overall household income increases within communities such as Inanda and Bergville, electricity may become increasingly inaccessible. The majority of respondents (83.6% in Inanda and 75.8% in Bergville) from both communities agreed and strongly agreed with the statement that electricity is inaccessible to the household. This could reflect physical and financial access, given that a noteworthy proportion of respondents from Bergville were not connected to the electricity grid. A further 66.3% from Inanda and 52.8% from Bergville strongly disagreed with the statement that electricity was inefficient. This resonates with earlier results that show preferences to specific energy sources were based on their ability to service multiple energy needs. It is interesting to note that the majority of respondents from Inanda (71%) and Bergville (70%) disagreed or strongly disagreed with the statement that electricity causes environmental pollution. This indicates that respondents are unaware of how electricity is currently generated in South Africa. According to Faisers and Neame (2006), individuals displaying awareness of the impacts of energy production and use are more likely to adopt renewable energy sources. In this regard, awareness campaigns on climate change and environmental impacts may assist in promoting the use of renewable energies within Inanda and Bergville. Respondent perceptions of electricity, specifically the cost, agree with some of the main challenges highlighted by the focus groups participants.

5.8.3 Paraffin

Paraffin was the third most utilised source of energy among both groups of households. Similar to electricity, most respondents from Bergville (82.8%) and Inanda (83.8%) agreed or strongly agreed with the statement that paraffin is expensive, highlighting costs to be a major concern among households (Table 5.41). Likewise, the majority of respondents from both communities (63.3% in Inanda and 71.3% in Bergville) agreed or strongly agreed with the statement that the use of paraffin was bad for the health. This indicates that even though respondents recognised the harmful impacts associated with the use of paraffin, it was still a commonly used household energy source. Again, these trends highlight that there is a lack of suitable energy sources available to households in Inanda and Bergville. These results underscore the vulnerabilities and risks imposed on households as a result of energy poverty, and further suggests that households had limited energy choices available to them, given their socio-economic status.

Table 5.41: Level of agreement with specific statements on paraffin (in %)

Statements	**Inanda (n=400)**						**Bergville (n=400)**					
	1	**2**	**3**	**4**	**5**	**Mean**	**1**	**2**	**3**	**4**	**5**	**Mean**
Is expensive	3	9.3	4	30	53.8	4.39	3.5	4.5	9.3	21	61.8	4.52
Is bad for health	5	6.3	25.5	25.3	38	4.06	6	8.5	16.8	29.3	42	4.28
Is unreliable	14	15.3	36.6	18.3	16	3.17	23	15.5	7.6	28	26	3.67
Causes environmental pollution	12	15.3	12.3	27	33.8	3.62	12	21	31.9	14	21.3	3.45
Inefficient	29	35.8	16	10	9.3	1.83	24	25.3	5	27	18.8	2.66
Is inaccessible	13	11.3	22.3	27	26.8	3.56	12	9	11.3	40	28.5	4.13

(1-Strongly disagree, 2-Disagree, 3-Neutral; 4-Agree; 5-Strongly agree)

In this regard, Bergville respondents displayed higher dissonance to paraffin being reliable and easily accessible compared to respondents from Inanda. In relation to efficiency, a higher proportion of respondents from Bergville (45.8%) agreed with the statement that paraffin is inefficient compared to Inanda (53.8%). Mean values show that overall perceptions of paraffin were similar between communities with some variations noted in level of agreement with paraffin being inaccessible (3.56 in Inanda and 4.13 in Bergville), inefficient (1.83 in Inanda and 2.66 in Bergville) unreliable (3.17 in Inanda and 3.67 in Bergville) and causes environmental pollution (3.62 in Inanda and 3.45 in Bergville). Mean values for level of agreement show that slightly more respondents from Inanda perceived the use of paraffin to cause environmental pollution, while most respondents from Bergville remained neutral. Energy studies describe paraffin as a transitional fuel which is often used as an indicator of progression and retrogression in relation to energy hierarchies (Sola et al., 2016). Furthermore, the use of transitional fuels can also reflect changes in household energy security (Mensah & Adu, 2015; Sola et al., 2016).

5.8.4 Fuelwood

A noteworthy proportion of respondents from Inanda (49.3%) strongly disagree or disagreed with the statement that fuelwood is expensive while the majority of respondents from Bergville (73.8%) strongly agreed or agreed with this statement (Table 5.42). This is expected given the disproportionate use of fuelwood between communities. More than 60% (61.3% in Inanda and 67.8% in Bergville) strongly agreed or agreed with the statement that the use of fuelwood was bad for the health. These trends align with earlier statements made by the focus group participants. Despite these perceptions, a significantly larger group of respondents from Bergville used this source on a daily basis. These results demonstrate that regardless of the impacts associated with household fuelwood consumption, many household continued their reliance on this energy source suggesting that poverty and affordability have a more pronounced impact on household energy behaviour.

Table 5.42: Level of agreement with specific statements on fuelwood (in %)

Statements	Inanda (n=400)						Bergville (n=400)					
	1	2	3	4	5	Mean	1	2	3	4	5	Mean
Is expensive	33.5	15.8	22.8	12	16	2.14	10.8	5.3	10.3	34.8	39	4.31
Is bad for health	9	6	23.8	10	51.3	4.82	10	9.8	12.8	33.8	34	4.27
Is unreliable	16	11.5	29.5	15	28	3.86	20	16.3	23.5	12.3	28	2.78
Causes environmental pollution	4	8.8	6.8	31	49.8	4.34	5	5.6	12.9	29.8	47	3.93
Inefficient	45	27	9	7	12	1.26	23	42.3	10	10	15.3	1.84
Is inaccessible	12	7	11.8	36	33.3	4.61	10	7.3	14.8	31	37.3	4.37

(1-Strongly disagree, 2-Disagree, 3-Neutral; 4-Agree; 5-Strongly agree)

Both groups of respondents displayed similar perceptions in relation to the accessibility of fuelwood with the majority (69.3% in Inanda and 68.3% in Bergville) strongly agreeing and agreeing with the statement that fuelwood is inaccessible. Interestingly, most respondents from Bergville (65.3%) and Inanda (72%) strongly disagreed and disagreed with the statement that fuelwood was inefficient. This could have been influenced by the fact that households stated multiple uses for fuelwood, for example, cooking and heating. Contrarily, Kaygusuz (2011) shows that fuelwood is less efficient compared to gas and electricity. Respondent perceptions could also reflect the influence of culture and tradition on household energy choices. A further 80.8% of respondents from Inanda and 76.8% from Bergville strongly agreed with the statement that fuelwood causes environmental pollution. This shows that the majority of respondents were familiar with the health and environmental impacts associated with the use of fuelwood.

5.8.5 Gas

The majority of respondents from Inanda (69.8%) and Bergville (76.8%) agreed or strongly agreed with the statement that gas was expensive. Overall both groups of respondents perceived modern sources such as gas and electricity to be more expensive. Furthermore, the disparate consumption of modern energy sources between populations confirm that rural communities in particular, display increased energy related vulnerability and insecurity. In terms of health impacts, most respondents (70% in Inanda and 64% in Bergville) agreed or strongly agreed with the statement that gas was bad for the health. However, noteworthy percentages of respondents from Inanda (47.5%) and Bergville (57.5%) disagreed or strongly disagreed with the statement that gas is an inefficient energy source.

Table 5.43: Level of agreement with specific statements on gas (in %)

Statements	Inanda (n=400)						Bergville (n=400)					
	1	**2**	**3**	**4**	**5**	**Mean**	**1**	**2**	**3**	**4**	**5**	**Mean**
Is expensive	13	8.3	9	29.8	40	4.31	8.8	6.5	8.1	28.5	48.3	4.78
Is bad for health	14.3	9.5	6.3	32	38	4.11	10.8	8.8	16.9	30	34	3.91
Is unreliable	22.8	19	19	15.5	24	3.12	20	18.8	26.9	12	22.6	3.21
Causes environmental pollution	9	9.3	28.5	30.5	22.8	3.35	14.3	9.5	20.5	32.5	23.8	3.15
Inefficient	22.5	25	11.3	18.8	23	2.36	30	27.5	6.8	18	17.8	1.70
Is inaccessible	3	9	14.3	26	47.8	4.62	11	7.5	7.3	21	53.6	4.32

(1-Strongly disagree, 2-Disagree, 3-Neutral; 4-Agree; 5-Strongly agree)

More than 73% of respondents from Inanda (73.8%) and Bergville (74.6%) strongly agreed or agreed with the statement that gas was inaccessible. This shows that modern energy sources may be physically and financially inaccessible to low-income households within peri-urban and rural communities. Results from the focus group discussions presented earlier attribute these perceptions to a lack of transportation and the cost of gas, illustrating that physical and financial accessibility to gas was a concern for both groups of respondents. A further 28.5% of respondents from Inanda and 20.5% from Bergville neither agreed nor disagreed with the statement that gas causes environmental pollution. These perceptions suggest that respondents may be unfamiliar with the impacts associated with the use of gas.

Perceptions displayed by respondents from Inanda and Bergville were generally similar, highlighted by mean values for levels of agreement presented in Table 5.43.

5.8.6 Candles

Candles were the second most commonly used energy source by both populations. Respondents from Inanda and Bergville showed consensus in their dissention (that is disagreed and strongly disagreed) with the statements that 'candles cause environmental pollution' (58.5% and 51.5%, respectively) and 'candles are inefficient' (57.5% and 60.5%, respectively) (Table 5.44). Respondent perceptions of the efficiency of candles align with findings by Kaygusuz (2011) who states that candles showed the least luminosity of all energy sources commonly used by households. Interestingly, mean value for level of agreement with the statement 'candles are bad for the health' suggest that higher proportions of respondents from Inanda (46%) and Bergville (47.3%) did not agree with the statement. This suggests that respondents are unaware of the health and fire risks associated with the use of candles as indicated by Denton (2002) ad Modi et al. (2006).

Table 5.44: Level of agreement with specific statements on candles (in %)

Statements	**Inanda (n=400)**						**Bergville (n=400)**					
	1	**2**	**3**	**4**	**5**	**Mean**	**1**	**2**	**3**	**4**	**5**	**Mean**
Is expensive	44.8	12.3	3.3	19.8	20	1.89	23.3	7.8	3.3	26.8	39	3.86
Is bad for the health	18	28	14.5	20	19.5	2.63	24	23.3	17	19	16.8	2.32
Is unreliable	34	14.3	12	21.3	18.5	2.79	26	25.3	20.3	10	18.5	2.62
Causes environmental pollution	32	26.5	15.5	12	14.5	1.57	35.5	16	16.3	13	19.5	1.81
Inefficient	35	22.5	9.5	16	17	1.42	34.5	26	8.5	12	19.3	1.55
Is inaccessible	23.3	45.5	5	14.5	12.3	2.13	13	9.3	8.5	16	53.5	4.30

(1-Strongly disagree, 2-Disagree, 3-Neutral; 4-Agree; 5-Strongly agree)

These results do not support results from the focus group discussions where participants indicated that candles pose a threat to life due to risk of fires. In this case, household energy needs could have outweighed risk. Results show that that the majority of respondents from Bergville (69.5%) agreed or strongly agreed with statement that candles are inaccessible, Respondents from Inanda displayed divergent opinions, where the majority (68.8%) disagreed or strongly disagreed with this statement. Similarly, 57.6% of respondent from Inanda disagreed or strongly disagreed with the statement that candles are expensive while

65.8% or respondents from Bergville agreed or strongly agreed with this statement. This underscores the rural-urban differences highlighted in relation to energy access as well as affordability.

5.8.7 Renewable energy sources

Additionally, the survey probed respondents' perceptions and level of awareness of renewable energy sources with a focus on solar, given the large-scale emphasis on the latter within South Africa. Most perception-based studies focus on willingness to pay and adopt RETs (Farhar, 1994; Wüstenhagen et al., 2007; Rogers et al., 2008; Cass et al., 2010; West et al., 2010). With the exception of Kishore and Kisiel (2013), who examined perceptions of solar energy among high school students, to the best of the researcher's knowledge there has been a dearth of studies that interrogate perceptions of specific terms such as solar energy among potential users. The researcher is of the opinion that understanding the perceptions and knowledge of specific energy sources may inform implementation strategies, as these can also reflect user capabilities and preferences. Furthermore, the literature shows that households tend to rely on known sources of energy (Stephenson et al., 2010; Kowsari & Zerriffi, 2011; van der Kroon et al., 2013). Establishing a status quo in relation to awareness and attitudes towards renewable energy sources can assist in formulating specific awareness campaigns. Improving local knowledge and awareness of renewable energy sources may allow for energy users, specifically the poor who are most at risk to the impacts of energy poverty, to make more informed decisions in relation to their selection of household energy sources.

The majority of the respondents (75.3% in Inanda and 75.6% in Bergville) were not familiar with the term 'renewable energy' (Table 5.45). Chi-square tests revealed that awareness of renewable energy was most prevalent among individuals with higher levels of formal education ($p<0.0001$). Moreover, a higher proportion of males were familiar with the term compared to females ($p=0.041$). These findings correspond with respondents' socio-demographic characteristics which show that more male respondents displayed higher levels of formal education.

Table 5.45: Respondent awareness of renewable energy (in %)

Awareness	Inanda (n=400)	Bergville (n=400)
Yes	24.8	24.5
No	75.3	75.6

Respondents indicating awareness of renewable energy provided specific descriptions of their perceptions as seen in Table 5.46. Most of these respondents from Inanda (64.6%) defined renewable energy as another form of electricity. Close to a third of the respondents (32.7%) from Bergville and 24.2% from Inanda considered it to be ‘energy derived from nature’. This was followed by smaller groups from both communities citing ‘cheaper form of energy’ (18.2% in Inanda and 13.3% in Bergville). ‘Energy that is free’ (12.1% in Inanda and 15.3%) in Bergville), ‘energy that works with the sun’ (12.1% in Inanda and 12.2% in Bergville), ‘energy that is safer’ (4% in Inanda and 18.4% in Bergville), and 14.1% of respondents from Inanda stated that renewable energy use was a ‘way of saving electricity’. The main elements underpinning respondent perceptions of renewable energy were cost and modes of production, reflected specifically in their belief that renewable energy would be cheaper or free, and this type of energy is derived from natural sources, for example, the sun.

It is interesting to note that very respondents associated renewable energy with the sun. Furthermore, almost the same responses were noted for Inanda and Bergville despite solar energy projects being implemented in Inanda. This indicates that solar energy projects are implemented intermittently in Inanda (that is, it is not wide spread) and / or that ‘solar’ is not well understood in the community.

Table 5.46: Respondents’ definitions of renewable energy (Multiple responses, in %)

Perceptions	Inanda (=99)	Bergville (n=98)
Energy that is free	12.1	15.3
Another form of electricity	64.6	43.9
A way of saving electricity	14.1	-
Cheaper form of energy	18.2	13.3
Energy that is derived from nature	24.2	32.7
Energy that is safer	4.0	18.4
Energy that works with the sun	12.1	12.2

The misconception that renewable energy is free because it is derived from natural sources may present a problem for future programmes that require capital investment and/ or buy-in from users. Furthermore, these perceptions may influence willingness to pay for specific

RETs. Bastakoti (2003) illustrates that when dealing with novel energy carriers and technologies such as RETs, perceptions among end-users vary considerably and can be a major obstacle in adoption and implementation phases. Similarly, Mondal et al. (2010) assert that limited levels of awareness on RETs produce difficulties during implementation, as individuals may have difficulties incorporating unfamiliar technologies in their daily routine.

