An Exploration of Household Energy Use Patterns Among Grid Electrified Households in Low-income Rural and Peri-Urban Communities in South Africa

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DECLARATION

I, Yachika Reddy declare that this dissertation is my own original work. I know the meaning of plagiarism and declare that all the work in this document, save for that which is properly acknowledged, is my own. This dissertation is being submitted in partial fulfilment of the requirements for the degree of Master of Science in Applied Science (Energy Studies) at the University of Cape Town. It has not been submitted before for any degree or examination at any other university.

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YACHIKA REDDY

Dated at _____this day of _____2008

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ABSTRACT

The high prevalence of poverty in South Africa (afflicting 40% of South African citizens) is a major challenge facing the country. Access to safe, reliable and affordable energy services is identified by national government as a tool for alleviating poverty, yet delivery of such services remains a challenge. This study therefore explores the energy use patterns of low-income grid electrified households in rural and peri-urban areas of South Africa – rural and peri-urban areas being the two areas where majority of the poor reside - as a means to inform insights on the energy use of the poor within these two landscapes. It is important to understand the energy use patterns of these households, in order to inform policy interventions aimed at enhancing the energy welfare of low-income households through improved access to safe, affordable and reliable energy services to be designed and targeted congruent to the energy needs of poor households.

Energy use patterns of low-income households in this study were examined using data from a household energy survey conducted by the University of Cape Town. These patterns between rural and peri-urban households were determined by investigating several factors, namely the prevalence of fuels used, the end-uses of different fuels consumed, variation in expenditure on the range of fuels used, the energy burden of households i.e. the share of the household budget on energy expenditure, multiple fuel use patterns and appliance ownership associated with the use of different fuel types. These factors were further analysed across a range of demographic and socio-economic variables such as household income, size, gender composition, age and education to understand how household energy use patterns (demand) interacts with and possibly influenced by these demographic and economic household characteristics.

From this analysis, it emerged that multiple fuel use was a common phenomenon among both rural and peri-urban households and across all income groups. Despite all households in the sample being electrified, it was found that electricity was in fact used as an additional fuel to meet energy needs of households. Paraffin, fuelwood, electricity and candles were the most widely used fuels in this study, with fuelwood use being considerably more widespread in rural households than urban households. Peri-urban households were found to spend more on energy per capita than rural households. However among rural households in particular, where fuelwood was a dominant source of energy, much of it was self-collected and its value was not included in the total energy expenditure of a household, as it proved difficult to attribute a monetary value to self-collected fuelwood. Thus, rural household energy expenditure is somewhat understated. Expenditure on electricity and paraffin accounted for most of the energy budget of households throughout the sample. The level of energy burden (i.e. energy expenditure expressed as a percentage of total household expenditure), experienced by all surveyed households was of a magnitude that reflected all were living in a state of

energy poverty – with the level of energy burden being greater for peri-urban households (16%) than rural households (11%). With regard to social and economic characteristics of the surveyed households and their interaction with household energy use patterns, household income and household size emerged as the two main factors revealing relationships with household energy demand. It was found that biomass (fuelwood and bio-fuels) use decreased with increasing income of household across the entire sample, signalling a shift away from traditional fuels to greater uptake of modern commercials with improved income. Further households were observed to spend more on energy with increased income. However poorer households spent a larger proportion of their household budget on energy than least poor households. In terms of household size, larger households were found to be using biomass fuels more commonly than smaller households, in the rural areas in particular, given the more widespread use of these fuels in these areas. Further across the entire sample larger households were found to spend less on energy. This was largely for reasons that larger households had lower incomes and that energy use usually reflects economies of scale with increasing household size - thus while total energy consumption increases with household size, per capita energy consumption declines. In terms of end uses almost all of the urban households use electricity and paraffin as their main fuels for cooking and water heating, a slightly lower proportion of rural households use electricity for these end uses, with paraffin being used by a substantially lower proportion. Fuelwood use in the rural areas dominates for cooking and water heating. In rural and urban areas electricity was mainly used for lighting relative to paraffin. In term of appliance ownership and use, despite much higher electricity and paraffin consumption in urban areas, there is no large-scale difference in electrical and paraffin appliance ownership and use across the rural and urban samples. This may suggest that access to appliances is not a major driver of fuel use patterns.

It was concluded that household energy use patterns differ greatly between rural and urban areas. In addition income category and household size (which are inversely related) also show strong relationships with energy use patterns. Energy use patterns showed markedly less variation with increasing level of education of household, and very little variation with respect to changing gender compositions and average ages of household.

This study and other literature show that despite being electrified and hence having better quality and safer lighting, low-income households continue to use and direct a large proportion of their energy budget towards other fuels such as fuelwood and other biomass fuels and paraffin for their thermal energy needs. The continued reliance on fuelwood in low-income rural households remains an issue of grave concern, especially because of the negative health implications for women and children. Thus, energy policy planning should for the foreseeable future target resources at improving the safety and efficiency with which these other fuels are used.

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LIST OF ACRONYMNS AND ABBREVIATIONS

ASGISA	Accelerated and Shared Growth Initiative of South Africa
DME	Department of Minerals and Energy
EBSST	Electricity Basic Services Support Tariff
EDRC	Energy and Development Research Centre (now named ERC)
ERC	Energy Research Centre (formed from the merger of EDRC and ERI)
ERI	Energy Research Institute
FBE	Free Basic Electricity
EBSST	Electricity Basic Services Support Tariff
GDP	Gross Domestic Product
GEAR	Growth, Employment and Redistribution
GW	Giga Watt
GWh	Giga Watt-hour
kWh	kilowatt hour
kg	kilogram
kgoe	kilogram of oil equivalent
kW	kilowatt
LPG	Liquefied Petroleum Gas
MW	Megawatt
NEP	National Electrification Programme
INEP	Integrated National Electrification Programme
PDC	Palmer Development Corporation
PIR	Poverty and Inequality Report
RDP	Reconstruction and Development Programme
UCT	University of Cape Town
US$	United States Dollar

CHAPTER 1: INTRODUCTION

Sketching the background of South Africa in the initial part of this introductory chapter locates the context in which energy use patterns of low-income rural and peri-urban households in South Africa is explored in this dissertation. At an overarching level, household energy use patterns of the poor (low income) rural and peri-urban areas in South Africa, have largely been influenced and shaped by historical processes such as the development of economic structures based upon a labour migration system which served the mining and industrial sectors substantially as well as the restriction of a burgeoning population to small, overcrowded and under-resourced "homeland" areas.

1.1 South Africa – an overview

1.1.1 Transformation in South Africa – process and policies

South Africa is testimony to a fourteen -year old fledgling democracy. The first democratic election, a landmark event in South Africa's history, was held in 1994, which led to a change from an apartheid system of governance (which called for the separation of people on the basis of race, codified into law), to a democratic form of governance, giving rise to new directions in almost all spheres of government and public life. The aim of the newly elected South African government of 1994 was to transform a system that was characterised by severe poverty, high unemployment and structural inequalities in access to economic assets, basic services, processes and institutions. Indications in 1993 revealed that 50% of the South African population were considered poor and that the gap between rich and poor was among the largest in the world. These high levels of poverty and inequality influenced living standards, economic growth, as well as levels of crime and social stability (May 2000). Restructuring was therefore crucial in both addressing poverty and inequality generated by the apartheid system as well as placing the economy on a new path of sustainable development and growth. In doing so the newly elected government of 1994 was not only committed to the various provisions for democratic governance as outlined in the country's constitution but also focussed strongly on the provision of basic services to the poor and the disadvantaged who formed the overwhelming majority of South Africa's population. Provision of modern energy services formed a key component of such services, particularly good quality electricity supplies. Modern energy provides services which support the provision of basic needs such as cooked food, pumping, transporting and heating water, maintaining a comfortable living temperature, lighting, the use of appliances, piped water or sewerage, essential health care, education aids, communication (radio, television) and transport (UNDP 2000). Moreover energy fuels productive activities of the poor (WEA 2000). A strong link therefore emerges between access to modern energy services and poverty alleviation (Davidson & Mwakasonda, 2003).

An overarching strategy guiding the social and economic transformation in South Africa is the Reconstruction and Development Programme (RDP), an integrated policy platform geared towards social and economic advancement, with a central focus on development of infrastructure in poor communities. The RDP came to form the benchmark for the new government's economic and social development policies, programmes and strategies. The key objectives of the RDP are: 1) meeting basic needs, 2) building the economy, 3) democratising the state and society, 4) developing human resources and 5) building the nation. In practice the RDP aims to address the issues of poverty and inequality through widening the economic benefits to the majority of South Africa via improved education, health care, housing, infrastructure development, welfare and affirmative action to promote the interests of the historically disadvantaged groups (ANC 1994).

Building on from the RDP, and as the country developed and faced new constraints, two key broad economic policy frameworks emerged, both playing a critical role in the shaping of the current political and economic landscape of the country. They are the, Growth, Employment and Redistribution (GEAR) strategy introduced in 1996 and more recently the Accelerated and Shared Growth Initiative of South Africa (ASGISA), both of which promote economic growth and development, and serve to underpin government economic and development strategies and policy development. GEAR a macroeconomic strategy adopted by government while successful in ensuring overall economic stability (fiscal deficit reduced from 10% to 4% of GDP in 1997/98 and inflation controlled to 7% in 1998), failed to address the poor and unemployment adequately (Roberts 2005). However the government was aware of the challenge it faced in achieving an effective balance between meeting pressing social development needs and macroeconomic stability, both fundamental components in the growth and development of the country.

South Africa continues to undergo profound changes and challenges, since the achievement of democracy in 1994. Poverty, inequality and unemployment continue to loom large, despite the enormous strides made by government in addressing these challenges through the provision of basic services[1] (such as education, health, housing, personal security and social safety nets for the most vulnerable) to millions of previously deprived South Africans, job creation through the Expanded Public Works Programme[2] (as well as through macroeconomic stability. The state of prevailing poverty, inequality and unemployment can be partly ascribed to the pace of service delivery and job creation not keeping up with the increased demand for basic services and employment, further compounded by intensified migration from the rural localities to the urban centres.

[1] Approximately 71% of South African households have access to sanitation, up from 50% in 1994, while 80% of households have access to electricity – i.e. 4.2-million households have received electricity connections since 1994. 2.3 million housing subsidies have been completed and up to 12 million South Africans receive social grants (PCAS 2007).

[2] Expanded public works programme has created a million jobs since 2004 in an attempt to reduce the gap between the formal economy and the vast numbers of unskilled and unemployed people who were not enjoying the benefits of economic development

ASGISA, introduced in 2006, is an initiative by government focusing largely on skills acquisition, work experience and major infrastructure investment in key economic sectors, as a means to halve unemployment poverty levels by 2014. It is seen as a set of interventions that would serve as catalysts to accelerated and shared growth development. The growth rate targets by ASGISA enabling the government to meets its social objectives is an average yearly growth of 4.5% from 2006 to 2009, accelerating to 6% from 2010 to 2015 (ASGISA 2007).

1.1.2 The economy of South Africa

By international standards South Africa has a highly energy intensive economy, meaning it consumes a relatively large amount of energy for each unit of national economic output produced in comparison to other countries. This is largely driven by the related issues of relatively large coal resources (coal contributes 77% of primary energy demand and 93% of electricity generation in South Africa), low energy prices, low levels of efficiency in energy consumption, as well as energy intensive primary minerals extraction and beneficiation arising from the country's rich endowment of natural resources such as coal, gold, diamonds, metals and minerals. ((DME 2005b, GoSA 2006).

Relative to African standards, South Africa has the highest per capita energy consumption and is among the best performing economies in Africa (expressed as Gross Domestic Product (GDP)), yet the country displays high levels of poverty[3] (Davidson & Mwakasonda 2003). The economy has grown since 1994 by an average rate of 2.8% per year, increasing to an average of 3.5% between 1999 and 2005, further rising to 4.5% since 2005, compared to the decade prior 1994 when economic growth averaged at 1.8% a year (PCAS 2007).

GDP per capita, another economic indicator reflecting the state of a country's economy, grown since 2000 standing at 3.6% for 2006. Since 2002 the overall income growth in the country - including the expansion of social grants to about 12 million recipients – has resulted in a rise in income of the poorest 10-20% of the population. However the rate of improvement of the poor has not kept pace with that of the rich, hence while income poverty appears to be declining, inequality has grown. Given the current situation with an annual GDP growth rate of over 4.5% and a population growth rate of 1.06 (2005/06 estimate), the government anticipates the average wealth per person to continue to rise at a rate of 3.5% per year for the near future. Due to the past political system, major differences across the different race groups persist, as reflected by the inequalities in average monthly household incomes, ranging from R2 160 ($311.45) for Africans[4], through to Coloureds and Indians earning

[3] Past experience indicates that high levels of per capita energy consumption of modern energy, including electricity is usually associated with vast improvement in prosperity – an association determined from decades of energy research performed worldwide which repeatedly indicate the strong link between income and energy use (IEA 2004:25)

[4] Racial terms, routinely used in South Africa for the purposes of measuring prevailing inequalities, are 'African', 'Indian', 'Coloured' and 'White'.

respectively R4 250 ($612.81) and R7 083 ($1 021.30), with Whites earning the highest levels at R13 166 ($1 898.40) (SSA 2002).

At present unemployment lies at 25.5% using the narrow (official) definition (i.e. people seeking employment but could not find work in the last 2 weeks) and rises to over a third of the population i.e. 37.3% using the broad definition (i.e. including people who would like to find employment but have been discouraged from seeking employment and therefore have not actively sought work in the previous month) (PCAS 2007:19). It can be observed that the official unemployment definition only partially reflects the gravity of the situation.

1.2 Poverty in South Africa

Since the focus of this study is on the exploration of household energy use patterns of low-income peri-urban and rural households in South Africa, it is important to outline the characteristics of poverty in South Africa and identify who the poor are in order to define the focus of the study.

Defining and measuring poverty is indisputably difficult and therefore remains a subject of wide debate locally and internationally. This in part can be ascribed to poverty being manifest in living conditions that are dynamic, multifaceted in nature and therefore not easily quantifiable. An emerging consensus sees poverty in South Africa as being characterised as the inability of individuals, households or entire communities to obtain a minimum standard of living, measured in terms of consumption needs or the income essential to meet basic needs. Further it includes lack of opportunities and choices to advance human development i.e it includes alienation from the community, food insecurity, crowded homes, usage of unsafe and inefficient forms of energy, lack of adequately paid and secure jobs, and fragmentation of the family (May 2000, Noble et al 2006). Another concept closely associated with poverty in South Africa is 'inequality', defined by the Poverty and Inequality Report (PIR) [5] as "being the opposite of equality, a state of social organisation which enables or gives equal access to resources and opportunities to all members" (May et al 1998).

Poverty and inequality loom large in South Africa, with their particular configuration being rooted in past (Apartheid) social and economic policies. A significant feature across South African households is the highly unequal distribution of income and wealth. South Africa, although recognised as an upper-middle income country in per capita terms, has a large proportion of its population living in varying conditions of poverty, varying between outright poverty to continued vulnerability to being poor (May et al 1998). Further, South African society displays one of the greatest income differentials in the world, and the highest in the Southern African region (Clark & Dimrie 2002). The Gini

[5]The Poverty and Inequality Report was commissioned by the Office of the Deputy President, Thabo Mbeki, in 1997. This report was the first substantial and comprehensive post-apartheid publication using historical and contemporary data to review the extent and nature of poverty and inequality in South Africa.

coefficient[6], a widely used measure to determine income inequality stood at 0.68 in 1991 (Whiteford 1994). By 2000 the Gini coefficient declined to 0.59 (second highest in the world after Brazil) with the exclusion of social transfers (pensions and grants), and 0.35 if social transfers were included (PCAS 2003). In practical terms, inequality as revealed by the PIR manifests as the poorest 40% of households comprising approximately 50% of the population who receive a mere 11% of total national income, while the richest 10% of households making up 7% of the population receive in excess of 40% of total income. This trend reflects that the democratic government policies and measures have yet to be robust in improving access to physical and social assets to the disadvantaged communities, households and individuals. (May et al 1998)

Having largely outlined the extent of inequality pervasive in South Africa, it is also important to address the extent and nature of poverty prevailing in the country.). The poverty line a widely used measure of poverty is a cut-off point in income or consumption below which an individual or household is defined as poor. The poverty line is based on the expenditure required to maintain a minimum standard of living i.e. an amount sufficient to buy nutritionally adequate food and other necessities (World Bank 2001).Poverty lines vary between countries, reflecting country specific economic and social conditions. In South Africa, numerous poverty lines have been calculated, however one of the more widely used poverty lines emanates from the PIR. The PIR in 1998 using a method adopted by the RDP, estimated the poverty line as a monthly household expenditure of R352,53 per adult equivalent (households are ranked on adult equivalent expenditure), below which households are regarded as poor, while households with a monthly expenditure of less than R193,77 per adult equivalent are classified as ultra-poor. This amounts to 40% of South African households being classified as poor, comprising little less than 50% of the population (19 million people), while the ultra-poor constitute the poorest 20% of these households, making up 27% of the population (10 million people) (May et al 1998).

A distinctive feature of poverty in South Africa is its strong racial, gender and spatial dimensions (see Table 1.1) within which wide disparities prevail in relation to income levels, as well as in access to assets such as land, employment, education and other social services (May et al 1998; Eberhard & Van Horen 1995). In terms of income and other indicators (such as access to basic services, health, employment, education etc) the rural areas emerge as more impoverished than the urban areas. The rural areas are resident to 45% of the population of which 71% are poor (fall below the poverty line used by the PIR). Further, of all the poor people living below the poverty line 72% reside in the rural areas (May et al 1998). Substantial provincial disparities also prevail, with those encompassing the most populous former homelands (namely KwaZulu-Natal, Limpopo Province, Eastern Cape and Free State) bearing the larger share of the poverty burden. According to the PIR, Limpopo and Free State

[6] The Gini coefficient, used widely to measure the distribution of income across a society, ranges from 0 indicating perfect equality where everyone earns the same income to 1 indicating perfect inequality, where one person earns all the income (UNDP 2003).

experience the highest poverty rates, while the depth of poverty (the amount required to move people beyond the poverty threshold) was found to be highest for Eastern Cape and Free State (May et al 1998). Of the 21.9 million people classified as poor in South Africa, 59% reside in the provinces of KwaZulu-Natal, Limpopo and Eastern Cape (UNDP 2003). It is thus apt that this dissertation locates the exploration of energy use patterns of low-income households within these provinces, in order that a relatively representative picture may be created to shed insight into the use of energy by South Africa's poor in fulfilling their basic domestic needs.

With respect to the gender dimension of poverty, women are in a relatively deprived position with respect to income and other indicators (such as land ownership, employment, education, as well as control over household resources and decision-making) (UNDP 2003; Eberhard & Van Horen 1995). This is attested by 54.4% of the poor (11.9 million people) being women in comparison to the 10 million who are male (Table 1.1) (UNDP 2003). More telling is the fact that female-headed households have a higher incidence of poverty than households with a residing male head (poverty rates of 60% for a female headed household and 31% of a male headed household were reported by May (2000)). Some of the factors accounting for this gendered differential are: 1) greater probability that female headed households are based in rural areas where poverty rates are higher, 2) female headed households are likely to have fewer adults of working age, 3) higher unemployment rate among females, and 4) the continuing differential between male and females wage earnings (Woolard 2002).

Lastly another aspect closely linked to poverty is vulnerability. Vulnerability reflects the dynamic nature of poverty, and the propensity of individuals or households to move into and out of poverty. This dynamic situation is the result of a myriad of factors, such as natural disasters, ill health causing loss of income, increased family size exerting a strain on household budget, or conversely household members gaining employment, households receiving a regular remittance etc

Having sketched an overall picture of poverty and inequality in South Africa, it is evident that these issues pose a fundamental challenge to human development and economic growth in South Africa. Robust policy decisions and effective policy implementation are critical for the redistribution of physical and social assets and as well as reducing inefficiencies in economic markets and social institutions serving as vehicles of service delivery, if reduction in poverty and inequality as well as sustained economic growth are to be realised.

Having provided this overview to the condition of poverty experienced in South Africa, the energy dimension to poverty can now be discussed.

Table 1.1: Trends in absolute poverty in South Africa (1995 and 2002)

		National Poverty Line	
		Population below the poverty line (%)	
		2002	1995
	National	48.5%	51.1%
Gender	Male	45.9%	48.9%
	Female	50.9%	53.4%
Race	African	56.3%	62.0%
	Coloured	36.1%	38.5%
	White	6.9%	1.5%
	Indian	14.7%	8.3%
Province	Western Cape	28.8%	28.6%
	Eastern Cape	68.3%	71.2%
	Northern Cape	54.4%	55.4%
	Free State	59.9%	63.6%
	KwaZulu Natal	50.5%	53.2%
	North West	56.5%	59.4%
	Gauteng	20.0%	18.4%
	Mpumalanga	54.8%	59.7%
	Limpopo	60.7%	62.7%

Source: UNDP 2003

(Note: Income poverty declined between 1995 and 2002 from 51.1% to 48.5% poverty of the population, using the national poverty line. Over this same time period, growth in population occurred, increasing the total number of poor people from approximately 19-20.2 million in 1995 to 21.9 million in 2002)

1.3 Energy Poverty in South Africa

The RDP considers energy a basic need. Human survival is reliant on the production and use of energy (UNDP 2000). To this end energy forms an integral input to the primary development challenge of providing sufficient food, shelter, clothing, water, sanitation, medical care, education and access to information. Moreover energy fuels productive activities such as agriculture, mining, industry, commerce and manufacturing. Energy thus emerges as critical for sustained human development and economic growth universally. It is recognised worldwide that the provision of adequate and affordable energy is integral to poverty alleviation, improving human welfare and increasing living standards (UNDP 2000).

Importantly, energy is not consumed for itself, but for what it can do i.e. the services it provides such as cooking, lighting, heating, cooling and the production of goods and services. These energy services are essential in helping meet other basic needs, in the form of cooked food, lighting, comfortable living temperature, use of appliances, piped water, sewerage, health care, education aids and communication (radios, televisions) (UNDP 2000).

Since energy is essential for human and economic development, the challenge lies in the approximately 2.4 billion people in the world (including South Africa), that is a third of the world's population who live in energy poverty. They lack access to clean, safe and reliable cooking and heating fuels and are reliant on traditional biomass (firewood, charcoal, animal and crop wastes and other woody biomass material) as sources of energy. The energy dimension of poverty known as **energy poverty** is thus defined as the lack of choice in accessing adequate, reliable, good quality, safe and environmentally benign energy services to sustain economic and human development. Another aspect of energy poverty throughout the developing world (including South Africa), where the poor are forced to rely on biomass for energy sources, are the inefficient ways of producing and using these energy sources which result in adverse health and environmental impacts in turn increasingly endangering the welfare of these communities and biodiversity worldwide (GoSA 2006/7; Banks 2003; UNDP 2000;Thom 2000).

The energy dimension to poverty in South Africa unsurprisingly reflects the same wider inequalities pervasive in the country along the lines of race, gender and space, as discussed earlier. Energy poverty is manifest in poor households using multiple sources of energy to meet basic energy needs (Cowan & Mohlakoana 2005, UCT 2003, UCT 2002, Thom 2000, Melwhana & Qase 1999, Eberhard &Van Horen 1995). The use of energy among the poor in rural and peri-urban areas of South Africa is for survival needs, in particular food preparation (Eberhard & Van Horen 1995).

While energy is considered a basic need by government[7], as much as 40% of households in South Africa (comprising almost entirely of previously disadvantaged, low income households in rural and urban informal settlements) are reliant on inferior and expensive fuels (DME 2007). This amounts to over 4.85 million households (19.85 million people) using paraffin, biomass or coal as sources of energy for cooking and heating, these being the two most energy intensive domestic activities which form the primary energy needs of a household. It is primarily these thermal energy needs that continue to entrap households in poverty (World Bank 1996). Studies have indicated that despite the introduction of electricity to poor households, the use of inferior fuels does not cease, but merely shifts in application, due to the burden of poverty (Prasad et al 2006: 64-67, Lloyd & Cowan 2005: 85; Thom 2001, Thom 2000). Electricity tends to be used for lighting and communication (television and radio), while fuels such as wood, dung and paraffin continue to be used to fulfil thermal energy needs. Electricity has shown to be not only unaffordable to meet the range of basic household energy needs, but the minimum threshold fee for electricity together with the price of related appliances is beyond the reach of households that function on low and unpredictable income levels (Prasad et al 2006: 64-67).

[7] The White Paper on Energy (1998) identifies energy as a basic need and as one of its key national energy policy objectives, it aims to promote increased access to affordable, adequate, and secure energy services for disadvantaged households.

Further, the collection and use of the various types of these biomass fuels is not only arduous but the associated technologies/appliances used are inefficient and the resultant emissions have deleterious environmental and health impacts. Poor households mainly in the rural areas obtain as much as 50% of their net household energy from firewood (GoSA 2006/7). Their energy poverty is further intensified by the increasing scarcity of firewood, as areas become denuded of trees due to the strong demand for wood. In addition poor households often cannot afford to use amounts of energy needed for simple income generating activities, as a means to improve economic well being. Energy poverty however is not confined to rural areas, but is also prevalent in peri-urban areas of the country where a large segment of the poor and disadvantaged also reside. Studies have shown a high prevalence of households in urban areas (even with access to grid electricity services) using coal and other dirty and relatively expensive fuels with the associated health and safety risks, to meet basic energy needs, as they are not able to afford electricity for all thermal applications (Prasad et al 2006; Qase & Annecke 1999). Further, due to fuels being generally more commercialised in the urban areas than the rural areas, poor urban households are compelled to spend a higher proportion of their income on energy (Barnes et al 2000, Eberhard & Van Horen 1995).

Another manifestation of energy poverty in South Africa is that the limited resources and unpredictable incomes of poor households lock them into making frequent purchases of small quantities of fuel such as paraffin, which tends to be more expensive than buying such fuels in larger quantities. Moreover the use of firewood and paraffin for cooking and lighting respectively are not cost efficient compared to using modern fuels (such as electricity and liquefied petroleum gas) for the same end uses (Barnes et al 2005:107). As a result poor households tend to spend a higher proportion of their income on energy services than households with more resources.

Another widely documented characteristic of energy poverty in South Africa is that women and children endure the harshest consequences of this condition (IEA 2002, Barnes et al 2000; Eberhard & Van Horen 1995). Women are generally the primary users and managers of energy in the household, since they shoulder the responsibility for reproductive activities such as the care, feeding, education and health care of children and families (UNDP 2001: 9, Annecke 2000: 45). Rural women in particular are confronted with the arduous burden of collecting wood and sometimes dung (inefficient and unhealthy fuels) and the associated health risks (Mokoena & Afrane–Okese 2005). Fuelwood gathering imposes a huge social burden on women. Its collection involves immense labour and time (anything from up to 3 hours per trip with 2 to 4 trips per week) which could be spent on more economically and socially productive as well as enjoyable activities such as farming, education and entertainment. Apart from long distances walked and more time and physical energy spent in search of fuel as fuelwood becomes scarce (due to over harvesting, land clearing and environmental degradation), chopping, bundling and carrying heavy headloads (as much as 35kg) bear a heavy toll on women's health in the form of neck, back and child bearing complications (Annecke 2000).

Moreover, the indoor air pollution arising from the combustion of fuelwood, dung and coal and the associated severe health implications are particularly directed at women and children who spend the largest amount of time around chimneyless cooking fires and in poorly ventilated spaces. Numerous studies have associated the inefficient use of traditional biomass and coal for indoor cooking and heating with acute respiratory infections (ARI's) and chronic obstructive pulmonary disease, as a result of poor indoor air quality (Mdluli et al 2005, Sparks et al 2003, IEA 2002:7-8, Scorgie et al 2001, UNDP 2000). ARIs are among the leading causes of death among black South African children[8] (Poggiolini 2007, Mduli et al 2005). Indoor air pollution levels caused through coal combustion exceeds the World Health Organisation's recommended level by up to 10-15 times, in parts of the Highveld urban areas in South Africa particularly during the winter months when thermal needs are greatest (Poggiolini 2007). Moreover solid fuels such as firewood and dung and charcoal, due to their low thermal and heat transfer efficiencies generate 10-100 times more respirable particulate matter[9] (pollutants that are inhaled) per meal than modern cooking fuels like LPG (Nathan & Kelkar 1997: 221). This provides insight into the severity of exposure of women and children to harmful indoor air pollutants. Health impacts associated with the use of biomass and coal are low birth weight, still-births, cataracts, persistent headaches and frequent eye and ear infections (IEA 2002). Such impacts are substantial with regard to the economic and social burden this places on women and children, as well as on the economy as a whole.

As highlighted previously, poor households are out of necessity compelled to use a potentially harmful and unhealthy fuels for their daily survival. Poor households tend to experience irregular income flows, and when cash resources are acquired, a low cost accessible fuel like paraffin is chosen for its convenience and affordability in satisfying their basic energy needs of cooking, heating and lighting. Research conducted by the Paraffin Safety Association of Southern Africa reported approximately 40% of South Africans using paraffin for their household energy needs. Despite the electrification of majority of the households in South Africa, paraffin use persists, due to the burden of poverty. It remains the most affordable, convenient and practical energy source for many poor South African households, rural and urban alike. This is further exacerbated by the current electricity crisis facing South Africa resulting in frequent power outages nationwide and limiting the roll-out of electricity provision to more remote areas. All these factors lead energy researchers and analysts to predict that the use of paraffin in many impoverished communities will continue into the foreseeable future. Paraffin by nature is a toxic (produces high levels of pollutants such as carbon monoxide) and highly inflammable fuel (Bailie et al 1999, Muller et al 2007). Poorly ventilated homes, typical of the poor, increase the risk of household members inhaling the toxic fumes and contracting or exacerbating respiratory illnesses, and in turn negatively impact the productivity of the poor and the economy as a

[8] ARIs are recognised as the 6th largest killer of children under the age of four in South Africa (Poggiolini 2007).
[9] Particulate matter (PM) in recent studies has been selected as the pollutant most accountable for the shortening of life from exposure to dirty air (Mduli et al 2005)

whole. Moreover commonly used paraffin stoves sold in South Africa do not meet the basic national safety standards and often explode resulting in the high incidence of fires (over 40 000 fires annually) destroying approximately 100 000 homes annually (particularly in high density informal settlements), as well as resulting in fatalities and burns, the latter being the leading cause of death among young children (Kruger 2005). Coupled with paraffin, candles used by poor households for lighting are also known to be a leading cause of fires and associated fatalities and burns when accidentally overturned, wreaking immense devastation particularly in dense informal settlements of crowded, improvised shacks (Annecke 2003:252; Spalding-Fecher et al 2000:10). Further, another health hazard associated with paraffin use is accidental poisoning of children through ingestion due to mistaken identity of paraffin usually stored in a beverage bottle. The 2003 Treasury Report, estimated the annual South African externality cost[10] of paraffin related incidents to be R104 billion, which exceeds the annual turnover value of paraffin sold by a factor of fifty (PDC & SCE 2003).

Having provided an overview of energy poverty in South Africa, it is evident that this condition only serves to aggravate the plight of the poor. Malnutrition (due to patterns of energy use depressing nutrition), increased vulnerability to disease and death (attributed to the collection, use and appliances used with the inferior fuels to meet basic energy needs), restricted opportunities to reading, studying and income generating activities (due to the many hours spent collecting biomass as well as the reliance on candles or paraffin for lighting in the absence of electricity due to affordability or lack of access) are some of the direct effects linked to severe energy poverty in South Africa. The main cause of extreme energy poverty is largely the result of prevailing economic inequities (inequitable distribution of and access to resources) in the country, and has less to do with national energy supply capability (ERC 2006)

1.4 Overview of household energy access and use by low-income households in South Africa

Households require energy for survival, comfort and convenience.. Household fuels for the purposes of this dissertation and as defined in the literature are energy sources used for domestic lighting and thermal applications such as cooking, lighting, ironing and space and water heating and exclude fuel used for transportation or commercial purposes.