In addition to their perceptions, these respondents also specified their main source of information, listed in Table 5.47. Results show slight differences in the main sources of information between communities. For example, the majority of respondents (64.6%) within the Bergville subgroup obtained their information on renewable energy through word of mouth from family/ friends or other community members. This was followed by radio (29.3%) and television sources (28.7%). Close to 60% of Inanda respondents who indicated awareness of renewable energy, received their information from television (59.8%) and family/ friends or community members (56.3%). Smaller proportions from Inanda noted radios (39.7%), and magazines and newspapers (19.6%). Approximately 13% from Inanda (13.8%) and Bergville (13.4%) listed 'school' as their main source of information.

Table 5.47: Sources of information for renewable energy (Multiple responses, in %)

Main source of information	Inanda (n=99)	Bergville (n=98)
Radio	39.7	29.3
Television	59.8	28.7
Magazine/ Newspaper	19.6	6.7
Books	4	1.8
Internet	2.7	1.8
School	13.8	13.4
Family /community members/ friends	56.3	64.6

According to Fasier and Nemae (2006) and Munien (2014), television, radio, newspapers, and pamphlets can be used as effective tools for the dissemination of information and can assist in framing RETs as marketable and attractive alternatives to consumers. Likewise, Mfune and Boon (2008) highlight the importance of suitable media platforms for the dissemination of information to improve local awareness and knowledge of renewable energy. Mallet (2007) states that improved awareness and knowledge on renewable energy devices and carriers are vital in facilitating social acceptance among targeted users. However, results suggest that electronic-based media such as television and radio may reach a wider audience in communities like Inanda, whereas pamphlets and workshops may be better suited to Bergville. Further, these results highlight the limited connectivity and access to modern forms of communication, especially the internet which is a main and increasing source of information in developed contexts.

In understanding respondent perceptions, the survey also probed awareness of benefits or problems associated with the use of renewable energy (Figure 5.15). Respondent perceptions of renewable energy benefits differed between communities. For example, most respondents from Bergville (65.2%) noted that renewable energy was cheaper than their current sources this was followed by the perception that renewable energy was safe to use (43.5%). An equal proportion of respondents from Bergville (34.8%) noted that renewable energy was environmentally-friendly and reliable. Most respondents from the Inanda group felt that renewable energy was cheaper and environmentally-friendly (48.8%). A smaller proportion from Inanda (29.3%) were under the impression that renewable energy did not impact health negatively (29.3%), was safe to use (14.6%) and reliable (17.1%).

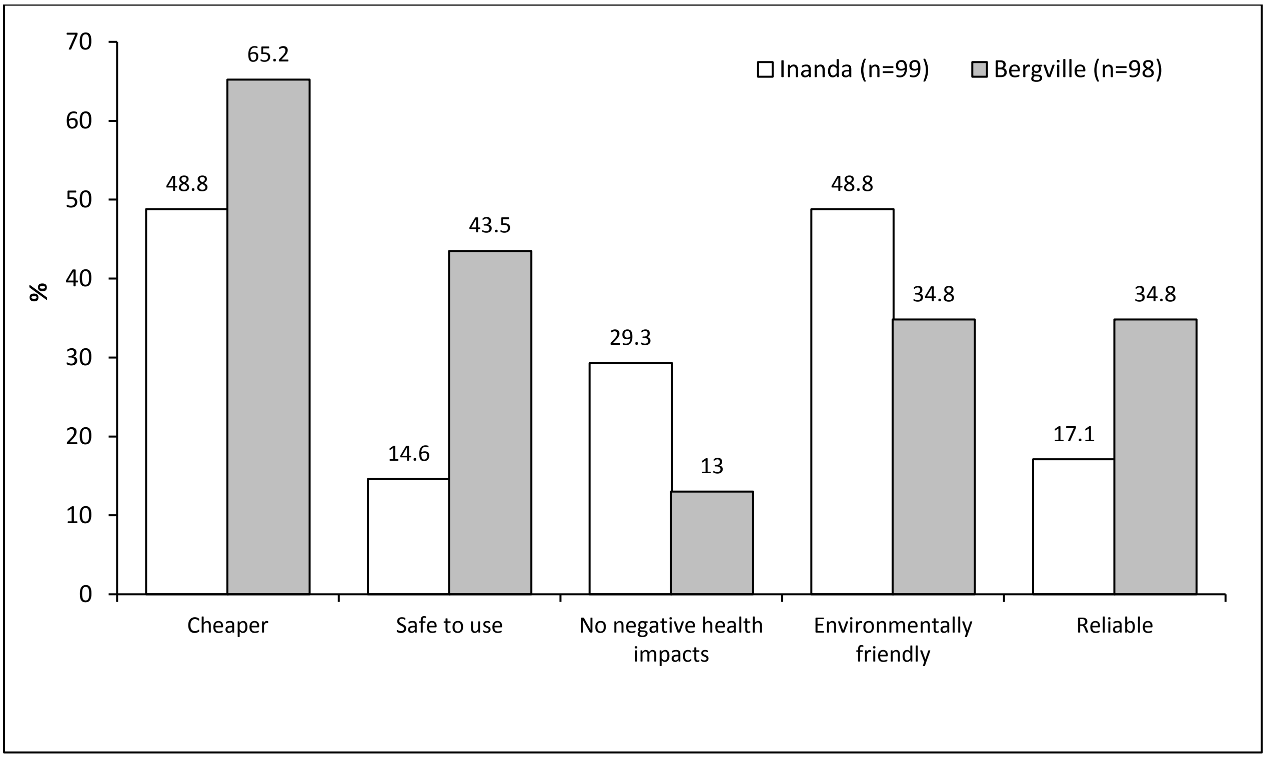

Figure 5.15: Perceived benefits of renewable energy

Once again the perception that renewable energies are cheaper than conventional sources emerges very strongly among respondents. As mentioned earlier, this may impact future renewable energy initiatives, especially in relation to uptake and purchase of RETs. More specifically, the use of RETs in the low-income context of South Africa centres on SWHs. These devices are preinstalled in many homes constructed through the Reconstruction and Development Programme (RDP), which focuses on providing homes for the poor in marginalised or previously disadvantaged communities. Furthermore, the price of these devices are heavily subsidised for the low-income groups. These initiatives could have contributed to RETs being perceived as being cheaper. Additionally, a noteworthy proportion of respondents from both communities perceived renewable energy to be safe to use (14.6% in Inanda and 43.5% in Bergville).

South Africa currently undergoes planned power cuts in an attempt to conserve electricity (load-shedding) and the use of devices such as SWHs during these power cuts could have influenced the perception that renewable energy is reliable. Given that family/ friends and other members of the community were noted as one of the main sources of information on renewable energy, respondent perceptions of renewable energy could have been influenced by their personal experiences or that of their family/ friends and other community members. Reddy and Painully (2004) show that the utility, cost and quality of RETs, compared to conventional technologies, are key factors influencing how these energy sources are perceived by the public.

The majority of the respondents (78.8% in Inanda and 69.4% in Bergville) who were aware of renewable energy did not identify any challenges. The rest (21.2% in Inanda and 30.6% in Bergville), specified their perceptions of main challenges (Table 5.48). Among the Bergville group, respondents stated that renewable was not available locally (18.4%), unreliable (14.3%) and difficult to use (10.2%). A minority from Bergville found renewable energy to be expensive (5.1%), too time consuming to use (5.1%) and associated with high maintenance costs (5.1%). Respondents from the Inanda group indicated that renewable energy was unreliable (20.2%), expensive (19.2%) and had high maintenance costs (15.2%). This was followed by smaller proportions citing the lack of availability locally (7.1%), too time consuming (6.1%) and difficult to use (4.1%).

Table 5.48: Awareness of the types of problems associated with alternate energy (Multiple responses, in %)

Challenges	Inanda (n=99)	Bergville (n=98)
None	78.8	69.4
Not found locally	7.1	18.4
Too expensive	19.2	5.1
Does not work all the time / unreliable	20.2	14.3
Too time consuming	6.1	5.1
Difficult to use	4.1	10.2
High maintenance costs	15.2	5.1

Although the minority of respondents from both communities listed challenges associated with the use of renewable energy, these perceptions align with findings from other developing countries. For instance, Masini and Menichetti (2013) show that usability and maintenance were the main challenges cited by RET users. Others such as Miller et al. (2015) show that the main concerns among RET users were that the device was unreliable, was too time consuming to use and did not permit multiple uses. Several studies show that user perceptions of renewable energy sources and devices are influenced by factors such as age, income, level of education and environmental concern (Ek, 2005; Ku & Yoo, 2010; Zogarafakis et al., 2010; Masini & Menichetti, 2013). However, these aspects could not be established within this study, given the overall limited levels of awareness displayed by both groups of respondents. Additionally, even though a relatively small proportion of respondents from both communities displayed awareness of renewable energy, the majority of these individuals exhibited positive attitudes and perceptions. Chaurey and Kandpal (2010) demonstrate that understanding levels of awareness, perceptions and attitudes of potential users towards RETs can highlight valuable information that can improve implementation and up-take. Moreover, the limited level of awareness in this study can be seen as an opportunity to inform opinions rather than modify them, which can be a more difficult task.

In light of the current drive towards solar energy sources and devices within the country, this study set out, in part, to examine perceptions and attitudes towards solar energy. In an attempt to promote sustainable energy consumption and improved access to energy services among the poor, solar energy, more specifically SWHs and PV panels are being widely implemented throughout the country (Sebitosi & Pillay, 2008; DoE, 2014). However, implementation has been met with multiple difficulties (Winkler, 2007; Lemaire, 2011; Msimanga & Sebitosi, 2014; Baker, 2015; Nakumuryango & Inglesi-Lotz, 2016). This study examined levels of awareness, attitudes and perceptions towards solar energy specifically, discussed in the subsequent section.

5.8.8 Solar energy

Survey data shows that the majority of respondents (72.3%) from Inanda and 54% from Bergville indicated that they were familiar with the term solar energy (Figure 5.16). Chi-square tests revealed that there were significant differences in the levels of awareness between communities ($p<0.0001$), with a higher proportion of respondents from Inanda being familiar with solar energy. This trend could be a consequence of the fact that SWHs and PV panels are mostly installed within urban and peri-urban communities within South Africa, resulting in increased exposure to RETs in these areas, specifically. Further testing revealed that a significantly higher proportion of these individuals were female ($p=0.014$). Additionally, a significant proportion of these individuals were between the ages of 18-45 years ($p=0.006$), illustrating that older respondents displayed limited levels of awareness of solar energy. Moreover, chi-square tests showed significant differences in the level of awareness across education categories, showing that respondents with improved levels of formal education were more familiar with solar energy ($p<0.03$). It was also evident that age, level of education and gender may be important variables to consider when examining levels of awareness.

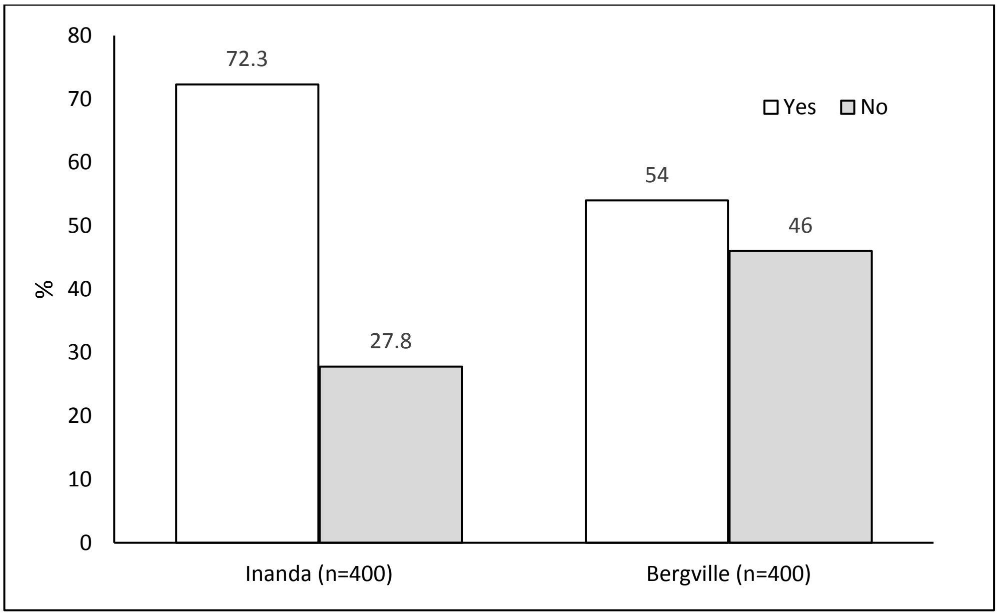

Figure 5.16: Respondent level of awareness of solar energy

Respondents were asked to describe their perceptions of solar energy. These were coded and are illustrated in Figure 5.17. Most respondents from Bergville (50.5%) and Inanda (54.7%) explained solar energy to be a form of electricity from sunlight. This was followed by the perception that solar energy was energy from the sun (32.9% in Inanda and 36.1% in Bergville). There were no significant differences in respondent perceptions of solar energy between communities (p=0.18; chi-square tests). Respondent perceptions of solar energy closely align with accepted scientific definitions. It is interesting to note that approximately 25% of respondents noted that they were familiar with the term renewable energy, however, more that 50% of respondents stated that they were aware of solar energy. These findings suggest the respondents could not make the link between solar and renewable energy.

A minority of respondents from Inanda (11.8%) and Bergville (8.8%) stated that solar energy was used to warm water. As mentioned earlier, it is not uncommon for individuals' perceptions to be influenced or entirely based on experiences. Solar energy devices most commonly used within the South African context is the SWH therefore, it is unsurprising that a small group of respondents from both Inanda and Bergville associated solar energy with the process of heating water. Furthermore, a minority of respondents from both communities (4.5% in Inanda and 8.3% in Bergville) indicated that solar energy was 'energy from nature'.

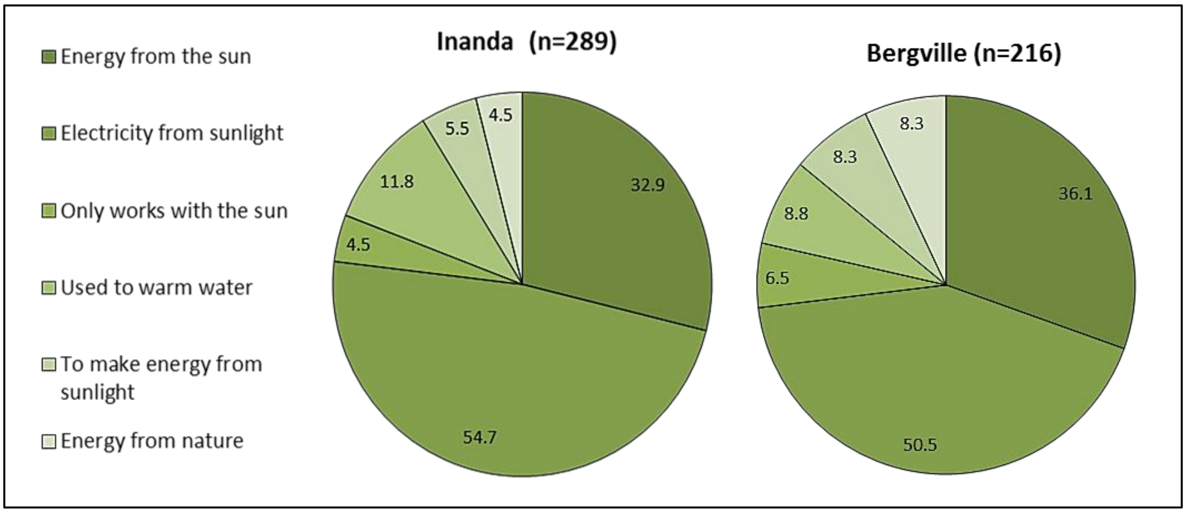

Figure 5.17: Respondent perceptions of solar energy (Multiple responses, in %)

According to Mallet (2007), social acceptance is another important factor influencing uptake and perceptions of RETs which can be understood by examining willingness to pay for these devices. The majority of respondents from both communities displayed a willingness to pay for solar energy (Table 5.49). This finding highlights significant potential in extending the use of renewable energy, specifically solar within Inanda and Bergville. Individuals displaying a willingness to pay for solar energy on a monthly basis also provided an estimated amount (in Rands), as seen in Table 5.50.

Table 5.49: Respondents willingness to use solar energy (in %)

Willingness	**Inanda (n=400)**	**Bergville (n=400)**
Yes	87	87.8
No	13	12.3

The majority of respondents (87% in Inanda and 87.85 in Bergville) displayed a willingness to use solar energy. This shows significant potential for the future implementation and use of solar energy within the Inanda and Bergville communities. Additionally, all respondents who indicated willingness to use solar energy also displayed a willingness to use this source on a monthly basis. These results are presented in Table 5.50.

Most respondents from Bergville indicated a willingness to pay between R50-R100 (44.5%), and R101-R200 (45.1%) per month for solar energy. Respondents from Inanda provided slightly different values, with most (42.6%) specifying an amount between R101-R200 per month. A higher proportion of respondents from Inanda were willing to pay between R201-R300 per month for solar energy, compared to Bergville (10.4%). Mean monthly estimates were lower in Bergville (R86.21 compared to Inanda (R124.56). The amounts indicated by respondents could have been influenced by their limited monthly income. However, despite the fact that most respondents noted limited monthly incomes, they did express a willingness to pay which can be viewed as an opportunity for the use and introduction of renewable energy sources within both these communities.

Table 5.50: Amount (in Rands) respondent is willing to pay per month for solar energy (in %)

Amount	**Inanda (n=348)**	**Bergville (n=351)**
R50-R100	38.1	44.5
R101-R200	42.6	45.1
R201-R300	18.2	10.4
Mean	**R124.56**	**R86.21**

Respondents who indicated unwillingness to use solar energy provided reasons for their choice (Table 5.51). Main reasons forwarded by respondents differed between communities, with most respondents from the Inanda group stating that solar energy was inconvenient to use (46.2%). Similarly, 11.5% of the Bergville group noted 'inconvenient to use'. This is expected since most experiences of solar energy among respondents from Inanda were related to PV panels and SWHs that function optimally during sunny days only. One of the major challenges associated with these solar devices is the limited functionality at night and during winter months when solar radiation levels are the lowest (Mawire et al., 2010). More than a third of the respondents (34.6%) in Inanda highlighted theft as the main reason. Main reason forwarded by the Bergville group of respondents was the lack of accessibility (26.1%), high costs (11.5%) and unreliable (10.8%). A noteworthy proportion from both communities (21.1% in Inanda and 39.1% in Bergville) could not provide a reason for their unwillingness to use solar energy. A further 17.3% of respondents from Inanda and 26.1% from Bergville stated that solar energy was not easily accessible and were therefore unwilling to use this source. These aspects were probed during the focus group discussions.

Table 5.51: Reasons for unwillingness to use solar energy (multiple response, in %)

Main reasons	Inanda (n=52)	Bergville (n=49)
Did not disclose	21.1	39.1
Not easily accessible/ available	17.3	26.1
Too expensive	11.5	11.5
Inconvenient to use	46.2	11.5
Too time consuming	11.5	6.5
Unreliable	15.4	10.8
Theft	34.6	-

In relation to theft, participants from Inanda stated that households with SWHs have complained that steel pipes and sheeting were stripped and sold as scrap metal. As a result households spend more money repairing the heaters. Additionally, 2 participants stated that the heat pumps on the device were also susceptible to theft and it was the component most prone to failure. Furthermore, 7 participants from Bergville and 9 from Inanda stated that some households do not want solar because they do not want to be classified as poor. These findings echo respondents' association of the use of renewable energy with poverty, mentioned earlier. This is unsurprising given that SWHs have been mainly implemented within the low-income communities across the country. Moreover, these findings demonstrate the impacts of perceptions on willingness to purchase and use RETs such as solar-water heaters.

During the focus groups discussions participants identified most suitable and priority areas for the installation of solar energy. Participants from Inanda identified these areas to be Inanda Condo, Langalibalele C, Inanda SP, Lindley, Ekafuleni A, Tafula Inanda and Amatikwe Area 9, as seen in Figure 5.18.

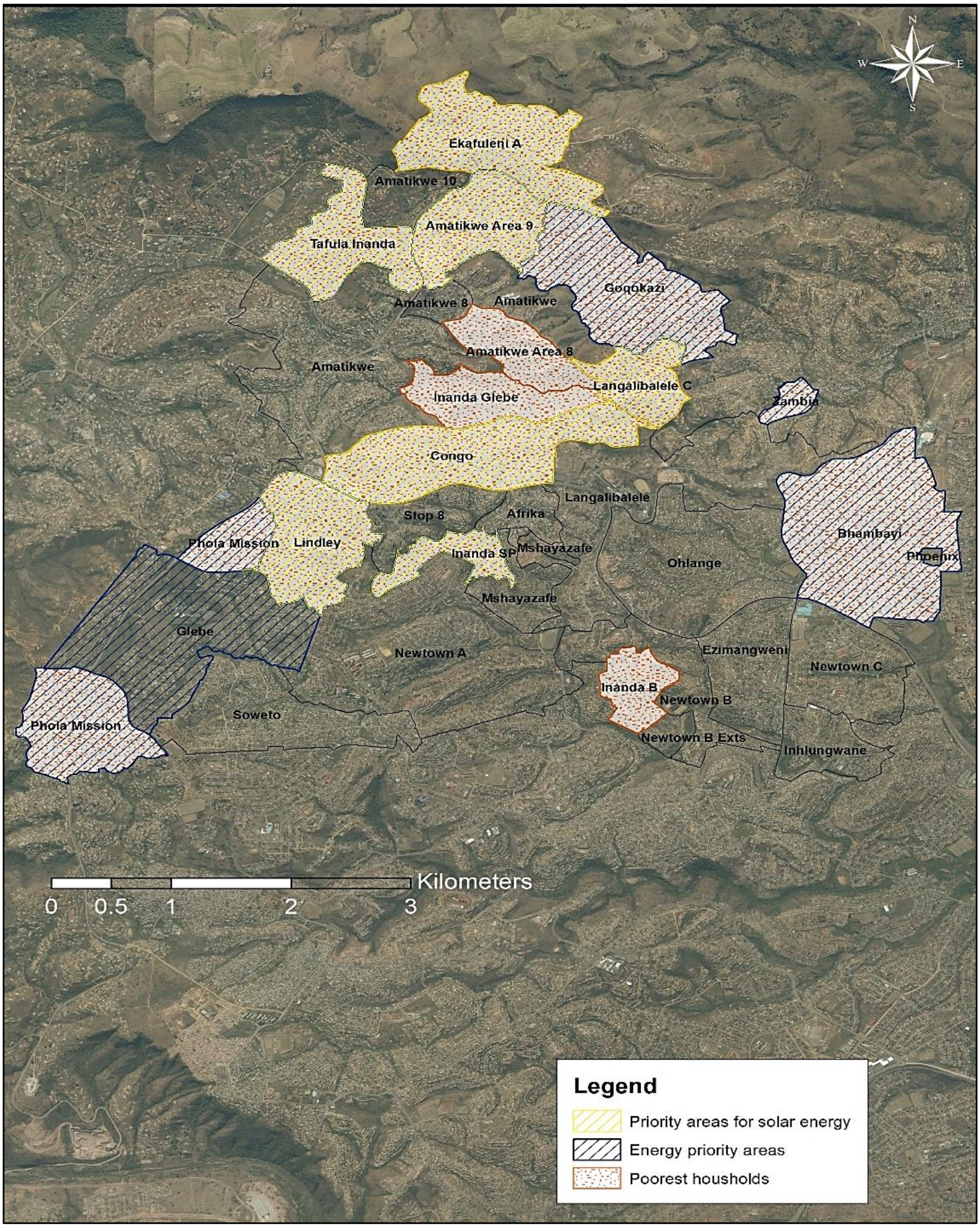

Figure 5.18: Perceptions of most suitable areas for solar energy in Inanda (Author, 2016)

Participants forwarded the main reason for their choice, for example, areas such Inanda SP and Amatikwe Area 9, was that they have a high proportion of retired individuals and purchasing energy on a monthly basis would be expensive and burdensome. The Tafula and Ekafuleni areas were described to have high proportions of fuelwood and candle users because many households could not afford to purchase electricity regularly. Similarly, in areas such as Inanda Congo, Langalbalele C and Lindley, unemployment rates were very high. Participants also noted that the Bhambayi area houses many poor households that are in need of energy, however, solar energy devices such as the SWHs will not be applicable. Participants added that houses in this area cannot support solar devices because there are mainly informal dwellings and the roofs and walls are not strong enough. Suitable areas identified for the implementation of solar energy was closely aligned with their perceptions of the poorest and most vulnerable areas. Furthermore, participants displayed some understanding of the physical requirements for the installation of solar energy, highlighted in their description of household characteristics.

The same exercise was carried out with participants from Bergville (Figure 5.19). Participants from Bergville identified Moyeni, Rookdale, Woodford, Bethany and Acton Homes for two main reasons. Firstly, these areas have formal housing structures which are suitable for the use of PV panels and SWHs. Secondly, these regions were perceived to consume the most energy within the community. Furthermore, participants noted that Mkukwini, Hoffenthal/ Kwama, Mhlwazini and Stulwane are most suitable due to the high levels of poverty and unemployment, but also many homes within these areas are not connected to the main electricity grid. Similar to the findings in Inanda, suitable areas identified within Bergville were closely aligned with participants perceptions of the poorest and most vulnerable areas as well as structural characteristics of dwellings deemed important for the installation of solar technologies.

Interestingly, participants from Bergville were of the opinion that households that use more energy should switch to solar. It can be argued that participants from Bergville displayed more conservative energy behaviours. This is further evidenced in their energy conservation practices, discussed earlier. More than 30% of the respondents from Bergville cooked meals once daily and used fuelwood in an attempt to conserve energy, more specifically electricity. According to Stephenson et al. (2010), the level of comfort and daily routine are important factors influencing household energy practices and choices. Similarly, conservative and low-income energy users are more willing to sacrifice their level of comfort (Stern, 2000).

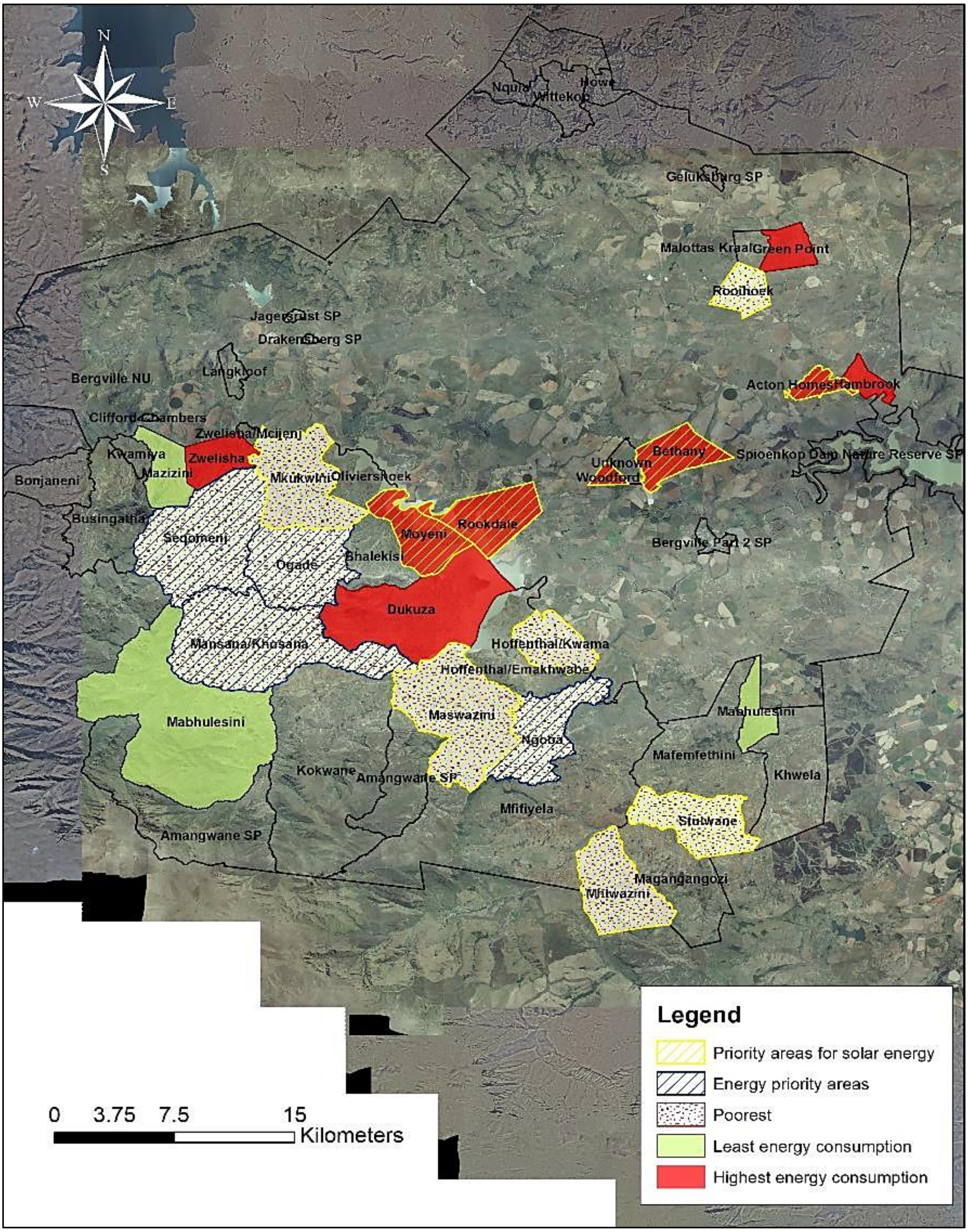

Figure 5.19: Perceptions of most suitable areas for solar energy in Bergville (Author, 2016)

One of the aims of this study was to examine the potential use of a prototype solar thermal box-cooker within low-income and poor communities. In this regard, the study probed perceptions, awareness and willingness to use and pay for this device. Furthermore, household energy profiles were examined to inform the function and capabilities of the cooker, specifically in relation to household energy needs and cooking practices. These aspects are discussed in the following sections.

5.9 Attitudes and perceptions toward solar thermal energy and technologies

The majority of respondents from Bergville (97.1%) and Inanda (98%) were not aware of a solar thermal cooker. However, a small group of respondents stated that solar thermal cookers were devices that work with energy from the sun (37.5% in Inanda and 16.7% in Bergville), cookers that don't use electricity (25 % in Inanda and Bergville), cookers that are charged by the sun (25% in Inanda and 41.7% in Bergville) and 'something that uses heat to cook' (12.5% in Inanda and 16.7% in Bergville) (Table 5.52).

Table 5.52: Perception of a solar thermal cooker (in %)

Perceptions	Inanda (n=8)	Bergville (n=12)
Something that uses heat to cook	12.5	16.7
Charged by the sun	25	41.7
Cooks with sun's energy	37.5	16.7
Cooks without electricity	25	25

Chi-square tests reveal that level of awareness among the male and female respondents did not differ significantly for both Inanda (p=0.384) and Bergville (p=0.748). After respondents' levels of awareness and perceptions were examined, interviewers provided respondents with a brief description of solar thermal energy and solar cookers. This allowed respondents to conceptualise a relatively unfamiliar device. In addition, specific perceptions, for example, willingness to pay and use the device were examined. The majority of respondents from Bergville (96.8%) and Inanda (90.3%) displayed a willingness to use solar cookers. Chi-square tests reveal no significant differences among male and female counterparts in relation to willingness to use the solar thermal cookers in both Inanda (p=0.239) and Bergville (p=0.635). Contrary to the assertions made by Modi et al. (2006) and Gumede et al. (2009), the majority of female respondents in both communities did show a keen willingness to embrace the technology. The respondents that did indicate an unwillingness to use the technology provided the following reasons for their choice: high costs (4%), lack of availability (2%) and inability to use during cloudy days and at night (3.5%).