The household sector in South Africa has been historically characterised by high levels of unequal access to services such as electricity along various racial, income and rural-urban boundaries. In the past despite significant surplus in electricity generation capacity, two thirds of the population

[10] The externality costs refer to the numerous deleterious economic and social consequences associated with the use of energy, commonly not reflected in the market price of energy such as health impacts of pollution of air, water and soil, and the ecological disturbance

remained without access to electricity, and relied instead on unhealthy and less convenient forms of energy such as coal, wood and paraffin. (Eberhard & Van Horen 1995: 88)

The democratic elections of 1994 heralded a new era where energy policy in South Africa shifted its emphasis from the security of energy supply and self-reliance of the past government to more universal goals of improving social equity (addressing the energy needs of the poor), economic efficiency and environmental sustainability, as a means to address historic inequalities. The White Paper on Energy Policy (1998) (an overarching document that establishes the government's policy on the supply and consumption of energy) recognises that access to adequate energy services by households for thermal applications, lighting and communication is a basic need. As a consequence it places strong emphasis on ensuring increased access to adequate, safe and affordable energy services to the majority of South Africans largely denied by past policies. Among its key objectives are 1) widening access to affordable, adequate and secure energy services for disadvantaged households (urban and rural), small business, small farms and community services, and 2) promoting access to cleaner and safer forms of energy to low-income households to improve the negative health impacts arising from the use of certain fuels (DME 1998).

In 1994, the newly elected government made universal access to electricity for all of its citizens by 2012 among its key objectives in the drafting of its energy policy, as a means of meeting the huge demands concerning service delivery, including electricity (DME 1998). To this end the government embarked on an accelerated national electrification programme, targeted at low-income households in both rural and urban areas previously deprived of access to electricity. This programme increased the level of household electrification from 36% in 1994 to 71% in 2004, a significant milestone for South Africa and unprecedented internationally (DME 2004). Most of these household electricity connection installations were in urban areas rather than rural areas, and while emphasis has been placed on improving rural coverage, the last comprehensive survey in 1999 reported that approximately 80% of households were electrified in urban areas and just under 50% in rural areas (DME 2001). Figure 2 illustrates levels of rural and urban electrification until 2001.

The difference in levels of electrification between rural and urban areas is largely due to it being more expensive to electrify rural communities as they are more remote from the national grid and settlements tend to be more dispersed (ERC 2006).

Despite widespread electrification of poor households throughout the country and South Africa charging consumers one of the lowest electricity prices in the world, studies show that most low-income electrified households continue to use a combination of alternative energy sources such as paraffin, solid fuels like coal or wood extensively to satisfy the main household energy needs such as cooking and heating (Shackleton et al 2007, ERC 2006, Lloyd & Cowan 2005, SSA 2001, Davis 1998). Both local and international research have found that the use of these alternative energy sources impose a heavy health, environment and social burden on these households. (Spalding-Fecher

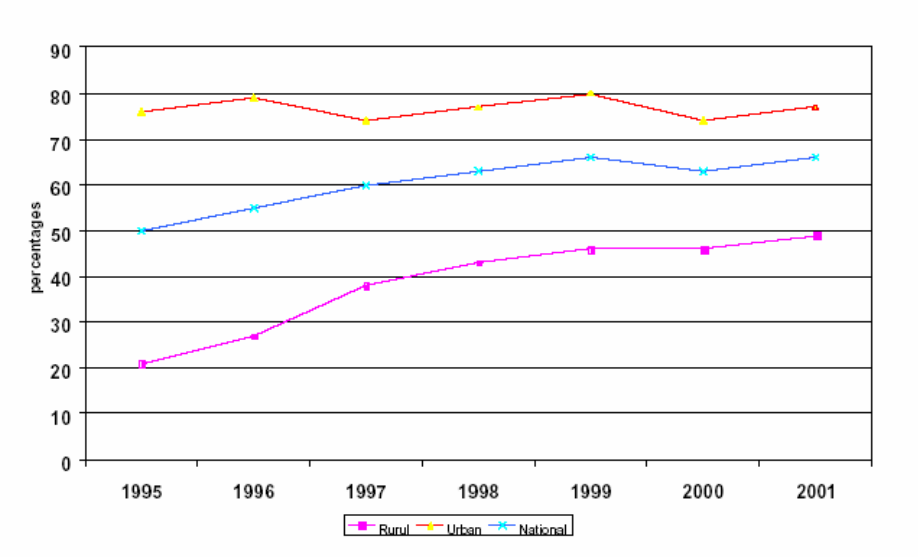


Figure 1: Electrification of households in South Africa, 1995-2001
(Source: NER 2003)

et al 2000) The use of these alternative fuels is largely attributed to households' inability to afford the electrical appliances and the monthly costs of electricity (Howells et al 2005, Qase et al 2001, Davis 1998, White et al 1997). Consequently, a national policy of Free Basic Electricity (FBE) of 50kWh of free electricity per household per month was introduced in 2004 (DME 2003) to reduce the cost of electricity and relieve the energy burden of the poor by providing affordable electricity to households.. However this energy subsidy does not adequately satisfy a household's main thermal needs.

While households in South Africa increasingly use electricity for lighting (which rose from 76.1% in 2002 to 80.2% in 2005 – possibly largely attributed to the 50kWh free basic energy administered to low-income households), 33.6 percent of households continue to rely on wood and paraffin for thermal needs i.e. mainly cooking (SSA 2006b). This national average however does not adequately capture the considerable provincial variations, most noteworthy being the poorer provinces (Limpopo and the Eastern Cape) that are heavily dependent on paraffin and fuelwood for cooking as reflected in Table 1.2.

It has become evident from the numerous studies and national statistical data cited above that low-income households, rural and urban alike, depend on multiple energy sources for their basic energy needs. Studies have shown that these choices are not only driven by the affordability (such as high electricity costs) and accessibility of the fuel but also by the cost of associated appliances (Madubansi & Shackleton 2006, ERC 2006, Howells et al 2005, Mehlwana & Qase 1999, White et al 1997). Thus when low-income households have access to electricity, they avoid using it for energy intensive applications such as cooking and space heating, and for which specialised appliances are required.

Table 1.2: Percentage of households connected to electricity and utilizing paraffin or fuelwood for cooking purposes

Province	Connected to electricity supply	Paraffin or wood used for cooking
Eastern Cape	66.7	58.4
Free State	88.7	24.9
Gauteng	82.7	16.4
KwaZulu-Natal	72.3	34.3
Limpopo	82.4	63.7
Mpumalanga	82.1	34.3
Northern Cape	88.3	23.0
North West	84.6	38.6
Western Cape	92.2	9.6
National	**80.1**	**33.6**

Source: Statistics South Africa 2006b

Having defined the background of the study by providing an overview of the country context and energy use by the low-income households, this study is now able to explore in detail the energy use patterns of low-income electrified households in rural and peri-urban areas across three provinces of South Africa, namely the poorer provinces of Limpopo, Eastern Cape and Kwa-Zulu Natal. Among the rural and peri-urban poor, energy is primarily used to fulfil the most basic of human needs, in particular cooking (Eberhard & Van Horen 1995). Different processes and circumstances prevail (as outlined in this chapter such as varying socio-economic contexts, levels of electrification, access and availability of energy sources, settlement patterns, access to services and economic opportunities) within the rural and peri-urban landscapes, which in turn play a differential role in influencing energy use patterns of the poor within these two landscapes. In addition most of the country's poor reside within these two areas. It is intended that through the detailed exploration of the patterns of household energy use within these loci of high levels of poverty, insights will emerge to contribute to urgently improving the status quo, i.e. improved access to safe, affordable and reliable forms of modern energy services, and ultimately assist in improving the welfare of these poor households.

Rural and peri-urban areas have different settlement patterns. Rapid urbanization has given rise to a significant surge in informal settlements located close to centres of economic activity. Further, past spatial planning shifted the poor to the margins of both urban areas and more significantly the country as a whole, placing the majority of South Africa's poor in the rural areas with a weak industrial and commercial base. With the result the depth and severity of poverty remain highest in the rural areas, followed by smaller cities and lowest in the country's four metropolitan cities (May 2000). Historically the poor living at the margins of urban areas served as a migrant labour pool working in mining and other industries. Studies indicate that the urban poor not only spend proportionally more on energy than their wealthier counterparts, but as the main users of less efficient and polluting fuels

bear an uneven proportion of the health and inconvenience costs associated with household energy consumption. (Barnes et al 2005)

1.5 Objectives of the study

From the above background provided, it is evident that the high prevalence of poverty in South Africa (afflicting approximately 40% of South Africa's citizens) is one of the major and critical challenges facing the country, and a key priority on the government's agenda. Access to safe, reliable and affordable energy services was identified by government as one of the crucial components in alleviating poverty, particularly for rural woman and children (GoSA 2006, DME 1998), yet delivery of such services remains a challenge as highlighted throughout this chapter. This study therefore focuses on addressing this challenge from the perspective of energy use in poor rural and peri-urban households –rural and peri-urban being the two areas where majority of the poor are located. There is a paucity of contemporary primary household energy data as well as quantitative studies, relating to the use of energy by low-income households in rural and peri-urban areas over broad geographic reaches of South Africa. Energy development research of the past (since the 1980's when energy development research took root in South Africa) in understanding the role of energy in the lives of the poor focussed on the context of energy use, using largely qualitative, anthropological and ethnographic research methods. It has now been identified that more quantitative focussed research is required, to build on this knowledge, and to this end appropriately inform large-scale integrated energy for development implementation initiatives (Annecke 2004). Thus this study, through exploring a contemporary quantitative primary energy dataset, covering rural and peri-urban areas and spanning a wide geographic area of South Africa, hopes to shed some important insights on energy use by the poor within these two landscapes.

A further justification for this study is that very few studies compare the energy use patterns of low-income households across rural and peri-urban areas of South Africa, even though patterns of energy use differ significantly between urban and rural areas.

It is important to understand the energy use patterns displayed by these households, in order that the planning and design of policy interventions aimed at enhancing the welfare of low-income households through improved access to clean, safe, reliable, convenient and affordable energy services, can be appropriately informed, targeted and designed congruent to current needs.

Hence the study is performed with the following objectives:

1) to examine the energy use patterns of poor electrified households between rural and peri-urban areas of South Africa by investigating:
    a) the choice of fuels used by these households,
    b) the end-uses of the different fuels used,

c) variation of expenditure across these different fuels,

d) the energy burden of the household i.e. share of the household budget allocated to fuel expenditure,

e) multiple fuel use patterns, and

f) trends in appliance ownership and use associated with different fuel types

2) to examine the energy use patterns in 1) above as they are associated with other household factors such as income, household size, gender, age and education.

1.6 Research methodology

The research in this dissertation commenced with an extensive review of the literature relating to household energy use patterns among the poor within rural and urban areas in South Africa. This was followed by a detailed quantitative analysis of data on low-income electrified households in three rural and two peri-urban areas, located across three provinces in South Africa. The analysis was conducted on a dataset generated from a household energy survey conducted by the University of Cape Town in 2001.

The data analysis first explored the social and economic characteristics of households in the 5 survey areas establishing demographic and economic profiles. This was followed by deeper analysis to investigate patterns of association in household energy use as outlined in the Objectives section 1.5 above.

1.7 Outline of Dissertation

The dissertation comprises five chapters. Chapter 1 and 2 of this dissertation are largely a literature survey, establishing the background to household energy use by the poor in South Africa. The first chapter provides the context for the dissertation, by outlining the political, economic and poverty characteristics of South Africa. It also gives a brief overview of the household energy sector and justification for the study, followed by an outline of the objectives and the structure of the study. Chapter 2 reviews South Africa's rural and urban context and explores the literature on energy use by low-income electrified households within these two South African contexts.

Chapter 3 explains the methodology used for the data analysis of the study. It describes the dataset used in the analysis and the survey areas from which the dataset was generated. It also explains how the data was analysed and discusses the data limitations encountered.

Chapter 4 presents the results of this quantitative study of household fuel use in the sampled rural and peri-urban communities. This covers the socio-economic characteristics of the surveyed households, the prevalence of different fuels used, household energy expenditure and consumption, an end-use analysis of the different fuels used, a description of multiple fuel use patterns displayed by the

surveyed households and appliances ownership and use associated with different fuels used. This chapter will compare the results for rural and peri-urban households and will examine the sample by income, gender, household size, age and education.

Chapter 5 discusses and interprets the findings of the study, illuminating on the patterns of household energy use that emerged from the analysis with respect to rural and peri-urban areas.

Chapter 6 presents conclusions from the study.

CHAPTER 2: A REVIEW OF HOUSEHOLD ENERGY USE RESEARCH AMONG LOW INCOME GRID ELECTRIFIED HOUSEHOLDS IN RURAL AND URBAN AREAS OF SOUTH AFRICA

This chapter reviews in more detail the literature on household energy use patterns of low-income households in rural and urban areas. It begins by explaining the concept of the household, followed by a brief overview of the rural and peri-urban context within which low-income households examined in this study are located. A review of the literature on low-income household energy use patterns ensues, beginning with an introduction of two defining energy policy interventions that have significant influence on energy use among low-income households. An overview of household energy use patterns in South Africa highlighting some key trends and important determinants of energy use among low-income households is provided. A detailed review of energy end-use patterns of low-income electrified households follows, with rural and urban households being reviewed separately, on account of differences that exist in the patterns of energy use in each of these areas. Literature is explored and discussed largely in terms of the main energy requirements of low-income households and fuels used to meet these requirements, including appliances owned and used to fulfil these energy service needs as well as household expenditure in procuring these energy services.

2.1 The household

The household unit forms the primary unit of analysis in this study, by which energy use patterns are examined, on account of two reasons. Firstly the household unit has emerged as a prominent and important component in the energy economy. This sector as outlined in the introductory chapter was characterised by deep inequalities and features prominently on the national development agenda following the emergence of the democratic government in South Africa, with its focus on social equity through emphasis on access to basic services to households. Historically commerce and industry were the central focus of the Electricity Supply Industry (as the past government's priority focussed on the development of a modern urban industrial society), however in more recent times household electrification has featured prominently in policy issues with respect to the energy economy.

Secondly the use of energy in many ways relates more directly to households than to individuals. For instance, electricity connections are made to households. Further the warmth of a space heater when switched on is enjoyed not only by individuals but by all in the household, similarly a light in a communal room provides illumination to all individuals within the household, while energy derived from a cooked meal is attained by all in the household who consume the meal. Since the scope of this study focuses on the household sector within poor rural and peri-urban

communities, it is necessary from the outset to define the term "household" as interpreted in this study, as well as briefly describe the context of rural and peri-urban households.

2.1.1 Definition of the household

The definition of the household remains an exhaustively debated topic among researchers across disciplines resulting in the absence of a common definition. The reason for this is that the multifaceted and dynamic nature of a "household" makes it difficult to incorporate all its aspects into a standard definition.

Statistics South Africa (2004) generally defines a household as a *"group of persons who spend on average four nights a week in a household, who live together, and provide for themselves jointly with food and/or other essentials for living, or a single person who lives alone."*

For the purposes of this study, researchers from the Energy Research Centre (ERC), University of Cape Town, who designed and conducted the survey, on which the results of this study are based, have defined the household as "*consisting of residents who regularly sleep and eat together in the home and share household resources. The total household size includes members contributing to and/or benefiting from the resources of the household but living elsewhere" (*UCT 2003).

2.2 The rural and peri-urban contexts of low-income households

Since the analysis of this study is performed on low-income households distinguished along rural and peri-urban lines, it is useful to give a brief overview of these two contexts.

Rural and peri-urban communities contain the most impoverished people in South Africa (SSA 2004). The energy use patterns of low-income households in these two types of communities also differ substantially. Levels of electrification for example are higher in urban than rural areas.

2.2.1 The peri-urban context

Rural and peri-urban communities have different settlement patterns. Peri-urban areas, a legacy of Apartheid, tend to be poorly serviced high-density informal settlements located at the fringes of urban areas associated with commercial and industrial activity. Historically, the poor living at these margins served as a migrant labour pool working in mining and commercial industries. The legacy of South Africa's migrant labour system gave rise to people moving between urban and rural areas. Migrant labour continued to have functional ties (i.e. remit money and consumables to rural households) and a strong commitment to their rural households, and in fact viewed life in the urban townships as transient (SSA 2006c, White et al 1998: 69, Mehlwana 1999: 7).

Rapid urbanization has since given rise to a surge in peri-urban informal settlements located close to centres of economic activity. Approximately 23% of South Africa's total population reside in informal settlements and make up 40- 60% of the labour force in several cities (SACN & CA 2007).

In 2001 there were approximately one million households in informal settlements in South Africa's nine largest cities. Despite the laudable track record of the national housing delivery programme (2.3 million households were built between 1994-2006), it struggles to keep pace with the rapidly growing number of households in informal settlements over the last decade (PCAS 2007, SACN & CA 2007). Peri-urban settlements due to being closer to urban areas, are more similar to urban than rural areas.

2.2.1.1 Urbanisation in South Africa

South Africa continues to experience rapid urbanisation, with approximately 58% of the country's population currently residing in urban areas (as shown in Figure 3), and forecasted to increase to 64% by 2030 (SACN & CA 2007). Figure 3 illustrates the levels of urbanisation in each province of South Africa, with Limpopo and Eastern Cape being the least urbanised in the country.

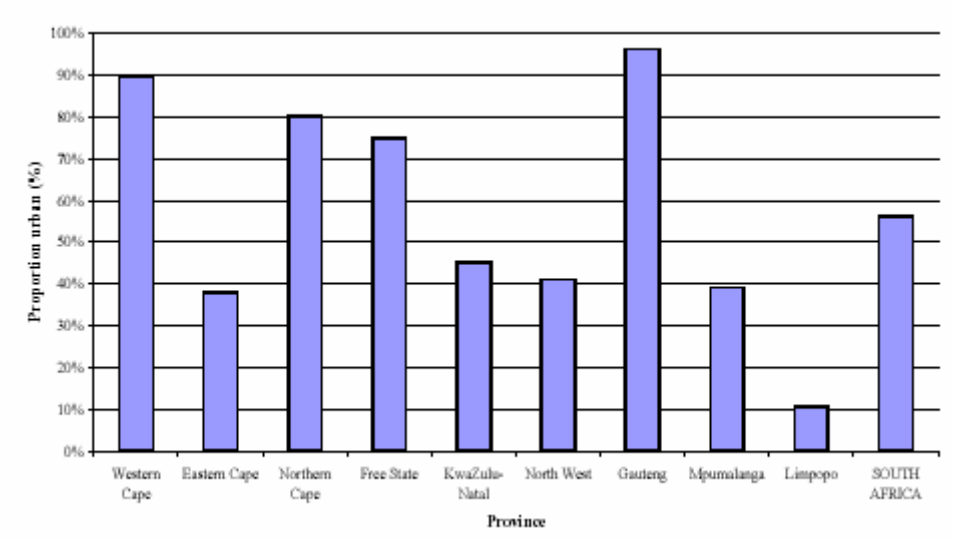


Figure 2: Levels of urbanisation in each province and for South Africa (2001)
(Source: Statistics South Africa 2006)

Data from the latest 2001 census also reflects that urbanisation is on the increase, demonstrated most markedly by a 20% increase in Gauteng's (South Africa's economic hub) population growth since 1996. This trend prevails across South Africa's nine largest cities, with their population growth reported to have been approximately 2.80% per annum between 1996-2001, which is higher than the national average population growth of 2.01% over the same time period (SACN 2004). This increasing local population growth is largely attributed to rural-urban migration to areas of higher economic potential i.e. urban centres where gainful employment opportunities can be found (PCAS 2007, SACN 2004).

Approximately 37% of the national population alone reside in the nine largest cities, which occupy less than 2% of the country's total land area. Cities are the centres of the nation's economic productivity, but ironically also the loci of its most impoverished people – 40% of the urban population live in a state of poverty (Parnell 2004, DPLG 2003). Cities have been unable to keep pace

with the rate and scale of city growth, resulting in the prevailing deepening urban poverty. These challenges are linked to various factors, namely: the legacy of Apartheid, delayed urbanisation as well as political transformation (SACN & CA 2007). Rapid urbanisation in South Africa serves to exert pressure on existing urban infrastructure and increases the demand for access to public goods and services such as energy services, water, sanitation and health amenities.

2.2.2 The rural context

Approximately 45% of South Africa's population reside in the rural[11] areas. Rural areas (depending on which definition is used) typically comprise of former homelands (where an estimated 85% of the rural population reside), commercial farms and small towns (GoSA 2000). Rural South Africa is largely characterised by severe poverty and low levels of literacy, education, productivity and skills development (as outlined in the introductory chapter). Rural communities tend to be dispersed settlements with limited access to gainful employment and public services. These dispersed settlement patterns make it more expensive to provide infrastructure relative to urban areas thus requiring increased efforts for effective delivery of services such as electricity, water, sanitation, health care, education and so on. For example it costs more to electrify rural areas due to longer power lines needed to reach rural villages where homesteads tend to be more dispersed.

In 2000, approximately 70% of South Africa's poor were reported to reside in rural areas. Incomes of the rural poor tend to be severely constrained by a weak industrial and commercial base owing to poorly developed infrastructure and weak local governments lacking funds and human capacity. Traditional/tribal authorities have more influence over the rural population than in urban areas. In addition the standard of living for the rural poor tends to be low, owing to more being spent on basic public services such as energy, food, water, health, education, transport and communication, on account of limited access to infrastructure, basic amenities and social services. Infrastructure provision in rural areas was historically skewed in favour of (white owned) commercial farming areas. Further the rural poor did not have adequate access to natural resources to support subsistence activities. In 2000 as much as 85% of the countryside was occupied by commercial farmers, while the population pressure in the former homeland areas had reduced the natural resource base to a point where only the subsistence needs of a few communities could be supported (DPLG 2005, GoSA 2000).

It must be noted that rural areas are diverse, ranging from areas with the incidence of the deepest poverty to relative prosperity (historically skewed in favour of commercial farming areas).

[11] Definitions of 'urban' and 'rural' areas in South Africa have been neither appropriate nor consistent (Thom 2000). Definitions of rural areas in the past only excluded towns and cities that had some form of local authority under the past government, but included many of the informal settlements adjacent to such towns and cities. Further most areas in the former homelands were classified as rural regardless of the size and density of the settlement. With the result ongoing research conducted by Statistics South Africa is close to

2.3 A review of research on energy use patterns of low-income electrified households in rural and urban areas of South Africa

The review of literature on energy use patterns of low-income electrified households is prefaced by a brief overview of two defining policy interventions, namely the Integrated National Electrification Programme (INEP) and Free Basic Electricity (FBE) instituted by government, in an attempt to improve access to safe, affordable and reliable energy services to low-income households. Studies have indicated that these interventions have played an influential role in the changed patterns of energy use in low-income households in South Africa (UCT 2003, Palmer 1999, Davis 1998).

2.3.1 The National Electrification Programme and Free Basic Electricity

Since the early 1990's, the South African government as part of its commitment to redress inequities and promote sustainable development instituted various energy interventions to promote affordable energy access for the poor, as a means to improve the welfare of the poor in South Africa. Key among these interventions was the Integrated National Electrification Programme (INEP) and more recently the Free Basic Electricity (FBE).

A major drive to electrify the majority of South Africa's population began in 1991 by Eskom under their 'Electricity for All' programme. At the end of 1993, approximately 36% of the total population was electrified – viz. 50% of the urban population and 12% of the rural population. The newly elected government in 1994, as part of the RDP embarked on an accelerated national electrification programme to widen the access to electricity to low-income households in previously disadvantaged communities, rural areas as well as schools and clinics at the cost of R 7 billion (ERC 2006). In Phase 1 (1994-1999) of this programme, led by Eskom (the national electricity utility), the proportion of households with access to electricity increased from 36% to 66% nationally, exceeding the RDP target of 2.5 million households agreed upon between government and the electricity supply industry. This first phase was subsidised and financed by Eskom and to a lesser degree by municipalities, which enabled the connection costs for poor households to be kept to a minimum (DME 2001).

In 2000, the second phase (2000-2005) of electrification commenced and was entirely subsidised by national government. This phase signalled a shift from a target-oriented approach (where number of electricity connections determined the measure of progress), to one where electrification planning addressed development aspects (such as job creation and skills development) in an integrated and coordinated manner. This change of approach arose after it was observed in Phase 1, that the use of non-electric fuels persisted in majority of low-income households (i.e. rural households and to a lesser degree urban households) to meet the more essential and energy intensive energy needs such as cooking, thus reflecting that the socio-economic benefits of electrification were being only marginally

arriving at a definition of urban and rural based on size and population density appropriate for South Africa's

realised by the poor. National government subsequently realised that in order for the wider social and economic benefits (such as income generating activities and job creation) of electrification to be accessed, electrification could not be viewed in isolation from other development needs but required integration with other improvements in infrastructure, services and economic development initiatives (Tinto & Banda 2005, DME 2004, Borchers et al 2001).

The new approach consequently included the integration of grid and non-grid technology. Since a large proportion of the rural poor are located in areas far from the existing electricity grid resulting in high costs to connect these households to grid electricity, the electrification programme has included off-grid renewable energy sources, in particular photovoltaic systems to provide electricity to these households.

Current levels of electrification stand at 72% nationally (with 80% of urban homes and 50% of rural homes being electrified) (PDC & SCE 2003). The national electrification programme is ongoing (planned on a 3 year rolling basis) with an aim to provide universal access to basic electricity services to all South Africans by 2012. The envisaged lifespan of the programme is 6 years (since 2002) but subject to current backlogs and funding levels (PDC & SCE 2003).

Although the national electrification drive in South Africa facilitated widespread access to electricity, the consumption levels of low-income households remained very low, as they could not afford to use electricity (ERC 2006). As a consequence these households were not able to derive the full benefits of access to electricity. National government, in an effort to remedy this situation and to ensure that low-income households benefit from the enormous investment in the INEP, introduced in 2003 the Electricity Basic Services Support Tariff (EBSST) (currently named Free Basic Electricity (FBE)), following comprehensive research conducted by UCT, Eskom and the DME, on the purpose, cost, benefits and processes relating to implementing such a tariff (UCT 2002). This tariff provides poor households with 50kWh of electricity per month free of charge, with an associated blocked or stepped tariff for electricity consumption levels exceeding 50kWh (DME 2003). This amount of free electricity enables the poor to meet some of their basic energy needs namely lighting, media access and some water heating (ERC 2006). FBE is funded by national government, through allocations made to local government and cross subsidies from high end users (i.e. industry and wealthy customers) (ERC 2006). Not all municipalities have implemented FBE or rather its application has occurred in varied forms, largely due to lack of capacity as well as institutional and funding challenges. Further, lowering the cost of targeting the poor also poses a major logistical challenge, as municipalities have the obligation to identify low-income households eligible to receive FBE (Prasad & Visagie 2006).

settlement patterns.

More recently in early 2008, the DME introduced a Free Basic Alternative Energy Policy. This policy aims to provide poor households that do not have access to electricity with alternative energy sources. This would involve providing energy to the value of R55 to an unelectrified poor household.

2.3.2 An overview of energy use among low-income households in South Africa

This section highlights some of the main trends in energy use by low-income households and introduces some of the factors influencing such trends.

2.3.2.1 Multiple fuel use

Energy research in South Africa over the years has increasingly identified the use of multiple energy sources to fulfil the energy needs of low-income rural and urban households to be a dominant feature of energy use in these households (UCT 2003, UCT 2002, Mehlwana & Qase 1999, Eberhard & Van Horen 1995, Williams 1994, Golding & Hoets 1992). Energy transition theory, a widely used tool in the analysis of household energy use patterns suggests that with improving socio-economic circumstances particularly with respect to income and education, households move up the energy ladder in a smooth and linear progression away from low quality traditional biomass fuels such as wood through to more convenient, versatile and less polluting modern fuels such as hydrocarbons and eventually through to electricity (Viljoen 1989, Leach 1987). However more recent research has revealed that this linear movement from one fuel to another seldom occurs in low-income households where fuel use decisions based on conditions of resource scarcity and uncertainty are often made on a daily basis (Annecke 2003, UCT 2003, Barnett 2000, Masera et al 2000, Mehlwana & Qase 1999, Davis 1998, Eberhard & Van Horen 1995). Thus the transition is a much more dynamic one, as most households decide to use a combination of fuels, often spanning both upper and lower rungs of the energy ladder. The reason being is that as low-income households move back and forth unpredictably between improved to worsened economic conditions, different fuels or a combination of fuels are used (Annecke 2004). Improved economic circumstances in the household for example through remittances received, part-time employment or informal selling may enable the use of paraffin for a few days. The loss of a job or lack of access to an income will necessitate reverting to fuelwood. Lack of money to purchase a prepaid card for electricity or a power failure (common occurrence in some areas) will result in candles being used. Research has shown that even though low-income households may use electricity for lighting, other fuels such as paraffin, gas or coal is often used for cooking as a result of the fuel and appliances being cheaper (Mehlwana & Qase 1999, ERC 2006, Howells 2005). Thus it is evident that the pattern of fuel use by low-income households better resembles a portfolio of different energy sources at any time, and the varied fuels chosen often depend on budget, need, availability and preferences (i.e. a complexity of social and economic factors determine household fuel use) (Heltberg 2004). This is further supported by a large body of research of the past decade which has demonstrated that a multiplicity of factors besides income influence fuel choice, contrary to

the suggestion of energy transition theory (UNDP/ESMAP 2003, Thom 2000, Eberhard & Van Horen 1995).

In summary multiple fuel use refers to the use of varied fuels for different end-uses as well as the same end-use, to fulfil household energy needs – a phenomenon predominant in low-income households of South Africa (but not restricted to poor households). In the case of different fuels being used for the same end-use, this could be illustrated by cooking for example with paraffin, coal and electricity[12]. Multiple fuel use is not only associated with fuels but also appliances, which are necessary to transform energy carriers into energy service providers. Eberhard and Van Horen (1995) explain that low-income households usually make energy choices based on "combinations" of appliances and fuels that can satisfy the desired energy services required, subject to households' availability of resources. The multi-functionality of appliances and fuels is very important for poor households, such as in the case of paraffin and coal stoves which can be utilized for both cooking and heating purposes, whereas two electrical appliances would be required to fulfil these two tasks and at a greater expense.

Multiple fuel use patterns in low-income households in South Africa are influenced by several factors, only one of which is income. The White Paper (DME 1998:17) on energy policy concludes: *"It is fair to say that the tendency to multiple fuel use and emphasis on traditional (fuelwood) and low-cost fuel (Illuminating paraffin) is likely to prevail for the foreseeable future."*

2.3.2.2 Determinants of fuel use

Household energy use patterns are influenced by both macro- (external to the household) and micro-(within the household) determinants (UNDP/ESMAP 2003, Afrane-Okese 1999, Eberhard & Van Horen 1995). One of the main macro-determinants of household energy consumption in South Africa is geographic location of which climate (seasonal variation) and access to cheap coal (determined by distance from the coal mines) are important factors affecting energy use in low-income households, especially with regard to space heating (space heating requirements vary significantly throughout South Africa and are influenced by climate) (Eberhard & Van Horen 1995).

Micro-determinants include household income and expenditure, household size, gender, age, education, dwelling type (includes household construction, insulation), access to water supplies and access to energy supplies. Leach and Gowan (1987) compiled a range of factors that influence household energy use, after reviewing a large number of energy surveys conducted throughout the world. These are presented in Table 2.1 below. Other factors reported to influence household fuel use are household composition, age of decision makers and power relations within the household. Thom (1994) asserted that fuel choice is determined by complex decision making processes influenced by a

[12] Ross (1993) observed that households altered their main cooking fuels as much as four times, as a result of changing income levels, change in tenants and availability of labour to collect fuelwood.

range of factors which are likely to change over short spaces of time, emphasising that social power relations within households are more important in determining fuel choice than income and other external variables. Further, Mehlwana and Qase (1999) state: *"Though income and gender are significant factors…a better vantage point is locate decisions in specific contexts"*

In terms of household income, high levels of poverty and unemployment result in many low-income rural and urban households experiencing irregular and erratic sources of cash flows, giving rise to expenditure patterns that do not allow for large discrete amounts of income to be spent on energy such as paying an electricity bill at the end of the month or buying a large quantity of fuel for the month. Thus energy has to be procured in small amounts (e.g. bucket of coal, litre of paraffin, prepaid electricity card for the minimum amount of R10), enabling the household to spend smaller amounts at a time, given their available income (Mehlwana & Qase 1999). Annecke (1994) pointed out that aside from income, the availability or accessibility of a fuel also determines it use and in this same study she concluded: "*Women were found to use the fuel which was available and most convenient according to the requirements and conditions of their households. Cost played significant part in the decision making but was not the only factor."*

Table 2.1: Supply and demand determinants of fuel choice

Supply variables	Demand Variables
Price and availability of fuels	Household income
Time and effort spent on fuel collection and use	Household size
Non-fuel demand for biomass resources	Climate
Location: urban, peri-urban or rural	Cultural factors (cooking habits, diet)
Fuel characteristics and preferences	Cost and performance of appliances

Source: Leach & Gowan (1987)

2.3.3 Energy use patterns of low-income electrified households in rural areas

Household energy use patterns vary considerably between rural and urban areas, owing to various factors such as levels of urbanisation, economic development and standards of living, electrification status and access to commercialised fuels (Dzioubinski & Chipman 1999, Eberhard & Van Horen 1995).