The majority of respondents (87.8% in Inanda and 91.8% in Bergville) indicated a willingness to pay for solar cooker devices. Studies show that willingness to pay can be used as an indicator of social acceptance, and may be seen as an opportunity for up-take and use of specific devices (Mallet, 2007; Narula & Reddy, 2015). The actual amounts that respondents were willing to pay are listed in Table 5.53.

Table 5.53: Amount in Rands respondent is willing to pay per month for solar cookers (in %)

Amount	**Inanda (n=351)**	**Bergville (n=367)**
R50-R100	40.2	53
R101-R150	45.4	26.5
R151-R200	8.6	19.7
R201-R500	5	0.8
Mean	**R112.36**	**R75.60**

Most respondents from Bergville were willing to pay between R50-R100 per month for the device. This was followed by a smaller group indicating between R101-R150 (26.5%) and between R200-R500 (20.5%). Results varied slightly among Inanda respondents, with respondents mainly willing to pay between R50-R100 (40.2%) and R100-R150 (45.2%) per month for the device. Respondents in Inanda were willing to pay slightly more (R122.36) than their Bergville counterparts (R75.60). Respondents from Inanda displayed higher monthly incomes which could have influenced the amounts they were willing to pay for the solar cooker. Ku and Yoo (2010) show that willingness to pay for RETs is based on perceived affordability and economic status of users.

Ku and Yoo (2012) state that the prospect of increased job creation, environmental protection, a reduction in air pollution and the perceived benefits associated with the use of specific technologies can develop a favourable perception and thus, improve on willingness to pay. In light of the limited levels of awareness of a solar cooker displayed by most respondents, willingness to pay may increase with improved user knowledge of available RETs. Even though these amounts are not substantial, overall willingness to pay for the cooker can be viewed as an opportunity when implementing similar RETs.

Conventional solar cookers have been associated with low cooking speeds; reduced functionality at night, winter and during rainy seasons, and dangerous exposure to solar radiation, as some of the main challenges associated with the use of modular cooking units (Mawire et al., 2010). Furthermore, Negi and Purohit (2005) and Yettou et al. (2014) are of the opinion that improving thermal storage capacities of cookers can improve efficiency however, this increases production costs and these devices may become financially inaccessible to the poor. According to Pinel et al. (2011) one of the major disadvantages of solar thermal devices is the fluctuating heat storage potential due to seasonal changes, however, this can be overcome by increasing the size of the device to maximise heat capture and storage. Up-scaling the technology from individual household units to a community-based facility will ensure higher temperatures during the cooking processes, and enhance the potential applications to frying, baking and boiling for extended periods. In addition, a community-based facility will potentially service a greater number of households and may be associated with reduced production and implementation costs.

Although the survey did not probe on start-up costs specifically, these were examined during the focus group discussions. Focus group participant's displayed consensus that start-up costs exceeding R500 would not be feasible in most households. There was, however, a strong position by all participants that solar thermal cookers need to be subsidised and provided by the government, as in the case of SWHs, for it to be viable in Inanda and Bergville. In terms of the maintenance costs, there were concerns raised by most participants that this was rarely factored into the costing of RETs. Participants in Inanda, specifically stated instances where SWHs had stopped functioning but households did not know how to repair the device or get them repaired externally. One participant also indicated that some of the households in his neighbourhood had SWHs that have fallen of the roof and have not been subsequently repaired. These concerns raise issues in relation to the broader sustainability of introducing RETs in low-income households, who often do not have the funding or know how to maintain these devices. When they break, there are no alternatives for heating water leading to households and reverting to the use of primitive and transitional fuels.

Additionally, the survey probed the willingness of the respondent to use a community-based facility for cooking purposes (Figure 5.20) and the main reasons for respondents choices are listed in Table 5.54. The majority of respondents from Bergville (77.8%) and Inanda (89.5%) were unwilling to use a community-based facility for cooking, as seen in Figure 5.20.

Although a relatively small proportion of respondents indicated a willingness to use a community-based facility, a significantly higher proportion of respondents from Bergville were keen to do so (22.3%, *p*=0.026) compared to 10.5% in Inanda. Additionally, chi-square tests reveal that willingness to use the community-based facility did not differ significantly among the sexes in both communities (Inanda- *p*=0.236; Bergville- *p*=0.357).

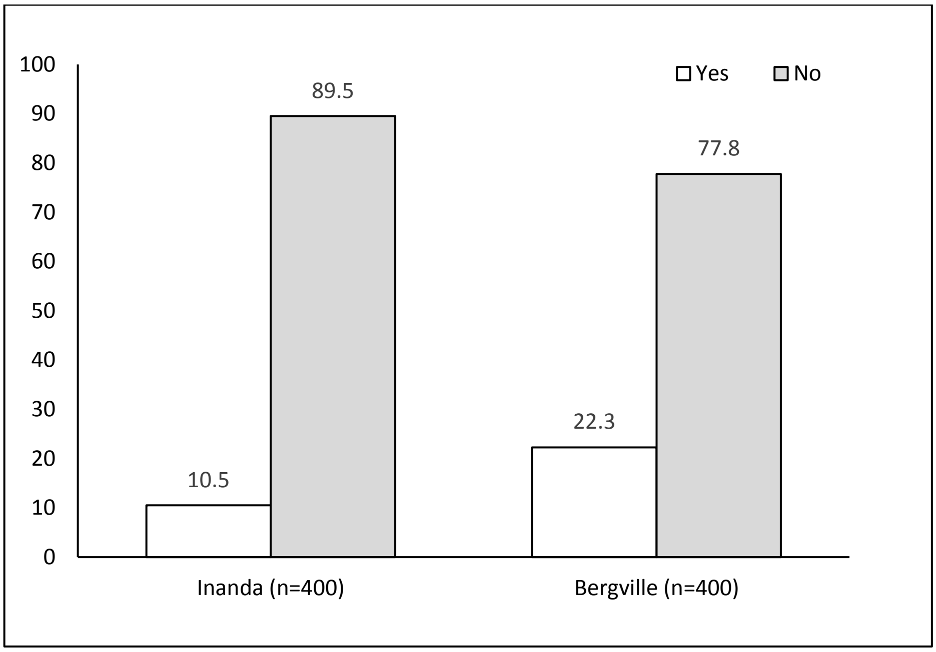

Figure 5.20: Willingness to use a community-based cooking facility (in %)

Respondents provided reasons for their reluctance, listed in Table 5.54. Results show that the majority of the respondents from both communities felt that community-based cooking facilities were not private enough (94.9% in Inanda and 60.8% in Bergville). Similar sentiments were expressed by 56.7% of respondents in Inanda and 28.9% in Bergville who indicated that they were not comfortable cooking in public. Smaller groups noted that cooking should be done within the household (29.6% in Inanda and 18.3% in Bergville). These reasons highlight the influence of culture and tradition which suggests that respondents consider cooking a private practice. This resonates with earlier descriptions of cooking practices highlighted by participants during the focus group discussions. Energy behaviour studies show strong cultural underpinnings to household energy patterns, specifically cooking practices (Stern 1992; Stephenson et al., 2010; West et al., 2010; Sola et al., 2015; Day et al., 2016).

Table 5.54: Reasons for unwillingness to use community-based cooking facilities (Multiple response, in %)

Reasons	Inanda (n=358)	Bergville (n=311)
Not private enough	94.9	60.8
Not comfortable cooking in public	56.7	28.9
It's not safe	22.6	35.0
Cooking is done within the household	29.6	18.3
Too time consuming due to congestion	2.8	0.6
Old age	3.9	3.9
Conflict	5.9	2.6

Smaller groups highlighted safety (22.6% in Inanda and 35% in Bergville), conflict (5.99% in Inanda and 2.6% in Bergville), age (3.9% each in Inanda and Bergville) and congestion (2.8% in Inanda and 0.6% in Bergville) as the reasons for unwillingness. These reasons reflect more on the local conditions, specifically the risk associated with the use of these facilities. van der Kroon et al. (2013) highlight social relations, culture, risk, security preferences, and levels of comfort as factors that could influence perceptions and utility of RETs. Similarly, Reddy and Painully (2004) show that consumer perception and behavioural factors influence how RETs are perceived in relation to its utility, cost and quality compared to conventional technologies.

Likewise, Masini and Menichetti (2012) state that perceived risks associated with the use of RETs can wane on willingness to pay and adopt these technologies. The fact that respondents highlighted conflict, theft and congestion suggest that they associated a certain level of risk with the use of a community-based facility. Studies show that perceptions are strongly influenced by personal experiences and overall philosophical standing (West et al., 2010; Broomell et al., 2015; Cheng & Wu, 2015; Pearce et al., 2015). Given the limited levels of awareness displayed by most respondents, it can be argued that solar cookers and facilities are abstract concepts to respondents, and without actual experiences of the technology, culture and risk overpower their perceptions. It should be noted that focus group participants supported the construction of a communal facility, which could be used for community events.

The Sol de Vida foundation in Costa Rica serves as an illustrative example of the potential of community-based solar kitchens (UNDP, 2004). Initially, the community-based facility was met with dissention from the public, however, once the facility was constructed and community members were able to experience the benefits, their attitudes and perceptions were transformed but, more importantly, the solar kitchen was used more widely within the community (UNDP, 2004). Similarly, Veldmann and Brinkmann (2007) show that market demonstrations, trade fairs, pilot tests and focus group presentations can be effective strategies to improve up-take, but warn that these should be carried out in cognisance of the different socio-cultural backgrounds. This study shows that although the proposed solar cooker may not service all cooking needs, it has the potential to offer multiple benefits in terms of health, improved indoor air quality and overall standards of living, given the use of energy sources such as fuelwood and paraffin indoors. Focus group participants also shared their perceptions of the priority areas for the implementation of solar cookers (Figures 5.21 and 5.22).

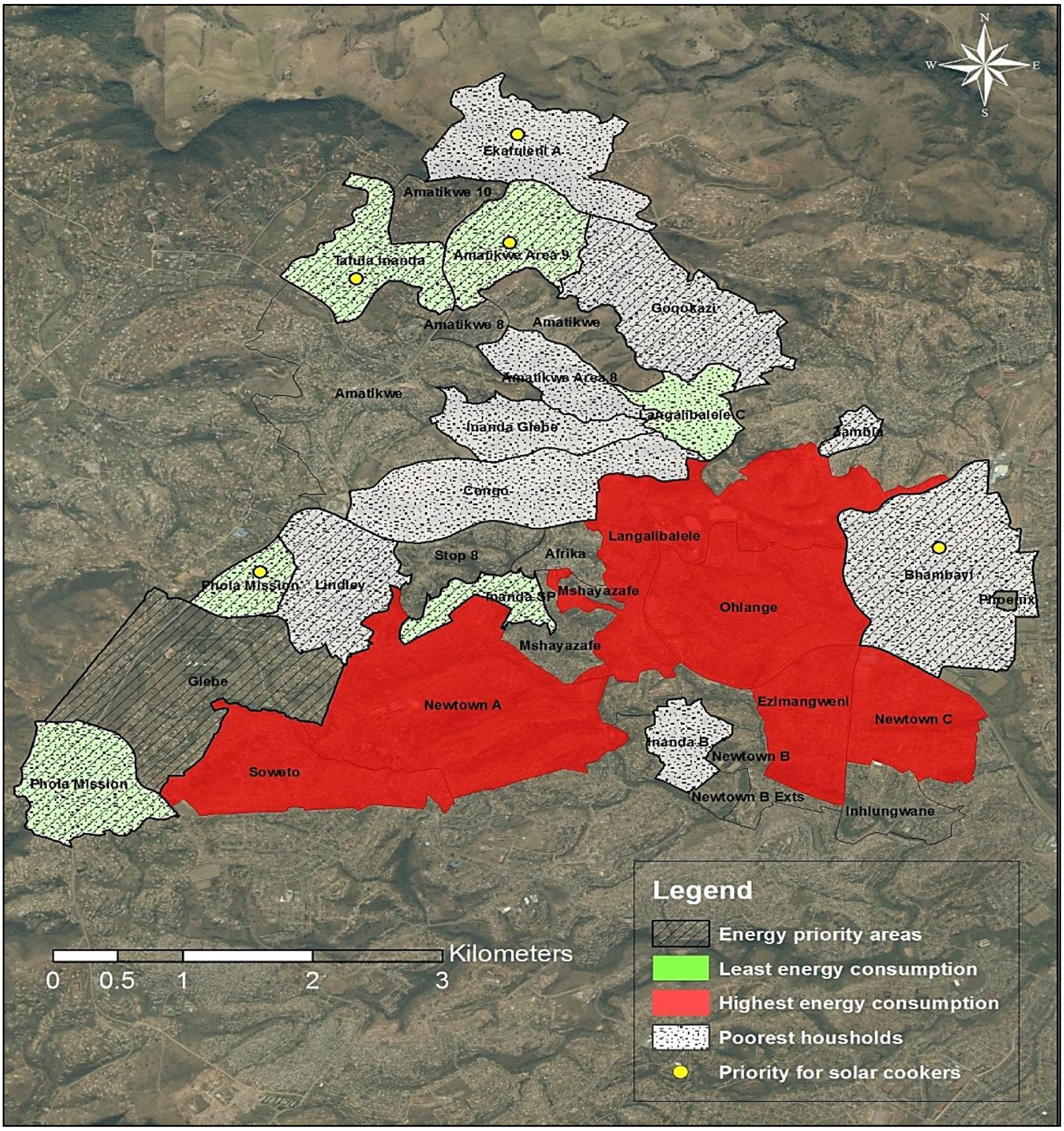

Figure 5. 21: Perceptions of the most suitable areas for the use of solar cookers in Inanda (Author, 2016)

Focus group participants from Inanda identified Tafula, Amatikwe Area 9, Phola Missions and Bhambayi as the most suitable areas for the solar cookers. The main reasons for their selection were due to the high proportion of children and the aged and the fact that these areas were considered to house a high proportion of poor households. It is important to note that while areas such as Glebe, Phola Misson, Lindley, Inanda SP and Goqokazi were highlighted as energy priority areas, they were not considered suitable for the implementation of solar cookers. Focus group participants stated that lack of space, theft, limited understanding of the device, and high proportions of aged populations in these areas were the main constraints.