Leach and Gowan (1987) observed that among the poorest households in developing countries cooking and heating (includes space and water heating) constituted as much as 90 to 100% of energy consumption, while lighting accounted for the remaining energy use. Research in South Africa has revealed similar trends among low-income households, with the major end-uses being cooking, heating and lighting. Low-income electrified households have also been observed to regularly use energy for media and entertainment services (i.e. radio and television) and to a lesser degree refrigeration (ERC 2006, Thom 2000).

Rural South Africa tends to be more impoverished than urban areas. Infrastructure is much less developed in rural areas than other parts of the country, since it is more expensive to provide infrastructure in rural areas. Rural households generally have lower incomes than urban households, and this is reflected in the patterns of energy use. Further rural areas have lower electrification rates than the rest of the country, due to large distances between villages and dispersed settlement patterns that raise the electricity connection costs (ERC 2006).

Over 75% of South Africa's rural households rely on fuelwood and paraffin as the dominant sources of energy (Banks 2003, Davis 1998). The use of these fuels impose a major social, health and safety burden to these already economically impoverished households (as highlighted in the introductory chapter). In addition to fuelwood and paraffin, these households utilize candles, dry cell batteries and electricity to fulfil other basic energy needs but often find these expensive (Madubansi & Shackleton 2006, Howells et al 2005, Davis 1998). Research indicates that even after electrification, most newly electrified rural households continue to use fuelwood as their major cooking fuel, as they are unable to afford the high costs of electrical appliances and/or the relatively high electricity costs incurred for energy intensive applications such as cooking and space heating (ERC 2006, Madubansi & Shackleton 2006, Prasad & Visagie 2006, Howells et al 2005, Davis 1998). Although electricity costs have been reduced by national government's application of FBE of 50kWh per household per month, it is generally not adequate to fulfil a household's thermal needs such as the primary task of cooking. Energy analysts and energy planners predict that a significant proportion of low-income electrified households mainly in the rural areas will continue to use fuelwood over the next few decades (Madubansi & Shackleton 2006, DME 1998:17). Rural households usually procure fuelwood through gathering it from the surrounds free of charge (other than the opportunity cost of labour which tends to be low in rural areas where high unemployment levels and a low level of skills prevail), where it is available. Studies indicate that sustainable fuelwood supplies will have to be maintained to meet the energy needs of the poor (Prasad & Visagie 2006, Eberhard & Van Horen 1995).

2.3.3.1 Appliance ownership and use

Energy use cannot be considered in isolation of appliances, as appliances are required to transform energy into a useful form to fulfil energy service needs such as cooking. In the transformation of energy into a useful form to provide a desired energy service, significant efficiency losses occur i.e. only a fraction of useful energy is utilised to provide an energy service. The quantity of 'useful' energy harnessed depends on the efficiency of the appliance. Further a dynamic relationship exists between appliance use, the affordability and availability of energy sources, socio-economic conditions of the household, gender as well as geographic factors (PDC & SCE 2003, Mehlwana & Qase 1999).

A significant proportion of low-income electrified households in rural areas were observed to own electrical appliances such as stoves/hotplates, kettles, irons, refrigerators, televisions and radios/hi-fis (Thom 2000, Thom & Mohlakoana 2001). Thom & Mohlakoana (2001) showed in a longitudinal

study conducted in a low-income rural village in the Limpopo province pre and post electrification in 1999 and 2001, that over 70% of surveyed households, owned four or more electrical appliances since electrification, far exceeding the national average (of 37-47% of households) (Davis & Ward 1995). They ascribed this to several factors namely: 1) outdated national figures, 2) the surveyed areas had been electrified for a relatively long period i.e. 4 years, 3) people in the area aspired to convenient modern lifestyles (to the extent some households owned but did not use appliances, as they served as status symbol), 4) appliances were accessible from neighbouring towns, 5) women played an important role in making decisions to acquire appliances and 6) household income appeared to be higher than the average for the Limpopo province.

Further, Davis and Ward (1995), in their analysis of data collected for the Project for Statistics on Living Standards and Development (PSLSD), observed that the ownership of electrical appliances appeared to be closely related to income. This was demonstrated by the fact that with the exception of radios, electrical appliance penetration within lowest income group of electrified households varied between 10% and 20% while for the high-income group it ranged from 53% and 67%. The same study revealed that ownership of paraffin stoves was however inversely related to income – approximately 80% of households in the lower income groups owned paraffin stoves. Research indicates that generally electrical appliance ownership increases with increasing household income (Thom 2000). However anthropological studies have shown that while income plays an important role in the purchase and use of appliances, it is in fact more often the dynamic interaction of multiple social and economic factors that determine appliance acquisition and use (Mehlwana 1999, Mehlwana & Qase 1999, White et al 1998,).

Another feature of appliance ownership and use in rural areas was that not all households use the electrical appliances they own on a regular basis (Thom 2000). Reasons for acquiring appliances appear complex in nature – utilitarian considerations such as usefulness, cost and availability of space appear to be only some of important factors influencing appliance acquisition and use, while the considerations of symbolic value of appliances also emerged as important, as a means to conceal conditions of poverty and a desire to be seen as adopting a particular (modern) lifestyle (Thom 2000). Further PDC (2003) also observed that rural households may own electrical or non-electrical appliances, but do not necessarily use them either out of choice or due to constraining factors such as not being able to afford the fuel or maintenance or experiencing problems with the installation of appliances (e.g. in the case of installing a gas stove). These findings of appliance ownership versus use are further confirmed by Thom and Mohlakoana (2001), who noted among the surveyed households in Limpopo Province, a significantly lower percentage of households using hotplates/stoves than owning them, as a result of broken hotplates/stoves being a common occurrence in households and a lack of maintenance and repair facilities in rural areas. This study also attributed the lack of use of hotplates/stoves to concerns raised by households regarding cost of electricity for

cooking purposes in particular with preparing foods that required long cooking times. This indicated that people were not well informed about the costs of using electricity.

PDC in 2001 investigated appliance ownership, acquisition and frequency of use in a survey conducted among low-income electrified rural households in the Limpopo Province. Their findings revealed that despite access to electricity (in this study households were electrified for 6-7 years), households continued to use a variety of appliances and energy forms to meet their energy needs, as shown in Figure 4 below.

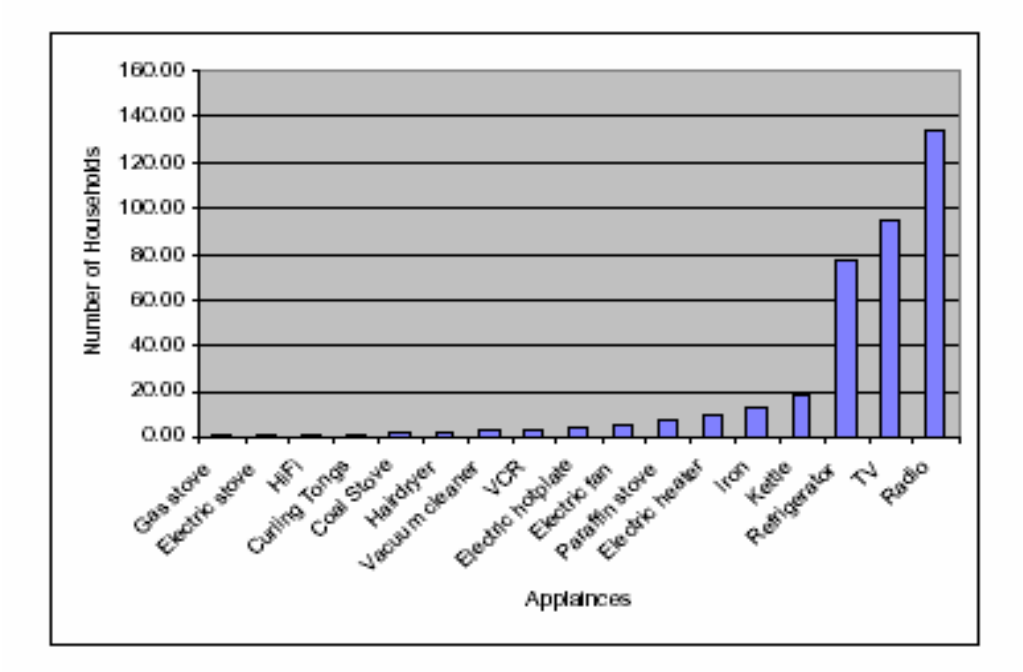


Figure 3: Household appliance ownership
(*Source: PDC, 2003)*

The appliance mix of these households reflected the use of electricity mainly for entertainment and media appliances as well as convenience appliances such as kettles and irons. Appliances used for cooking included a combination of coal, paraffin, gas and electrical appliances. Despite being electrified, continued use of fuelwood in open fires as the primary cooking fuel prevailed among the surveyed households. This suggested that households with access to electricity for a significant period of time, use it for particular purposes (primarily for lighting and entertainment and media purposes) and do not switch completely to electricity and associated electrical appliances to meet all their energy needs (this confirms continued patterns of multiple fuel use and appliance use in low-income rural electrified households). The study also revealed that the purchase of appliances, particularly expensive appliances depended on the availability of consumer credit, while cheaper appliances could be purchased on a cash basis. Procuring appliances on credit means that the final price of the appliance will be significantly higher than the purchase price, however poor households cannot afford to buy larger appliances on a cash basis.

Lastly with regard to appliances, Thom and & Mohlakoana (2001) concluded from their longitudinal study performed over a period of three years in a low-income rural village in Limpopo Province, that appliance ownership was not a reliable indicator of household electricity consumption. This study demonstrated that while households that consumed less than 30kWh per month used few if any appliances, no clear relationship between appliance ownership and electricity consumption at higher consumption levels could be established. Households that consumed just more than 30kWh per month all owned television sets, radios/hi-fis, irons and hotplate stoves, while households with much higher consumption levels, showed a higher incidence of ownership of kettles, fridges and freezers.

The introduction of FBE appears to influence appliance ownership and use to a certain extent, as illustrated by the UCT (2003) study. From a survey conducted by UCT (2003), which measured the impact of FBE on two rural villages located in different provinces (Eastern Cape and Free State provinces), an increase in the use of electrical appliances was reported for both villages. These included appliances that were owned by the household but were previously not used because of affordability constraints. Appliances observed to be used more frequently after FBE was implemented in these villages included radios, televisions, electric irons and kettles, while in one of the villages a few households reported frequent use of hotplate stoves. Further households in both villages reported repairing appliances as well as purchasing electrical appliances since receiving FBE.

2.3.3.2 Energy services

Cooking

Cooking is undeniably the most important energy service need required by households, as it converts many foodstuffs into an edible form essential for human survival.. This is evidenced by the fact that together with space heating particularly in colder climates, cooking accounts for 90% to 100% of household energy demand in majority of the developing world (Leach and Gowen 1987).

Research has demonstrated that the amount of energy used for cooking is dependent on several factors namely: the type of food cooked, the amount of meals cooked, size of the household, the different combinations of energy and appliances used for cooking and the way in which these are employed (Williams 1994, Annecke 1993). Research has further indicated that cooking is usually part of a range of energy services provided by the same appliance-energy carrier combination. A coal stove for example provides both space and water heating simultaneously with cooking, which in turn makes it difficult to ascertain the efficiency of delivery of the specific end-uses provided, as it is not possible to establish where the one service ends and next service starts (Williams 1994).

Studies have indicated that the use of electricity for cooking is highly valued by poor rural households, in spite of cooking not being done exclusively with electricity in these households (James 1997, James & Ntutela 1997, Hansmann et al 1996). Research has shown that low-income rural electrified households continue to use fuelwood and paraffin as their principal sources of energy to

meet most of their cooking needs (DME 1998). Although rural households regard electricity as important for cooking, and consequently purchase electric stoves/hot plates, they do not use them on a regular basis to fulfil most of their cooking tasks (as mentioned above in the appliance ownership section 2.3.3.1) (Thom 2000). Davis (1998) further found that as much as 40% of rural electrified households used electricity for cooking, accompanied by another fuel as a secondary choice. He noted that while electricity appeared to displace other fuels such as wood and paraffin for cooking, this trend prevailed only for households in the higher income groups of the study, and even within this group only 26% used only electricity for cooking, while fewer relied solely on electricity for water heating. This indicates that the displacement of electricity is more common in higher income households, however full displacement only occurs in a few households. Electrical appliance ownership such as stoves was also shown to be closely related to income levels. Davis (1998) highlighted a similar trend for lighting, space heating and water heating, where as incomes increased low income rural electrified households were observed to move away from fuelwood and paraffin to electricity to fulfil these needs. However among the lower income groups, a large proportion of electrified households appeared to use electricity in addition to other fuels, rather than as a replacement. It must be noted that in spite of electrification, 79% of surveyed electrified households used fuelwood and paraffin as their primary fuel for cooking needs (Davis 1998).

Similarly Prasad & Visagie (2006) observed from their analysis of more recent surveys performed on low-income rural electrified households in South Africa, that those in the lowest income groups made scarce use of electricity for cooking while the proportion increased with rising income. The inverse was true for fuelwood - use of fuelwood for cooking decreased with rising income.

Another trend emerging from research with respect to energy use and cooking among low-income rural electrified households was the variety of appliances and fuel combinations being used for this application (Annecke 1996, James 1997). For example electrified households were observed to cook with an electric stove/hot plate or coal stove, paraffin stove or over a wood fire. In poor households the multifunctionality of appliances and fuels is an important factor – for example a paraffin and coal stove can be used to achieve the dual tasks of cooking food and space heating at the same time. In the case of electrical appliances, two appliances would be required to fulfil these tasks, and at a greater cost (DME 1998).

Thom and Mohlakoana (2001) observed that prior electrification rural households in their survey sample used fuelwood and paraffin as the main fuels for cooking and water heating, while after electrification, electricity almost displaced paraffin entirely for cooking and water heating in some households. They also found that in many households some activities previously carried out on a wood fire, were subsequently achieved with electricity such as ironing and fast cooking. However the study concluded that for the majority of households surveyed, fuelwood use persisted to a large extent and was not replaced by electricity. This was later corroborated by findings of Madubansi and

Shackleton (2006), who reported from a follow-up study conducted in 2002 that over 90% of low-income rural electrified households surveyed continued to use fuelwood as their main source of energy for cooking and other thermal applications. This study revealed that only 1% of electrified households used electricity exclusively for thermal applications. The few households in their study that used paraffin and gas for cooking used them in combination with fuelwood. The authors attributed this high prevalence of fuelwood use for cooking to several factors: 1) fuelwood in rural areas is largely self collected for "free" at no cash cost (other than opportunity cost of labour which is low in rural areas where levels of employment and skills are low), 2) fuelwood was perceived by 70% of surveyed households to perform cooking faster than other fuels and 3) households that purchased fuelwood, found it cheaper relative to other fuels. In addition electrified households reported that using fuelwood for thermal applications i.e. cooking and heating does not require the use of appliances that are expensive.

In terms of the impact of FBE on low-income households with respect to cooking, it was shown that that there was a general reduction and in some cases an elimination of the use of paraffin for cooking and heating (Prasad & Ranninger 2003). Additionally marked savings were observed in the amount of energy and time spent by women and children involved in the arduous task of collecting fuelwood for cooking and heating (Prasad & Ranninger 2003). Thus FBE assisted in reducing some of the social and health burden associated with this task (as outlined in the introductory chapter). Scarcity of fuelwood in rural areas compels women and children to seek fuelwood further afield, increasing the time and energy spent gathering fuelwood, while reducing the time people can spend on more productive and enjoyable activities such as farming, education and entertainment. FBE was found to be particularly beneficial in the study areas experiencing a scarcity of fuelwood by reducing the time and effort to perform this task (UCT 2003).

Lighting applications

Studies have shown that rural electrified households commonly use electricity for lighting (Thom 2000). However the use of fuels such as candles for lighting persists in a significant proportion of these households. One of the reasons cited was that households experience both technical and financial difficulty in wiring the entire household, in order to make electric lighting available in all rooms of the household (James & Ntutela 1997). When Eskom connects low-income households to electricity they provide households with a readyboard consisting of a light and a row of plug sockets, which enables immediate access to electricity, while reducing the cost to both the customer and the utility of wiring the entire house. However using this approach means that the light and sockets are placed in a specific room, thus households have to access skills as well as endure the cost of extending supply to other rooms of the homestead. The placement of the readyboard is therefore an important consideration when installation occurs, so as to benefit the household optimally. (Thom 2000). Davis and Ward (1995) in their analysis of the electrified PSLSD sample reported that

approximately 60% of rural households supplemented the use of electricity with candles and paraffin for their lighting needs. This was however attributed to the fact that not all households connected to electricity grid at the time were able to use electricity, as they could not afford to pay the connection fee that enabled access to the electricity use (Thom 2000). Davis and Ward also identified two clear income trends emerging from their analysis: 1) a relatively high proportion (33%) of electrified households in the low-income groups relied on candles for lighting while 2) there was a tendency for households in the higher income groups to rely solely on electricity, which reflected that electricity substituted other fuels for lighting needs. Overall, the authors concluded from their study that despite electrification, candles continued being an important lighting source for low-income electrified households, even though they spend a relatively large amount of money on them.

Madubansi and Shackleton (2006) more recently in a follow up study in the rural Bushbuckridge area of the Limpopo province in South Africa revealed similar trends to earlier studies, noting that between 1991 and 2002 despite widespread use of electricity for lighting purposes in the study areas, 50% of households continued to use candles however mainly for backup purposes in times of power failures or when households did not have sufficient money to purchase prepaid electricity. The study also attributed the high proportion of candle use to some electrified households not being completely wired and consequently with only one electrical connection point and only an electric light in one room. With the result other rooms in the homestead were illuminated with candles.

The introduction of FBE in 2003 however showed an improvement in the lighting situation of low-income rural electrified households. The UCT study (2003) which examined the impacts of FBE on two rural villages in South Africa, found that rural households were motivated to extend the wiring for lights as well as replace broken lights, after receiving FBE. Moreover approximately 25% of the rural households surveyed were observed to be using more lights after the introduction of FBE (Prasad & Ranninger 2003).

Another lighting trend observed among low-income electrified households was the purchase of new electricity prepayment units before they were used up, to ensure continued supply of electricity for their lighting needs (Thom & Mohlakoana 2001). While relatively little energy is consumed for lighting, this end use is highly valued by the household as it is known to contribute significantly to improved standard of living. Thom and Mohlakoana (2001) in their longitudinal pre and post electrification study, conducted in a rural village in the Limpopo province between 1999 and 2001, noted that even the very poor households actively sought money to purchase electricity for lighting, but sometimes stayed without electricity for as much as a week. However, later on in 2003 with the introduction of FBE, these poorer households were reported to run out of electricity less frequently than before (Prasad & Ranninger 2003). Overall, Thom and Mohlakoana (2001) observed that surveyed households since electrification used mainly electricity for lighting, while prior

electrification these households relied chiefly on candles for illumination. Electricity appeared to be the preferred lighting source as it offers a significantly improved quality of service relative to candles.

This study also reported that in most cases electrified households used candles only during times of power failures, however poorer households continued to use candles in rooms that had no electric lighting. Similar to previous studies poorer households were not able afford the cost of extending electric wiring to the entire household, especially in cases where the household consisted of separate structures and long extension cords were needed. These households prioritised the money that they had available for other household basic needs.

Further, the same study reported that over 40% of rural households left lights on throughout the night, as it was highly valued for its purpose of perceived improved security in the area (Thom & Mohlakoana 2001). The authors also observed the use of outside lights to be prevalent among households with higher electricity consumption levels, concluding that this service was therefore not accessible to the poorest households. However the implementation of FBE in 2003 enabled the poorest households to access this important benefit - studies have indicated that approximately 25% of poor rural households were able to keep outside lights on for longer period per day and in some cases throughout the night (UCT 2003).

Media applications – radio

Studies have revealed widespread ownership of radios among low-income electrified rural households (Thom & Mohlakoana 2001, Thom 2000, Davis & Ward 1995). Davis and Ward (1995) reported from their analysis of the PSLSD sample that over 87% of rural electrified households owned radios. Although these appliances consume a small amount of energy, they are an important feature in households by providing recreational and educational opportunities. Studies further indicated that the type of radios owned by rural electrified households were predominantly battery-operated, largely because the ownership of such radios dated back to pre-electrification times (Thom 2000). Radios such as these utilize dry cell batteries, which are expensive relative to the amount of energy delivered by them. Some studies have indicated that dry cell batteries account for a significant portion of households' energy expenditure i.e. up to 30-40% were observed for some unelectrified villages (Griffin et al 1992, cited in Thom 2000). Further James and Ntutela (1997) investigated the energy use patterns of low-income households with 2.5 Amps electricity supply (for which a fixed charge of R15 had to be paid monthly), and observed a significant increase in energy expenditure for households where electricity had not replaced other fuels for lighting or batteries for radio and television. Dry cell batteries were found to account for a large share of the household budget under these conditions. The same study found that electrification however appeared to have the least impact on the budgets of 2.5 Amp households without radios, which were not spending the usual minimum of R8.20 per month on batteries.

More recently Madubansi and Shackleton (2006) in a follow-up study conducted in 2002 in rural villages in the Limpopo Province found that within an 11-year period (1991 and 2002) a notable shift had occurred among the majority of low-income rural electrified households, from dry cell batteries to electricity to power entertainment appliances such as radio and hi-fis. Only 32% of these households reported continued use of dry cell batteries in 2002, which was a third of what was reported in 1991, and this was mainly used to power appliances that could not be powered by electricity such as portable radios, torches and clocks.

2.3.3.3 Multiple fuel use

Multiple fuel use is a dominant feature of energy use among low-income households in South Africa, including low-income electrified households. A study carried out by Afrane-Okese (1999) based on a national survey conducted in 1993, revealed that multiple fuel use was common practice in majority of South African households (68% of households - both electrified and unelectrified). This study further indicated that the use of a combination of 3 or more fuels to meet daily household energy needs was prevalent among as much as 45% of all households in the country, and these fuels comprised predominantly paraffin, fuelwood and candles. The same study also observed a reduced a reduced reliance on a combination of fuels in both rural and urban areas, with the onset of electrification. The reason being that electricity is flexible and suitable for most household energy end-uses, however only if the service and the necessary appliances are affordable.

Similarly Davis (1998) from a later survey found that the majority of sampled rural low-income electrified households used a diverse mix of fuels for their energy needs i.e. electricity was used in combination with other fuels rather than as a replacement for other energy sources. Different fuels were often chosen for different end-uses, however the use of two or more fuels for one end-use such as cooking, was also common practice. The study further indicated that majority of households in the lower income groups used three fuels (mainly fuelwood, paraffin and electricity) in combination to fulfil their basic energy needs. It was also observed that electrified households spent a greater proportion on energy and displayed less reliance on a combination of fuels relative to unelectrified households. Further the incidence of electricity replacing other fuels was shown to be greatest among the high-income groups. This supports the suggestion made by energy transition theory that movement up the energy ladder *is* influenced by income, although in this case this movement occurs in a different configuration to that postulated by the theory.

Madubansi and Shackleton (2006) more recently confirmed continued multiple fuel use when they found that between 1991 and 2002, over 50% of households in surveyed rural settlements in the Limpopo Province used four or more fuels to fulfil their basic energy requirements, despite widespread electrification in the areas over the same time period. Again it is evident that electricity does not replace other fuels but adds to the portfolio of fuels used by the household.

Using electricity in combination with other fuels could be ascribed to a number of reasons, chief among them being economic constraints (Madubansi & Shackleton 2006, Afrane-Okese 1999, Davis 1998). Electricity proves to be too expensive for low-income households to use to meet their full range of basic energy service needs. The minimum cost of a prepaid electricity card together with the price of related appliances is often not affordable to many low-income rural households where limited and uncertain income flows are a frequent experience. Hence poor households use other fuels alongside electricity, in particular paraffin, given that it can be purchased in small quantities at a time, subject to available income of a household. Further paraffin appliances prove to be more versatile in their range of uses, particularly for repeated energy intensive thermal applications such as cooking and heating (Cowan 2003). Lastly, another reason for the use of alternative fuels by poor households is in times of interruptions in the supply of a single fuel, such as instances of power failures or a shop running out paraffin supplies.

Studies have also indicated that the use of a diverse mix of fuels is favoured because they fulfil multiple tasks at any one time (Heltberg 2004). Low-income households have a tendency of meeting their energy needs through a combination of appliances and fuels, subject to the available resources of the households (Annecke 2003, DME 1998, Eberhard & Van Horen 1995,). White et al (1997) reported that low-income electrified households preferred to use coal and paraffin to electricity because appliances using coal and paraffin are cheaper and can be used for multiple end-uses simultaneously: paraffin and coal stoves can be used to cook food while providing space and water heating, whereas two electrical appliances would be required to perform these tasks and at a greater cost.

It appears that multiple fuel use among low-income electrified households will persist in the foreseeable future i.e. low-income households largely due to income constraints will remain reliant on low quality and polluting fuels such as paraffin, fuelwood and coal other than electricity for meeting essential thermal needs (Thom 2000, DME 1998).

2.3.3.4 Energy expenditure

Energy budget share of low-income electrified households

Energy expenditure features prominently in the economy of low-income households, and generally constitutes a significant proportion of monthly household expenditure (Cowan 2003, Eberhard & Van Horen 1995). It has been widely documented that low-income households spend a larger share of their income on energy than wealthier households (ERC 2006, Barnes et al 2005, UCT 2002, Davis 1998, Eberhard & Van Horen 1995). This is largely due to limited economic resources compelling households to use inefficient cooking and lighting appliances fuelled by paraffin, wood, coal and candles that the poor commonly utilize as energy sources rather than the electricity, to fulfil their basic energy needs (Barnes et al 2005, Eberhard & Van Horen 1995). Wealthier households have a

comparatively lower energy budget share as they utilize electricity and the associated efficient electrical appliances to meet most their energy needs. Electricity delivers a substantially more cost effective energy service than for example paraffin and candles i.e. electricity provides a better quality service at a lower cost in comparison to candles and paraffin (Eberhard & Van Horen 1995). To illustrate this further electricity delivers as much as 15 times more light than the same quantity of energy contained in paraffin, and this value can extend to 200 times more depending on the type of paraffin and electrical lighting appliance (Barnes et al 2005).

Another reason for energy shares of low-income households being higher than wealthier households is that the savings earned from electricity delivering energy services more cheaply compared to other energy carriers (such as candles and batteries) are redirected to using more electricity by way of purchasing more lights to extend the duration of lighting hours at night or purchasing new electrical appliances such as refrigerators and kettles (Thom 2000).

Energy expenditure trends

Davis (1998) observed the trend of increasing electricity expenditure with rising income within low-income electrified rural households, with electricity in turn constituting an increasing share of total energy expenditure of households. Davis (1998) also indicated that rural electrified households tended to spend more on energy than unelectrified households across all income groups (i.e. low, medium and high income groups).

Madubansi and Shackleton (2006) more recently reaffirmed some of Davis' findings. The authors found in a longitudinal study conducted in 2002 a general decline over an 11-year period (of 5%) in total expenditure on paraffin, candles, dry-cell batteries and gas by rural households. The authors ascribed this to an increased use of electricity to meet energy needs that were previously fulfilled using the above fuels. Similarly to Davis (1998), they found that electrified households spent more on energy than unelectrified households. Electrified households were found to spend as much as 60% of their total fuel expenditure on electricity, in spite of their use of FBE of 50kWh per household per month. With regard to particular fuels, they found that in electrified rural households, that electricity accounted for 45% of the monthly energy budget. Together with fuelwood and paraffin, it covered 85% of the energy Studies in other developing countries have shown similar trends of electricity accounting for the main energy cost of low-income households (Kabede et al 2002, Priyantha & Attalage 2002, Kituyi et al 2001, Gupta & Ravindranath 1997). However Madubansi and Shackleton (2006) envisaged the future uptake of electricity within their study area to be slow, given that the majority of households surveyed were not able to afford the full use of electricity. Murphy (2001) noted similarly that in the absence of increases in per capita income levels and/or economic incentives to attract investment in electrical appliances, low-income rural households would not be able to derive the benefits of electrification in as far as cooking the primary energy need is concerned.

Thom and Mohlakoana (2002) in contrast to the previously quoted studies found no clear patterns in household fuel expenditure among rural low-income electrified households in their longitudinal qualitative study conducted in 1999 and 2001. They observed that some households spent more or less or the same on energy after electrification, however no distinct pattern emerged. This could possibly be attributed to factors such as a small survey sample of households i.e. 29 households in total were surveyed relative to other studies or the surveyed households were electrified for a shorter period relative to previously quoted studies, hence no distinct patterns were evident at the time of study analysis.

With respect to the influence of FBE on household fuel expenditure, the UCT (2003) study found that majority of rural electrified households spent less on electricity, in contrast to findings of Madubansi & Shackleton (2006). This could be due to significant factors such as both studies were conducted in different areas with different socio-economic contexts and the length of time since the implementation of FBE could have varied for each study, in turn influencing the varied benefit documented in each study. Increased electricity expenditure demonstrated by only a few households in the UCT (2003) study was attributed to increased use of lighting and purchasing of electrical appliances. The study also observed a general decline in the use and expenditure of other fuels such as candles, paraffin and fuelwood, since the implementation of FBE.

Another trend observed from the literature,

2.3.3.5 Gender

Gender issues relating to the allocation of a women's time, gendered perspectives on expenditure priorities and social power relations (arising from the fact men and women have different skills, play different roles in household economy, have disproportionate control over various components of household budgets and have different interests and energy demand patterns) have an important influence on decision making with regard to energy and appliance use as well as energy acquisition and expenditure of households (Annecke 2003, Davis 1998, Makan 1994). It is widely documented that women are the principal end-users of energy, as they usually manage the household, which includes the procurement, management and use of energy sources for a range of energy services such as cooking, heating and ironing, while other services such as media and entertainment (radios and television) are controlled mainly by men in the household (Annecke 2000, Eberhard & Van Horen 1995). Further men tend to make the final decisions on issues extending beyond the daily area of women's responsibility such as choices to be made relating to the purchasing of appliances (Makan 1994). In addition the gendered division of labour in the household is such that an unequal distribution of labour exists in as far as energy sources are collected and acquired (Annecke 2000). The arduous task of collecting fuelwood in the rural areas generally lies with women. Challenges of wood scarcity experienced in rural areas bears an increased burden on women in terms of labour and

time spent gathering fuelwood as well as health and safety risks associated with this task (Annecke 2000, Eberhard & Van Horen 1995).

With respect to gender issues in relation to fuel use of low-income rural electrified households Thom and Mohlakoana (2002) found that among the surveyed electrified households in their study, the domestic workload of women remained the same in spite of electrification, however the nature of work sometimes altered. Households reported that electrification brought little relief in terms of the time and energy spent on laundry and collecting fuelwood, the most arduous tasks preformed by rural women. However it was observed that electrical appliances such as hotplates/stoves, kettles and irons did have an impact on domestic work. Due to the greater convenience, cleanliness and speed of electrical appliances (compared to paraffin), access to electricity resulted in significant time and labour savings for women with regard to cooking, water heating and ironing. In this study, electric irons had the greatest impact on domestic workload, they were more extensively used relative to electric hotplates/stoves and kettles, demonstrated by 60% of households surveyed using an electric iron at least once a week, relative to the 44% of households who reported using a hotplate/stove and kettle with only 26% and 35% reporting daily use of hotplates and kettles respectively. The use of electric irons thus saved time and eased the domestic load of women. Prior electrification ironing was performed using steel presses heated on a wood fire or paraffin stove.

In terms of the FBE, it was noted to have a clear and positive impact through significant savings in time and energy of women and children involved in collecting fuelwood for cooking and water heating. These savings were particularly significant in areas experiencing a scarcity of fuelwood – where women had to expend greater energy and time walking greater distances in search of fuelwood (Prasad & Ranninger 2003).

2.3.4 Energy use patterns of low-income electrified households in urban areas

Williams (1994) identified three pervasive trends in energy use of low-income households in South Africa. First, multiple fuel use was observed to be common with two to three fuels being commonly used to fulfil the same end-use. Second, the structure of energy use was noted to vary for differing types of households. Important determinants influencing this structure of energy use were recognised to be economic status, household size and location both nationally and within the city itself. Third, patterns of energy consumption were found to be dynamic, changing with time as social contexts (occurring both within and outside of the household), fuel prices, household incomes and access to different energy sources, alter.

Another feature of energy use among low-income urban households more recently observed is the gradual disappearance of fuelwood use (Prasad & Visagie 2006, Cowan & Mohlakoana 2005). Fuelwood cost, availability and convenience are major attributes for the growing disappearance of

fuelwood in the energy portfolio of urban households. In turn this has the potential to serve as a self-regulatory process in reducing indoor and outdoor air pollution (Prasad & Visagie 2006).

Having established a brief context for energy use by low-income urban households, various energy services sought by these households and associated factors will be examined below.

2.3.4.1 Appliance ownership and use

The accessibility of fuels, cost and availability of appropriate appliances, methods of financing appliance purchases and household income are some of the important factors influencing appliance ownership and use (ERC 2006, Mehlwana & Qase 1999, Simmonds & Mammon 1996). In low-income urban households where survival and security of energy supply are important, different strategies are adopted either to save on fuel or to ensure maximum efficiency of appliances. As a consequence households have shown a preference for appliances that can be used for multiple purposes such as paraffin heaters that can be utilised both for cooking and water and space heating. The use of appliances by households depends largely on whether the household can afford to buy the appliance or the fuel required to use the appliance (ERC 2006, Mehlwana & Qase 1999).

Studies have shown that the ownership of electrical appliances generally seems to increase with rising income among low-income electrified households with the exception of hotplate stoves (Thom 2000). Further, research conducted in various low-income urban localities have shown a higher prevalence of hotplates than stoves with ovens among low-income electrified households suggesting that even after electrification the costs associated with appliances maybe a significant barrier to their use (White 2000, Mehlwana & Qase 1999, Palmer 1999).

Although research has shown income, gender and income generation opportunities (through ownership of fridges for example), to play a significant role in the appliance ownership, it appears that there are other important determinants influencing electrical appliance purchase. Anthropological studies conducted in low-income urban areas have revealed an 'interplay' of wider socio-cultural and political factors playing a major role in influencing decisions relating to appliance ownership and use (Mehlwana & Qase 1999). As a consequence these studies emphasise the importance of considering the specific social context within which households make decisions to purchase appliances, when analysing appliance ownership in low-income households.

Regarding ownership of appliance versus use, research has interestingly shown that low-income electrified urban households may own appliances but do not necessarily use them (Mehlwana 1999, Simmonds & Mammon 1996). Anthropological studies have indicated that coupled with utilitiarian factors such as usefulness, cost and availability of space important considerations of symbolic value also influence decisions to buy, use or keep appliances. Such considerations include the desire to conceal poverty and appear to be embracing a particular lifestyle (Mehlwana & Qase 1999). Thus electrical appliances relative to non-electrical appliances tend to have positive symbolic associations

among low-income urban households – they serve as symbols of modernity and progress (Thom 2000). White (2000) further confirmed in an analysis of energy use in four metropolitan areas in South Africa, that many low-income urban electrified households had electrical appliances solely for symbolic value, evidenced by the common occurrence of broken appliances kept on prominent display.

However in contrast, more recent energy research conducted in low-income urban communities in Cape Town, South Africa reported a high incidence of electrical appliance ownership and use among majority of electrified households surveyed (Borchers & Annecke 2003, Cowan & Mohlakoana 2005). One such study, conducted in Khayelitsha, an urban township in Cape Town, biased towards poorer communities in the township reported 68% of households with a normal metered electricity supply owning and using an electric stove as their main cooking appliance, while 53% of households that obtained an electricity supply from their neighbours household using an extension cord, reported the same (Cowan & Mohlakoana 2005). Despite this evidence of almost complete transition to electricity for cooking, 24% of electrified households reported ownership of multiple cooking appliances, with paraffin stoves being their main cooking appliance. These findings challenge the conventional viewpoint emerging from studies of previous years that low-income electrified urban households tend to use electricity for less energy intensive applications such as lighting and media, instead of high-energy demand tasks such as cooking. This move to using mainly electricity for cooking could be attributed to the length of time these households were electrified, which ranged from 5-10 years as well as the introduction of FBE. A significant proportion of the sampled households (i.e. 50%-60%) reported using more electricity since the implementation of FBE. This was evidenced by the fact that electricity consumption had risen by 30-35kWh per month per customer since the introduction of FBE relative to previous years (Cowan and Mohlakoana 2005).

2.3.4.2 Use of energy for particular services

Cooking

Energy for cooking is essential for meeting the basic human need of survival. In South Africa, a significant proportion of households experience difficulty satisfying this basic need. Leach and Gowan (1987) pointed out that cooking together with space heating (in colder climate) account for 90 to 100% of household energy consumption in developing countries, and the same prevails for low-income households in South Africa (Eberhard & Trollip 1994).

It has been illustrated by various studies that even after electrification and despite a strong preference for electricity, low-income urban electrified households continue their extensive use of polluting and inconvenient fuels such as paraffin in particular and coal to fulfil the task of cooking, largely due to income constraints (ITDG et al 2002, Mehlwana & Qase 1999, Afrane-Okese 1999, Gervais 1987). These households cannot afford the use of electricity and the associated electrical appliances to fulfil

basic energy needs such as cooking and heating (Howells et al 2005). They are then compelled to use paraffin and coal which are more widely available and can be purchased in small quantities, suiting the fluctuating and unpredictable income flows of poor households. Moreover paraffin appliances tend to be relatively cheap and widely accessible. However the purchase of only small quantities of fuel at a time ends up being more expensive than when bought in bulk. It must also be noted that paraffin is a comparatively costly energy source for end uses such as cooking, heating and lighting, which could be delivered more effectively by electricity. Further, as covered in the introductory chapter, the extensive use of paraffin and coal impose an enormous health and safety burden on low-income households. In areas of the country such as the Highveld region where coal is cheaply available (as a result of close proximity to the coal mines), Gervais (1987) in an analysis of the Soweto electrification project (Soweto was electrified since 1983), found that as much as 67% of low-income electrified households in this area continued to use coal for cooking in the winter while 50% used it in the summer. Evidence suggests that low-income electrified households in this region shifted from using coal in the winter to paraffin in summer for cooking in order to avoid the space heating effects of coal (PDG 1995, cited in Simmonds & Mammon 1996). However it was also observed to be common for both fuels to be used throughout the year in this region, paraffin being used for quick heating and cooking while coal being used for meals that take longer to cook (Eberhard & Trollip 1994). It must be noted that despite extensive use of coal and paraffin used by electrified households in Soweto as mentioned above, 70% of these households also reported using electricity for cooking (Eberhard & Trollip 1994). This clearly illustrated the use of electricity in combination with other fuels for cooking, and the fact that electricity did not replace other fuels for cooking purposes, among low-income households. In other parts of the country such as Cape Town, low-income urban electrified households were observed to use mainly paraffin and gas for cooking (Mehlwana & Qase 1999). Coal use is rare in Cape Town due to its relatively high price.

Simmonds & Mammon (1996) also attribute the continued use of other fuels for cooking, among low-income electrified households to factors such as appliance purchasing conditions, 'fear' of the unknown and social relations.

In contrast to the above studies, (as noted earlier in the appliance section 2.3.4.1), one of the key findings from a recent study on barriers to modern energy services in low-income urban communities in Cape Town, was that over 60% of low-income electrified households used electricity as their main cooking fuel (Cowan & Mohlakoana 2005). This was attributed to the length of time these households were electrified, which ranged from 5-10 years as well as the introduction of FBE enabling greater use of electricity for a range of energy services, including cooking.

Lighting

Electricity is commonly used for lighting among low-income urban electrified households (Simmonds & Mammon 1996). Studies have indicated that lighting tends to be the first use of electricity in low-

income urban households (Barnes et al 2005). Low-income households tend to use electricity more extensively for lighting than for other end-uses, since little energy is consumed for lighting (incurring a smaller cost) and the efficiency of electric lighting is much higher than paraffin lamps or candles. The superior quality of lighting provided by electricity (relative to candles and paraffin) often results in low-income urban households diversifying their activities when they acquire access to electricity through engaging in reading and sewing in the evenings and children being able to study for longer hours (with possible benefits with regard to education) and so on (Barnes et al 2005, Simmonds & Mammon 1996). Although research has shown that low-income electrified households use electricity as their main lighting fuel, widespread multiple fuel use for lighting also persists. In many cases electrified households are not fully wired, and as a consequence paraffin and candles are utilized to light up non-wired rooms (Thom 2000).

This was further confirmed by a longitudinal study conducted in a peri-urban-area in the Mpumalanga Province, where Palmer (1999) observed a significant change in the fuels used for lighting by households two years after electrification. Soon after electrification majority of households in the study area were using electricity in combination with other fuels for lighting, while 40% of surveyed households reported no use of electric lighting. Two years after electrification however, the lighting situation shifted significantly, 79% of households used only electricity for lighting while 21% used it together with other fuels, mainly candles. The latter case was largely attributed to the structural limitations of the compact ready board, where not all rooms were wired for electric lighting, except for the room with a compact ready board. As noted earlier (Section 2.3.3.2 – lighting applications), when Eskom connected low-income households to electricity, it was done through the installation of a compact ready board which entailed one electricity connection point in the house, in order to reduce costs of wiring the entire house, and to this end incurring a saving for both the consumer and the utility.

Media - radios

Radios play an important role in low-income urban households in providing recreation and educational opportunities for households. This is demonstrated by the high incidence of radio ownership among low-income electrified households, in particular battery operated radios as indicated by findings from studies conducted in low-income urban areas of the Western Cape where a high proportion of electrified households (54%) were reported to use dry cell batteries to power radios (Mehlwana & Qase 1999). The authors attributed the use of dry cell batteries instead of electricity to widespread ownership of battery operated radios prior the electrification period. More recent studies confirmed these findings (Cowan & Mohlakoana 2005, Thom 2000).

2.3.4.3 Multiple fuel use

Studies have shown multiple fuel use to be pervasive among low-income South African electrified households. This pattern of energy use by households seems to decline significantly (i.e. the number of different types of fuel used to carry out the same end-use or different end-uses is reduced) with electrification in both urban and rural areas (Afrane-Okese 1999). This is attributed to the convenience and flexibility of electricity as an energy carrier to fulfil household energy needs, provided that the service and the required appliances are affordable to the household. (Afrane-Okese 1999) This trend of reduced multiple fuel use with electrification was affirmed in recent studies showing an almost complete transition to electricity use for energy needs particularly for cooking, after 5-10 years of electrification, among low-income urban households (Cowan & Mohlakoana 2005, Borchers & Annecke 2004).

Majority of electrified households in low-income urban areas utilise electricity in combination with other fuels to fulfil their energy needs, however fuel combinations appear to decrease with electrification (Afrane-Okese 1999, Simmonds & Mammon 1996, Eskom 1996). The trend displayed is of continued use of gas, paraffin, and coal for more energy intensive needs such as cooking and heating, while electricity is used to fulfil lighting and entertainment needs. The high cost of electrical appliances, their lack of mutli-functionality as well as the high costs of using electricity for cooking and space heating are some of the reasons attributed to the use of multiple fuels by majority of low-income electrified households in urban areas, more specifically newly electrified households. Multiple fuel use is also attributed to availability of energy sources as well as social factors such as "tradition", "culture", taste and households' personal histories of utilising different forms of energy (White 2000).

As a result of the above mentioned factors, multiple fuel use is envisaged to persist in the foreseeable future among low-income electrified households in urban areas, with a heavy reliance on fuels such as paraffin, coal and LPG other than electricity to satisfy their thermal needs (DME 1998, Mehlwana & Qase 1999).

2.3.4.4 Energy expenditure patterns

Studies indicate energy expenditure increases with increasing income among low-income electrified households (Thom 2000). Prasad & Visagie (2006) have further indicated that proportions of households using electricity for cooking increases with rising income.

However low-income urban households spend a higher proportion of their monthly income on energy than wealthier households (Prasad & Visagie 2006, Simmonds & Mammon 1996). Cowan & Mohlakoana (2005) in a recent energy study in Khayelitsha, Cape Town observed that the poorest households spent up to 14% of the household budget on energy, which was three times higher than that of their wealthier counterparts who spent a mere 3% of their monthly income on energy.

High energy expenditure by low-income households could possibly suggest that energy is a basic necessity and therefore could indicate that a certain minimum energy consumption is required to maintain a minimum standard of living. However, it could also reflect the fact that poorer households are consuming less energy but paying a higher price for energy consumed. This was illustrated by Cowan and Mohlakoana (2005), who observed from their study that higher income households tended to have a regular metered electricity supply, enabling them to benefit from FBE allowance of 50kWh, while households in the lower-income groups tended to be in un-serviced areas, and thus either obtained electricity from neighbouring households with metered supplies or had no electricity at all. In either case, these lower-income households were not able to access the benefits of the FBE allowance. As a result of these households not situated in a municipal approved area, they were not able to receive the benefits of a regular metered and subsidised electricity supply, and therefore would have had to pay more per kWh for their informally obtained electricity supply. Further this supply may not have been enough for their requirements or sufficiently secure for them to rely on electricity for cooking or other purposes, thus they were reported to use more non-electric fuels, than normal electrified households in Khayelitsha (Cowan & Mohlakoana 2005).

2.3.4.5 Persistence of the use of other fuels despite access to electricity

In summary it has become increasingly evident that in spite of access to electricity, low-income electrified households both in rural and urban areas continue to use other inconvenient and polluting traditional fuels to fulfil their main energy needs owing to a multiplicity of socio-economic factors. . Further the use of these fuels condemns these already economically impoverished households to enduring a further health, safety and social burden. More than 4.85 million households or just under half of South Africa's population (19.85 million people) use either coal, wood or paraffin for cooking and heating purposes (Szabo 2006). The reported sale of over 4 million non-electric stoves annually, notably reflects that energy sources besides electricity and the associated appliances to use such energy sources play a critical role in household energy consumption in South Africa (PDC & SCE 2003). This is further confirmed by as much as 56% of Eskom's prepayment customers consuming less than 50kWh per month while, 70 to74% use less than 100kWh on a monthly basis (PDC & SCE 2003). The significant proportion of households consuming less than 50kWh monthly reflects that electricity is not used extensively for thermal applications such as cooking, space heating or water heating. The consumption of electricity remains low, despite areas being electrified for a number of years, largely due households not being able to afford the use of electricity (PDC 2003). As a consequence research shows that a large proportion of low-income households use electricity mainly for less energy intensive applications such as lighting, the operation of radios and televisions and small appliances (PDC & Science Cooperation, 2003, DME 1998). It therefore becomes increasingly important that other essential energy services (such as primary task of cooking) required by poor households are addressed and that access to clean , affordable and safe energy sources to meet the

energy needs of the poor is ensured, and which in turn do not have an adverse impact on human health and the environment.

Table 2.2: A summary of the major features of energy use patterns by low-income electrified households in rural and urban areas

Parameter	Rural	Peri-urban
Context	Severe poverty, low levels of literacy, education, productivity and skills development. Rural communities tend to be dispersed settlements with limited access to gainful employment and public services. More impoverished than urban areas.	Peri-urban communities tend to be poorly serviced, high-density informal settlements, located at margins of urban areas, home to 23% of the country's population, and making up 40-60% of the labour force in several cities.
Level of urbanisation	42% of the country's population resides in the rural areas.	58% of the country' population reside in urban areas.
Level of electrification in South Africa	50% of rural homes are electrified – lower than urban areas owing to dispersed settlements typical of rural areas that in turn serve to raise electricity connection costs.	80% of urban homes are electrified.
Gender	Women tend to be the primary managers of the household which includes acquiring and using energy sources for a range of energy services such as cooking, heating and ironing. The arduous ask of wood collection generally lies with women. The collection and use of fuelwood for energy services has serious negative health impacts on women, as well as reduces the time for women to potentially engage in other productive activities such as farming, education etc, as it is a time consuming task. Men in the household tend to make the final decisions on issues beyond daily realm of women's responsibility such as choices relating to purchase of appliances.	Same as for rural however wood collection features to a lesser extent, given that the occurrence of natural woodlands are scarce in the more built up urban areas. As a consequence fuelwood use is used to a lesser extent among low-income urban households.
Prevalence of main fuels used	Fuelwood, paraffin used as the main sources of energy i.e. energy used to meet the main energy intensive tasks such as cooking. Candles used as a supplement to electricity and paraffin for lighting.	Paraffin is used as the main energy source i.e. energy used to meet the main energy intensive tasks such as cooking. Fuelwood use is disappearing from the energy portfolio of urban households, largely due to cost, availability and convenience. Candles used as a supplement to electricity and paraffin for lighting.
Energy expenditure	Low-income households spend a larger share of their household budget on energy than wealthier households. Studies have shown electricity makes up an increasing share of total household energy expenditure.	Same as for rural.
Energy services	**Cooking/heating** Although electricity is highly valued by poor households for cooking and used to a small extent, fuelwood and paraffin are the primary fuels used for these tasks. **Lighting** Households commonly use electricity for lighting, however use of candles and paraffin persists owing to various factors such as nature of electric wiring of household, candles used only in times of power failures or when households did not have sufficient money to purchase pre-paid electricity. **Media/Entertainment** Widespread ownership of radios. A shift has occurred from dry cell battery to electricity use to power entertainment appliances such as radios and hi-fis.	**Cooking/heating** Despite a strong preference for electricity, households use paraffin and coal as the energy forms for cooking. **Lighting** Same as for rural **Media/Entertainment** High incidence radio ownership. A high proportion of households use dry cell batteries instead of electricity to power radios, due to the purchase of battery operated prior the electrification period.
Multiple fuel use	A dominant feature of energy use in households. Households have a tendency to meet their energy needs through a combination of appliances and	Same as for rural.

	fuels, subject to their available resources being among the factors. A reduced reliance on a combination of fuels used to meet energy service needs with the onset of electrification i.e. electricity is used in conjunction with other fuels and does not serve as a replacement for other energy sources.	Same as for rural.
Appliance ownership	A significant proportion of households own electrical appliances, but not often used on a regular basis. Electrical appliance ownership increases with rising income, while paraffin appliance ownership indicated an inverse relationship with income. Appliance ownership and use also determined by multiple social and economic factors. Despite access to electricity households continue to use a variety of appliances and energy forms to meet their energy needs.	Recent studies have shown a high incidence of electrical appliance ownership and use, while earlier studies have pointed to a high incidence of ownership but not necessarily of use. Same as for rural The cost of the appliance, the number of services that an appliance can provide as well as the fuel required to use the appliance are important considerations when a household decides which appliance is to be utilised with energy sources.

CHAPTER 3: METHODOLOGY

This chapter explains the methodological approach employed to analyse the dataset used for this dissertation, which was generated from the surveys undertaken. Descriptions of the surveyed areas and the data set employed for the empirical analysis in this study are provided. The analysis of the data is explained. The chapter concludes with a discussion of identified data issues and shortcomings and measures taken to minimise the latter where possible. To these ends this chapter supports achieving the principle objectives of the study, which are to obtain a detailed picture of the household energy use patterns among low-income electrified households in rural and peri-urban areas of South Africa, and to examine the differences in energy use between the rural and peri-urban households.

3.1 Data source

The data used in this study is from a survey conducted by the University of Cape Town (UCT) during the period 2001-2. The survey formed a component of a major research undertaking commissioned by the South African government to UCT, in particular the Energy Research Centre, to assess the social, economic, financial, health and environmental feasibility and impact of providing the amount of 50kWh/month electricity per household free of charge as a lifeline subsidy/support service to the poorest households of South Africa. The government's principle objective in providing poor households with this amount of free electricity (this amount enables the use of electricity for basic lighting, a TV, a radio and occasional thermal applications such as using a kettle or a hotplate) was to mitigate the worst effects of poverty prevalent in South Africa. In July 2000 the government announced its commitment to implement a basic electricity support tariff, and UCT was subsequently commissioned to examine the feasibility and impact of such a tariff. The tariff, over the years has assumed a series of titles, and is currently called Free Basic Electricity (FBE). As part of the research in measuring the effect of the FBE tariff on the poverty levels of households, UCT conducted comprehensive pre- (baseline) and post FBE household surveys, comprising detailed quantitative and qualitative questions posed to members of household in face-to-face interviews by trained and locally familiar interviewers. These energy surveys included the collection of detailed data on household demographics and composition, income from all possible sources, expenditure on all household energy sources and all other major items and patterns of fuel and electricity use and purchase. It was this household survey data, which was used in the analysis for this study.

The pre FBE implementation survey was undertaken during 2001 and 2002 in a total of five areas, i.e. within three rural communities, namely Antioch, Garagopola and Maqongqo, and two peri-urban communities, Umgaga and Ikgomotseng, all located in different provinces of the country as indicated in Figure 5. The survey focussed on electrified households as FBE would only be accessible to households that had an electricity connection.

After having received FBE for 6 months to a year, a post FBE implementation survey was conducted on the same households interviewed in the pre FBE survey. Due to various constraints, the post survey was conducted in only two of the five pre-FBE survey sites, namely the two rural communities of Antioch and Garagopola.

3.2 Surveyed areas

The areas surveyed capture a relatively representative picture of the low-income rural and peri-urban landscape of South Africa, which tend to be characterised by high levels of underdevelopment, poor basic services, large population densities on economically marginal land and high levels of poverty including energy poverty. This is in large part a legacy of past apartheid spatial planning which controlled the accommodation of black South Africans, whereby the majority of the population was legislatively confined to rural (in the past called "homelands") and peri-urban areas. The peri-urban study areas, as in many other parts of the country, are "urban" settlements established on the outskirts of the main economic hubs of activity originally set up to accommodate a labour pool in close enough proximity to work in local commerce and industry, while at the same time isolating them from the more affluent sectors and suburbs of the cities.

The five areas surveyed were identified by the Energy Research Centre with assistance of Eskom (the national electricity utility), for FBE to be administered experimentally to poor households, as they served as a roughly representative sample of poor rural and peri-urban communities in South Africa. Further, Antioch and Garagopola were communities in which Eskom had already performed research relating to the impact of electrification in rural areas (Thom 2001, Thom et al 2001). Hence there was prior knowledge of these areas with respect to energy consumption.

The ensuing descriptions of the surveyed areas provide not only a locational context to the study but also facilitate a deeper understanding of both the energy use patterns displayed by these poor households. Further the different kinds of settlement patterns displayed by the surveyed rural and peri-urban areas also help to understand the access to and availability of energy sources, which play a role in energy use patterns of poor households being different in rural and peri-urban areas.

The surveys were conducted primarily on electrified households in the following areas.

Maqongqo

Maqongqo is a deep rural mountain village comprising of about 2000 inhabitants, and located about thirty kilometres away from Pietermaritzburg a major urban centre, in the province of Kwa-Zulu Natal. Hillsides of the area are adorned with sugar cane, which is a major commercial crop of the area. The village was electrified about 15 years ago and prepayment meters were introduced in 1997/8. At the time of the study there was one electricity vendor in the village, from whom electricity could be purchased.

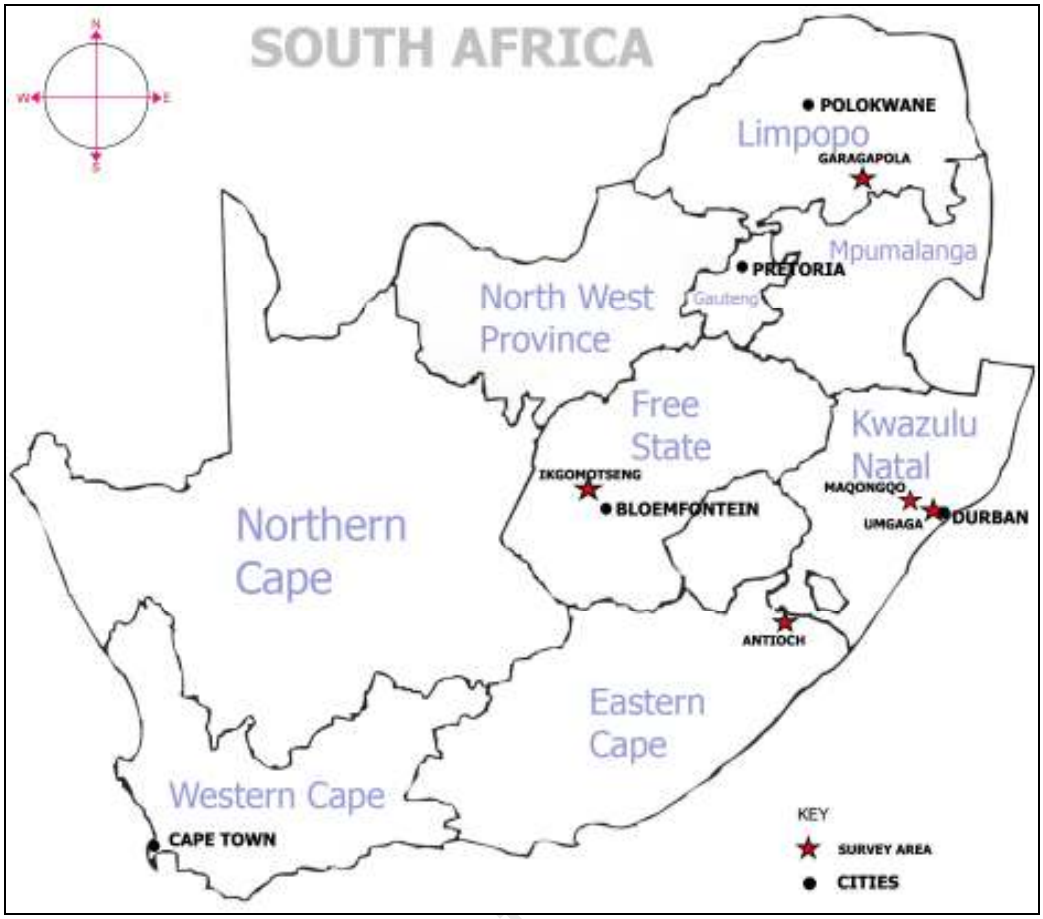


Figure 4: Location of survey sites in which interviews were conducted

The Free Basic Electricity subsidy (poverty tariff) was introduced to this village using the self-targeted approach. Customers willing to be eligible for the new tariff (i.e. 50 units of electricity for the price of R5.00), had to apply to Eskom to be downgraded from their usual 60 and 20 Amps electricity supply to 8 Amps supply, thus self-targeting their households for receiving the poverty tariff.

Garagopola

Garagopola, a rural village, falls under the GaMaroga Tribal Authority within Greater Tubatse Municipality, in the Limpopo Province. The villages lies 200 kilometers south-east of Polokwane, the provincial capital, and 20 kilometers away from the nearest urban centres, namely Burgersfort and Steelpoort where food and other necessities are procured.

Several chrome mines and associated industries (smelters) surrounding Steelpoort serve as a major source of employment for many people residing in Garagopola.

Garagopola is located at the base of a mountain, in a wooded environment where inhabitants gather wood for their energy needs. Most households are situated on large plots of land and are engaged in

subsistence farming, growing mainly maize. People from the area also sell vegetables procured from the nearby towns. Several households also own livestock, such as chickens, goats and cattle.

Lifestyles and values of people in Garagopola reflect a mixture of traditional and modern influences.

The village has three schools and one clinic. The area has communal water taps, and payment for the use of water was implemented by the municipality through a prepayment system. In 2001 Telkom installed fixed-line telephones in the village.

Garagopola was electrified in 1997 by Eskom, who offered households three electricity supply options namely:

1) 8 Amps (no connection fee)
2) 20 Amps (R65 connection fee)
3) 60 Amps (R450 connection fee)

All households opted for the 8 Amp supply which incurred no connection fee, with the result that all households were electrified.

Antioch

The remote mountain village of Antioch forms part of the Umzimkulu Local Municipality located in the Eastern Cape, and falls under the authority of Chieftainess Msingapansti who resides in Antioch. The nearest urban centres to these two villages are Pietermaritzburg and Umzimkulu which lie 180 and 35 kilometers away respectively.

The village can only be accessed by a tortuous dirt road in poor condition, which traverses the steep mountain slopes. Most of the village procures basic goods and services from the nearest town Umzimkulu, which is an hour's drive away during dry weather.

Due to steep mountainous hillsides in which Antioch is located, homesteads typically comprise of traditional rondavels built in a row on terraces. Households generally have gardens in which vegetables are grown for own consumption. Several households grow maize in larger fields.

Antioch, relative to the surrounding villages, tends to be better served in terms of public services provided; it has a primary and small secondary school and is visited once a week by a mobile clinic. In addition the village has six shops and an electricity vending station. Antioch has communal taps from which water is available. Water is acquired through a gravity fed system from the local spring.

Eskom supplies electricity to the area. Antioch and a few surrounding villages were electrified since 1997. All households that formed part of the study had prepayment systems. Households in Antioch generally bought electricity from the nearest town, Umzimkulu, due to the poor service provided by the electricity vendor in the village, who limited the quantity of electricity sold to households at times and often failed to satisfy demand due to running out of electricity units to vend.

Umgaga

Umgaga a long established, increasingly densely populated peri–urban informal settlement, perched on the steep slopes of the Umlazi River Valley, lies 35 kilometres from city of Durban, in the province of Kwa-Zulu Natal. The dwellings and shacks are tightly packed together and are constructed of a mixture of mud, wood and concrete blocks. Most households own their homes and some residents have lived in the township for as long as 20 years. There are a few tarred roads. However there are mostly dirt paths, which meander between the densely arranged dwellings. In some places these paths serve as drains. Few dwellings possess an indoor latrine, and most households use a communal outdoor toilet. Very few households have inside taps.

Umgaga was electrified 1995, although older houses in the settlement have been electrified long before. Access to electricity has served to instil a sense of permanency and security in Umgaga as a whole.

Electricity supply is provided by eThekwini Metropolitan Municipality. Umgaga has several vendors vending prepaid electricity, some are situated in close proximity to dwellings. However households in general prefer to buy electricity from vendors located farther away from their settlement. A redevelopment project is planned for the area, and if this materialises, boundaries of plots will be specified enabling owners to acquire official tenure of their dwelling.

Ikgomotseng

Ikgomotseng is a relatively new peri-urban informal settlement, situated about 50 kilometers north west of Bloemfontein, the provincial capital of the Free State province. The village consists mainly of RDP houses with a small shack area. The village comprising of about 10 000 people, is well laid out, has piped water with a tap in each yard, and waterborne sewage. The village council had established an indigent tariff for water and sewage. Half the population of Ikgomotseng applied for this tariff and were eligible. Few jobs are available in the village. Some residents of the area find gainful employment through servicing the community (teacher, nurse) or working in the nearby salt works, while the majority migrate to the large urban centres such as Bloemfontein, Welkom and Johannesburg. People who work in the nearby cities return home on the weekends.

The area was electrified in 1991-2. At the time of the survey all electrified households were on prepayment meters. Most households were installed with either 60 Amps or 20 Amps electricity supply, whilst a few had 8 Amps electricity supply. The village was serviced by one electricity vendor who owns a shop in the area.

The surveyed areas on the whole, typical of the former 'homelands' are characterised by underdevelopment, inadequate infrastructure, high unemployment and household dependency on social grants and remittances from migrant workers. As a consequence surveyed households were observed to engage in a variety of informal activities to support their livelihoods, including arable

agriculture, home gardens, livestock husbandry as well as the collection of natural resources such as fuelwood, crop residues, dung and medicinal plants, casual employment, migrant labour and small-scale enterprises.

3.3 Survey sample

The data used in the analysis for this study is based on a pre FBE implementation survey sample and includes a total of 226 electrified households (147 rural households and 79 peri-urban households) from three rural and two peri-urban communities. Tables 3.1 and 3.2 present a summary of selected features of the survey sample.

Table 3.1: Summary of selected characteristics of survey areas

Survey area	Province of survey area	Area type	Number of households interviewed
Garagopola	Limpopo	Rural	56
Antioch	Eastern Cape	Deep rural	41*
Maqongqo	Kwa-Zulu Natal	Deep rural	50
Umgaga	Kwa-Zulu Natal	Peri-urban: informal planned	47
Ikgomotseng	Free State	Peri-urban: informal planned	46**
Total sample			240

** The Ikgomotseng surveyed sample included 14 households that were not electrified. This study however examines the energy use patterns of electrified households and therefore the 14 unelectrified households were excluded from the data set, resulting in a total sample of 226 households used for the analysis.