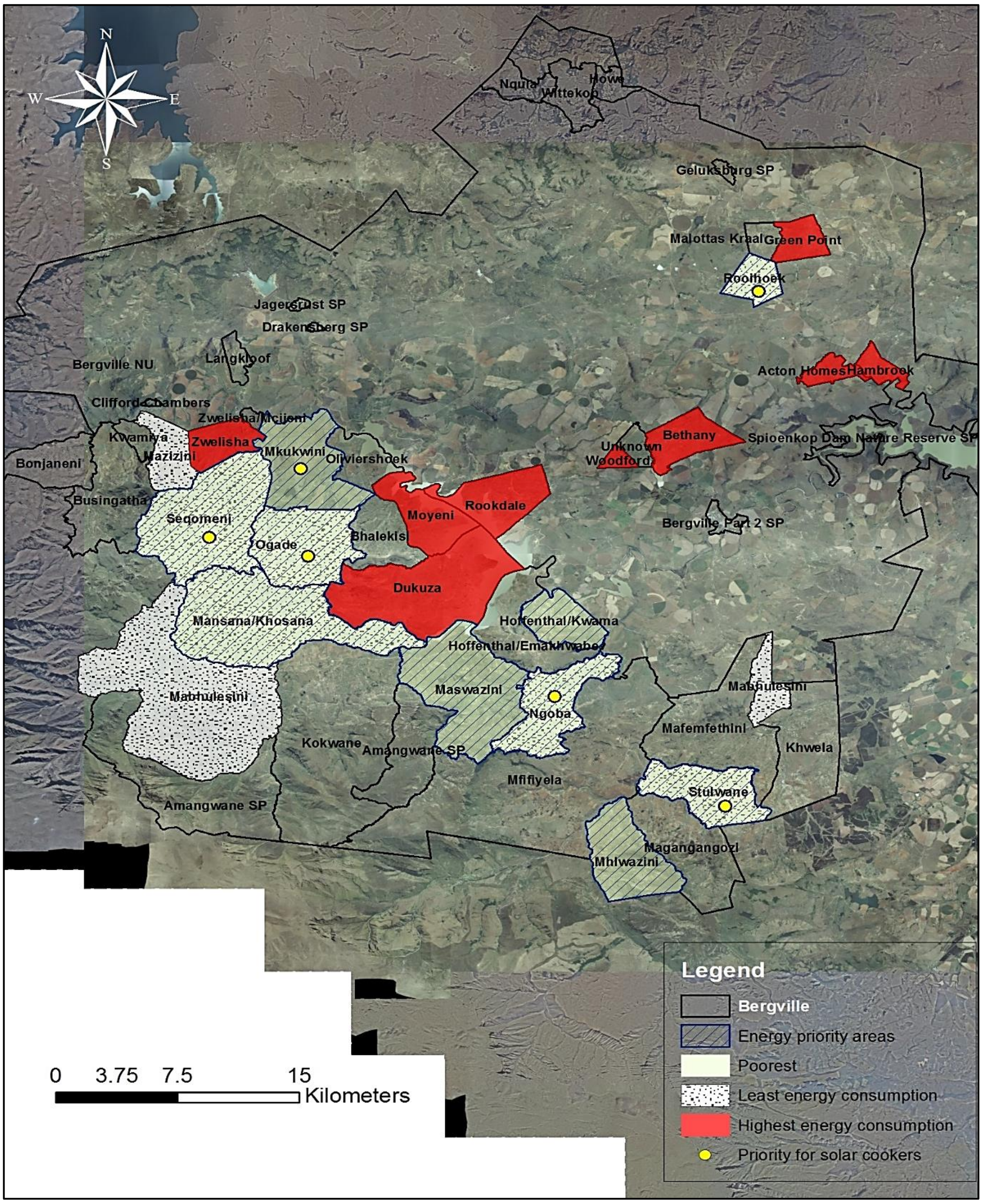

Figure 5.22: Perceptions of the most suitable areas for the use of solar cookers in Bergville (Author, 2016)

Focus group participants from Bergville identified Ngoba, Ogade Seqomeni, Stulwane, Rooihoek and Mkukwini as the priority areas for the implementation of solar cooking devices. Participants indicated that these regions did not have access to electricity and fuelwood was extensively used for cooking purposes. Also, the Ogade and Seqomeni areas did not have access to roads and had a high proportion of older residents, which was perceived as a problem, since most of the households collected fuelwood for use. Furthermore, even though regions such as Hoffenthal, Maswazini, Mhlwazini, Mkukwini and Mansana were highlighted as energy priority areas, participants did not consider these areas as suitable for the use and implementation of solar thermal cookers. Main reasons forwarded by focus group participants included the age of the population, large household sizes and poor road access.

It is evident that participants from Inanda and Bergville acknowledged internal and external household factors as important for the implementation of renewable energy. Participants' perceptions of the most suitable and priority areas for solar technologies were largely influenced by their perception of needs and risks associated with the use of current energy sources. These findings reflect the assertions by studies which show that user perceptions of RETs is influenced by their experiences and perceived risks (Keirstead, 2006; Wilson & Dowlatabadi, 2007; Chaurey & Kandpal, 2010; Stephenson et al., 2010; Kaplowitz et al., 2012; Cherp & Jewell, 2014). In addition, both participants and respondents showed a strong association of RETs, particularly solar-based technologies with poverty.

5.10 Conclusion

This chapter presented the analysis and discussion of data collected from quantitative household surveys and focus group discussions obtained from the Inanda and Bergville communities. The comparative data analyses show that there were both significant differences and similarities in household energy behaviours and associated perceptions. The main findings suggest that households from these communities experience multiple impacts of energy poverty which are shown to be related to other socio-economic and geographic variables. Furthermore, the results highlight perceptions as an important factor that may influence energy profiles and the implementation of RETs. More importantly, the results demonstrate the need for context-specific strategies in an attempt to alleviate the impacts of energy poverty and improve up-take and use of modern energy sources. These aspects are discussed in detail in the next chapter, which summaries the key findings and presents concluding remarks and recommendations emanating from this study.

CHAPTER SIX

SYNPOSIS OF RESULTS, RECOMMENDATIONS AND CONCLUDING REMARKS

6.1 Introduction

This research endeavour set out to examine the socio-economic and geographic factors that impact household energy profiles and security in an attempt to inform the implementation of specific renewable energy technologies within low-income communities in South Africa. This study is underpinned by the following main research questions: what are the energy profiles and behaviours of peri-urban and rural households in South Africa and are there differences between these contexts? What are the current perceptions towards energy sources and technologies, and what are the opportunities and challenges for the implementation of specific RETs in low-income communities in South Africa? A comparative analysis of energy profiles, behaviours, experiences, and perceptions was conducted within the Bergville and Inanda communities which provided the rural and peri-urban contexts, respectively.

The theoretical frameworks adopted in this study served as a guide to understanding and investigating socio-economic and energy vulnerability, as well as the factors influencing household energy behaviours, profiles and perceptions. Furthermore, the theoretical frameworks reflected on the political and historical dimensions of energy consumption patterns and highlighted affordability, accessibility, reliability and availability as the main factors impacting the South African energy sector. Also, the energy cultures and household energy choice frameworks show that perception, culture, tradition and socio-economic and geographic factors produce variations in energy behaviours. Moreover, the case study approach adopted in this study allowed for the examination of energy behaviour in real life contexts.

The use of quantitative and qualitative data collection tools allowed for the establishment of general community-based trends, but also assisted in unpacking some of the narratives and reasons behind household energy practices and overall perceptions. This provided robust primary data that was further interrogated using secondary data sources comprising key literature and the theoretical frameworks that guided this study. This chapter provides a synopsis of the main findings in relation to the objectives that framed this study, specific recommendations in relation to the socio-economic and energy aspects examined, and the use and implementation of renewable energy sources and technologies. The chapter culminates with concluding remarks on the overall research process.

6.2 Synopsis of results

The main findings of this study were discussed thematically in relation to the overall aim and objectives described in the introductory chapter. Furthermore, this study unpacked socio-demographic contexts, energy profiles, practices and behaviours, and respondent perceptions of and willingness to use renewable energy technologies such as solar thermal cookers. This was achieved by addressing the research questions posed in Chapter 4. This summary indicates that the overall aim and objectives guiding this study were achieved.

6.2.1 Socio-economic and demographic profiles

The literature highlighted in this study demonstrates that energy security, vulnerability and practices are underpinned by socio-economic factors. It should be noted that South Africa is characterised by diverse socio-economic and demographic landscapes, largely attributed to the political history which produced strong racial and geographic bias in the provision of basic services. Peri-urban and rural communities like Inanda and Bergville are occupied by previously disadvantaged groups and are still facing severe backlogs in service delivery, especially in relation to the provision of domestic and community services. The impacts of the political history of South Africa are pertinent to this discussion as it provides a backdrop for the analyses of energy related vulnerabilities and critical development needs. Moreover, in some ways vulnerabilities are exacerbated in rural communities given the urban-rural dichotomies in accessing services and livelihood opportunities, (for example, employment and income potential). The results obtained in this study resonate with these aspects and show that even though both Inanda and Bergville displayed significant socio-demographic stressors, the impacts were more pronounced in Bergville.

Bergville and Inanda displayed significantly different socio-demographic profiles, specifically in relation to age, levels of education, formal training and skills, employment status, and household income. Respondents from Inanda were younger with the majority being 45 years and younger. Close to a third of the respondents from Bergville were older than 65 years. These findings highlight trends noted in national Census data that show a higher dependency ratio and older populations within rural areas like Bergville (SSA, 2011). Additionally, the increased rural-urban migration patterns of economically active groups in search of improved livelihood opportunities could explain the higher proportion of elderly individuals in Bergville.

In terms of level of education, a significantly higher proportion of respondents from Bergville did not possess any formal education. In comparison, respondents from Inanda displayed higher levels of formal education with the majority having completed or partially completed secondary level schooling. Participants from the focus group discussion in Bergville noted that there was a lack of adequate secondary schools available in the community and learners have to travel long distances to attain a secondary level education, which could be a major obstacle for educational achievement in Bergville. These trends are indicative of the critical challenges in accessing basic education within rural South Africa.

Further analyses showed that male respondents displayed higher levels of formal education compared to their female counterparts; this trend was significant in both populations. These findings highlight the gendered differences in socio-economic vulnerabilities within low-income communities. Patriarchy and the gendered distribution of domestic tasks can be a major obstacle for female participation in educational activities, thereby negatively impacting on the empowerment of women (Munien & Ahmed, 2012). Suguna (2011) and Sandhya (2015) describe education as a major factor contributing to the empowerment of women. Moreover, female respondents from Inanda showed higher levels of education compared to those from Bergville. Walker et al. (2010) show that levels of education are linked to technical capacities which could influence the willingness to adopt RETs such as solar cookers.

Both Inanda and Bergville displayed critical levels of unemployment, with close to 60% of respondents being unemployed in Bergville. Results from Inanda are disconcerting as a higher proportion of young, formally educated respondents were unemployed demonstrating that job opportunities are critical a concern within this community. Once again, the majority of unemployed and retired respondents were female illustrating that more women can be classified as dependent. This study shows that household income in Bergville and Inanda were significantly lower than the provincial and national averages (SSA, 2011). In energy studies the level of household income and income stability are crucial aspects that determine energy security. Although both groups of respondents and households can be classified as low-income with limited levels of employment, respondents and households from Bergville displayed significantly lower incomes.

Moreover, both communities showed a heavy reliance on state support in the form of old age pensions as well as disability and child grants demonstrating high levels of state dependence. In relation to the sustainable livelihoods framework, households in Bergville and Inanda can be classified as vulnerable given their limited income generating options, formal education and skills. The lack of income generating options threatens livelihood security and, more relevant to this study, illustrates a limited capacity to purchase modern energy sources and respond to changes in the energy sector. In the South African context, this is problematic as electricity prices have increased by 25% in the last two years (DoE, 2014). Further increases in the price of domestic electricity may result in more extensive fuel-switching practices and a greater reliance on cheaper fuels such as paraffin and kerosene. Pachauri and Rao (2013) argue that purchasing power and decision-making capacity are linked to income and level of education and, therefore are important factors that determine household energy use. This study shows that women displayed reduced purchasing power given their limited incomes and suggests that they may not have equal decision-making power and representation in household level energy choices, especially within Bergville where the gender differences emerged more strongly.

Another important aspect to consider in energy planning is household size. On average, households in Bergville were larger suggesting higher demands for basic energy. This raises concerns over energy affordability given that household incomes within Bergville were lower. With the exception of Bhambayi (an informal settlement in Inanda), all households in Inanda were formal brick dwellings with stable roof structures. On the other hand, Bergville consisted of a combination of traditional and formal brick dwellings. Traditional dwellings have thatch roofs that lack structural stability and therefore may present challenges during the implementation of RETs such as solar PV panels and SWHs. Traditional and informal dwellings are associated with reduced thermal efficiency proposing that these households may require more energy and, more poignantly, face increased risks to the impacts of energy poverty. More importantly, these dwelling types do not support the installation technologies such as PV panels and SWHs, however, modular solar lighting and cooking devices may be more applicable in this context.

Overall, the alarming levels of unemployment, limited education and formal skills, the lack of income generating options and heavy reliance on state support demonstrate that respondents and households from Inanda can be classified as low-income to poor, while respondents and households from Bergville can be viewed as very poor. These are important aspects to consider in the implementation of RETs and in relation to the financial accessibility of modern, efficient and safer sources of energy. The differences in the socio-economic and demographic conditions displayed by both groups of households necessitate the need for energy policy and decision-makers to consider context specific energy planning. The conceptual frameworks and literature used in this study argues that energy behaviour and profiles cannot be viewed in isolation, and is a direct consequence of local socio-economic and demographic contexts. These findings are discussed in the subsequent sections.

6.2.2 Household energy sources

It is argued that household energy profiles contribute to a more robust understanding of local experiences of specific energy policies and interventions, and has the potential to inform future energy policies. A key contribution of this study is the empirically-based examination of household energy profiles across different geographic and socio-demographic contexts. In addition, there is a dearth of studies in the South African context on the reasons and practices of fuel-switching at the household level. This study shows that the majority of households in Inanda were connected to the national electricity grid while some of the sampled households in Bergville lacked a formal connection to the national grid. These values are slightly above the national average of 87% domestic electrification (DoE, 2014). However, household energy profiles are more complex and do not only reflect physical accessibility. Increasingly, the literature highlights the need for longitudinal-based assessments of household energy consumption and reliance, as this provides a more rigorous account of household energy vulnerability. Results show significant differences in the selection of main sources of energy for cooking, heating and lighting purposes between Inanda and Bergville. Households from Inanda mostly used electricity as their main source of energy for basic needs, while households in Bergville displayed a broader mix, specifically the use of fuelwood for cooking and heating purposes, and candles for lighting purposes. Given the definitions of energy poverty cited in Chapter 3, this shows that households in Bergville experience higher levels of energy poverty and vulnerabilities.

This study shows that even though most households had access to electricity, the practice of fuel-switching was prevalent in Bergville and Inanda, however, this was more extensive within Bergville. More specifically, this study showed that the type of additional sources of energy used by households were indicative of their overall socio-economic conditions, cultural practices and external factors such as accessibility and energy prices. The practice of fuel-switching occurred regularly throughout the month in both populations. Households in Inanda showed a tendency to switch to other cheaper modern fuels, for example, gas and transitional fuels such as paraffin. Bergville households preferred to switch to primitive and transitional fuels like fuelwood, dung and paraffin. This raises concern over the quality of energy services rendered by these sources. Furthermore, additional sources of energy chosen by both groups of households are associated with reduced efficiencies. This is most evident in the selection of candles for lighting services and the use of fuelwood for cooking and heating practices. More importantly, the type of additional fuels used by households raises concerns over the health-related impacts, specifically the extensive indoor use of fuelwood and paraffin for cooking practices. Environmental impacts are also of concern.

A key finding of this study is that Bergville households displayed a greater reliance on collected sources of energy, specifically fuelwood and dung; suggesting a reduced capacity to purchase energy sources. In this regard, focus group participants highlighted energy prices, physical accessibility, lack of transportation and culture as the main factors influencing household selection of energy sources. According to Day et al. (2016), these results are expected as most low-income and very poor households choose energy sources that are best suited to their budget rather than their energy needs. Moreover, the differences in household selection of energy sources between Bergville and Inanda emphasise the differences in socio-economic conditions between urban and rural contexts. This warrants the need for national and provincial level energy planning to accommodate for these differences.

Furthermore, statistical testing highlighted sex, household size and household income (Bergville only) as the main factors influencing the selection of main energy sources for cooking, heating and lighting purposes. The selection of additional sources of energy appeared to be more complex, with the main factors differing between populations. For example, level of education, employment status and household size influenced the selection of additional energy sources among Inanda households, while household income and size were highlighted as the main factors among Bergville households. It can be argued that within Bergville, specifically, level of education and employment were critically low and therefore did not emerge as factors influencing the selection of energy sources. Nonetheless, this study shows that socio-economic and demographic factors influence household selection of main and additional sources of energy.

6.2.3 Energy needs and preferences

This study shows that energy needs differed between communities. For example, results from the focus group discussions show that among Inanda households, cooking, income generation and education were the most prioritised energy needs, while agriculture, heating and entertainment were the least prioritised. Bergville households ranked cooking, income generation, agriculture and education as the most prioritised, with entertainment, lighting and heating as the least prioritised energy needs. It can be argued that household energy needs reflect overall community needs, specifically in relation to the need for income generation. Furthermore, these results are of concern, especially among Bergville households, as heating and lighting are considered basic energy needs. These findings suggest that due to the lack of affordability, basic energy needs are often not prioritised by households. Also, the use of appliances and communication devices received low scores from both groups of participants indicating that both communities do not prioritise modern energy needs. The lack of prioritisation of heating and lighting needs are reflected in household selection of main and additional sources of energy for heating and lighting services; more specifically, the use of fuelwood, paraffin and candles. Additionally, the use of these energy sources shows that households experience poor quality heating and lighting services.

Similarly, this results show that electricity was the most preferred energy source by both groups of participants; second and third choices differed between communities. For example, gas and paraffin were the 2^{nd} and 3^{rd} most preferred sources of energy among Inanda households while households in Bergville chose fuelwood, paraffin and dung as their 2^{nd} and 3^{rd} options. Once again, households from Bergville showed a higher preference for cheaper sources of energy, more specifically collected sources such as fuelwood and dung. What emerges from these preferences is the failure of most households to recognise other opportunity costs associated with their preferences and the use of specific energy sources. In this regard, health and safety risks associated with the indoor use of paraffin and fuelwood, and the risk of injury from the collection of fuelwood may have not been as important in household energy choices and preferences. Moreover, respondents provided specific reasons for their selection of specific energy sources; which were mainly attributed to convenience, cost and accessibility of these sources. It is important to note that these factors are fundamental in attempting to transform current household energy practices and should therefore appear more prominently in energy planning and policy discussions.

6.2.4 Household energy consumption and expenditure

In addition to household selection of energy sources, the conceptual frameworks and literature that guided this study argue that specific consumption patterns and behaviours can also reflect the underlying factors that influence household energy security. This study shows that the energy sources were consumed differently in Inanda and Bergville on a monthly basis. Electricity was consumed more frequently by households in Inanda, while paraffin, fuelwood and candles were consumed more frequently by households in Bergville. This demonstrates that poorer households consumed modern sources less frequently compared to primitive and transitional fuels. Furthermore, collected sources were used more frequently by households in Bergville whereas households from Inanda displayed a higher consumption of purchased sources of energy. A noteworthy proportion of households used additional sources of energy throughout the month, indicating that they could not sustain their consumption of electricity. In relation to the energy stack and ladder models, households from Inanda can be ranked higher up on the energy hierarchy, indicating that households in Bergville are more vulnerable to the impacts of energy poverty and the risk of household energy insecurity. These findings resonate with the assertions made by current energy studies that show a greater level of energy related risk among rural communities.

Given that electricity prices were regulated at the national level it was possible for this study to extrapolate electricity consumption in basic units of kWh. Unfortunately, the price of other energy sources are not regulated and actual usage in basic units could not be established. Simulated indicators of household energy consumption illustrate that in Inanda households consume approximately 242.15kWh of electricity per month, with significantly lower values in Bergville. In relation to electricity consumption per capita, on average annual consumption of electricity per person in Inanda is 629.14kWh compared to an alarming 266.47kWh per person in Bergville. This is a major concern and demonstrates that individuals from Bergville do not have access to adequate energy to meet their productive and modern energy needs and therefore can be classified as energy poor. This reinforces earlier assertions made in relation to the accessibility of modern energy sources, suggesting that affordability of modern energy sources is a critical concern within the Bergville community.

In terms of energy expenditure, households in Bergville spend on average 25% of their income on energy sources. This figure was slightly lower in Inanda. Studies show that households that spend more than 10% of their income on energy are deemed energy poor (Parajuli, 2011; Mayer et al., 2014), indicating that both groups of households can be classified as energy poor. A finer inspection of household energy expenditure demonstrated that households in Bergville spend a significantly higher proportion of their income on fuelwood and paraffin compared to Inanda. This is a concern given that close to half of the households that used fuelwood collected this source. In addition, Inanda households spent a significantly higher proportion of their household income on modern sources of energy compared to Bergville. Further statistical analyses revealed that household size and income were positively correlated with monthly energy expenditure in the Inanda population. Interestingly, these variables did not influence monthly energy expenditure among Bergville households. Another important finding emanating from this study is that among very poor households, changes in household size and income did not influence monthly energy expenditure. Similarly, household income was negatively correlated with proportion spend on primitive and transitional fuels in both populations, suggesting that increases in household income was associated with a reduced reliance on fuelwood and paraffin, specifically.

Overall, households examined in this study can be viewed as conservative energy consumers. Households in Bergville displayed a reduced capacity to respond to changes in household demand for energy, more specifically to increase their use or purchase of modern fuels to compliment increases in household size. Nonetheless, increases in household income were associated with an increased consumption and purchase of electricity, demonstrating that improving household income can lead to an improvement in access to modern energy sources among low-income and poor households.

6.2.5 Energy related perceptions and attitudes

The majority of respondents perceived electricity to be expensive and inaccessible, yet efficient. Similar findings were noted for fuelwood, gas and paraffin. Interestingly, most respondents perceived paraffin and fuelwood as having negative impacts on health. This shows that contrary to their perception of the risks associated with the use of these energy sources, a significant percentage of households still used these sources regularly throughout the month and deemed the sources to be efficient. These trends indicate that affordability overpowers the perception of risk in the selection of household fuels and, more importantly, low-income and poor households knowingly risk their safety and health to attain energy services. With the exception of candles, all other energy sources used by households were perceived to have negative environmental impacts. Conversely, respondents noted that solar energy was not associated with environmental pollution.

Respondents also displayed limited levels of awareness of climate change and renewable energy sources. Most respondents who indicated awareness of these terms had higher levels of formal education and were predominantly male. Thus, this study shows that level of education and sex are important factors when examining levels of awareness. It is interesting to note that although most respondents indicated that they were unfamiliar with the term 'renewable energy', the majority of respondents from Inanda and Bergville indicated awareness of the term solar energy, proposing that respondents failed to make the link between renewable and solar energy sources and technologies (SETs). The general perception of solar energy was that it was derived from the sun and was a 'free' energy source. The latter could present a problem if households are required to pay for the solar energy devices. It should be noted that focus group participants and respondents who indicated an unwillingness to use solar energy linked this energy source to SWHs; and noted theft, high maintenance costs and unreliability to be their main concerns. In relation to solar thermal technologies, the majority of respondents were not familiar with the term or any of the associated devices. Nonetheless, most respondents displayed a willingness to use and pay for RETs and SETs. This shows considerable potential for the future use and implementation of RETs within the Bergville and Inanda communities.

It should be noted that respondents and focus group participants in both Inanda and Bergville displayed perceptions that the use of SETs were closely linked to the concept of poverty or being poor. The extensive use of SWHs in low-income contexts across South Africa may have contributed to the perception that RETs and SETs are exclusively used by the poorer groups in society. This can result in unfavourable consequences for future implementation programmes.

6.2.6 Household energy behaviours

Overall both groups of households can be described as hybrid energy users who engage in extensive fuel switching. This study shows that sex, household size and household income are important internal factors that influence energy behaviours across both communities. Other variables such as level of education and employment status were noted as key factors influencing energy behaviours within peri-urban communities such as Inanda, specifically. Households in Inanda display characteristics of transitional energy users, with a higher reliance on modern energy sources and a tendency to use transitional fuels during periods of stress or for activities that are deemed less important or have higher energy demands. Bergville households can also be described as transitional energy users, however, this group shows a tendency to rely on primitive fuels to service their energy needs and supplement the use of electricity. This raises concerns over the impacts of energy poverty, specifically the health impacts associated with the use of these fuels as children and the elderly are more susceptible to respiratory illnesses associated with the use of these fuel sources (UNDP, 2014). The downward movements along energy ladders and stack models displayed by both groups of households illustrates high levels of household energy insecurity, especially in relation to the use of modern sources of energy. Furthermore, these trends show that rural communities such as Bergville experience higher levels of risk and energy insecurity.

Although cost and affordability emerged strongly as main determining factors, culture and tradition play a major role in household energy choices. In this regard, both groups of participants noted that fuelwood is often used by households to prepare larger meals and foods that require longer cooking periods, and for heating of water. A key finding of this study is that low-income and poor households switch to cheaper or collected sources for activities that are associated with higher energy demands. Likewise, this study shows that sex, household size, level of income, culture and tradition are important endogenous indicators that influence household energy behaviours across rural and peri-urban environments. For peri-urban communities especially, energy behaviours are also influenced by level of education and employment status. In addition, the influence of culture and tradition emerges very strongly among Bergville households, specifically the use of separate cooking facilities and the use of fuelwood. Thus, this study establishes that the influence of culture and tradition are more profound within rural contexts, suggesting that the influence of culture and tradition on energy behaviours differs across geographic and socio-economic gradients.

Moreover, this study shows that external factors such as the availability of adequate roads and public transportation influence physical accessibility to energy sources and therefore energy behaviours. Generally, the impact of energy policies, mainly the cost of domestic energy, was seen as a major exogenous factor influencing household energy behaviour across both rural and peri-urban contexts. However, given the differences in household income, energy affordability emerged as a greater challenge for Bergville households, highlighting affordability to be critical concern among very poor rural communities. This is further emphasised by the political history of the country, which has resulted in previously disadvantaged groups, especially African rural dwellers, displaying higher levels of socio-economic vulnerability. Consequently, external factors such as geography and political climate become fundamental factors to consider in unpacking household energy behaviours in the South African context. The impact of geography was further emphasised by the results of the participatory mapping exercises, which showed households furthest away from central nodes (in both communities) to be characterised as having lower household incomes, higher dependency ratios, limited services such as formal dwellings and electricity, and a higher consumption of primitive fuels.

Lastly, even though awareness of climate change and the main contributing factors was limited among respondents, most households in Bergville and Inanda engaged in energy conservative practices, mainly switching off and unplugging appliances and lights when not in use, and reducing energy intensive activities. As a result, this study identifies cost as a major determinant of energy conservation practices, more specifically perceptions that electricity and other energy sources were considered expensive and therefore too costly for sustained use. The household and community energy-mix is reflective of socio-economic and environmental conditions. It is only through understanding existing energy profiles that one can recommend relevant alternatives that are positioned to improve livelihoods and achieve goals of social development, sustainability and environmental-well-being.

6.2.7 Attitudes towards the solar thermal box cooker

Although most respondents displayed a willingness to use and pay for the solar thermal cooker, given the current energy consumption patterns and household energy behaviour; the device may not be applicable as household level modular units. The practice of boiling dry lentils, beans and maize is energy and time consuming. Furthermore, the preparation of meals for households with 5- 6 members may not be applicable to the smaller prototypes that display limited ability to support larger cooking pots. The main reasons for limited willingness to use and the solar cookers were related to cost, size and ability to store sufficient energy that would support current household cooking and heating practices. In this regard, a key recommendation emanating this study is that individual household solar thermal cooker units may not be applicable to the Inanda and Bergville contexts, however, larger community-based facilities may be able to provide more efficient energy services that complement existing needs and cultural practices. Even though households from both communities indicated a willingness to pay for this device, these amounts were exceptionally low. Unless heavily subsidised, many households will not be able to afford to purchase these cookers. In addition, due to the differences in dwelling and roof structures, a modular solar cooking device may only be applicable to a few households in Bergville and Inanda.

It is important to note that cooking did emerge as a key energy need for both populations and, more importantly, the current sources of energy used for cooking were associated with multiple health and safety risks. In this regard, the prospect of a community-based facility may be more applicable to the needs and energy behaviours of Bergville and Inanda households. A community-based facility has the potential for greater heat storage and thermal efficiencies, which may be better suited for cooking practices displayed by both groups of households. However, it must be noted that both groups of respondents and focus group participants displayed an unwillingness to use a community-based cooking facility for household cooking although the focus group participants supported such a facility for community events. This is largely attributed to cultural practices associated with cooking, safety and theft concerns, and the lack of privacy. The Sol de Vida foundation in Costa Rica showed that public perceptions and use of community-based cooking facilities can be successfully improved once people are able to see and experience the benefits of these facilities first hand (UNDP, 2004). This study shows that although the proposed solar cooker may not service all cooking needs, it has the potential to offer multiple benefits in terms of health, improved indoor air quality, and overall standards of living, given the use of energy sources such as fuelwood and paraffin indoors.

Nevertheless, during the participatory mapping exercises suitable sites were identified for the implementation of the solar thermal cookers. These sites were also identified as the poorest sites, areas that used the least energy, and those that were most in need of electricity and energy-related support. Interestingly, participants from Bergville identified some areas that they perceived as having high energy demands. Overall, the selection of suitable sites for the implementation of RETs and the solar cookers were related to specific perceptions and attitudes held by respondents and participants. The general trend associated with the selection of these sites was primarily based on energy needs and socio-economic vulnerability. However, once again, the location of sites suggest a strong association between perceptions of poverty and the use of SETs.

One of the main objectives of this study was to construct a framework/ model that informed the implementation of renewable energy sources and technologies within peri-urban and rural contexts of South Africa. This objective is informed by existing household energy practices, behaviours, overall perceptions and attitudes, and the broader socio-economic conditions deemed important to profile household energy behaviours. The next section presents a conceptual framework for the implementation of renewable energy sources and technologies that is informed by the primary and secondary results obtained in this study as well as the multiple conceptual frameworks that guided this research process.

6.2.8 A framework for the implementation of renewable energy sources and technologies

Results from the focus groups discussions, survey data and guiding theoretical approaches used in this study led to the establishment of a basic conceptual framework for the implementation of renewable energy sources and technologies within the South African context (Figure 6.1). The model demonstrates that as the contextual domain broadens from the individual to the community and national/ regional domain, the factors that show potential to influence the up-take and implementation of RETs and SETs changes, but are related. For example, this study highlighted respondents' sex, level of education, employment status and attitudes and perceptions towards energy sources as main factors influencing household energy behaviours and practices.

Similarly, the simulated indicators showed that household size and income were significantly correlated with the selection, consumption and expenditure for specific energy sources. Likewise, the prioritisation of specific energy needs, and preferences displayed towards energy sources influenced household selection of energy sources. Other factors such as culture and tradition, emphasised in the cooking practices, also influenced household selection of energy sources. In addition, dwelling suitability emerged strongly during both focus group discussions and indicated that roof structure and dwelling type were main concerns for participants in their assessment of the suitability of solar cookers and SWHs. Thus, the researcher is of the opinion that these factors may also influence the selection, use and purchase of renewable energies and associated technologies.