Table 3.2: Electrification status and duration over which pre and post FBE surveys were conducted in surveyed areas

Survey area	Year of electrification*	No. of years electrified before pre FBE survey	Pre FBE Survey	Duration over which FBE was piloted	Post FBE Survey
Garagopola	1997 (3 supply options offered)	4	May 2001	Feb 2002-Sep 2002	September 2002 (10 months after FBE was piloted)
Antioch	1997	4	Oct/Nov 2001	Nov 2001-Oct 2002	September 2002 (7 months after FBE was piloted)
Maqongqo	1992-1993 (prepayment meters introduced in 1997-8	9	Aug 2002	Aug/Sept 2002-Feb 2003	No post survey conducted
Umgaga	1995	6	Nov/Dec 2001	Was planned to begin in May 2003	No post survey conducted
Ikgomotseng	1991-1992	10	September 2002	September 2002	No post survey conducted

* It must be noted that not all households within each survey area were electrified

3.4 Data Analysis

The 'household' formed the primary sampling unit for this study, by which energy use patterns were examined for low-income rural and peri-urban areas. The analysis was based on grid-electrified households. A range of socio-economic variables including the composition of the household were identified and further analysed in terms of their relationship with household energy use patterns. Comparisons were generally made across rural and peri-urban household categories and the main energy use variables were further examined by income, household size, education, age and gender.

Data from the questionnaires were already collated. However for a large part of the analysis, particularly with regard to key variables (such as data relating to the different sources of household income and expenditure items) that were analysed, data had to be recaptured from the questionnaires due to recurrent inaccuracies found in the previously captured data. Data was collated and analysed using Microsoft Excel (Excel 2000) and SPSS 15.0 for Windows.

For ease of reference, peri-urban households will be termed urban households hereafter for most of this study.

Section 3.4.3 below outlines the reasoning behind using the observation of patterns resulting from the cross tabulation of data (i.e. without statistical tests of significance) as the main method of analysis.

3.4.1 Income and expenditure data

Three income groups were defined in terms of tertiles, based on the households' reported total monthly expenditure and using the entire sample (i.e. it splits the total sample of 226 households into income tertiles i.e. not separately for the urban and rural samples). The distribution of households within each tertile across the rural and peri-urban study areas are presented in Table 3.3. Tertile 1 (the low income group) included all households with a monthly expenditure of less than R84 per capita, while Tertile 3 (the high income group) encompassed all households with a monthly expenditure of more than R157 per capita. Tertile 2, the middle-income group fell between these two tertile categories. In terms of the poverty datum line estimated by Statistics South Africa of R341.32[13] per capita per month (calculated on the basis of expenditure in 2001 prices), the sample is primarily made up of poor households, living well below the poverty line. It must be noted however that the welfare of the sampled households was based on reported cash household expenditure per capita, which does not take into account the potential input from non-monetary subsistence activities which generally form an important part of the rural economy, and therefore would have likely occurred in the surveyed rural areas. The analysis therefore explored the relationships between income and household characteristics across areas to establish patterns, with the view that cash expenditure may not present a complete picture of the welfare of rural households.

[13] (Statistics of South Africa and Department of National Treasury estimated a poverty datum line of R341.32 (in 2001 prices) using the national 2000 Income and Expenditure survey (SSA 2007)

The income groups in the data analysis were defined according to household expenditure per capita instead of household income (household expenditure was used a proxy for household income in the analysis) for the following reasons:

1) Household expenditure data served as a more accurate reflection of the amount of money available in a household to be spent on household items.

2) It was also observed from the data that expenditure was also more reliably reported on than household income.

3) Further it became evident from the survey questionnaires that the income questions differed for the different areas surveyed. As a result inconsistency arose in the type of income data collected for the different areas, rendering it difficult to make comparisons across the areas based on income. In four of the five surveyed areas households were asked for the amount of income earned/received as well as income contributed to the household from most income sources, with the exception for a few sources where either income earned or income contributed questions was asked. While in the survey area of Garagopola, income questions elicited information relating to income contributed to the household from some income sources, and income earned from other sources. As a result of this inconsistency in the data collected for 'income earned' and 'income received' for the different areas, household expenditure was used as proxy for income in the data analysis. Household expenditure questions were consistent over the entire sample allowing for rigorous comparisons to be made.

Lastly, with respect to income, per capita household expenditure was used as income grouping as it was observed to be a better measure of income of the household than household expenditure as household sizes vary significantly.

Table 3.3: Distribution of rural and peri-urban household sample across income groups

	Income	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
Total number of households surveyed (N)	Rural	54	44	49	147
	Urban	22	31	26	79
	Total	76	75	75	226

3.4.2 Energy sources and end use data

Analysis of the energy sources data explored the prevalence of use of the different energy forms by rural and peri-urban household categories across a range of factors (among which were income groups, gender of household, household size, age and highest level of education of household) to establish possible patterns in energy use in association with these factors.

Analysis of the end use data explored for potential patterns in the use of different forms of energy for different end uses across rural and peri-urban household categories.

The households' share of expenditure on energy was compared across income groups within rural and peri-urban household categories to indicate the magnitude of the energy burden experienced by households.

Differences in appliance ownership and use between income groups and gender across rural and peri-urban areas were examined.

3.4.3 Data issues

Purpose underlying the data collection and sample size

The chief purpose for conducting the survey was to facilitate a speedy assessment of the likely impact of the FBE tariff. Hence, the sampling and data collection processes were challenged by severe time and related cost constraints set by the South African government within which the FBE research project had to be completed. This further implied that the sampling and data collection were initially undertaken with only a view to comparing the fuel use patterns existing in these areas before and after the implementation of the tariff.

This resulted in the size of the samples and sampling methodology not being geared towards attracting data to be representative of any particular region (eg. for a province or nationally) with any meaningful credibility i.e. the sample does not lend itself to more complex statistical tests and analyses being performed. To expand on this, it is common in statistical circles to purport that statistical significance can sometimes confound whether something is statistically meaningful. For example, if using this data, it was found that households with a greater proportion of women exhibited a certain trait in the rural sample, but not in the urban sample (and this difference was supported by a chi-square or t-test of significance [e.g. $p<0.05$]), it would not be correct to use this to draw a conclusion on the probability of this difference existing in the rural and urban populations in South Africa at large.

Taking all of this into account, it was decided that cross tabulation would be the primary investigative tool for this study, with the patterns that were observed not being tested for statistical significance, but instead being assessed (manually) with reference to current literature, with the main aim being to provide a further quantitative reference point in a sparsely resourced field of research.

It was considered critical to the value of this study that the judgement and assessment of the extent of differences and associations observed were consistently applied across all analyses. Rules of thumb that were applied are as follows:

- Differences of less than 10% in prevalence rate were generally ignored as being too small to be credible with the data size and representivity issues
- Differences of greater than 10% were generally assumed to indicate patterns that would be worthy of noting for comparison with current literature and for further investigation

I would expect the results from this study, integrated with the other current literature to provide a sound base for designing and implementing more measured, focused, comprehensive and regionally representative low-income household fuel use studies.

Income and expenditure data challenges

a) Data was collected through interviews with a household member who was asked about income and expenditure of a typical month. The reliability and accuracy of the data obtained in this manner would have been prone to several uncertainties such as erratic cash flows typically experienced by poor households from month to month, honest responses relating income of household members could not be guaranteed, as well as respondents may have found find it difficult to recall the required information accurately.

b) Further, the surveys focussed on collecting data relating to cash income, resulting in the important contribution of subsistence activities prevalent in rural areas, such as collecting firewood, cleaning the household, cooking, raising young children and growing a few crops, being overlooked.

c) As noted earlier in the chapter (in Section 3.4.1), the questions eliciting income data from the surveyed areas were not consistent over the entire sample, thus limiting comparative income analysis from being undertaken. As a consequence expenditure data was used as a proxy for household income, since expenditure data was consistent for the entire sample.

Energy data challenges

There are particular energy related features of the questionnaire that merit attention.

a) Level of expenditure on the different fuel types used was asked in all surveyed areas. Further, all areas with the exception of Garagopola, were asked whether fuels were included in the grocery expenditure of the household. With the result, double accounting could have occurred with regard to Garagopola's energy expenditure, by way of the respondents providing an expenditure amount for each fuel type asked, as well as quoting a grocery expenditure which could have included fuel expenditure.

b) Determining the energy consumption of the different fuel types used by the household to meet basic energy needs, proved difficult for a number of reasons. In the case of paraffin although the total monthly quantity of paraffin used by the household could be calculated, the quantity of paraffin used for the different end uses was not available. With the result monthly household consumption of paraffin included quantities used by households for purposes other than satisfying the household basic needs such as paraffin sold by the household or used to prepare food to sell to the neigbourhood. Difficulty also arose with determining coal consumption, as quantities provided were in varying units ranging from bags to tins, for which sizes or volumes were not available to convert into standard units. With regard to

wood, a complete picture of wood use by households in terms of consumption or expenditure could not be obtained. This was an important limitation in the analysis, given the widespread use of wood by both rural and peri-urban surveyed households. This was attributed to households reporting quantities of wood used in varying units (ranging from irregularly sized bundles and headloads to wheel barrow loads and truck loads) that could not be converted into a uniform unit. Further these varying units differ from person to person, regionally and seasonally, resulting in it being difficult to acquire precise measurements from this survey. Difficulty also arose with determining total monthly household expenditure on wood, since imputing a monetary value of self collected wood, depends on a range of factors such as wood species and moisture content of wood, among a few, for which there was no available data. In an attempt to impute a value of self collected wood, using number of the hours taken to collect wood daily by the minimum hourly wage of a poor rural household (applicable to 2001, the year of the survey), it was soon found that half the rural sample (where self collected wood is widely used) was not asked the amount of daily hours it took to collect wood.

As a consequence of these consumption data challenges for some of the main fuels used by households, rigorous comparisons between the different fuel types with regard to consumption could not be made.

Further due to household surveys not being identical for each area surveyed, caution must be taken with regard to representivity of the data.

CHAPTER 4: RESULTS

This chapter presents the results of a quantitative analysis of household energy use patterns in low-income rural and peri-urban communities in South Africa. The results are presented in seven sections. The first section provides an overview of the socio-economic status of the surveyed households in the study areas as the background for understanding the household energy use patterns analysed in the study. It describes the households in terms of their size and composition, electricity connection status and economic conditions. This is followed by the second section, which examines the prevalence of different fuels used in the different areas. This includes the extent of use of various fuels such as fuelwood, dung, paraffin, candles, coal dry cell batteries, LPG and grid electricity by surveyed households. The third section explores the dependence of households on different fuels used through examining household expenditure on the different fuel types used as well as the total energy expenditure expressed as both a monetary value and as a share of household expenditure. The chapter next examines household energy consumption patterns by analysing the quantities of the different fuels used. The fifth section disaggregates fuel use by different end-uses, in order to examine the extent to which different fuels are used in the household. The chapter then goes on to explore multiple fuel use patterns displayed by households, providing insight into the fuel mix adopted by households to provide essential energy service needs. Lastly, appliance ownership and use by households is explored, examining the extent of ownership and use of electric and non-electric appliances in surveyed households. For ease of reference households surveyed in the peri-urban communities are referred to as urban households throughout the rest of the dissertation.

4.1 Characteristics of surveyed households

The main household characteristics are described below, providing breakdowns per area as well as totals for the entire sample. Sketching the socio-economic profile of the surveyed households provides the context for understanding the energy use patterns analysed in this study.

4.1.1 Household demographics

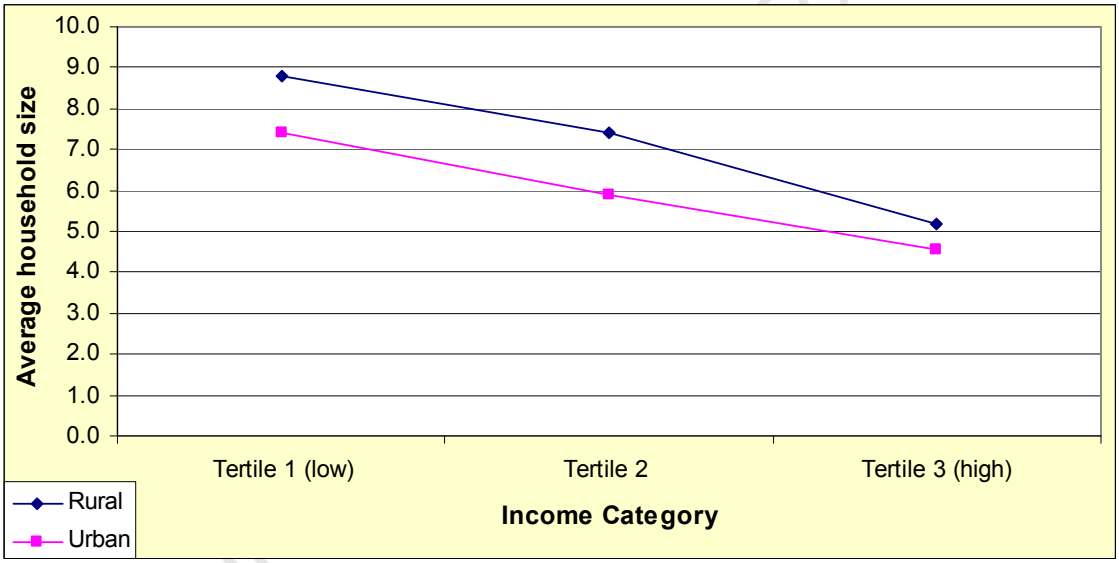
4.1.1.1 Household size

The number of people in a household (household size) has been shown by studies to have an influence on household energy use patterns (UNDP/ESMAP 2003, Baranzini & Goldemberg 1996). It is thus useful to briefly analyse the average and distribution of household sizes of the sampled households. Household energy use often reflects large economies of scale occurring with increasing household size. Therefore, despite total energy consumption usually increasing with household size, per capita energy consumption may reduce.

The average household sizes of the study areas are illustrated in Table 4.1 below, together with the average number of adults and children. Rural households displayed higher average household sizes (7.2 persons) than urban households (5.9 persons). Antioch had the highest average household size (7.7 people) with the lowest average household size (4.0 people) in Ikgomotseng.

A great diversity in household composition was displayed, in terms of the many types of different relatives living within a household. There were also many occurrences of changing configurations to households where a sister or brother of the previous head would then assume the position of household head. Both the size and constitution of the households often related to a strategy of survival and risk management adopted by the household.

In addition, it appears that household sizes were higher in areas that have been established for a long period time, as shown by Ikgomotseng, a relatively newly established informal settlement with a considerably lower average household size of 4.0 relative to other longer established areas which range from 6.7 to 7.7.



*Rural **n**'s (households): Tertile 1 –54; Tertile 2 –44; Tertile 3 –49; Total –147*

*Urban **n**'s (households): Tertile 1 –22; Tertile 2 –31; Tertile 3 –26; Total –79*[14]

Figure 5: Relationship between per capita income and average household size

Further with respect to household size, from Figure 6, it appears that average household size has an approximate linear relationship with per capita income for urban and rural households - in general the average household size decreases with increasing per capita income for both area categories of households. The slightly different gradients shown in each of the linear relationships in Figure 6 indicate that the influence of income on average household size may occur at slightly different rates in urban and rural households.

[14] Refer to section 3.4.1 for a description of the derivation of the income tertiles across the entire sample.

Table 4.1: Household demographics

	Rural				Urban			Total
	Garagopola	Antioch	Maqongqo	**Total**	Umgaga	Ikgomotseng	**Total**	
n (number of households surveyed)	*56*	*41*	*50*	***147***	*47*	*32*	***79***	***226***
Household size								
Household size (mean)	6.7	7.7	7.3	**7.2**	7.1	4.0	**5.9**	**6.7**
Number of children (mean)	3.2	3.1	3.2	**3.2**	3.0	1.6	**2.4**	**2.9**
Number of adults (mean)	3.5	4.5	4.1	**4.0**	4.1	2.5	**3.4**	**3.8**
Gender (whole household)								
% female	55%	54%	51%	**53%**	51%	49%	**50%**	**52%**
% male	45%	46%	49%	**47%**	49%	51%	**50%**	**48%**
Average Age of household (%) per area								
0-21	39%	24%	28%	**31%**	36%	19%	**29%**	**31%**
22-27	27%	34%	32%	**31%**	36%	38%	**37%**	**33%**
>27	34%	41%	40%	**38%**	28%	44%	**34%**	**37%**
Highest level of education of household								
Grade 9 and lower	16%	24%	20%	**20%**	17%	53%	**32%**	**24%**
Grade 10 or 11	38%	24%	26%	**30%**	28%	25%	**27%**	**29%**
Grade 12 and higher	46%	51%	54%	**50%**	55%	22%	**42%**	**47%**
Household head (Gender)								
% female	36%	32%	46%	**38%**	34%	38%	**35%**	**37%**
% male	64%	68%	54%	**62%**	66%	63%	**65%**	**63%**
Household head (Education)								
No schooling	31%	5%	6%	**15%**	11%	22%	**15%**	**15%**
Primary education	47%	43%	76%	**56%**	33%	56%	**43%**	**51%**
Secondary education	20%	53%	18%	**29%**	53%	22%	**41%**	**33%**
Higher education	2%	0%	2%	**1%**	2%	0%	**1%**	**1%**
Age group frequencies (%) per area								
0-18	49%	41%	44%	**45%**	45%	39%	**43%**	**44%**
19-35	27%	32%	33%	**31%**	36%	29%	**34%**	**32%**
36-60	18%	21%	17%	**18%**	17%	27%	**20%**	**19%**
>60	5%	5%	7%	**6%**	2%	5%	**3%**	**5%**

4.1.1.2 Gender

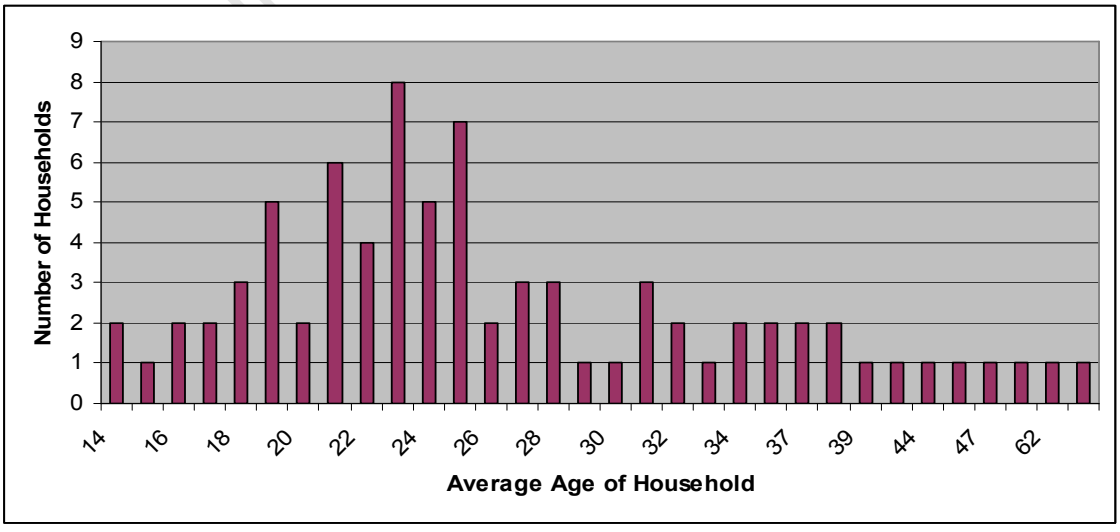
Gender plays an important role in household energy use patterns. Women generally manage the household and are the primary end-users of energy (Eberhard & Van Horen 1995, Makan 1994). In both the rural and urban sample, in general a higher prevalence of females to males is evident, with the exception of Ikgomotseng. The higher prevalence of females in the sample households is consistent with national figures, which indicate that 52.2% of the population is female (SSA 2003).

Although females make up the greater share of households, household headship is dominated by males. Studies have shown in the past that household heads were the usual decision-makers of the households. Thus the gender of the household heads and their presence would influence decisions made relating to energy use and appliance ownership. However more recently research has pointed to the main income earners of the household as having the key influence on decisions taken in the household (Prasad 2007 pers comm).

4.1.1.3 Age

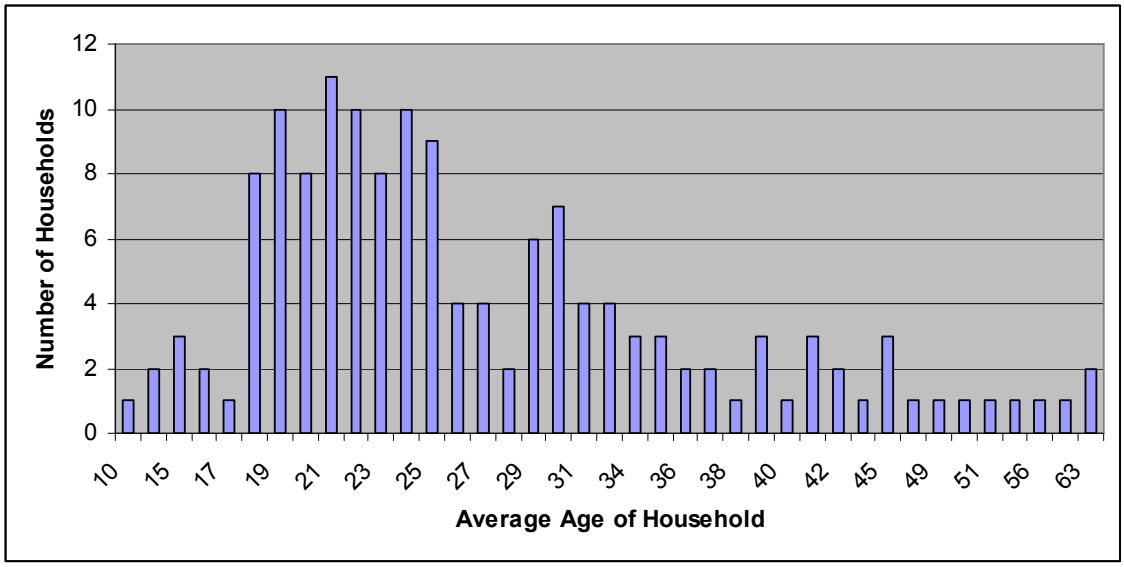
The age group frequencies of the sample shown in Table 4.1 indicate that both rural and urban households comprised mainly of children (0-18 years) and young adults (19-35 years). The prevalence of children was higher in households relative to other age group categories. This predominance of youth in the sample is consistent with national figures, which suggest that 45.7% of the population are younger than 19 years (SSA 2003). Ikgomotseng, a peri-urban community was the only area in the sample indicating a lower proportion of children making up households, i.e. 39% in relation to the average of 43% of children that occupied urban households in the sample.

Age was also analysed by exploring the average age of household. This was done in order to explore the relationship between fuel use and the age characteristics of the household (further on in this chapter).



*Rural **n** (households): Total –147*

Figure 6: Average age of urban households



*Urban **n** (households): Total –79*

Figure 7: Average age of rural households

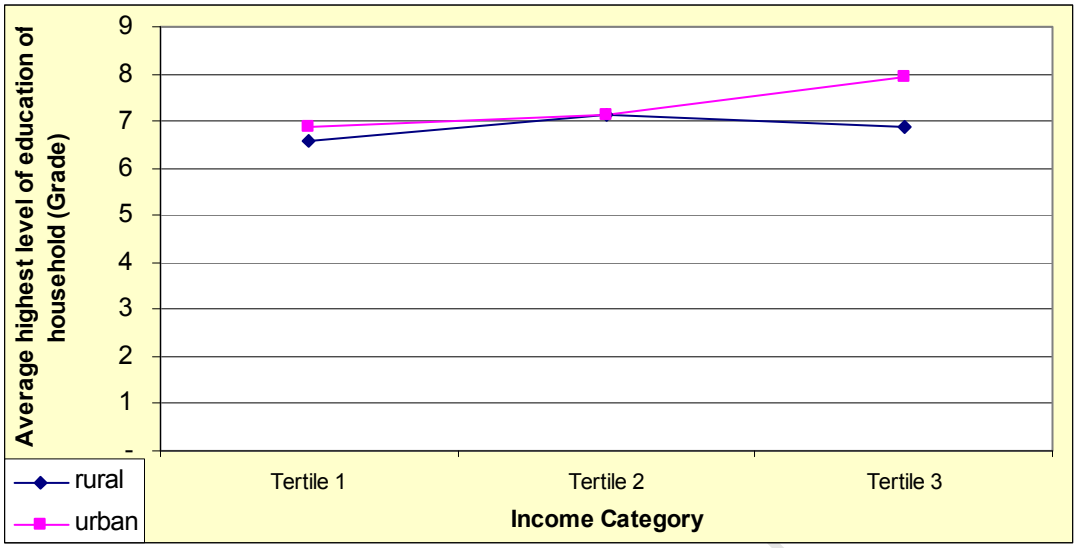
It is evident from the graphs above that the average age of households is concentrated in the below 30 years age group for both the rural and urban sample. The categories were established using the smaller of two samples, namely the urban sample, to ensure that there were at least 20 households in each category. The resulting, cut off points were 0-21 years, 22-27 years and greater than 27 years, as shown in Table 4.1.

4.1.1.4 Education

The highest level of formal education obtained by a household member could influence decision-making concerning energy use in the home (UNDP/ESMAP 2003). Table 4.1 shows the difference between the highest education levels for the surveyed households in the different areas. It is evident that all sampled households reported some form of formal education. As can be seen, households with the highest level of education being Grade 12 and higher (i.e. matric and higher), made up the largest proportion of households in both the rural and urban sample with 50% and 42% of rural and urban households respectively reporting this level of educational attainment. In the rural sample, households with the highest level of education being Grade 9 and lower (this category includes some secondary, primary and no schooling) i.e. the lowest education category made up the smallest proportion of households. Whereas in the urban sample, the smallest proportion of households made up those with the highest level of education being Grade 10 or 11 (senior secondary education). It is also interesting to note within the urban sample, that Ikgomotseng has a markedly high proportion of households (53%) in the lowest education category relative to the average for the urban sample as a whole, which is 32%.

range from 6.7 to 7.7.

On the whole, differences in levels of education could directly be a significant driver in energy decision-making in the household, as well as possibly having a secondary impact through increased income (perhaps linked to better employment prospects) and therefore a greater ability to afford modern energy forms.



*Rural **n**'s (households): Tertile 1 –54; Tertile 2 –44; Tertile 3 –49; Total –147*

*Urban **n**'s (households): Tertile 1 –22; Tertile 2 –31; Tertile 3 –26; Total –79*[15]

Figure 8: Relationship between per capita income and average highest level of education of household[16]

With respect to the highest level of education of households, from Figure 8, it appears that average highest level of education has an approximate (even if only slight) linear relationship with per capita income for urban and rural households - in general the average highest level of education increases with increasing per capita income for both area categories of households, with this pattern being more pronounced in urban areas. It is important to note that while one might expect this relationship to be stronger in general, this sample is drawn from a population of solely low-income households.

4.1.2 Economic conditions of the household

Income and expenditure

Household income and expenditure provides a broad picture of the socio-economic status of the household. Table 4.2 below shows the average income and expenditure of the sampled households in the five study areas, as well as for the entire sample. For the purposes of this study, household expenditure is used a proxy for household income for reasons outlined in detail in the methodology chapter, section 3.4.1.

[15] Refer to section 3.4.1 for a description of the derivation of the income tertiles across the entire sample.
[16] Average education of household was derived using higest school grade completed, with no schooling given a value of -1 and tertiary education given a value of 13

The average monthly income for the rural sample is R816, which is significantly higher than the urban sample of only R667, as shown in Table 4.2. It is thus evident that the surveyed areas are indeed poor communities. The median incomes between the rural and urban sample reveal a relatively small difference, compared to the mean incomes for the two areas. Households in Antioch reported the lowest average monthly income of R660 in the rural sample, while Umgaga in the urban sample reported households with lowest average income of R641. In contrast to the average monthly incomes reported by urban and rural households, the reported average monthly per capita income of rural households was lower than for urban households. This is consistent with the previous observation of larger household sizes in rural areas (Table 4.1).

Household expenditure, similar to household income, appears to be higher among rural households than urban households. The average household expenditure for households in the rural sample is R914, while in the urban sample it is R819. Again, as for the reported income figures, per capita expenditure is observed to be lower for the rural sample than the urban sample as shown in Table 4.2. Per capita expenditure is a more accurate measure of a household's socio-economic status, as it accounts for variations in household size, thus reflecting levels of dependency and the economic burden of the wage earners of the household. In calculating per capita amounts (i.e. Rands per month per size of household) an equal weighting was applied to both children and adult members of households. Thus the per capita expenditure for a household is the total reported household expenditure divided by the number of people comprising the household.[17]

Since per capita amounts are a more realistic measure of a household's socio-economic status, poverty levels are usually determined according to per capita income or expenditure, rather than levels of total household income or expenditure.

Based on Statistics South Africa's (the national statistics body) poverty line of R341.32 per capita expenditure (in 2001 prices) to define the poor, sampled households in all five study areas are living in poverty, as shown in Table 4.2. Antioch has the highest incidence of poverty with 100% of surveyed households reporting to be living under the poverty line. The proportion of households living below the poverty line is higher for the rural sample (92%) than the urban sample (86%). It must be cautioned that despite a higher incidence of poverty among the rural sample, based on reported cash household expenditure per capita, opportunity for subsistence activities involving non-monetary income is high in rural areas. Thus the level of poverty may not be as severe as the figures suggest for the rural sample, as rural households in comparison to urban households have greater access to land on which to grow crops and rear livestock for subsistence, and which is not reflected in the cash expenditure of the household. Table 4.3 demonstrates the extent of subsistence crop activity, namely growing food, reported by the surveyed households. As can be seen a significantly higher

[17] Some methodologies allocate a smaller rating to children when calculating per capita amounts (Cowan & Monlakoana 2005).

Table 4.2: Reported economic data for sampled households

	Rural				Urban			
	Garagopola	Antioch	Maqongqo	**Total rural**	Umgaga	Ikgomotseng	**Total urban**	**Total**
n (number of households surveyed)	*56*	*41*	*50*	***147***	*47*	*32*	***79***	***226***
Household size (mean)	6.7	7.7	7.3	**7.2**	7.1	4.0	**5.9**	**6.7**
Household income								
Household income per month (mean)	R 922	R 660	R 825	**R 816**	R 641	R 701	**R 667**	**R 764**
Household income per month (median)	R 570	R 600	R 620	**R 600**	R 600	R 525	**R 577**	**R 600**
Per capita household income (mean)	R 172	R 97	R 137	**R 139**	R 118	R 230	**R 166**	**R 148**
Household expenditure								
Household expenditure per month (mean)	R 949	R 721	R 1,034	**R 914**	R 1,010	R 538	**R 819**	**R 881**
Household expenditure per month (median)	R 703	R 539	R 968	**R 764**	R 801	R 426	**R 630**	**R 735**
Per capita houshold expenditure (mean)	R 184	R 95	R 185	R 159	R 167	R 179	R 172	R 164
Households in poverty								
Percentage of individuals below poverty datum line of R341 per month in 2001 prices *	89%	100%	88%	**92%**	91%	78%	**86%**	**90%**

* StatsSA estimates a poverty datum line of R322 per month - calculated on the basis of expenditure (in 2000 prices) - This was inflated to 2001 prices i.e R341.

Table 4.3: Reported subsistence food growing activities

	Rural				Urban			
	Garagopola	Antioch	Maqongqo	**Total rural**	Umgaga	Ikgomotseng	**Total urban**	**Total**
n (number of households surveyed)	*0*	*37*	*50*	***87***	*45*	*32*	***77***	***164***
Proportion reporting on growing food	n/a	90%	100%	**59%**	96%	100%	**97%**	**73%**
Proportion growing food	n/a	65%	26%	**43%**	33%	19%	**27%**	**35%**
Proportion not growing food	n/a	35%	74%	**57%**	67%	81%	**73%**	**65%**

proportion of rural households (43%) report growing food for themselves than urban households (27%). Further, Antioch reported the highest incidence of poverty relative to households in other sampled areas but also reveals the highest proportion of households in the sample engaged in subsistence farming. This demonstrates that Antioch's level of poverty may not be as severe as the figures suggest.