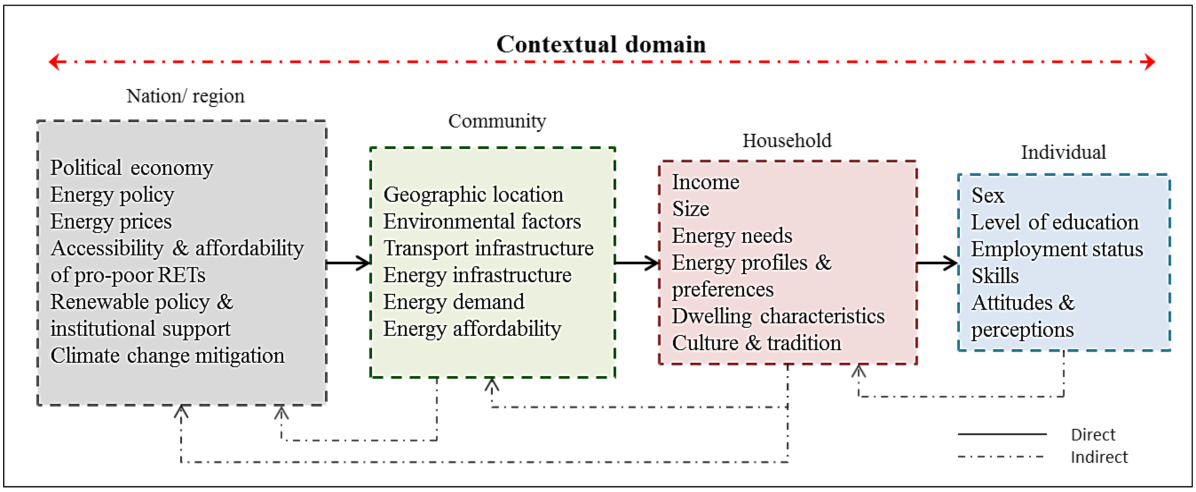

Figure 6.1: A conceptual framework for the implementation of renewable energy in the South African context (Author, 2016)

The literature, the conceptual frameworks guiding this study, and some elements from the primary data informed the community-level and national/ regional factors that may influence the implementation of renewable energies within peri-urban and rural contexts in South Africa. Given the impacts of the political history of South Africa, geographic location emerges as an important factor that may constrain the implementation of renewable energy. For example, the Group Areas Act of 1950 resulted in large-scale differences in the availability and access to basic services within previously disadvantaged communities. Rural and peri-urban communities such as Bergville and Inanda experience severe backlogs in the provision of basic services, consequently exacerbating socio-economic and environmental stressors. This is further emphasised in data collected during the focus group discussions, where access to energy sources, transport, basic education and domestic services surfaced as main factors influencing household energy profiles. The lack of transport and energy infrastructure within these communities can be major obstacles in the implementation of renewable energies.

Furthermore, South Africa is characterised by diverse environmental conditions; that may influence the implementation of RETs. For example, steep terrains coupled with the lack of adequate road access may threaten the implementation of RETs. Nonetheless, the country receives high levels of solar radiation throughout the year and therefore there is considerable potential to support the large-scale implementation of solar energy (Zawliska & Brooks; 2011; Pollet et al., 2015). However, there are seasonal and community-levels differences in the intensity of solar radiation which could present challenges in the efficiency of specific devices. Mundezi and Sebitosi (2009) argue that areas of higher solar intensities should be serviced with smaller panels while regions with lower levels of radiation ought to be serviced with larger panels to improve intended energy services. However, this will result in variations of costs across communities and may be a problem within low-income and poor communities. Moreover, the differences in population density across rural and urban gradients will also influence overall energy demand, and therefore return on investment from renewable energy programmes may not be considered viable from an economic perspective in the more remote and sparsely populated communities.

On a broader scale, national and regional factors have also been identified to influence the up-take and implementation of RETs. The political economy of the country is also vital, especially in relation to economic growth, political stability and performance in global markets which have a direct bearing on investment in socio-economic development and the renewable energy sector. Improved donor support and government investment in RETs is pertinent in extending access to poor and low-income communities. The REIPPP, REEEP and NSWHP programmes have been shown to result in improved access and implementation of RETs among poor and low-income households (DoE, 2014). Additionally, this research and other documented case studies within South Africa, show that the use of these devices were abandoned after a few years due to poor maintenance, mechanical failure, theft, reduced functionality, lack of affordability and limited levels of awareness (Bikam & Mulaudzi, 2009; Tsikata & Sebitosi, 2010; Lemaire, 2011; Govender, 2013; Maharaj, 2014; Baker, 2015; Nakumuryango & Inglesi-Lotz, 2016). In this regard, the role of energy policy and institutional support can assist in producing more favourable outcomes.

It is argued that within the South Africa context, energy policy could also have a detrimental impact on the implementation of renewable energy. For example, the supply of cheap and abundant coal-based electricity may be considered a more viable option, compared to renewable sources that require more capital investment, maintenance, and reduced functionality and applicability across most domestic appliances (Tsikata & Sebitosi, 2010). In addition, although the South African government has made significant progress in relation to renewable energies, it is still among the largest producers of coal-based electricity contributing to GHG emissions and climate change. Coal-based electricity production is a vital component of the economy and shifting reliance away from this source may have serious repercussions for economic growth and consequently, local-level development. Nevertheless, efforts to reduce GHG emissions and improved climate change adaptation and mitigation strategies and policies have the potential to positively impact on the implementation of renewable energy sources, devices and technologies.

6.3 Recommendations

The analyses in the previous chapter and discussion in this chapter has highlighted several recommendations emanating from the findings of this research. This section presents the main recommendations which are discussed thematically and in relation to the overall aim and objectives that informed this study.

6.3.1 Socio-economic and demographic contexts

Bergville and Inanda communities displayed several socio-economic stressors and were classified as very poor and low income, respectively. The socio-demographic profile of respondents was seen to have a direct impact on energy related vulnerability and the manner in which the impacts of energy poverty were experienced. More precisely, level of education, employment, income and formal skills and training should be the main focal areas for intervention since these can perpetuate and enhance poverty and vulnerability within the community. In this regard, small-scale renewable energy industries have the potential to improve employment opportunities, strengthen household income generation and impart some level of formal training and skills development among the youth. This may be most applicable in the Inanda community which houses a large percentage of formally educated, young individuals. In relation to education, skills and employment within Bergville, a more long-term strategy is required, as most respondents lacked formal education or completed primary level schooling. In light of the MDGs and more recently the SDGs, the provision of secondary level schools should be prioritised in IDPs and SDPs for Bergville.

It is also alarming to note that a large proportion of women in both communities were unemployed, lacked formal skills and training, and displayed lower levels of formal education compared to their male counterparts. The high levels of dependency displayed by women in particular are of concern and this study recommends that women are prioritised in future development initiatives to encourage empowerment and equality among the sexes in relation to household and community level decision-making and representation. Studies show that power and decision-making capacities are directly linked to energy practices, especially the decision to choose ‘free’ energy sources that pose a greater threat to women and children (Pachauri & Rao, 2013; Behera et al., 2015). Furthermore, both communities displayed a worrying reliance on state support, which demonstrates unsustainable sources of household income. The provision of state grants can have contradictory results: it can assist poor households in meeting basic needs or it can create a dangerous and unsustainable dependency. This study showed that a noteworthy proportion of respondents were unemployed, formally educated and listed child support or disability grants as a source of income. In this regard, the provision of state grants needs to be re-examined.

The lack of access to basic services such as roads, schools, formal housing, sanitation, and portable water also challenges households and emerged as some of the main community needs. Studies show that improved service delivery within poor communities can strengthen and diversify livelihood strategies (World Bank, 2004; Beltrán-Morales, 2007; UN, 2010). This bottom-up approach to development and improved sustainability at the household and community level can be applied to other aspects of development, poverty alleviation and service delivery in poor communities. Given that unemployment and underemployment is a major concern in both Inanda and Bergville, enlisting local community members for specific projects, for example, working for water or energy programmes, can produce multiple benefits and address some of the socio-economic challenges, concurrently.

6.3.2 Household energy profiles and preferences

Although most households had access to electricity, both groups of households engaged in extensive fuel-switching on a monthly basis. This shows that most households could not afford to sustain their use of modern energy sources. This study concludes that Bergville and Inanda households may be classified as energy poor, with more pronounced impacts being experienced in the latter. It should be noted that even though a portion of domestic energy is subsidised for poor and low-income households in South Africa, it does not adequately service their household energy needs, and as a result the use of energy cannot be sustained throughout the month. This study shows that there are significant differences in the energy affordability between and within Bergville and Inanda households warranting the need to develop context specific energy planning and programmes. In this regard, the role of energy policy and government institutions are emphasised in improving financial accessibility to modern (and preferably renewable) sources of energy to poor communities such as Bergville and Inanda. This highlights the role of renewable energy sources and technologies in providing basic energy services to lessen the burden of purchasing electricity.

Furthermore, this study shows that the use of fuelwood and paraffin are pronounced among the poorer respondents. These sources are known to have significant health impacts and may have serious consequences given the limited income to afford suitable health care. In this case, the impacts associated with the use of primitive and transitional fuels are exacerbated among the poor. Short-term responses to the indoor use of paraffin and fuelwood include increased ventilation in rooms used for cooking practices and improving levels of awareness on the health and safety impacts of indoor use of primitive and transitional fuels. Given the strong cultural and traditional links to cooking practices, targeted awareness campaigns and the use of more efficient and safer stoves and energy sources may be suitable long-term solutions. Consequently, renewable energy options offer suitable alternatives, however, there is a need to increase donor agency and government support for the purchase or subsidisation of RETs given the limited purchasing power displayed by respondents and households.

Furthermore, the proposed community-based solar thermal cooking facility could be positioned as a possible future initiative. Such decentralised, bottom-up projects could also assist in creating suitable employment and capacity building opportunities for local communities. Likewise, Stambouli (2011) and Becker and Fischer (2013) highlight the additional benefits of such systems to include improved access to lighting, communication and heating services. This study supports the concept of localised context specific initiatives given the large-scale differences noted within and between the Bergville and Inanda communities. Furthermore, this study demonstrates that households in both communities experience poor quality lighting and heating services. As a result, RETs and SETs that attempt to service multiple household energy needs will have a significant impact on their quality of life and lived experiences of energy poverty.

In addition, households switched between fuels based on their energy needs for specific activities and preferred the cheaper fuels for activities that required larger amounts of energy, and for energy services that were least prioritised. Gauging energy priorities at a household level may assist in the selection of RETs and SETs that are more complimentary to existing household energy needs and practices.

Based on the results obtained in this study it is evident that using a self-reporting survey to establish household energy consumption of specific energy sources may have resulted in misreporting since many households are unaware of the quantity they consume. Additional research should include an economic modelling component to better establish the costs and benefits of current household energy behaviour. Additionally, the literature recognises that intra-household dynamics are important, examining this aspect empirically was beyond the scope of the study. However, future studies should unpack these issues to gain a better understanding of household energy behaviours as well as related perceptions of specific energy sources among different household members. This will require multiple surveys to be conducted within sampled households.

6.3.3 Attitudes and perceptions towards energy sources

Most respondents perceived energy sources to be expensive yet efficient. A limited proportion of respondents indicated awareness of the environmental impacts associated with the use of their main household fuels. Likewise levels of awareness of climate change and renewable energy were limited. Despite displaying awareness of the health impacts associated with the use of paraffin and fuelwood, household reliance on these sources persisted. Respondents and participants perceived that solar energy was free. This may be a challenge and most respondents failed to recognise the associated production, installation and maintenance costs. Despite their limited levels of awareness of renewable energy sources, the majority of respondents displayed a willingness to pay for and use these sources. This is viewed positively for future energy related development. Overall, perceptions warrant the need for awareness campaigns and targeted education programmes to inform local perceptions.

It is of concern that some respondents associated the use of SETs and RETs with being poor. Currently, RETs such as SWHs are extensively used within low-income communities hence, it is unsurprising that respondents and participants associated the device with the concept of being poor. Walwyn and Brent (2015) posit that municipalities and other private sector companies should also embrace the use of the RETs such as SWHs in an attempt to elicit more favourable public perceptions of these devices. Permeating these discussions is the need to extend the use of RETs to different sectors and across the socio-economic gradient to encourage greater public acceptance and awareness of these devices. This study supports the findings of Mallet (2007), Wüstenhagen et al. (2007) and Ku and Yoo (2010) who show that social acceptance has a positive influence on willingness to pay and use these devices.

6.3.4 The use of spatial tools and participatory techniques in energy studies

The use of spatial and participatory techniques in household energy studies is relatively uncommon. However, within this study it offered several benefits and led to the following outcomes:

- highlighted and mapped out priority areas for socio-economic and energy related needs;
- allowed for a spatial overview of energy use within and between Bergville and Inanda;
- assisted in highlighting key environmental and geographic factors that promote or constrain household energy behaviours;
- was a time and resource efficient method of highlighting possible suitable sites for the introduction of specific RETs;
- provided an overview of community-level dynamics and vulnerabilities; and
- encouraged participation of local community members.

This study recommends the use of participatory techniques and spatial tools in the examination of suitable locations for the implementation of RETs. More specifically, for projects that are implemented in phases, examining local perceptions and knowledge of energy priority areas may allow for the needs of the poorest groups in communities to be prioritised. Also, participatory techniques can be an effective way to build relationships with local communities and encourage participation in local development programmes. This is also associated with a number of positive outcomes, especially regarding social acceptance of initiatives. Additionally, participatory techniques can also provide a suitable platform to examine and showcase local opinions, perceptions and indigenous knowledge systems effectively. In this regard, caution should be exercised in ensuring adequate representation of all groups within the community.

6.3.5 Implementation of renewable energy sources and technologies

A major recommendation of this study is that renewable energy implementation strategies should consider local socio-economic profiles, household energy needs and practices. This will permit the selection of technologies that complement existing livelihood practices in an attempt to improve overall quality of life. Although the SWHs were envisaged to address an important household energy demand, (heating of water), many other studies and results from focus group discussions in this study, show that these devices may do little to improve access to energy services. As indicated in this study, households that did use SWHs also used electricity and paraffin to heat water during winter and some cloudy days. Furthermore, this study showed that cooking is the most prioritised household energy need, but is also associated with high risk. An evaluation of household energy needs and priorities may assist in identifying more suitable RETs that will significantly improve energy security and reduce energy related household vulnerability.

Additionally, it may be useful to consider hybrid energy systems that comprise a variety of devices, for example, SWHs and solar lighting as opposed to focusing on RETs that are only able to service a specific energy need. This may assist in extending the use and up-take of RETs. Furthermore, level of education, technical skills and competencies have been identified as important factors that facilitate the transfer and up-take of technologies (Gumede et al., 2009; Barry et al., 2011; Onyeji et al., 2012; Miller et al., 2015). This study underscores the need for renewable energy implementation strategies, in the South African context, to examine and reflect on the socio-economic, environmental, and energy attitudes and perceptions at varying levels. More specifically, there is a need to unpack individual, household and community-level conditions in energy debates and policy planning.

Furthermore, even though this study did not adopt a longitudinal approach in examining energy behaviours and practices, it is recommended that future energy-related studies examine the temporal-based changes in household energy practices for a robust understanding of energy behaviour. Moreover, there is a need for an in-depth examination of energy behaviours among middle to upper income groups. This was beyond the scope of the current study, but middle and upper income households display higher levels of economic stability and therefore may be better positioned to embrace the shift towards RETs. These groups display considerably higher energy consumption and consequently, a larger ecological footprint. It might be useful to examine the potential use of RETs within these contexts to reduce consumption of coal-based electricity, and to thereby reduce domestic GHG emissions.

In addition, both the literature and primary data collected in this study highlight concerns over the maintenance, repairs and servicing of currently installed SWHs. There is a need for renewable energy implementation programmes to include the provision of maintenance, repairs and servicing support to households, post-installation. This should be carried out for a minimum period of 3-5 years which will allow for the transfer of knowledge and skills to potential users, and allow sufficient time for the transfer of technologies and successful up-take and acceptance.

South Africa, being a developing country, may not have the necessary financial or logistical resources for long-term support, however, there are other possibilities in extending the service and support to RET users. For example:

- given the limited employment, local community members could be trained and skilled to provide this support for a reduced fee to their communities (this will also contribute to much needed locally-based job creation);
- awareness and skilling workshops for communities as an additional outcome of all renewable energy implementation plans;
- encouraging private-public partnerships for the development of small and medium sized enterprises to produce and service these devices; and
- promote and subsidise the use of improved RETs that have higher start-up costs but are associated with lower maintenance costs and display longer life spans.

This study highlights the need for institutional and legislative support for the swift and sustainable implementation of RETs. In the absence of suitable policies and government investment in the wide-scale provision of RETs, especially among the low-income and poor communities such as Bergville and Inanda, the use of renewable energy sources and technologies will be limited to a select few households. The following section provides the main recommendations for South African energy policy and planning.

6.3.6 Energy policy and planning in South Africa

This study highlights some of the rural-urban discrepancies in the provision of basic and affordable domestic energy services within the South African context. Despite the successes in extending the national electricity grids over the past 20 years, there are still some rural communities such as Bergville that have households who lack formal electricity connections. Access to affordable, safe and efficient energy has the potential to strengthen livelihood sustainability and improve overall quality of life. Energy planning and policy cannot view these development agendas in insolation. The political history and diverse socio-economic and demographic contexts warrants the need to develop localised, context and geographic specific approaches to energy development. The use of generic frameworks do not adequately accommodate for these diversities. Furthermore, despite having more than 80% rates of electrification, most low-income South African households engage in extensive fuel-switching practices, demonstrating that energy affordability is an equal if not more urgent development need. As illustrated in this study, there is need for energy policy to interrogate household level energy behaviours, attitudes and perceptions across longitudinal and geographic scales.

As mentioned earlier, South Africa displays diverse socio-economic and geographic conditions, and as established in this study, these can be important factors affecting household energy practices and preferences. This study focused on 2 case studies; however, there is a need for more comparative case studies to examine general trends and practices, as well as the main determining factors. Future energy research within South Africa should consider the context specific conditions and variations to household energy behaviours, attitudes and perceptions to gain a more robust understanding of the overall energy sector. This may improve the implementation and up-take of renewable energy options at the household level and encourage more responsible and sustainable energy behaviours.

6.4 Concluding remarks

This study critically assessed the socio-economic, environmental and political factors that influence household energy security, energy behaviours and the implementation of renewable energies within peri-urban and rural communities. This was carried out against the backdrop of large-scale implementation of renewable energy sources and technologies among low-income households within South Africa, and the growing recognition of the broader impacts of energy poverty and access on livelihoods. This study showed that household energy security and behaviours are influenced by a range of factors across a broad contextual domain. Key findings also demonstrated that the focus on household attitudes and perceptions towards energy sources has the potential to inform renewable energy implementation strategies, specifically in relation to the selection of suitable RETs, the price, the affordability and applicability to their current energy needs and profiles. In addition, this study showed that most households in peri-urban and rural communities within South Africa experience the multiple impacts of energy poverty despite having access to electricity.

A key contribution of this study to the broader understanding of household level energy behaviours, perceptions and the factors influencing implementation of renewable energy sources and technologies is a conceptual framework that is intended to guide the energy planning and implementation process within the South African context. Furthermore, the use of spatial analysis provides a methodological contribution to collecting and presenting data on energy poverty in different contexts. Additionally, the findings of this study support the assertions made by the conceptual frameworks, specifically in the peri-urban context in relation to the broad range of factors that influence household energy profiles and preferences. The need for context specific approaches to the implementation of RETs such as solar thermal cookers are further emphasised by the fact that rural communities such as Bergville show significantly different energy profiles to poor households in other geographic locations such as Inanda. Finally, it must be said that whilst the provision of energy can improve livelihoods, it is the improvement of livelihoods that can sustain access to safe, modern and efficient energy.

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APPENDIX A

HOUSEHOLD SURVEY
ENERGY NEEDS ANALYSIS QUESTIONNAIRE

Date :	
Questionnaire #	

Community

1. Inanda	2.Bergville

Enumerator Name/#:________ Fieldworker name: ______________________ Date completed: ____________

I am undertaking a survey of energy needs in your community on behalf of a student, Ms Suveshnee Munien for her PhD 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.

SECTION A: SOCIO-ECONOMIC AND DEMOGRAPHIC PROFILE OF RESPONDENTS

A1. What is your age (in years)? ______________

A2. What is your sex? (note)

M	**F**

A3. What is your employment status?

1. Employed	2. Unemployed	3. Self- employed	4. Retired	5. Medically bordered
6.Other (specify)				

A4. What is your highest educational level attained?

1. No formal Education	2. Partial primary	3. Primary
4. Partial secondary- Grade 10	5. Secondary completed	6. Certificate/ diploma
7. Undergraduate degree	8. Postgraduate degree	9. Adult Based Education (ABED)

A5. What is the current household size?

No of males		No of females	

A6. What is the total monthly income (in Rands)? ________________

A7**.** What additional sources of income does the household have access to?

1. Employment	2. Remittances	3. Old age pension	4. Child grant	5. Disability grant
6. Sale of agricultural produce		7. Other (specify)		

A8. What current activities take place on the property currently? (Multiple responses permitted – ask for each)

1. Crafting	2. Hairdressing/ beauty care	3. Small business/ Vendor
4. Traditional medicine	5. Crop production	6. Catering/ cooking
7. Livestock rearing	8.Child/ elderly/ sick care	9. Sewing
10. Construction/building	11. Other (specify)	

A9.1Would you like to engage in any other activities?

1. Yes	2. No

A9.2 If yes or maybe, indicate the type of activity?

1. Income generating	2. Agriculture	3. Education
4. Entertainment/leisure	5. Other (specify)	

A9.3 If yes, what is preventing you from engaging in these activities currently? (Multiple responses permitted)

1. Personal choice	2. Access to energy	3. Insufficient time
4. Lack of skills	5. Culturally unacceptable	6. Lack of infrastructure
7. Lack of resources	8. Other (specify)	

SECTION B: ENERGY PROFILE OF HOUSEHOLDS

B0. Do you currently have access to electricity?

1. Yes	2. No

B1. Which current household activities (except for cooking, heating and lighting) require energy? (Multiple responses permitted)

1. Crafting	2. Crop production	3. Sewing	4. Reading	5. Entertainment
6. Education	7. Businesses	8. Communication	9. Other (specify)	

B2. What is your main source of energy for the above activities?

1. Electricity	2. Fuelwood	3. Gas	4. Paraffin	7. Candles	8. Other (specify)

I would now like to ask you a few questions regarding cooking, lighting and heating specifically. *(Please tick)*

	1. Electricity	2. Fuelwood	3. Gas	4. Paraffin	5. Candles	6.Other (specify)
B3. What is your main source of energy for cooking?						
B3.1 What are your other sources of energy for cooking? (Multiple responses)						
B4. What is your main source of energy for lighting?						
B4.1What are your other sources of energy for lighting? (Multiple responses)						
B5 What is the main source used for heating?						
B5.1What other sources of energy do you use for heating? (Multiple responses permitted)						
B5.2 Which of these sources do you use daily?						
B5.3 Which source do you use on a monthly basis?						
B6. How many times per day do you use this source *(use codes)*						
B7. How many hours per day do you use this source *(use codes)*						

Codes B6	**Codes B7**
01 Once	01 <1 hour
02 Twice	02 1-2 hours
03 Thrice	03 2-3 hours

Codes B8.1	**Codes B8.2**	**Codes B10**
01 Collected 02 Purchased 03 Both	01 Village Friends/neighbours 02 Local vendors 03 Village market 05 Supermarkets 06 City 07 Other (specify)	01 Convenient 02 Easily accessible 03 Only option available 04 Requires less time for reparation 05 Cost effective 06 Other (specify)

Please answer the following questions in relation to the energy sources used *(please tick)* **NOTE SOURCES IN B2**

Source	1. Electricity	2.Fuelwood	3.Gas	4.Paraffin	5.Candles	6.Other (specify)
B8.1 How do you obtain this source/s? *(use codes)*						
B8.3How much do you pay for this source/s per month?						
B10 Main reason why do you choose this source? *(use codes as per re3sponses)*						

B11. Rate the following statements with regards to the energy source/s listed
(0=I do not know 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree)

Statements	1. Electricity	2. Fuelwood	4. Paraffin	3.Gas	5. Candles
1.Is expensive					
2.Has negative impacts on health					
3.Is unreliable					
4.Causes Pollution					
5 Is environmentally friendly					
6.is easily accessible					
7. Is safe to use					

B12. Main area used for cooking?

1. Indoors	2. Outdoors	3. Other (specify)

B13. Main method of cooking your meals?

1. Stove top	2. Fire top	3. Other (specify)

If fuelwood is used for cooking, heating or lighting, please answer B20 and B21:

B14. Who is responsible for obtaining fuelwood?

0. Everybody	1. Women only	2. Men only

B15. What distance do you travel to collect fuelwood? ___________________________

B16. Which source/s have you previously used and is no longer in use? (Multiple responses permitted)

0. None	1. Electricity	2. Fuelwood	3. Gas
4. Paraffin	5. Candles	6. Other (specify)	

B17. Why have you stopped using this source/s? (Main responses permitted)

Don't know	2. No longer available/accessible	3. Too expensive
4. Inconvenient to use	5.Too time consuming	6. Other (specify)

B18. Do you or any occupants of this household conserve energy?

1. Yes	2. No

B19. If yes, please specify how you do so?

1. Switch of lights when not in use	2. Unplug appliances when not in use	3. Use energy saving bulbs
4. Reduce temperature of geyser	5. Close windows when using heater	
5. Other (specify)		

SECTION C: AWARENESS AND PERCEPTIONS OF RENEWABLE ENERGY

C1. Are you aware of renewable energy?

1. Yes	2. No

C1.1 If yes, what in your opinion is renewable energy?

____

C1.2 If yes, what types of energy do you consider to be renewable? (Multiple responses permitted)

1. Solar	2. Wind	3. Hydro	4. Biofuel	5. Biomass	6. Biogas
7. Nuclear		8. Fuelwood	9. Other (specify)		

C1.3. What makes it a renewable source of energy?

____

C3. Where did you get this information from? (Multiple responses permitted)

1. Radio	2. Television	3. Magazine	4. Newspaper	5. Books	6. Internet	7. School
8. Family member/ friends/ neighbours			9.Place of work	10.Other (specify)		

C4. Would you use renewable energy?

1. Yes	2. No

C4.1 If no, what is the main reason? (Multiple responses permitted)

1. Don't know	2. Not easily accessible/ available	3. Too expensive	4. Inconvenient to use
5. Too time consuming	6. Other (specify)		

C4.2 If yes, which source/s would you use? (Multiple responses permitted)

1. Solar	2. Wind	3. Hydro	4. Biofuel	5. Biomass	6. Biogas	7. Other (specify)

C4.3. If yes, which activities would you use the source of energy for? (Multiple responses permitted)

1. Cooking	2. Lighting	3. Heating	4. Crafting	5. Sewing
6.Studying/Reading	6. Entertainment	7. Income generating	8. Other (specify)	

C6. Did you use renewable energy previously, but currently stopped?

1. Yes	2. No

C6.1. If yes, which source did you use?

1. Solar	2. Wind	3. Hydro	4. Biofuel	5. Biomass	6. Biogas	7. Other (specify)

C7.2 Why did you stop using this source? (Multiple responses permitted)

1. Don't know	2. Not easily accessible/ available	3. Too expensive	4. Inconvenient to use
5. Too time consuming	6. I did not know how to use it	7. Other (specify)	

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

1. Yes	2. No

C8.1 If yes, please indicate type of impacts. (Multiple responses permitted)

1. Not easily accessible/ available	2. Too expensive	3. Inconvenient to use	4. Too time consuming
5. Too difficult to use	6. No negative health impacts	7.Not reliable	8. Environmental impacts
9. Inadequate supply of energy	10. High maintenance costs	11. Other (specify)	

C9. Do you know of any benefits of using renewable energy?

1. Yes	2. No

C9.1 If yes, please specify. (Multiple responses permitted)

1. Cheaper	2. Easy to use	3. No negative health impacts	4. Environmentally friendly
5. Reliable	6. Other (specify)		

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

C10. Are you aware of solar energy?

1. Yes	2. No

C10.1 If yes, what in your opinion is solar energy?

____

C12. Would you use solar energy?

1. Yes	2. No

C12.1 If no, what is the main reason?

1. Don't know	2. Not easily accessible/ available	3. Too expensive	4. Inconvenient to use
5. Too time consuming	6. Other (specify)		

C12.2. If yes, which activity/ies would you use the solar energy for? (Multiple responses permitted)

1. Cooking	2. Lighting	3. Heating	6.Education/Reading	6. Entertainment
7. Income generating	8. Other (specify)			

C13. How much (in Rands) would you be willing to pay as start-up costs for solar energy? _______________

C14. How much (in Rands) would you be willing to pay for solar energy per month? __________________

C15. Have you heard of solar thermal energy?

1. Yes	2. No

C16. Have you heard of a solar thermal cooker?

1. Yes	2. No

C17.1 If yes, what do you understand a solar thermal cooker to be?

____

(At this stage explain to respondent what a solar thermal cooker is- show the printed examples)

C18. Would you use a solar thermal cooker?

1. Yes	2. No

C18.1 If no, specify the main reason/s? (Multiple responses permitted)

1. Don't know	2. Not easily accessible/ available	3. Too expensive	4. Inconvenient to use
5. Too time consuming	6. Other (specify)		

C19. Would you need training on how to use the solar cooker?

1.Yes	2. No

C20. Do you think that training will increase the amount of people use it?

1. Yes	2. No

C21. How much (in Rands) are you willing to pay per month for a solar cooker? ______________________

C22. Who should be responsible for maintenance and up keep of the solar thermal cooker?

1. I do not know	2. Sponsors	3. Community members	4. Government
5. Trained professionals	6. Household members	7. Other (specify)	

C23. Would you be willing to prepare your meals using a community-based cooking facility?

1. Yes	2. No

C23.1 If no, please indicate main reason?

____

I would now like to ask you some general questions

C24. Are you aware of the term energy poverty?

1. Yes	2. No

C24.1f yes, what is your understanding of energy poverty?

____

____

C25. Are you aware of Climate Change?

1. Yes	2. No

C25.1 If yes, what is your understanding of Climate Change?

____

C26. Is there anything else you would like to share?

____

____

____

THANK RESPONDENT FOR TIME AND COOPERATION AND END INTERVIEW

APPENDIX B

FOCUS GROUP SCHEDULE
HOUSEHOLS ENERGY STUDY

1. Background Information

1.1 Name of Community:

1.2 Date of interview:

1.3 Interviewer:

1.4 Note taker:

1.5 Interview start time:

1.6 Interview end time

2. Energy uses- household and community

1. What are your current energy sources?
2. What are the reasons for your choice?
3. What are your current energy uses?
4. What are your current energy needs?
5. Please rank your energy preferences? (Matrix)
6. Are there any other additional sources that members would like to use?

3. Challenges

1. What are you main energy realted challenges?
2. How can the city assist you with these challenges?

Mapping

Task one:

1. Which are the areas that are most vulnerable/ poor energy?
2. Which areas use the most and least energy?
3. Which areas are suitable for the use of solar energy?
4. Which regions use in the future will require the most energy?
5. Which are the region's most suitable for the use of solar thermal cookers?

   Indicate on the map, with the red dots, the areas most in need of energy

Discussion:

Why do think these regions need energy the most?

Tea break

Discussion

Needs

1. Indicate the 3 most important features that households need
2. Indicate 3 most important features that the community needs

Solar energy

1. Do you think solar energy will allow you to engage in more income generating activities?
2. Would you use solar energy?
3. Would you like to know more about solar energy?
4. What is your preferred source of information?
5. Do you think that if the community was involved in producing the technology, (show pictures again), they will be more willing to use solar energy?
6. Do you think that solar energy is more suited to community based facilities, eg clinics, libraries, schools, halls etc?
7. Would you use these facilities?
8. Who should be responsible for maintenance of the technology?
9. Is there any other information you would like to share?

Thank group for taking the time to assist us.