4.1.3 Electrification

As mentioned earlier in the Methodology chapter, all surveyed households were electrified i.e. they were connected to the national grid. At the time of the survey, almost all sample households (219 out of 226 households) had regular metered electricity supplies via prepayment meters, with the exception of 7 households. The latter households reported being disconnected, three of which consequently obtained electricity supplies from neighbouring households, using an extension cord. Households attributed their electricity disconnection status either to problems experienced with the prepayment meter box or the compact ready-board or unpaid electricity bills.

4.2 Prevalence of different fuels

This section provides a broad picture of fuel use occurring in the sampled households in urban and rural communities. Further, the prevalence of different fuels used by households is analysed in terms of various socio-demographic factors, as a means to shed insights into the underpinnings of the prevalence of fuels used. The prevalence of an energy source, conveyed as proportion of households that use it, is a widely used statistic to describe energy use within a household.

4.2.1 The overall situation

As depicted by Table 4.4 below, households use a variety of different fuels in both urban and rural areas to meet their energy needs. At first glance, a general observation of the overall situation (for both rural and urban households) is that multiple fuel use is a common phenomenon among all surveyed households, since the percentages of households using different fuels when added far exceed 100%. This observation is later revisited in detail in Section 4.6. It can be seen in general that candles, paraffin, fuelwood and electricity are the most widely used energy sources by households across the entire sample. In the rural sample the most commonly used energy sources were electricity (99%), candles (94%), paraffin (84%) and fuelwood (82%), while in the urban sample, electricity (96%), paraffin (85%) and candles (72%) were most widely used. In sharp contrast is the prevalence of coal and LPG (liquefied petroleum gas) use, which appear to be less popular forms of energy, with not more than 5% of households using them. Although coal and LPG appear to be less commonly used among the households in this study (possibly due to reasons of seasonality, affordability and accessibility), it should be cautioned that they are not necessarily less important and are known to play an important role in the livelihoods of poor households with no access to other forms of energy

or are not able to afford other energy sources, as noted in the literature review. Apart from the extensive use of fuelwood as a traditional energy form, the use of bio-fuels in particular dung appear to be a widely used fuel among surveyed households, with as much as 51% of rural households reporting its use.

4.2.2 Fuelwood

Fuelwood is the one of the most widely used energy sources in rural households – 82% of the sampled rural households reported using this fuel. This is in stark contrast to the urban sample where only 22% of households reported its use. As depicted in Table 4.5 below – of the 82% of rural households using fuelwood, the majority of households (62%) only collected it (i.e. collect wood from available sources without purchasing it), while 14% only purchased it. A few rural households both collected and purchased fuelwood (5%). Only 1% collected fuelwood by vehicle as compared with the 61% that collected it by foot. Fuelwood collection methods have important consequences concerning the extent of energy expenditure incurred by households. Fuelwood is usually gathered from the local surrounds such as farms or natural woodlands. Thus the actual value of self-collected fuelwood is not reflected in the household expenditure on energy. It can also be seen from Table 4.5 above that wood was more commonly collected in Garagopola (77%) and Maqongqo (66%) in the rural sample and fewer households in these areas purchased wood. In rural Antioch, a different trend is displayed where approximately a third of sampled households (32%) collected fuelwood (by foot) and another third purchased it (39%). These differences in the proportions of how rural households gathered fuelwood in the sampled areas could possibly be due to Garagopola and Maqongqo having better availability of fuelwood resources such as through surrounding farms and/or natural woodlands from which to collect fuelwood than Antioch.

Fuelwood use by urban households is significantly less than rural households. However, of the 22% of urban households who used firewood, 15% collected fuelwood by foot (predominantly in Ikgomotseng) while only 5% purchased it. Unlike in the rural areas, urban households either purchased or collected fuelwood, as reflected by the 0% of households that both collected and purchased fuelwood in Table 4.5.

With respect to fuelwood-using households, a greater proportion collected fuelwood than purchased it across both the rural and urban sample.

Table 4.4: Prevalence of fuel use (% of households using each fuel)

	Rural				Urban		
	Garagopola	Antioch	Maqonggo	**Total rural**	Umgaga	Ikgomotseng	**Total urban**
n (number of households surveyed)	*56*	*41*	*50*	***147***	*47*	*32*	***79***
Candles	98%	100%	84%	**94%**	70%	75%	**72%**
Paraffin	93%	93%	68%	**84%**	81%	91%	**85%**
Coal	9%	2%	0%	**4%**	0%	0%	**0%**
Fuelwood	86%	88%	72%	**82%**	17%	28%	**22%**
Dry cell batteries	4%	44%	28%	**23%**	9%	13%	**10%**
Gas	4%	10%	0%	**4%**	2%	3%	**3%**
Biofuels	n/a*	71%	34%	**51%**	0%	13%	**5%**
Electricity	100%	98%	98%	**99%**	96%	97%	**96%**

** households interviewed in Garagopola were not asked about their use of biofuels*

Table 4.5: Prevalence of each type of fuelwood user for the surveyed areas

	Rural				Urban		
	Garagopola	Antioch	Maqonggo	**Total rural**	Umgaga	Ikgomotseng	**Total urban**
n (number of households surveyed)	*56*	*41*	*50*	***147***	*47*	*32*	***79***
nn (number of households using fuelwood)	*48*	*36*	*36*	***120***	*8*	*9*	***17***
Collect fuelwood by foot	77%	32%	66%	**61%**	9%	25%	**15%**
Buy fuelwood	7%	39%	2%	**14%**	6%	3%	**5%**
Collect by foot and buy fuelwood	2%	17%	0%	**5%**	0%	0%	**0%**
Collect fuelwood by vehicle	0%	0%	4%	**1%**	2%	0%	**1%**
Non-wood users	14%	12%	28%	**18%**	83%	72%	**78%**

Income

Table 4.6: Fuelwood users by income category

	n	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
			Rural		
Collect fuelwood by foot	*89*	70%	48%	61%	**61%**
Buy fuelwood	*21*	7%	25%	12%	**14%**
Collect by foot and buy fuelwood	*8*	7%	7%	2%	**5%**
Collect fuelwood by vehicle	*2*	2%	2%	0%	**1%**
Non-wood users	*27*	13%	18%	24%	**18%**
			Urban		
Collect fuelwood by foot	*12*	18%	23%	4%	**15%**
Buy fuelwood	*4*	9%	0%	8%	**5%**
Collect by foot and buy fuelwood	*0*	0%	0%	0%	**0%**
Collect fuelwood by vehicle	*1*	5%	0%	0%	**1%**
Non-wood users	*62*	68%	77%	88%	**78%**

In terms of income variation with type of fuelwood users, there were no clear trends apparent, as shown in Table 4.6. However it is apparent that for the rural and urban sample, the prevalence of wood use decreases with increasing household income. This possibly indicates that poverty is one of the main factors influencing household fuelwood use, and that households' dependence on fuelwood could be reduced significantly with opportunities of income generation.

Household size

Table 4.7: Fuelwood users by household size

	n	1-5 persons	6-8 persons	9+ persons	Total
			Rural		
Collect fuelwood by foot	*89*	62%	62%	57%	**61%**
Buy fuelwood	*21*	13%	14%	17%	**14%**
Collect by foot and buy fuelwood	*8*	4%	5%	7%	**5%**
Collect fuelwood by vehicle	*2*	0%	0%	5%	**1%**
Non-wood users	*27*	21%	19%	14%	**18%**
			Urban		
Collect fuelwood by foot	*12*	16%	12%	20%	**15%**
Buy fuelwood	*4*	2%	8%	10%	**5%**
Collect by foot and buy fuelwood	*0*	0%	0%	0%	**0%**
Collect fuelwood by vehicle	*1*	0%	4%	0%	**1%**
Non-wood users	*62*	81%	77%	70%	**78%**

As evident in Table 4.7 above, across both the rural and urban sample, larger households generally have a higher prevalence of fuelwood use and are more likely to purchase fuelwood.

Gender composition

Table 4.8: Fuelwood users by household gender composition

	n	Less than or equal to 50% female	Greater than 50% female	Total
		Rural		
Collect fuelwood by foot	*89*	59%	62%	**61%**
Buy fuelwood	*21*	15%	13%	**14%**
Collect by foot and buy fuelwood	*8*	4%	7%	**5%**
Collect fuelwood by vehicle	*2*	1%	1%	**1%**
Non-wood users	*27*	20%	16%	**18%**
		Urban		
Collect fuelwood by foot	*12*	10%	26%	**15%**
Buy fuelwood	*4*	6%	4%	**5%**
Collect by foot and buy fuelwood	*0*	0%	0%	**0%**
Collect fuelwood by vehicle	*1*	2%	0%	**1%**
Non-wood users	*62*	83%	70%	**78%**

From Table 4.8 above, fuelwood use in rural areas appears to be independent of the households' gender composition. On the other hand, in urban areas, there appears to be a higher prevalence of wood use in households with a higher proportion of females.

Age

Table 4.9: Fuelwood users by household average age

	n	0-21 yrs	22-27 yrs	>27 yrs	Total
			Rural		
Collect fuelwood by foot	*89*	63%	60%	59%	**61%**
Buy fuelwood	*21*	9%	18%	16%	**14%**
Collect by foot and buy fuelwood	*8*	9%	4%	4%	**5%**
Collect fuelwood by vehicle	*2*	0%	4%	0%	**1%**
Non-wood users	*27*	20%	13%	21%	**18%**
			Urban		
Collect fuelwood by foot	*12*	0%	24%	19%	**15%**
Buy fuelwood	*4*	4%	10%	0%	**5%**
Collect by foot and buy fuelwood	*0*	0%	0%	0%	**0%**
Collect fuelwood by vehicle	*1*	0%	0%	4%	**1%**
Non-wood users	*62*	96%	66%	78%	**78%**

Among rural households, average age of household does not appear to have a major interaction with fuelwood using households (Table 4.9 above). However among the urban sample, a greater proportion of households in the 22-27 years average age category (34%) used fuelwood**.** This was substantially higher than the prevalence of fuelwood use in households in the youngest average age category of 0-21 years (4%).

Education

Fuelwood use appears to be independent of the highest level education (obtained by a member of a household) of a household in urban areas, whereas the data in Table 4.10 below suggests that in rural areas, those with lower levels of education are more likely to be fuelwood users.

Table 4.10: Fuelwood users by highest level of education household

	n	Grade 9 and lower	Grade 10 or 11	Grade 12 and higher	Total
			Rural		
Collect fuelwood by foot	*89*	69%	61%	57%	**61%**
Buy fuelwood	*21*	14%	11%	16%	**14%**
Collect by foot and buy fuelwood	*8*	7%	9%	3%	**5%**
Collect fuelwood by vehicle	*2*	0%	2%	1%	**1%**
Non-wood users	*27*	10%	16%	23%	**18%**
			Urban		
Collect fuelwood by foot	*12*	16%	24%	9%	**15%**
Buy fuelwood	*4*	4%	0%	9%	**5%**
Collect by foot and buy fuelwood	*0*	0%	0%	0%	**0%**
Collect fuelwood by vehicle	*1*	0%	0%	3%	**1%**
Non-wood users	*62*	80%	76%	79%	**78%**

4.2.3 Paraffin

Paraffin is among the most extensively used fuels, both in rural (84%) and urban (85%) households, as shown in Table 4.4. There was a similar prevalence of fuelwood and paraffin use in rural households. However, within the urban sample, paraffin use was significantly more widespread (85% of households) than fuelwood (22% of households) possibly due to greater accessibility (including cost) and availability of paraffin over firewood within urban areas. Despite all surveyed households being electrified, it can be seen that use of less desirable fuels such as paraffin and fuelwood are significant.

Table 4.11: Prevalence of fuel use by income category

	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
		Rural		
n	*54*	*44*	*49*	*147*
Candles	98%	93%	90%	**94%**
Paraffin	80%	86%	88%	**84%**
Gas	0%	7%	6%	**4%**
Firewood	87%	82%	76%	**82%**
Biofuels (dung and crop residues)	65%	49%	36%	**51%**
Coal	4%	5%	4%	**4%**
Dry cell	22%	30%	18%	**23%**
Electricity	100%	98%	98%	**99%**
		Urban		
n	*22*	*31*	*26*	*79*
Candles	73%	71%	73%	**72%**
Paraffin	82%	90%	81%	**85%**
Gas	5%	0%	4%	**3%**
Firewood	32%	23%	12%	**22%**
Biofuels (dung and crop residues)	18%	0%	0%	**5%**
Coal	0%	0%	0%	**0%**
Dry cell	5%	13%	12%	**10%**
Electricity	100%	90%	100%	**96%**

Table 4.12: Prevalence of fuel use by household size

	1-5 persons	6-8 persons	9+ persons	Total
	Rural			
n	*54*	*44*	*49*	*147*
Candles	94%	95%	93%	**94%**
Paraffin	81%	90%	81%	**84%**
Gas	0%	5%	7%	**4%**
Firewood	79%	81%	86%	**82%**
Biofuels (dung and crop residues)	33%	71%	47%	**51%**
Coal	4%	2%	7%	**4%**
Dry cell	21%	19%	31%	**23%**
Electricity	98%	98%	100%	**99%**
	Urban			
n	*43*	*26*	*10*	*79*
Candles	70%	73%	80%	**72%**
Paraffin	84%	85%	90%	**85%**
Gas	2%	4%	0%	**3%**
Firewood	19%	23%	30%	**22%**
Biofuels (dung and crop residues)	2%	8%	10%	**5%**
Coal	0%	0%	0%	**0%**
Dry cell	9%	15%	0%	**10%**
Electricity	95%	100%	89%	**96%**

Table 4.13: Prevalence of fuel use by proportion of females in household members

	Less than and equal to 50 percent	Greater than 50 percent	Total
	Rural		
n	*54*	*44*	*98*
Candles	95%	93%	**94%**
Paraffin	87%	81%	**84%**
Gas	5%	3%	**4%**
Firewood	80%	84%	**82%**
Biofuels (dung and crop residues)	48%	54%	**51%**
Coal	3%	6%	**4%**
Dry cell	22%	25%	**23%**
Electricity	99%	99%	**99%**
	Urban		
n	*54*	*44*	*98*
Candles	69%	78%	**72%**
Paraffin	85%	85%	**85%**
Gas	4%	0%	**3%**
Firewood	17%	30%	**22%**
Biofuels (dung and crop residues)	4%	7%	**5%**
Coal	0%	0%	**0%**
Dry cell	12%	7%	**10%**
Electricity	98%	92%	**96%**

Table 4.14: Prevalence of fuel use by average age of household

	0-21 yrs	21-27 yrs	>27 yrs	Total
	Rural			
n	*46*	*45*	*56*	*147*
Candles	91%	96%	95%	**94%**
Paraffin	74%	89%	89%	**84%**
Gas	4%	7%	2%	**4%**
Firewood	80%	87%	79%	**82%**
Biofuels (dung and crop residues)	67%	51%	44%	**51%**
Coal	2%	4%	5%	**4%**
Dry cell	15%	29%	25%	**23%**
Electricity	100%	99%	96%	**99%**
	Urban			
n	*54*	*44*	*49*	*147*
Candles	78%	79%	59%	**72%**
Paraffin	87%	90%	78%	**85%**
Gas	0%	7%	0%	**3%**
Firewood	4%	34%	22%	**22%**
Biofuels (dung and crop residues)	0%	7%	0%	**5%**
Coal	0%	0%	0%	**0%**
Dry cell	0%	17%	11%	**10%**
Electricity	80%	100%	90%	**96%**

Table 4.15: Prevalence of fuel use by household's highest level of education

	Grade 9 and lower	Grade 10 or 11	Grade 12 and higher	Total
	Rural			
n	*29*	*44*	*74*	*147*
Candles	100%	98%	89%	**94%**
Paraffin	93%	73%	88%	**84%**
Gas	3%	0%	7%	**4%**
Firewood	90%	84%	77%	**82%**
Biofuels (dung and crop residues)	55%	48%	50%	**51%**
Coal	3%	2%	5%	**4%**
Dry cell	38%	16%	22%	**23%**
Electricity	97%	100%	99%	**99%**
	Urban			
n	*54*	*44*	*49*	*147*
Candles	64%	81%	73%	**72%**
Paraffin	80%	86%	88%	**85%**
Gas	4%	0%	3%	**3%**
Firewood	20%	24%	21%	**22%**
Biofuels (dung and crop residues)	4%	14%	0%	**5%**
Coal	0%	0%	0%	**0%**
Dry cell	12%	5%	12%	**10%**
Electricity	92%	95%	100%	**96%**

Although there are no material differences with regard to region (i.e. rural and urban) and income, it is clear that paraffin was used extensively in all areas and by all income groups as indicated in Table 4.11 above.

Similar trends persist, as do for income, with regard to the other socio-demographic variables analysed, namely average age, household size, gender composition and highest level of education i.e. widespread use of paraffin is evident across all categories for both the rural and urban households (Tables 4.12, 4.13, 4.14 and 4.15 above).

4.2.4 Candles

Candles are also one of the more widely used fuels among both rural and urban electrified households. As much as 94% of rural households used candles, while use was significantly lower among urban households at 72%. It is interesting to note the high prevalence of candle use across regions despite households being electrified.

As depicted in Table 4.11, candle use was equally prevalent in all income groups across rural and urban sampled areas.

Similar trends persist for household size, gender, age and education levels of households, thus indicating no major impact of these variables on candle use, except to show widespread use of candles across all these variables. The only exception to this is the relatively low prevalence of candle usage amongst the urban households with the highest average ages.

4.2.5 Gas and Coal

Bottled liquefied petroleum gas (LPG) and coal are used by only a small proportion of surveyed households in the both rural and urban sample. Only 4% of sampled rural households use coal and LPG, while urban households reported no use of coal at the time of the survey and only 3% of these households reported using gas. As mentioned earlier, extent of use of these fuels in the study is not representative of the country situation. Coal for instance is used extensively by low-income households close to coalfields in the Highveld region of the country, where it tends to be the cheapest fuel available for the poor. Apart from affordability, the low use of coal and LPG in the study sample could possibly be due to availability in that the rural and urban distribution network is not extensive. Distribution of coal and LPG is usually limited by the difficulties encountered in their bulk transportation. Thus it is likely that the use of coal and LPG are largely influenced by their proximity to coal fields and oil refineries respectively.

The low prevalence of coal and LPG use in the sample implies that the data available is insufficient for in-depth analysis by the socio-demographic variables.

4.2.6 Dry cell batteries

A significant percentage of rural households particularly in Antioch (44%) and Maqongqo (28%) used dry cell batteries, mainly for powering radios and also torches, as seen in Table 4.4. This corresponds to previous studies in rural electrified areas (Thom 2000). However the general prevalence of dry cell batteries in the rural sample (23%) was significantly lower than reported for rural Antioch and Maqongqo as well as previous studies. This was due to Garagopola showing a markedly low prevalence of dry cell battery use in the rural sample. Garagopola, having been electrified for a longer period of time, generally replaced their use of dry cell battery with electricity (Thom & Mohlakoana 2001).

The urban sample reflected a significantly lower prevalence of dry cell battery use - 10% of all surveyed urban households used dry cell batteries. Ikgomotseng had a higher incidence of dry cell use (13%) than Umgaga (9%), possibly due to Umgaga being electrified for a longer period and as a consequence dry cell use was gradually replaced with electricity.

Income

No clear income trend was evident among either the rural or urban samples. However, among the rural sample, the lowest prevalence of dry cell use occurred in the least poor households (Tertile 3), while the opposite was true for the urban sample where the lowest incidence of dry cell use occurred among the poorest households (Tertile 1), as shown in Table 4.11.

Household size

Among the rural sample, greater dry cell battery use occurred in the larger households than in other household size categories. No clear trend was evident for the urban sample.

Gender

Neither sample exhibited a clear trend between gender composition of the household and dry cell battery use. The urban sample reflected a slightly higher percentage of use of dry cell batteries in households not dominated by female occupants. This could possibly suggest that radio use (for which dry cell batteries are used to operate) was more frequent in more male dominated households than female dominated households within the urban study sample.

Age

For both the rural and urban samples, the lowest prevalence of dry cell use occurred in households with the lowest average ages (Table 4.14.).

Education

Across both the rural and urban sample, dry cell battery use was least prevalent in households where the highest education levels were Grade 10 and Grade 11.

4.2.7 Electricity

Electricity exhibits the highest prevalence of use relative to other fuels used by the household among both the rural and urban sample (Table 4.4). Although electricity was used by majority of surveyed households, it was not used for the more energy intensive and essential end-uses such as cooking and heating, which were performed using other fuels (discussed in more detail later in this chapter).

When electricity use was analysed with other household variables such as income, education, gender, household size, age, no clear relationships emerged. The reason being is that all surveyed households were electrified through the national electrification programme, and all efforts made by national government ensured that low-income households had access to electricity.

4.2.8 Other energy sources

Bio-fuels such as crop residues, dried plants and mainly animal dung were widely used among surveyed rural households (51%) and to a markedly lesser extent by urban households (5%) as shown in Table 4.4. Among both the rural and urban sampled households that used bio-fuels, animal dung appeared to be the major energy source that was used. In fact twice as many rural households were using dung relative to other bio-fuels, while in the urban sample, the few households that were using bio-fuels only used dung.

Among the rural sample, households in Antioch were the main bio-fuel users. This could possibly be due to Antioch being among the poorest of the surveyed areas, and as result of their economic situation households were compelled to use 'free', less desirable and polluting fuels such as dung to a greater extent. Dung would have been collected free of charge (except for the opportunity cost of collecting dung), thus bearing no cash cost to the household relative to the expense incurred for the purchase of paraffin and electricity. Within the urban sample, households in Ikgomotseng, were the only users of bio-fuels of which dung was the only bio-fuel used. Ikgomotseng is not a wooded environment, hence a lack of fuelwood resources would force poor households to use other less desirable (higher polluting) fuels such as dung, which could be obtained by collecting without any direct cost.

Income

Clear income trends with regard to bio-fuel use are evident for both rural and urban sampled households, with higher income groups less likely to use bio-fuels (Table 4.11). This trend is accentuated in the urban sample with bio-fuel use being restricted to households in the lowest income group (Tertile 1).

Household size

Across both the rural and urban sample, bio-fuel use was most common among larger sized households consisting of more than five people. Moreover, within the rural sample, prevalence of bio-fuel use was highest among 6-8 person households (71%), followed by 9+ person households (47%), as shown in Table 4.12.

Gender

Although no marked difference between gender of a household and bio-fuel use is evident, there does appear to be a greater tendency for bio-fuel use among female dominated households (Table 4.13)

Age

A clear trend emerged between average age of household and bio-fuel use within the rural sample, shown in Table 4.14. Rural households indicated decreased use of bio-fuels with increasing age of the household. Thus the incidence of bio-fuel use was highest among rural households with more children (67%) relative to other age categories. Since it is widely documented that biomass collection tends to

be primarily the task of women and children, it therefore corresponds that bio-fuel use is most common among households with children in this study, as they are the main labour source involved in gathering these fuels for the households.

Education

No clear trend between education and bio-fuel use was evident across the rural and urban sample, as evident in Table 4.15. There is a slight indication that bio-fuels were more commonly used among rural households with primary education. These households were likely to be composed largely of children as a result of the dominance of primary education, in turn corresponding to the previous observation where rural households with children displayed the highest incidence of bio-fuel use.

To conclude this section on prevalence of fuel use, it is useful to note that the range of fuels used by surveyed households as detailed in this section was generally available in the surveyed areas. This was evidenced by the fact that for most fuels, the proportion of households indicating availability was higher than the proportion of households using different fuels at the time of the survey, as indicated in Table 4.16. Thus, with the exception of coal and gas, non-availability of fuels would generally not be the reason why surveyed households had not used a particular fuel or had used it minimally.

4.3 Household energy expenditure patterns

Having provided an overview of household energy use within the sample through examining the prevalence of fuels used by households, the next step is to explore the dependence of households on the different fuels used. Analysing expenditure on energy sources used by the household gives some indication of this dependence.

This section thus outlines the extent to which energy is a financial burden to households, through examining the patterns of expenditure across individual energy sources compared with the total energy expenditure of households. It further highlights the energy expenditure variations between rural and urban surveyed households, in terms of income, household size, gender, education and age of household.

It must be noted that all results presented below reflect only cash and monetary expenditures, and therefore self-collected biomass fuels and consumables obtained through subsistence means are not included in these values.

Table 4.16: Prevalence of Fuel Use (% of households using each fuel) and Availability of Fuels

	Rural				Urban		
	Garagopola	Antioch	Maqongqo	**Total rural**	Umgaga	Ikgomotseng	**Total urban**
n (number of households surveyed)	*56*	*41*	*50*	***147***	*47*	*32*	***79***
Prevalence of Fuel Use							
Candles	98%	100%	84%	**94%**	70%	75%	**72%**
Paraffin	93%	93%	68%	**84%**	81%	91%	**85%**
Coal	9%	2%	0%	**4%**	0%	0%	**0%**
Fuelwood	86%	88%	72%	**82%**	17%	28%	**22%**
Dry cell batteries	4%	44%	28%	**23%**	9%	13%	**10%**
Gas	4%	10%	0%	**4%**	2%	3%	**3%**
Dung	n/a	71%	22%	**44%**	0%	13%	**5%**
Crop residues	n/a	32%	12%	**21%**	0%	0%	**0%**
Dried plants	n/a	12%	0%	**5%**	0%	0%	**0%**
Electricity	100%	98%	98%	**99%**	96%	97%	**96%**
n (number of households surveyed)	*n/a*	*n/a*	*50*	***50***	*n/a*	*32*	***32***
Availability of Fuels							
Candles	n/a	n/a	100%	**100%**	n/a	100%	**100%**
Paraffin	n/a	n/a	94%	**94%**	n/a	97%	**97%**
Coal	n/a	n/a	2%	**2%**	n/a	100%	**100%**
Fuelwood	n/a	n/a	100%	**100%**	n/a	100%	**100%**
Dry cell batteries	n/a	n/a	64%	**64%**	n/a	81%	**81%**
Gas	n/a	n/a	2%	**2%**	n/a	16%	**16%**
Dung	n/a	66%	78%	**73%**	0%	66%	**27%**
Crop residues	n/a	20%	24%	**22%**	0%	0%	**0%**
Dried plants	n/a	32%	60%	**47%**	0%	0%	**0%**
Electricity	100%	100%	100%	**100%**	100%	100%	**100%**

4.3.1 Reported price of fuels

The average prices of the main household fuels for the surveyed rural and urban areas were gathered from the interviews with the households, and they were as follows:

Table 4.17: Average reported prices of fuels (in Rands)

	Unit	Rural	Urban	Total
n		*147*	*79*	*226*
Candle	Rands/candle	0.61	0.55	0.59
Paraffin	Rand/Litre	2.69	2.59	2.65
Gas	Rand/kilogram	5.98	5.74	5.94
Electricity	Rands/kWh	0.38	0.38	0.38
Firewood	*could not be determined due to non -standard quantities purchased*			
Dry cell batteries	*could not be determined since various types of dry cell batteries were used*			
Coal	*could not be determined due to non -standard quantities purchased*			

4.3.2 Total fuel expenditure

The average total monthly energy expenditures for the rural and urban sample by income group are presented below (Table 4.18).

The monetary amounts presented in these tables are expressed as Rands per month.

In absolute amounts sampled rural households spent similar amounts on average on energy (R83.62) monthly when compared with urban households (R79.29). It is important to bear in mind that these total average energy expenditures exclude the cost of self-collected biomass fuels and that the average household size for the rural sample was higher (7.2) than for the urban sample (5.9). Thus on examining the average household energy per capita expenditure for the rural and urban sample, the expenditures were more markedly different - R14.75 for rural households and R18.05 for urban households. Urban households spend more on energy per person.

A clear income trend was evident for the rural and urban sample, with households spending more on energy as incomes rose. The average monthly household per capita energy expenditure (see Table 4.19 below) of the poorest rural households (Tertile 1) was R8.34, while the least poor households (Tertile 3) were observed to be spending just under three times as much on energy (R22.87). Similarly for households within the urban sample, average monthly household per capita energy expenditure for the lowest income group was R10.56, which was less than a half of the R26.84 per capita expenditure in the highest income group.

Energy expenditure as a percentage of total household expenditure

The "energy burden" (energy budget share of household) of households is often expressed as a ratio of household energy expenditure to total household expenditure (UNDP/ESMAP 2003). This can be used as a measure of an aspect of energy poverty. Poor households in need of modern energy sources for their survival can spend substantially large proportions of their household budget on energy (ranging from 15-40%) (Annecke 2004, Williams 1994). Thus energy considered as a basic need can

Table 4.18: Average household energy expenditures for individual fuels across income groups (R/month)

	Tertile 1 (low)		Tertile 2		Tertile 3 (high)		Total	
	User average	*Sample average*	*User average*	*Sample average*	*User average*	*Sample average*	*User average*	*Sample average*
	Rural							
n	*54*		*44*		*49*		*147*	
Electricity	25.89	25.89	29.88	29.20	45.68	44.74	**33.62**	**33.17**
Paraffin	30.40	21.80	34.41	28.81	43.86	35.63	**36.32**	**28.50**
Candle	4.39	4.05	3.46	3.06	3.77	3.12	**3.91**	**3.44**
Gas	0.00	0.00	43.39	2.96	88.33	5.41	**65.86**	**2.69**
Firewood (purchased only)	67.13	9.94	82.32	26.19	44.52	6.36	**69.00**	**13.61**
Coal	2.50	0.05	12.23	0.56	27.00	1.10	**16.19**	**0.55**
Dry cell batteries	13.90	2.57	9.48	2.80	9.33	1.71	**10.82**	**2.36**
All fuels *(sample average)*	63.75		92.93		97.16		83.62	
	Urban							
n	*22*		*31*		*26*		*79*	
Electricity	32.85	32.85	47.22	42.50	46.86	46.86	**42.77**	**41.09**
Paraffin	39.81	32.23	37.52	31.46	45.40	34.92	**40.64**	**32.82**
Candle	5.32	3.72	5.85	3.90	6.10	3.88	**5.76**	**3.84**
Gas	16.00	0.73	0.00	0.00	109.00	4.19	**62.50**	**1.58**
Firewood (purchased only)	26.00	2.36	0.00	0.00	6.25	0.48	**16.13**	**0.82**
Coal	30.00	1.36	0.00	0.00	0.00	0.00	**30.00**	**0.38**
Dry cell batteries	0.00	0.00	23.88	3.08	1.00	0.04	**19.30**	**1.27**
All fuels *(sample average)*	71.46		79.07		86.18		79.29	

Table 4.19: Average per capita household energy expenditures for individual fuels across income groups (R/per person/month)

	Tertile 1 (low)		Tertile 2		Tertile 3 (high)		Total	
	User average	*Sample average*	*User average*	*Sample average*	*User average*	*Sample average*	*User average*	*Sample average*
	Rural							
n	*54*		*44*		*49*		*147*	
Electricity	3.28	3.28	4.38	4.28	11.33	11.10	**6.27**	**6.19**
Paraffin	4.18	3.00	4.91	4.11	10.64	8.65	**6.64**	**5.21**
Candle	0.60	0.55	0.55	0.48	1.10	0.90	**0.73**	**0.65**
Gas	0.00	0.00	4.45	0.30	9.76	0.60	**7.11**	**0.29**
Firewood (purchased only)	8.22	1.22	12.28	3.91	8.41	1.20	**10.23**	**2.02**
Coal	0.28	0.01	2.26	0.10	9.00	0.37	**4.56**	**0.16**
Dry cell batteries	1.98	0.37	1.56	0.46	1.55	0.29	**1.69**	**0.37**
All fuels *(sample average)*	8.34		13.55		22.87		14.75	
	Urban							
n	*22*		*31*		*26*		*79*	
Electricity	4.72	4.72	7.69	6.92	11.76	11.76	**8.13**	**7.81**
Paraffin	5.76	4.67	9.06	7.60	17.65	13.58	**10.90**	**8.80**
Candle	0.94	0.66	1.78	1.19	2.42	1.54	**1.72**	**1.15**
Gas	2.29	0.10	0.00	0.00	27.25	1.05	**14.77**	**0.37**
Firewood (purchased only)	6.29	0.57	0.00	0.00	0.45	0.03	**3.37**	**0.17**
Coal	2.50	0.11	0.00	0.00	0.00	0.00	**2.50**	**0.03**
Dry cell batteries	0.00	0.00	5.09	0.66	0.33	0.01	**4.14**	**0.27**
All fuels *(sample average)*	10.56		15.99		26.84		18.05	

constitute a sizeable expenditure item for low-income households. This is clearly demonstrated in this study where the average energy budget share for sampled rural households was 11%, while for urban households it was as high as 16%, as indicated in Table 4.20. This is in stark contrast to the 3-5% of middle to high households' income being used to meet energy needs in South Africa (SEA 2006).

Table 4.20: Energy burden by income groups

	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
	Rural			
n	*54*	*44*	*49*	*147*
Mean % of household expenditure comprising energy expenditure	14%	11%	8%	**11%**
Mean per capita household energy expenditure (R/month)	8.34	13.55	22.87	**14.75**
	Urban			
n	*22*	*31*	*26*	*79*
Mean % of household expenditure comprising energy expenditure	26%	14%	9%	**16%**
Mean per capita household energy expenditure (R/month)	10.56	15.99	26.84	**18.05**

The clear income trend observed above between energy expenditure and income similarly persists between income and energy burden. As evident from Table 4.20, the poorest households spent a higher proportion of their monthly income on energy than higher income households for both rural and the urban sample. Households in the lowest income group were spending the largest portion of the total household budget on energy (14% and 26% for rural and urban households respectively), while households in the highest income group were spending proportionately less i.e. 8% and 9% for rural and urban households respectively. In the case of poorest rural households they were spending almost double the proportion of income on energy than rural households in the top tertile, while the poorest urban households were spending almost three times more on energy than households in the highest income group for the urban sample. As can also be observed in Table 4.20 the energy budget share of urban households consistently exceeds the rural households in each tertile. Further the urban sample shows a steeper decline in energy budget shares with respect to increasing income. One of the likely reasons for these features is that the rural households (including the poorest of them) are more able to substitute biomass collection for cash fuels.

One of the most striking differences observed in total fuel expenditure was between fuelwood-purchasers and fuelwood-collectors as evident in (Tables 4.21 below).

Urban wood purchasing households spend markedly more on energy, in fact double the proportion (26%) of their total household budget on energy, than wood-collecting households (13%), and similarly for the rural sample where wood-purchasers spend close on twice the proportion (18%) of their household budget on energy than wood-collecting households (10%).

Table 4.21: Average household energy expenditure and burden for different types of fuelwood users

	n	Rural	
		Avg. HH energy expenditure	Energy expenditure proportion
Wood collectors	89	R 65.96	10%
Wood purchasers	21	R 157.69	18%
Purchasers and collectors	8	R 106.40	16%
Collect by vehicle	2	R 49.08	4%
Non-wood users	27	R 80.06	10%
Total	147	R 83.62	11%
	n	Urban	
		Avg. HH energy expenditure	Energy expenditure proportion
Wood collectors	12	R 68.68	13%
Wood purchasers	4	R 81.87	26%
Purchasers and collectors	0		
Collect by vehicle	1	R 88.00	81%
Non-wood users	62	R 81.04	14%
Total	79	R 79.29	16%

Household size

In terms of variations between energy expenditure and household size, Table 4.22 (below) illustrates a clear trend of household per capita energy expenditure declining sharply with increasing household size across both the rural and urban sample. This attests to the fact that household energy use often reflects large economies of scale occurring with increasing household size. Thus despite total energy consumption usually increasing with household size as evident in Table 4.22 (household energy expenditure in this case being a proxy for household energy consumption), per capita energy consumption (in this case in the form of per capita energy expenditure) reduces.

Gender

Table 4.23 shows no significant variation in the average energy expenditure as well as the energy budget share/energy burden by gender composition of a household for either the rural or urban sample.

Age

There were no clear trends between age and average energy expenditure as well as energy budget share of household, as evident in Table 4.24.

Education

The general pattern displayed across both the rural and urban sample, is that households energy expenditure increases with increasing levels of education of households, as evident in Table 4.25 above. However there is no clear variation in terms of education levels and average energy budget share of the household.

Table 4.22: Household energy expenditure by size of household

	1-5 persons	6-8 persons	9+ persons	Total
	Rural			
n	*47*	*58*	*42*	***147***
Average household expenditure	72.69	80.03	100.82	**83.62**
Average per capita energy expenditure of household	23.07	11.78	9.52	**14.75**
Average energy expenditure as % of household expenditure	12%	11%	10%	**11%**
	Urban			
n	*43*	*26*	*10*	***79***
Average household expenditure	75.04	75.90	106.36	**79.29**
Average per capita energy expenditure of household	24.52	11.23	7.96	**18.05**
Average energy expenditure as % of household expenditure	14%	13%	11%	**16%**

Table 4.23: Energy expenditure by gender composition of household

	> 50% males	> 50% females	Total
	Rural		
n	*47*	*58*	***147***
Average household energy expenditure	84.69	82.38	**83.62**
Average energy expenditure as % of household expenditure	12%	11%	**11%**
	Urban		
n	*43*	*26*	***79***
Average household energy expenditure	82.85	72.44	**79.29**
Average energy expenditure as % of household expenditure	17%	13%	**16%**

Table 4.24: Energy expenditure by average age of household

	0-21 years	22-27 years	> 27 years	Total
	Rural			
n	*47*	*58*	*42*	***147***
Average household energy expenditure	70.91	95.84	84.24	**83.62**
Average energy expenditure as % of household expenditure	10%	12%	12%	**11%**
	Urban			
n	*43*	*26*	*10*	***79***
Average household energy expenditure	90.44	83.59	65.17	**79.29**
Average energy expenditure as % of household expenditure	16%	16%	15%	**16%**

Table 4.25: Energy expenditure by highest education level of household

	Grade 9 and lower	Grade 10 or 11	Grade 12 and higher	Total
	Rural			
n	*47*	*58*	*42*	***147***
Average household energy expenditure	74.30	78.29	90.44	**83.62**
Average energy expenditure as % of household expenditure	12%	13%	10%	**11%**
	Urban			
n	*43*	*26*	*10*	***79***
Average household energy expenditure	59.49	84.02	91.28	**79.29**
Average energy expenditure as % of household expenditure	17%	15%	15%	**16%**

4.3.3 Expenditure on individual fuels used by the household

Expenditure on individual fuels can be calculated either as average values for those users using a particular fuel (user averages), or averaged over the entire sample (sample average). The user average gives an indication of the average amount of money spent by households on each fuel, while the sample average provides insight into the relative importance of individual fuels in the average energy budget. Both sets of results are presented in Tables 4.18 and 4.19. It is interesting to note from Table 4.17 (which excludes fuelwood and coal) that there was very little variation in reported costs for each particular fuel in the rural versus urban areas.

Tables 4.18 and 4.19 illustrate that the largest energy expenditure items are electricity, paraffin and fuelwood among sampled rural households, whereas for the urban sample they are paraffin, electricity and candles. In the case of the rural sample, apart from electricity the amount spent on paraffin exceeded that of all other fuels used by the households, while in the urban sample paraffin incurred the largest energy cost, followed closely by electricity (Table 4.19).

In the case of fuelwood, it must be noted that the results presented in these tables may be understated, since not all fuelwood used by households is purchased. As observed in the Table 4.6, the predominant use of fuelwood particularly in the rural sample is largely as a result of fuelwood being gathered from surrounding areas and not purchased. The rand value of collected fuelwood is not included in the fuelwood expenditure figures presented in the table below. Comparing average monthly household per capita expenditure on fuelwood between the sampled rural and urban households, it can been seen that not only is fuelwood used more extensively in rural areas than urban areas (Table 4.4), but also used more intensively in the sampled rural areas than the urban areas (on the assumption that the relative costs of fuelwood are the same or lower in rural areas). Rural households spend just less than R2 per capita monthly on fuelwood, while urban households just under R0.20 per capita monthly on fuelwood.

It is interesting to note that although candles were used more extensively among the rural sampled households than urban households (Table 4.4), second only to electricity, they were not used as intensively among rural households since the average household per capita expenditure for candles is low relative to the urban sample.

In the urban sample, despite a higher prevalence of electricity use (96%) relative to paraffin use (85%), the average monthly per capita expenditure was higher for paraffin than electricity.

Household per capita income

Tables 4.18 and 4.19 show the relationship between household income and household expenditure on individual fuels. With regard to both the rural and urban sample, expenditure on electricity and paraffin appear to vary by income. As household income increases, households spend more on electricity and paraffin. Expenditure on electricity is also the largest cash outlay across rural income

groups, while paraffin expenditure matches electricity expenditure in urban households in the lowest income group, becoming greater than the corresponding electricity expenditure for the two higher income groups. Expenditure on electricity and paraffin for both rural and urban households is substantially greater for the least poor households than for the poorest households.

4.4 Household energy consumption patterns

This section covers the energy consumption patterns of the surveyed rural and urban households providing further insight into how intensely various energy sources were utilised. It also explores the variation of consumption patterns with income of surveyed households. As for household energy expenditure patterns, consumption patterns would also give some indication of the level of dependence of households on individual energy sources.

The data is presented in the form of monthly household consumption and as well as monthly per capita consumption. The discussion is limited to the main fuels used by the household, with the exception of fuelwood and coal. In the dataset, the quantity of the different types of fuels used were available, however fuels such as fuelwood and coal were used in a range of quantities that could not be standardized into formal units, as discussed in the Methodology chapter (Section 3.4.3). Thus this section examines the consumption patterns of only the fuels that were used in standard quantity units and therefore omits fuelwood and coal.

Household energy consumption

Monthly consumption of energy sources on a household basis and household per capita basis are demonstrated in Table 4.26. As observed from this table, urban households showed greater consumption levels of these fuels (109.2 kWh of electricity and 11.3litres of paraffin) than rural households (88.2kWh and 9.2litres of paraffin). More electricity use among urban households could be due to more modernised lifestyles in urban areas with more modern appliances. Further the urban sample seemed to be electrified for a longer length of time than the overall rural sample, and this could possibly have resulted in higher consumption levels. Further, more appliances could be locally available in urban areas than rural areas, which could potentially promote consumption. In addition, greater consumption of electricity and paraffin in urban areas could be related to higher income levels in the urban areas relative to rural areas, resulting in higher affordability in the urban areas. Electricity use compared to the use of LPG suggests that improved accessibility of electricity relative to LPG has overridden any affordability considerations.

Candles although widely used in both rural (94%) and urban households (72%) (Table 4.4.), are only used in small quantities monthly (roughly an average of 5 candles per month among households in both areas), and with very little variation across income groups for both rural and urban surveyed

Table 4.26: Average household energy consumption of individual fuels

	Rural	
	Average consumption per month	**Average per capita consumption per month**
Paraffin *(l/month)*	9.2	1.7
LPGas *(kg/month)*	0.4	0.0
Dry cell batteries *(No./month)*	0.4	0.1
Candles *(No./month)*	5.4	1.0
Electricity *(kWh/month)*	88.2	16.4
	Urban	
	Average consumption per month	**Average per capita consumption per month**
Paraffin *(l/month)*	11.3	3.0
LPGas *(kg/month)*	0.2	0.1
Dry cell batteries *(No./month)*	0.3	0.1
Candles *(No./month)*	4.5	1.3
Electricity *(kWh/month)*	109.2	20.8

*Rural **n** (households): Total –147 and Urban **n** (households): Total –79*

households. This limited use of candles is due to the main lighting fuel in both rural and urban areas being electricity (Table 4.36).

Income

Examination of energy consumption in terms of different income levels in Table 4.27 below establishes that both per capita electricity consumption and per capita paraffin consumption increase as income increases in both rural and urban households.

A trend is not as evident in the case of per capita candle consumption in rural areas, but it appears that in urban areas, per capita candle consumption also increases with an increase in level of income.

Table 4.27: Average monthly household per capita energy consumption by income category

	Tertile 1 (low)	**Tertile 2**	**Tertile 3 (high)**	**Total**
	Rural			
Paraffin *(l/month)*	1.0	1.4	2.7	**1.7**
LPGas *(kg/month)*	0.0	0.1	0.1	**0.0**
Dry cell batteries *(No./month)*	0.0	0.1	0.1	**0.1**
Candles *(No./month)*	0.9	0.8	1.2	**1.0**
Electricity *(kWh/month)*	8.7	11.4	29.5	**16.4**
	Urban			
Paraffin *(l/month)*	1.6	2.7	4.4	**3.0**
LPGas *(kg/month)*	0.0	0.0	0.2	**0.1**
Dry cell batteries *(No./month)*	0.0	0.1	0.1	**0.1**
Candles *(No./month)*	0.7	1.3	1.8	**1.3**
Electricity *(kWh/month)*	12.6	18.4	31.3	**20.8**

It was not possible from the survey data to estimate household fuelwood consumption in terms of a standardised quantity unit such as kilogram of oil equivalent (kgoe). It has been observed in earlier results that fuelwood use is highly prevalent in rural areas and much less so in urban areas. Thus, some of the observed higher (kgoe) energy consumption in urban areas when compared with rural areas in Table 4.28 below could indicate that there is substitution of fuelwood for paraffin and electricity in urban areas.

Table 4.28: Energy use by income group (kgoe* per capita per month)

	Rural			
	Paraffin	**Gas**	**Electricity**	**Candles**
Tertile 1 (low)	0.8	0.0	0.7	0.1
Tertile 2	1.1	0.1	1.0	0.1
Tertile 3 (high)	2.2	0.1	2.5	0.1
	Urban			
	Paraffin	**Gas**	**Electricity**	**Candles**
Tertile 1 (low)	1.4	0.0	1.1	0.1
Tertile 2	2.2	0.0	1.6	0.1
Tertile 3 (high)	3.6	0.2	2.7	0.1

*Rural **n**'s (households): Tertile 1 –54; Tertile 2 –44; Tertile 3 –49; Total –147*

*Urban **n**'s (households): Tertile 1 –22; Tertile 2 –31; Tertile 3 –26; Total –79*

***** *The quantities of all fuels illustrated in this table were converted into a standard unit namely kilogram of oil equivalent (kgoe), in order that comparisons could be made between the use of individual fuels.*

Household size

Table 4.29 below confirms the trends observed in the analysis of energy expenditure by household size (Table 4.22) i.e. that larger households benefit from economies of scale implying decreasing per capita energy consumption with increasing household size.

Table 4.29: Average monthly household per capita energy consumption by household size category

	1-5 persons	6-8 persons	9+ persons	Total
	Rural			
n	*54*	*44*	*49*	*147*
Paraffin *(l/month)*	2.8	1.3	0.9	**1.7**
LPGas *(kg/month)*	0.0	0.1	0.1	**0.0**
Dry cell batteries *(No./month)*	0.1	0.0	0.1	**0.1**
Candles *(No./month)*	1.6	0.8	0.6	**1.0**
Electricity *(kWh/month)*	26.9	14.2	7.8	**16.4**
	Urban			
n	*43*	*26*	*10*	*79*
Paraffin *(l/month)*	4.3	1.5	1.1	**3.0**
LPGas *(kg/month)*	0.1	0.0	0.0	**0.1**
Dry cell batteries *(No./month)*	0.1	0.1	0.0	**0.1**
Candles *(No./month)*	2.0	0.5	0.3	**1.3**
Electricity *(kWh/month)*	23.2	19.7	12.1	**20.8**

4.5 Household energy end-use patterns

The energy use patterns for the end-uses of cooking, lighting and water heating were investigated in this study. Surveyed households were asked to identify their primary and secondary fuels for each end-use.

It must be noted that the analysis of the household energy end-use patterns of the rural households was conducted over a smaller rural sample than the rest of the analysis conducted in this study, due to the 56 households surveyed in rural Garagopola not having been asked about a main fuel and secondary fuel used for each of the main end-uses performed by households. As a consequence when

household energy end-use patterns of the rural sample are analysed by income group (tertile), average age of household and highest level education of household, the number of households in each of the income, age and education categories for these variables has also been reduced.

4.5.1 Fuels used for cooking

Cooking is the primary energy end-use of households. As shown in Table 4.30 below, most rural households used fuelwood (38% of households reported its use) as the main energy source for cooking, followed closely by electricity (30%) and paraffin (29%). It is interesting to note that despite being electrified, over two thirds of the rural households used more polluting fuels such as fuelwood and paraffin as their main energy source for cooking. Further, 5% of rural households use fuelwood as a supplementary fuel for cooking. Studies have extensively shown that the financial cost of electricity and the appliances associated with its use serve among the significant constraints toward a complete shift away from other fuels to cleaner and more efficient fuels such as electricity, and especially if fuelwood stocks are available and adequate or can be purchased at seemingly reduced prices relative to electricity. Electricity appears to be used by a third of rural and urban households only as a primary energy source for cooking (and not as second choice) (Table 4.30). In terms of bio-fuels, it was scarcely used as a main fuel by rural households for cooking, but rather used as a secondary fuel for this purpose and only by 5% of households as indicated in Table 4.30.

Table 4.30: Fuels used for cooking

	Rural		Urban	
	Main fuel	Second fuel	Main fuel	Second fuel
n (number of households surveyed)	*91*	*91*	*79*	*79*
Electricity	30%	0%	34%	0%
Candles	1%	0%	0%	0%
Paraffin	29%	1%	61%	0%
Gas	1%	0%	3%	0%
Fuelwood	38%	5%	3%	1%
Biofuels (dung and crop residues)	1%	5%	0%	0%
Coal	0%	0%	0%	0%
Total % having main and 2nd cooking fuels	100%	12%	100%	1%

The urban sample displays some notable differences compared to the rural sample with regard to cooking fuels. Paraffin and electricity were primary fuels used by most urban households for cooking, with most households consuming (61% of households) paraffin and a just over a third of households (34% of households) using electricity. The remaining 6% of urban households used either gas (3%) or fuelwood (3%) to meet their cooking needs. There was a notable absence of the use of a secondary fuel for cooking in the urban sample. The prevalence of electricity use was relatively similar across the rural and urban samples, however there were large differences in the proportion of households who used fuelwood and paraffin as main cooking fuels between both samples. The latter effects presented as a large scale substitution of fuelwood (in rural areas) with paraffin (in urban areas).

Variation of main cooking fuels used by income

The rural sample displayed substantial variation of electricity and fuelwood use as a main cooking fuel in relation to income (Table 4.31). There was a tendency for less poorer households to cook mainly with electricity i.e. 40% of households in Tertiles 2 and 3. Fuelwood on the other hand showed a strong pattern in the opposite direction to electricity, such that majority of households (61% of households) in the lowest income group (Tertile 1) used it as a main cooking fuel relative to the two higher income tertiles (29% and 24% of households in Tertiles 2 and 3 respectively). There was only a slightly higher prevalence of paraffin use by households as income increased. There were no other distinct patterns for main cooking fuels.

In the urban sample, substantial differences are evident for the use of paraffin and electricity as primary cooking fuels by income category. As evident in Table 4.31, an increasing proportion of households use electricity as a primary fuel for cooking as their income increases. In particular, the increased use of electricity as a main cooking fuel was apparent of households in the highest income group. Paraffin on the other hand showed the opposite trend, giving the impression of a substitution effect of electricity for paraffin with increasing income.

Among the few households using fuelwood in the urban sample, the pattern displayed was that fuelwood use declined with increasing income. In fact the least poor households had ceased using fuelwood.

Variation of main cooking fuels used by household size

Within the rural sample, the use of electricity, paraffin and fuelwood as the main cooking fuels were highest among all household sizes as evident in Table 4.32. Distinct patterns were evident for fuelwood and paraffin use in relation to household size. With regard to paraffin use, the proportion of households who used paraffin declined from 33% for the smallest household size category (1-5 persons) to 17% for the largest household size category (more than 9 persons), while fuelwood use increased from 33% to 53% for the same change in household size category. A further trend evident was that the largest households showed far greater dependence on the more polluting fuelwood than households in the other household size categories. Larger households, as pointed out earlier in Figure 6 above, tended to be in the poorest income group, hence their high dependence on cheaper and more polluting fuels such as fuelwood, which is largely self collected thus incurring little cash cost.

Within the urban sample, the use of electricity and paraffin as the main cooking fuel were highest among all household sizes as evident in Table 4.33. Clear household size trends for both electricity and paraffin use were also evident. The proportion of households using electricity increased from 23% for the smallest households size (1-5 persons) roughly doubled for the two larger household size categories. This marked increase in electricity use as household sizes grew for the urban sample, was somewhat of contrast to households in the rural sample, which showed very little difference in the

proportion of households using electricity as main cooking fuel as household sizes grew. No distinct patterns were evident for the other cooking fuels. It is interesting to note that urban households in the largest household size category used only electricity and/or paraffin as their main cooking fuels.

Variation of main cooking fuels used by gender

There were no distinct variations between gender of household and the main cooking fuels used for both the rural and urban sample. However across both rural and urban households in which females were majority, there were a fewer number of main energy sources utilised for cooking (Table 4.33).

Variation of main cooking fuels used by age

There was no obvious variation across the average household age categories in the urban sample. In the rural sample, the households in the highest average age category showed a lower use of fuelwood and a higher use of paraffin than their younger average household age counterparts.

Variation of main cooking fuels used by education

No distinct patterns between highest level of education of household and cooking fuels used emerged for the rural sample. However, in the urban sample, patterns were evident between education and electricity and paraffin use – the two most commonly used fuels for cooking by the urban households. The proportion of households using electricity increased with increasing highest level of education of households – an increase from 24% of household in the lowest education category to 42% of households in the highest education category. A less pronounced pattern showed paraffin declining in use with almost 10% fewer households using it in the highest education category (55% of households) relative to the lowest education category (64% of households).

4.5.2 Fuels used for lighting

It is evident from Table 4.36 that electricity is by far the dominant energy source used for lighting in both the rural and urban sample. Ninety six percent of sampled rural households used only electricity as a lighting fuel. A further 4% of households used candles as a main lighting fuel while 8% used it as secondary choice.

In the urban sample, a slightly lower proportion of households (86%) used electricity relative to the rural sample, nonetheless the majority of urban sampled households used electricity as the main lighting fuel. A further 9% of households used only candles, and 5% used only paraffin as a main lighting fuel. It is interesting to note that in the urban sample, no secondary lighting fuel was used by any of the sampled households.

Variation of main lighting fuels used by income

The very high prevalence of electricity as the main lighting fuel, in both the rural and urban sample, makes it difficult to analyse the variation in main lighting fuels by other variables

Table 4.31: Fuels used for cooking by income category

	Rural				Urban			
	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
n	*54*	*44*	*49*	*147*	*22*	*31*	*26*	*79*
Electricity	10%	40%	40%	**30%**	23%	29%	50%	**34%**
Candles	0%	0%	0%	**0%**	0%	0%	0%	**0%**
Paraffin	26%	26%	36%	**29%**	68%	68%	46%	**61%**
Gas	0%	3%	0%	**1%**	5%	0%	4%	**3%**
Fuelwood	61%	29%	24%	**38%**	5%	3%	0%	**3%**
Dry aloe	3%	0%	0%	**1%**	0%	0%	0%	**0%**

Table 4.32: Fuels used for cooking by household size

	Rural				Urban			
	1-5 persons	6-8 persons	9+ persons	Total	1-5 persons	6-8 persons	9+ persons	Total
n	*47*	*58*	*42*	*147*	*43*	*26*	*10*	*79*
Electricity	33%	29%	27%	**30%**	23%	46%	50%	**34%**
Candles	0%	0%	3%	**1%**	0%	0%	0%	**0%**
Paraffin	33%	35%	17%	**29%**	70%	50%	50%	**61%**
Gas	0%	3%	0%	**1%**	2%	4%	0%	**3%**
Fuelwood	33%	29%	53%	**38%**	5%	0%	0%	**3%**
Dry aloe	0%	3%	0%	**1%**	0%	0%	0%	**0%**

Table 4.33: Fuels used for cooking by gender composition of household

	Rural			Urban		
	>= 50% males	> 50% females	Total	>= 50% males	> 50% females	Total
n	*79*	*68*	*147*	*22*	*31*	*79*
Electricity	26%	34%	**30%**	33%	37%	**34%**
Candles	2%	0%	**1%**	0%	0%	**0%**
Paraffin	30%	27%	**29%**	60%	63%	**61%**
Gas	2%	0%	**1%**	4%	0%	**3%**
Fuelwood	38%	39%	**38%**	4%	0%	**3%**
Dry aloe	2%	0%	**1%**	0%	0%	**0%**

Table 4.34: Fuels used for cooking by average age of household

	Rural				Urban			
	0-21 years	22-27 years	> 27 years	Total	0-21 years	22-27 years	> 27 years	Total
n	*46*	*45*	*56*	*147*	*22*	*31*	*26*	*79*
Electricity	33%	27%	30%	**30%**	39%	31%	33%	**34%**
Candles	4%	0%	0%	**1%**	0%	0%	0%	**0%**
Paraffin	21%	23%	38%	**29%**	61%	59%	63%	**61%**
Gas	0%	0%	3%	**1%**	0%	7%	0%	**3%**
Fuelwood	42%	50%	27%	**38%**	0%	3%	4%	**3%**
Dry aloe	0%	0%	3%	**1%**	0%	0%	0%	**0%**

Table 4.35: Fuels used for cooking by highest level of education in household

	Rural				Urban			
	<= Grade 9	Grade 10 or 11	>= Grade 12	Total	<= Grade 9	Grade 10 or 11	>= Grade 12	Total
n	*29*	*44*	*74*	*147*	*25*	*21*	*33*	*79*
Electricity	30%	26%	31%	**30%**	24%	33%	42%	**34%**
Candles	0%	0%	2%	**1%**	0%	0%	0%	**0%**
Paraffin	30%	26%	29%	**29%**	64%	67%	55%	**61%**
Gas	0%	0%	2%	**1%**	4%	0%	3%	**3%**
Fuelwood	40%	48%	33%	**38%**	8%	0%	0%	**3%**
Dry aloe	0%	0%	2%	**1%**	0%	0%	0%	**0%**

Table 4.36 – Fuels used for lighting

	Rural		Urban	
	Used as main fuel	Used as 2nd fuel	Used as main fuel	Used as 2nd fuel
n (number of households surveyed)	*91*	*91*	*79*	*79*
Electricity	96%	0%	86%	0%
Candles	4%	8%	9%	0%
Paraffin	0%	0%	5%	0%
Gas	0%	0%	0%	0%
Fuelwood	0%	0%	0%	0%
Biofuels (dung and crop residues)	0%	0%	0%	0%
Coal	0%	0%	0%	0%
Total % having main and 2nd cooking fuels	100%	8%	100%	0%

(Table 4.37). However, even though no clear pattern emerges, the few households using candles in the rural and urban samples, displayed the highest incidence among the poorest households (10% and 14% in the rural and urban samples respectively).

In the urban sample, paraffin use only occurred among households in the middle-income group (Tertile 2) (Table 4.37).

Variation of main lighting fuels used by household size

There was no evidence of any clear variation between household size and lighting fuels utilised by sampled households. The use of electricity was dominant among all household sizes in the urban and rural samples. It is however evident that the smallest households in the urban sample used a range of electricity, candles and paraffin as lighting fuels, in contrast to households in the other categories which only used electricity and candles.

Variation of main lighting fuels used by gender

No distinct patterns were apparent between gender composition of household and lighting fuels used. A slightly higher proportion of female dominant households used electricity for lighting in both the rural and urban sample, corresponding with slightly lower proportion of these households using candles for lighting.

Variation of main lighting fuels used by age

Again, there was no clear relationship between lighting fuels and average age of household.

Variation of main lighting fuels used by education

No distinct patterns between highest level of education of household and lighting fuel used were apparent in the rural sample, except that the highest proportion of households using electricity (98%) instead of using candles (2%) as the main lighting fuel were those in the highest education category of Grade 12 and higher.

The urban sample revealed more distinct patterns, with electricity use increasing substantially and consistently with increasing (highest level of) education in the household, while candle and paraffin use correspondingly declined. In fact households in the highest education category only used electricity as main lighting energy source. In the two lower education level categories, the use of candles as a main lighting fuel was roughly twice that of paraffin.

Table 4.37- Fuels used for lighting by income category

	Rural				Urban			
	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
n	*54*	*44*	*49*	*147*	*22*	*31*	*26*	*79*
Electricity	90%	100%	96%	**96%**	86%	81%	92%	**86%**
Candles	10%	0%	4%	**4%**	14%	6%	8%	**9%**
Paraffin	0%	0%	0%	**0%**	0%	13%	0%	**5%**

Table 4.38 – Fuels used for lighting by household size

	Rural				Urban			
	1-5 persons	6-8 persons	9+ persons	Total	1-5 persons	6-8 persons	9+ persons	Total
n	*47*	*58*	*42*	*147*	*43*	*26*	*10*	*79*
Electricity	97%	97%	93%	**96%**	81%	92%	90%	**86%**
Candles	3%	3%	7%	**4%**	9%	8%	10%	**9%**
Paraffin	0%	0%	0%	**0%**	9%	0%	0%	**5%**

Table 4.39 – Fuels used for lighting by gender composition of household

	Rural			Urban		
	>= 50% males	> 50% females	Total	>= 50% males	> 50% females	Total
n	*79*	*68*	*147*	*22*	*31*	*79*
Electricity	94%	98%	**96%**	85%	89%	**86%**
Candles	6%	2%	**4%**	12%	4%	**9%**
Paraffin	0%	0%	**0%**	4%	7%	**5%**

Table 4.40– Fuels used for lighting by average age of household

	Rural				Urban			
	0-21 years	22-27 years	> 27 years	Total	0-21 years	22-27 years	> 27 years	Total
n	*46*	*45*	*56*	*147*	*22*	*31*	*26*	*79*
Electricity	100%	90%	97%	**96%**	87%	86%	85%	**86%**
Candles	0%	10%	3%	**4%**	9%	10%	7%	**9%**
Paraffin	0%	0%	0%	**0%**	4%	3%	7%	**5%**

Table 4.41– Fuels used for lighting by highest level of education in household

	Rural				Urban			
	<= Grade 9	Grade 10 or 11	>= Grade 12	Total	<= Grade 9	Grade 10 or 11	>= Grade 12	Total
n	*29*	*44*	*74*	*147*	*25*	*21*	*33*	*79*
Electricity	95%	91%	98%	**96%**	68%	86%	100%	**86%**
Candles	5%	9%	2%	**4%**	20%	10%	0%	**9%**
Paraffin	0%	0%	0%	**0%**	12%	5%	0%	**5%**

4.5.3 Fuels used for water heating

The fuels used for water heating varied for both the rural and urban sample. Among rural sampled households, the dominant fuel used for water heating was fuelwood (44% of households) followed by 31% of household using electricity and 23% of households using paraffin. A further 2% of households used fuelwood as secondary energy source for water heating, while 4% of household utilised bio-fuels in the form of dung and crop residues as a second water heating choice.

Table 4.42– Fuels used for water heating

	Rural		Urban	
	Main fuel	Second fuel	Main fuel	Second fuel
n (number of households surveyed)	*91*	*91*	*79*	*79*
Electricity	31%	0%	38%	0%
Candles	0%	0%	0%	0%
Paraffin	23%	0%	53%	0%
Gas	0%	0%	1%	0%
Fuelwood	44%	2%	3%	0%
Biofuels (dung and crop residues)	2%	4%	1%	0%
Coal	0%	0%	1%	0%
Total % having main and 2nd cooking fuels	100%	7%	97%	0%

In the urban sample however paraffin was used most extensively as a main water heating fuel (by 53% of households), followed closely by 38% of households using electricity, with as little as 3% of households utilising fuelwood for this purpose. As can be seen there is a substantially more extensive use of fuelwood in the rural households than urban households for water heating. In the urban sample, no fuels are used as a secondary choice for water heating indicating that households consistently apply their choice of water heating fuel. It is also apparent the sampled urban households show substantially greater use of more modern energy forms for water heating, in particular paraffin. It is also interesting to observe that the use of electricity is substantially lower for water heating than for lighting purposes in both the rural and urban sample.

Variation of main water heating fuels used by income

In terms of electricity use, a clear income trend is evident in the rural sample, with paraffin use increasing with income. Thirteen percent of households used paraffin for water heating in the poorest income group, followed by 23%and then 36% in the subsequent income groups (Table 4.43). Although the trend is not as clear for households using electricity as a main water heating fuel, the poorest income group had the lowest use of electricity for this purpose (13% of households). Fuelwood use for water heating showed a trend in the opposite direction to that of paraffin and electricity with a substantial decline in its use as incomes rose – a decline from 71% of households using it in Tertile 1 to 36% of households using it in Tertile 3. Despite the

Table 4.43 – Fuels used for water heating by income category

	Rural				Urban			
	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
n	*54*	*44*	*49*	*147*	*22*	*31*	*26*	*79*
Electricity	13%	49%	28%	**31%**	27%	35%	52%	**38%**
Paraffin	13%	23%	36%	**23%**	59%	61%	40%	**54%**
Gas	0%	0%	0%	**0%**	0%	0%	4%	**1%**
Fuelwood	71%	26%	36%	**44%**	5%	3%	0%	**3%**
Biofuels (dung/crop residues)	0%	3%	0%	**1%**	5%	0%	0%	**1%**
Coal	0%	0%	0%	**0%**	5%	0%	0%	**1%**
Dry aloe	3%	0%	0%	**1%**	0%	0%	0%	**0%**

Table 4.44 – Fuels used for water heating by household size

	Rural				Urban			
	1-5 persons	6-8 persons	9+ persons	Total	1-5 persons	6-8 persons	9+ persons	Total
n	*47*	*58*	*42*	*147*	*43*	*26*	*10*	*79*
Electricity	33%	29%	30%	**31%**	26%	46%	70%	**38%**
Paraffin	30%	19%	20%	**23%**	64%	50%	20%	**54%**
Gas	0%	0%	0%	**0%**	2%	0%	0%	**1%**
Fuelwood	33%	48%	50%	**44%**	5%	0%	0%	**3%**
Biofuels (dung/crop residues)	3%	0%	0%	**1%**	0%	0%	10%	**1%**
Coal	0%	0%	0%	**0%**	0%	4%	0%	**1%**
Dry aloe	0%	3%	0%	**1%**	0%	0%	0%	**0%**

Table 4.45 – Fuels used for water heating by gender composition of household

	Rural			Urban		
	>= 50% males	> 50% females	Total	>= 50% males	> 50% females	Total
n	*79*	*68*	*147*	*22*	*31*	*79*
Electricity	28%	34%	**31%**	35%	44%	**38%**
Paraffin	26%	20%	**23%**	55%	52%	**54%**
Gas	0%	0%	**0%**	2%	0%	**1%**
Fuelwood	44%	44%	**44%**	4%	0%	**3%**
Biofuels (dung/crop residues)	0%	2%	**1%**	0%	4%	**1%**
Coal	0%	0%	**0%**	2%	0%	**1%**
Dry aloe	2%	0%	**1%**	0%	0%	**0%**

Table 4.46 – Fuels used for water heating by average age of household

	Rural				Urban			
	0-21 years	22-27 years	> 27 years	Total	0-21 years	22-27 years	> 27 years	Total
n	*46*	*45*	*56*	*147*	*22*	*31*	*26*	*79*
Electricity	38%	27%	30%	**31%**	48%	28%	42%	**38%**
Paraffin	21%	23%	24%	**23%**	48%	59%	54%	**54%**
Gas	0%	0%	0%	**0%**	0%	3%	0%	**1%**
Fuelwood	42%	50%	41%	**44%**	0%	3%	4%	**3%**
Biofuels (dung/crop residues)	0%	0%	3%	**1%**	0%	3%	0%	**1%**
Coal	0%	0%	0%	**0%**	0%	3%	0%	**1%**
Dry aloe	0%	0%	3%	**1%**	0%	0%	0%	**0%**

Table 4.47– Fuels used for water heating by highest level of education in household

	Rural				Urban			
	<= Grade 9	Grade 10 or 11	>= Grade 12	Total	<= Grade 9	Grade 10 or 11	>= Grade 12	Total
n	*29*	*44*	*74*	*147*	*25*	*21*	*33*	*79*
Electricity	20%	35%	33%	**31%**	24%	33%	53%	**38%**
Paraffin	35%	9%	25%	**23%**	64%	52%	47%	**54%**
Gas	0%	0%	0%	**0%**	4%	0%	0%	**1%**
Fuelwood	40%	57%	40%	**44%**	8%	0%	0%	**3%**
Biofuels (dung/crop residues)	5%	0%	0%	**1%**	0%	5%	0%	**1%**
Coal	0%	0%	0%	**0%**	0%	5%	0%	**1%**
Dry aloe	0%	0%	2%	**1%**	0%	0%	0%	**0%**

substantial decline in fuelwood use across income groups, its use remains substantial in fact equal to that of paraffin use and higher than that of electricity among households in the highest income group.

For the urban sample, a clear income trend was evident with the proportion of households using electricity for water heating increasing with income levels with corresponding drops in other fuels used mainly for water heating, especially paraffin with 59% of households using it in Tertile 1, 61% in Tertile 2 and 40% in Tertile 3. It is noteworthy that households in the lower tertiles were largely dependent on paraffin, followed by electricity, while households in the highest income group displayed a reversal in this pattern, such that more households exhibited a greater dependence on electricity than paraffin for water heating. With regard to water heating, 50% fewer households in Tertile 1 used electricity than in Tertile 3 for this purpose.

Variation of main water heating fuels used by household size

In the rural sample the use of paraffin as a main water heating fuel appears to decline with increasing household size, falling from 30% in the smallest household size category (1-5 persons) to 20% for the largest household size category (more than 9 persons) (Table 4.44). Fuelwood use, on the other hand, displayed an increased use with increasing household sizes – roughly 20% more households were using fuelwood in the largest household size category than the smallest household size category. Electricity use was consistent across all household size categories, with about one-third of households using electricity in each category for water heating.

The urban sample displayed contrasting trends to the rural sample. Electricity use as a main water heating fuel appeared to increase consistently and substantially with increasing household size – increasing from 26% of households from the smallest household size category to as much as 70% of households using it in the largest household size category for this purpose. Paraffin use among urban households, similarly to but more distinct than in the rural sample, showed decreased use as a main water heating fuel with increasing household size. From these observations it is apparent that the urban sample signals a shift away from paraffin to electricity as the main water heating fuel used, and this trend is strongest for the largest household size category (more than 9 persons) – with 70%of household using electricity and 20% and 10% of household using paraffin and bio-fuels respectively as the primary fuels for heating water. The rural sample however displays a slightly different pattern of fuel use for water heating for this household size category, with 50% of households using fuelwood, 30% and 20% using electricity and paraffin respectively. Among rural households there appeared to be shift away from paraffin to mainly fuelwood followed by electricity to a smaller extent to fulfil water heating needs as the household size increased.

Variation of main water heating fuels used by gender

There appears to be no distinct trends between gender composition of household and water heating fuels used (Table 4.45). In both the rural and urban sample, there appears to be a slightly higher

proportion of households in which females are the majority, that use electricity, and a slightly lower proportion of such households using paraffin as a main water heating fuel. There is also a tendency for only female dominant households in both samples to use bio-fuels as a heating fuel, a noteworthy observation even if only a few households were using this type of fuel.

Variation of main water heating fuels used by age

In the rural sample, as noted earlier, the dominant fuels used for water heating were fuelwood, electricity and paraffin. No clear variation was noted with changes in the average age of the household. A, perhaps minor, notable feature is that electricity use as a main water heating fuel appeared highest in the youngest household category.

In the urban sample, the main water heating fuels used were paraffin, followed closely by electricity. The trend was the tendency for the middle age category of households to have a wider range of main water heating fuels in substitution of electricity for this purpose.

Variation of main water heating fuels used by education

In the rural sample, electricity use appeared to increase, while paraffin use concomitantly decreased with increasing education level of the household. Fuelwood the dominant fuel used by rural households for water heating showed no distinct pattern with highest level of education of household, except that 17% more households used fuelwood in the middle education category than the lowest and highest education categories. A notable feature was the dramatic decline from 35% of households using paraffin in the lowest education category (Grade 9 or lower) to 9% using it in middle category of Grade 10 or 11. Households in this latter category demonstrated greatest reliance on fuelwood for water heating (57% of households), followed by electricity (35% of households) and to a far lesser extent paraffin (9% of households). A similar trend persisted for households in the highest education category, however paraffin although used to relatively lesser extent was used by three times as many households than in the middle education category. Households in the lowest education category in contrast to households other two categories exhibited greatest dependence on fuelwood and paraffin, and to a lesser extent electricity for water heating needs.

In the urban sample, similarly and more clearly than in the rural sample, electricity use steadily increased and paraffin use gradually declined with increasing education of the household (Table 4.47). The proportion of households using electricity for water heating more than doubled between the lowest to the highest education category (i.e. increased from 24% to 53%), while paraffin concomitantly decreased from 64% of households in the lowest education category to the 47% of households in the highest education category. It is thus apparent from Table 4.47, that households in the lowest education category are largely reliant on paraffin for water heating (64% of households) and to a lesser extent electricity (24% of households) and to an even lesser extent fuelwood (8% of households). In fact the few households in the urban sample using fuelwood for water heating occur

only in the lowest education category. Households in the middle education category (Grade 10 or 11) similarly displayed greatest reliance on paraffin, followed by electricity, although the gap in reliance on the two fuels narrows from 40% in the lowest education category to about 20% in this one. In the highest education category (Grade 12 and higher) there was an even reliance on electricity (53% of households), and paraffin (47% of households) for this purpose.

4.6 Multiple fuel use

In both the Introduction and Literature Review chapters (Chapters 1 & 2) of this dissertation, the utilisation of a number of different fuels to meet basic energy needs was noted as common practice among the majority of low-income households in South Africa. This was affirmed earlier in the Results chapter in the discussion of the prevalence of fuel use (Section 4.2.1.) where it was observed in Table 4.4 that the total percentage of households using a range of fuels far was well in excess of 100% revealing that multiple fuel use is a common phenomenon among both rural and urban households of this study. This section further examines the variation of this phenomenon through the number of fuels utilized in relation to income, household size, gender, age and education across the surveyed rural and urban households. The main combinations of fuels used are also briefly analysed.

Table 4.48 – Average number of fuels used by low-income households

	Rural	Urban
Average of Number of fuels used per household	4.6	2.9

*Rural **n** (households): Total –147 and Urban **n** (households): Total –79*

It is clearly evident from Table 4.4 that despite being electrified the majority of both rural and urban surveyed households use a range of fuels to fulfil their energy needs. Moreover the average number of fuels used per household among the rural sample was as high as five fuels while for the urban sample, a combination of three fuels was the average feature (Table 4.48). To this end many households used different fuels for varying end-uses, while it was also common practice for households to utilise more than one fuel for a single application in particular cooking.

Table 4.49 – Percentage of households using multiple fuels

	Percentage of households using these numbers of fuels or less						
Number of fuels	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Rural	1%	3%	12%	20%	49%	14%	1%
Urban	6%	27%	43%	18%	5%	1%	0%

*Rural **n** (households): Total –147 and Urban **n** (households): Total –79*

It can be seen from Table 4.49 (with percentages) that only 1% of sampled rural households depended on a single fuel to satisfy their daily energy needs, while the rest of the sample relied on combinations of 2 or more fuels. The most common occurrence of multiple fuel use was the combination of 4 fuels (20% of households), 5 fuels (49% of households) and 6 fuels (14% of households) compared to the combinations of 2 fuels (3% of households) and 3 fuels (12% of households). The fuels involved in

two fuel combination multiple fuel use in rural households are shown in Table 4.50. For example, 44% of rural households use both biofuel and paraffin. It is clear that electricity is not used as a single fuel but used in combination with other fuels for the majority of the rural sample. The fuels mainly used in rural areas (as identified in Section 4.2, Table 4.4) are candles, paraffin, fuelwood, bio-fuels and electricity. The bold figures in the table below also give these prevalence rates. Compared with the other figures in the corresponding rows or columns, it is evident that all of these fuels are used in combination with other fuels. For example, 84% of rural households used paraffin and 81% used paraffin and candles, implying that of the households using paraffin, (81%/84%) 96% of them also used candles.

Table 4.50 – Multiple fuel use - Two fuel combinations in rural areas

	candles	paraffin	gas	fuelwood	coal	dry cell batteries	biofuels	electricity
candles	***94%***	81%	4%	79%	4%	21%	51%	93%
paraffin	81%	***84%***	4%	69%	4%	20%	44%	83%
gas	4%	4%	***4%***	3%	1%	1%	2%	4%
fuelwood	79%	69%	3%	***82%***	3%	18%	43%	81%
coal	4%	4%	1%	3%	***4%***	0%	1%	4%
dry cell batteries	21%	20%	1%	18%	0%	***23%***	18%	22%
biofuels	51%	44%	2%	43%	1%	18%	***51%***	48%
electricity	93%	83%	4%	81%	4%	22%	48%	***99%***

*Rural **n** (households): Total –147*

In terms of the urban sample (Table 4.49), and similarly to the rural sample, reliance on a single fuel for energy needs occurred among a few households (6%), while reliance on a combination of 2 to 4 fuels appeared to prevail among this sample, with the most common being a combination of 3 fuels (43% of households). The fuels mainly used by urban households were candles, paraffin, and electricity, and these were used in combination with each other (Table 4.51). For example, as illustrated in Table 4.51, of the 96% of urban households using electricity, 71% (68%/96%) also used candles and 84% also used paraffin.

Table 4.51 – Multiple fuel use - Two fuel combinations in urban areas

	candles	paraffin	gas	fuelwood	coal	dry cell batteries	biofuels	electricity
candles	***72%***	63%	3%	22%	0%	8%	5%	68%
paraffin	63%	***85%***	3%	18%	0%	9%	5%	81%
gas	3%	3%	***3%***	1%	0%	1%	0%	3%
fuelwood	22%	18%	1%	***22%***	0%	4%	4%	20%
coal	0%	0%	0%	0%	***0%***	0%	0%	0%
dry cell batteries	8%	9%	1%	4%	0%	***10%***	0%	10%
biofuels	5%	5%	0%	4%	0%	0%	***5%***	5%
electricity	68%	81%	3%	20%	0%	10%	5%	***96%***

*Urban **n** (households): Total –79*

Variation between multiple fuel use and income

It is clear from Table 4.52 that the use of 5 fuels is the predominant phenomenon across all income groups in rural areas. Further it is evident that multiple fuel use does not appear to have a strong relationship with income for low-income rural households.

In the urban sample, the use of 3 fuels is the most common multiple fuel use phenomenon across all income groups. Similarly to the rural sample, income appears not to have a strong relationship with multiple fuel use for low-income urban households.

Table 4.52 Percentage of households using these numbers of fuels or less by income category

	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
	Rural			
Number of fuels / *n*	*54*	*44*	*49*	*147*
1	0%	2%	0%	**1%**
2	2%	2%	6%	**3%**
3	11%	16%	8%	**12%**
4	17%	16%	29%	**20%**
5	56%	41%	49%	**49%**
6	15%	23%	6%	**14%**
7	0%	0%	2%	**1%**
	Urban			
n	*54*	*44*	*49*	*147*
1	14%	3%	4%	**6%**
2	14%	32%	31%	**27%**
3	41%	42%	46%	**43%**
4	14%	19%	19%	**18%**
5	14%	3%	0%	**5%**
6	5%	0%	0%	**1%**
7	0%	0%	0%	**0%**

Variation between multiple fuel use and household size

It is evident form Table 4.53, that there is no clear pattern of variation in multiple fuel use behaviour across household size categories, except perhaps that the middle sized rural households showed a slightly higher tendency to use five or more fuels than the smallest and largest rural households.

Table 4.53– Percentage of households using these numbers of fuels or less by household size

	1-5 persons	6-8 persons	9+ persons	Total
	Rural			
Number of fuels / *n*	*47*	*58*	*42*	*147*
1	2%	0%	0%	**1%**
2	2%	2%	7%	**3%**
3	15%	10%	10%	**12%**
4	30%	10%	24%	**20%**
5	43%	67%	31%	**49%**
6	9%	10%	26%	**14%**
7	0%	0%	2%	**1%**
	Urban			
n	*43*	*26*	*10*	*79*
1	7%	4%	10%	**6%**
2	30%	23%	20%	**27%**
3	42%	46%	40%	**43%**
4	16%	19%	20%	**18%**
5	5%	4%	10%	**5%**
6	0%	4%	0%	**1%**
7	0%	0%	0%	**0%**

Variation between multiple fuel use and gender

There appears to be no clear trend between gender composition of household and multiple fuel use among both rural and urban surveyed households, as shown in Table 4.54.

Table 4.54 – Percentage of households using these numbers of fuels or less by gender composition of household

	>= 50% males	> 50% females	Total
	Rural		
Number of fuels *n*	*79*	*68*	*147*
1	0%	1%	**1%**
2	4%	3%	**3%**
3	13%	10%	**12%**
4	20%	21%	**20%**
5	49%	49%	**49%**
6	14%	15%	**14%**
7	0%	1%	**1%**
	Urban		
n	*52*	*27*	*79*
1	6%	7%	**6%**
2	29%	22%	**27%**
3	42%	44%	**43%**
4	19%	15%	**18%**
5	2%	11%	**5%**
6	2%	0%	**1%**
7	0%	0%	**0%**

Variation between multiple fuel use and age of household

It is evident from Table 4.55 that there appears to be no strong relationship between the average age of the household and multiple fuel use, among the rural sample.

The urban sample however displayed observable trends. Among the households using the dominant combination of 3 fuels (43% of the urban households), it was observed that as the age of the household increased, the proportion of households using this combination of fuels decreased. The decrease was particularly substantial between the youngest age category (0-21 years) and the middle age category (22-27 years) i.e. from 61% of households down to 38% of households respectively.

Among the second most widespread combination of multiple fuel users i.e. the 2 fuel combination households (making up 27% of households in the urban sample), the trend towards using 2 fuels was highest for households in the oldest age category (greater than 27 years) and lowest for the middle age category (22-27 years old). Although the use of 3 fuels was most common among urban households, the trend towards using 3 fuels was evident in the youngest (0-21 years) and middle age (22-27 years) categories, and the trend towards 2 fuels was evident in the oldest age category (greater than 27 years).

Table 4.55 – Percentage of households using these numbers of fuels or less by average age of household

Number of fuels ı		0-21 years	22-27 years	> 27 years	Total
		Rural			
	n	*54*	*44*	*49*	*147*
1		2%	0%	0%	**1%**
2		7%	2%	2%	**3%**
3		13%	4%	16%	**12%**
4		22%	24%	16%	**20%**
5		41%	49%	55%	**49%**
6		15%	18%	11%	**14%**
7		0%	2%	0%	**1%**
		Urban			
	n	*23*	*29*	*27*	*79*
1		9%	3%	7%	**6%**
2		26%	14%	41%	**27%**
3		61%	38%	33%	**43%**
4		4%	31%	15%	**18%**
5		0%	10%	4%	**5%**
6		0%	3%	0%	**1%**
7		0%	0%	0%	**0%**

Variation between multiple fuel use and highest level of education of household

It is apparent from Table 4.56 that there is no clear relationship between multiple fuel use and highest level of education of household. However, it was observable among the 12% of households that used a combination of 3 fuels, substantially fewer (3%) from the lowest education category i.e. Grade 9 and lower used this combination of fuels relative to the 'Grade 10 or 11' (18%) and 'Grade 12 and higher' (11%) education categories.

Table 4.56 Percentage of households using these numbers of fuels or less by highest level of education of household

Number of fuels ı		<= Grade 9	Grade 10 or 11	>= Grade 12	Total
		Rural			
	n	*29*	*44*	*74*	*147*
1		0%	0%	1%	**1%**
2		0%	5%	4%	**3%**
3		3%	18%	11%	**12%**
4		24%	14%	23%	**20%**
5		48%	55%	46%	**49%**
6		24%	9%	14%	**14%**
7		0%	0%	1%	**1%**
		Urban			
	n	*25*	*21*	*33*	*79*
1		8%	14%	0%	**6%**
2		36%	10%	30%	**27%**
3		32%	48%	48%	**43%**
4		20%	14%	18%	**18%**
5		4%	14%	0%	**5%**
6		0%	0%	3%	**1%**
7		0%	0%	0%	**0%**

4.7 Appliances

This section explores the patterns of the appliance ownership among the surveyed households as a means to give further insight into household energy use patterns. The data collected did not give indications of the use of the appliances, except in the case of electrical appliances, with regard to which the results shown below are prevalence rates of ownership and use.

Households in both the rural and urban samples of this study demonstrated ownership of a wide variety of appliances as shown in Tables 4.57 to 4.61.

Table 4.57 – Paraffin appliance ownership

	Rural	Urban
Paraffin flame stove	56%	59%
Paraffin primus stove	22%	23%
Paraffin wick lamp	10%	0%
Paraffin lantern	5%	4%
Paraffin heater	5%	3%
Paraffin fridge	1%	0%
Paraffin geyser	1%	0%
Paraffin freezer	0%	0%
Other	0%	0%

Table 4.58 – Dry cell battery appliance ownership

	Rural	Urban
Torch	1%	4%
Radio	10%	3%
Clock	9%	4%
Other	0%	3%

Table 4.59 – Coal appliance ownership

	Rural	Urban
Coal Stove	1%	4%
Brazier/mbawula	9%	6%
Other	0%	0%

Table 4.60 – Gas appliance ownership

	Rural	Urban
Gas bottle with cooker/burner	2%	1%
Gas stove without oven	1%	0%
Gas stove with oven	3%	1%
Gas fridge	2%	0%
Gas freezer	1%	0%
Other	0%	0%

*Rural **n** (households): Total –147 and Urban **n** (households): Total –79 (applies to all four tables above)*

Since the majority of the households in this study used multiple fuels to meet their energy needs, they in turn used a range of appliances appropriate to the different fuels used to fulfil the same end-use

such as cooking or lighting. The tables further affirm earlier results that despite access to electricity households continue to use a range of other energy sources to meet their energy needs.

Tables 4.61 to 4.65 show the most commonly owned and used electrical appliances and their variation by the key socio-demographic variables examined in this study.

From the "Total" column in Table 4.61 it can be seen that both rural and urban households primarily own and use media and cooking electrical appliances, as well as convenience appliances such as kettles and irons and those related to refrigeration. One noticeable difference between rural and urban electrical appliance ownership and use was that while 66% of rural households owned and used an electrical iron, only 49% of their urban counterparts did so.

It is evident from Tables 4.57 – 4.61 that cooking appliances include electric, paraffin, LPGas and coal appliances. However paraffin cooking appliances were the most commonly owned cooking appliances (implications of which are discussed in Chapter 5), far surpassing both coal and gas cooking appliances, and to a lesser extent electric appliances. Coal and gas appliances in fact displayed negligibly low levels of ownership by both rural and urban households.

Table 4.61 – Electrical appliance ownership and use by income category

	Tertile 1 (low)	Tertile 2	Tertile 3 (high)	Total
	Rural			
n	*54*	*44*	*49*	*147*
Audio Media Appliance (e.g. radio)	65%	80%	73%	**72%**
Iron	61%	64%	73%	**66%**
Television	56%	66%	71%	**64%**
Electric Stove or Hotplate	50%	68%	63%	**60%**
Refrigeration Appliance	33%	52%	67%	**50%**
Electric kettle	33%	39%	53%	**41%**
Cell phone charger	7%	5%	31%	**14%**
Electric fan	4%	7%	16%	**9%**
Electric heater	2%	7%	8%	**5%**
Electric hair clipper	4%	2%	10%	**5%**
Toaster	2%	2%	2%	**2%**
Video machine	2%	0%	4%	**2%**
	Urban			
n	*22*	*31*	*26*	*79*
Audio Media Appliance (e.g. radio)	55%	74%	81%	**71%**
Television	59%	71%	58%	**63%**
Electric Stove or Hotplate	55%	55%	58%	**56%**
Iron	32%	52%	62%	**49%**
Refrigeration Appliance	27%	48%	62%	**47%**
Electric kettle	27%	45%	62%	**46%**
Cell phone charger	14%	13%	23%	**16%**
Electric fan	9%	13%	19%	**14%**
Toaster	14%	6%	4%	**8%**
Electric heater	5%	0%	12%	**5%**
Video machine	9%	3%	4%	**5%**
Electric hair clipper	0%	3%	4%	**3%**

Income variation with electrical appliance ownership and use

There appears to be a relationship between electrical appliance ownership and use and income among both the rural and urban surveyed households (Table 4.61 above). For the cooking, media and refrigeration appliances, those in the lowest income category exhibited lower ownership and use. Further, notably higher rates of ownership and use of the balance of the appliances, chiefly irons, electric kettles, cell phone chargers were apparent in the highest income categories.

Household size variation with electrical appliance ownership and use

Table 4.62 – Electrical appliance ownership and use by household size

	1-5 persons	6-8 persons	9+ persons	Total
	Rural			
n	*47*	*58*	*42*	*147*
Audio Media Appliance (e.g. radio)	75%	72%	67%	**72%**
Iron	58%	65%	83%	**66%**
Television	68%	60%	63%	**64%**
Electric Stove or Hotplate	53%	61%	70%	**60%**
Refrigeration Appliance	50%	58%	37%	**50%**
Electric kettle	33%	51%	40%	**41%**
Cell phone charger	10%	23%	7%	**14%**
Electric fan	8%	9%	10%	**9%**
Electric heater	5%	5%	7%	**5%**
Electric hair clipper	2%	7%	10%	**5%**
Toaster	0%	4%	3%	**2%**
Video machine	3%	2%	0%	**2%**
	Urban			
n	*43*	*26*	*10*	*79*
Audio Media Appliance (e.g. radio)	70%	63%	82%	**71%**
Television	53%	67%	73%	**63%**
Electric Stove or Hotplate	60%	52%	55%	**56%**
Iron	43%	48%	59%	**49%**
Refrigeration Appliance	33%	52%	59%	**47%**
Electric kettle	40%	41%	59%	**46%**
Cell phone charger	10%	15%	27%	**16%**
Electric fan	10%	19%	14%	**14%**
Toaster	3%	15%	5%	**8%**
Electric heater	3%	0%	14%	**5%**
Video machine	0%	7%	9%	**5%**
Electric hair clipper	3%	0%	5%	**3%**

There appears to be a relationship between household size and electrical appliance ownership and use, only with respect to ironing, cooking and refrigeration appliances. Ironing and cooking appliances showed greater ownership and use with increasing household size, while the largest households have the lowest prevalence of ownership and use of refrigeration appliances. (Table 4.62)

There were different patterns across household size in the urban sample with respect to electrical appliance ownership and use. Media and ironing appliance ownership and use appeared to increase

with increasing household size. Further, the largest households reported the highest rates of electric kettle and cell phone charger ownership and use.

Gender variation with electrical appliance ownership

Table 4.63 – Electrical appliance ownership and use by gender composition of household

	>= 50% males	> 50% females	Total
	Rural		
n	*79*	*68*	*147*
Audio Media Appliance (e.g. radio)	78%	66%	**72%**
Iron	68%	64%	**66%**
Television	68%	60%	**64%**
Electric Stove or Hotplate	63%	57%	**60%**
Refrigeration Appliance	50%	51%	**50%**
Electric kettle	45%	37%	**41%**
Cell phone charger	18%	10%	**14%**
Electric fan	8%	10%	**9%**
Electric heater	6%	4%	**5%**
Electric hair clipper	9%	1%	**5%**
Toaster	3%	1%	**2%**
Video machine	3%	1%	**2%**
	Urban		
n	*54*	*49*	*103*
Audio Media Appliance (e.g. radio)	73%	68%	**71%**
Television	61%	68%	**63%**
Electric Stove or Hotplate	47%	71%	**56%**
Iron	41%	64%	**49%**
Refrigeration Appliance	39%	61%	**47%**
Electric kettle	37%	61%	**46%**
Cell phone charger	16%	18%	**16%**
Electric fan	10%	21%	**14%**
Toaster	4%	14%	**8%**
Electric heater	4%	7%	**5%**
Video machine	4%	7%	**5%**
Electric hair clipper	2%	4%	**3%**

Among the rural sample, similar levels of electrical appliance ownership appeared to prevail for both male and female dominated households, with the exception of cell phone chargers and audio media appliances, which were more prevalent in male dominated households. For all of the appliances listed in Table 4.63, higher levels of ownership were found in male predominant households.

In contrast, the ownership and use of electrical appliances in the urban sample with the exception of the media appliances, showed relatively markedly higher rates in the predominantly female households. Most notable examples of the latter were the ownership and use of cooking, ironing and kettle appliances. (Table 4.63)

Age variation with electrical appliance ownership and use

Table 4.64 – Electrical appliance ownership and use by average age of household

	0-21 years	22-27 years	> 27 years	Total
	Rural			
n	*46*	*45*	*56*	*147*
Audio Media Appliance (e.g. radio)	74%	71%	71%	**72%**
Iron	60%	71%	66%	**66%**
Television	60%	71%	61%	**64%**
Electric Stove or Hotplate	58%	65%	57%	**60%**
Refrigeration Appliance	47%	56%	48%	**50%**
Electric kettle	44%	40%	41%	**41%**
Cell phone charger	12%	15%	16%	**14%**
Electric fan	16%	8%	4%	**9%**
Electric heater	5%	6%	5%	**5%**
Electric hair clipper	7%	6%	4%	**5%**
Toaster	2%	4%	0%	**2%**
Video machine	2%	2%	2%	**2%**
	Urban			
n	*22*	*31*	*26*	*79*
Audio Media Appliance (e.g. radio)	65%	65%	81%	**71%**
Television	54%	69%	67%	**63%**
Electric Stove or Hotplate	42%	58%	67%	**56%**
Iron	38%	54%	56%	**49%**
Refrigeration Appliance	38%	54%	48%	**47%**
Electric kettle	35%	46%	56%	**46%**
Cell phone charger	8%	19%	22%	**16%**
Electric fan	8%	15%	19%	**14%**
Toaster	0%	15%	7%	**8%**
Electric heater	8%	4%	4%	**5%**
Video machine	0%	15%	0%	**5%**
Electric hair clipper	0%	4%	4%	**3%**

Among the rural households, the notable pattern across average age of household groups was that the middle age category exhibited higher ownership and use of television and cooking appliances than both their older and younger counterparts.

In the urban sample, the households with the highest average ages had markedly higher audio appliance ownership and use, with the cooking and kettle appliance ownership and use increasing with increasing average age of household. Further, households in the youngest average age category had notably lower rates of television, ironing, refrigeration and cell phone charger ownership and use than their older counterparts. (Table 4.64)

Education variation with electrical appliance ownership and use

With regard to the rural sample, it is evident from Table 4.65 below that ownership and use of an iron increased with increasing categories of highest level of education in the household. Further, those households with the higher highest level of education displayed higher rates of ownership and use of

Table 4.65 – Electrical appliance ownership and use by highest level of education in household

	<= Grade 9	Grade 10 or 11	>= Grade 12	Total
	Rural			
n	*29*	*44*	*74*	*147*
Audio Media Appliance (e.g. radio)	69%	70%	75%	**72%**
Iron	51%	64%	77%	**66%**
Television	64%	61%	66%	**64%**
Electric Stove or Hotplate	51%	52%	70%	**60%**
Refrigeration Appliance	54%	48%	50%	**50%**
Electric kettle	33%	43%	45%	**41%**
Cell phone charger	10%	9%	20%	**14%**
Electric fan	3%	14%	9%	**9%**
Electric heater	3%	7%	6%	**5%**
Electric hair clipper	0%	9%	6%	**5%**
Toaster	5%	2%	0%	**2%**
Video machine	5%	2%	0%	**2%**
	Urban			
n	*25*	*21*	*33*	*79*
Audio Media Appliance (e.g. radio)	67%	67%	74%	**71%**
Television	60%	62%	65%	**63%**
Electric Stove or Hotplate	60%	52%	56%	**56%**
Iron	53%	43%	51%	**49%**
Refrigeration Appliance	33%	48%	51%	**47%**
Electric kettle	47%	57%	40%	**46%**
Cell phone charger	13%	24%	14%	**16%**
Electric fan	20%	24%	7%	**14%**
Toaster	13%	5%	7%	**8%**
Electric heater	0%	10%	5%	**5%**
Video machine	7%	5%	5%	**5%**
Electric hair clipper	7%	5%	0%	**3%**

electrical cooking appliances and cell phone chargers. Also, electric kettle ownership was lowest in the households that had the lowest level of education.

Among the urban households, no clear trend between appliance ownership and highest level of education of household is observable, with the exception of ownership and use of electrical refrigeration appliances, which was notably lower in the lowest level of education of household category.

CHAPTER 5: DISCUSSION

This chapter summarises the key findings from the analysis of the study. The study focussed on analysing household energy use patterns within low-income rural and peri-urban electrified households in South Africa, through examining prevalence of the different energy sources used, household expenditure and consumption patterns, household end-use patterns, patterns of multiple fuel use and appliance ownership and use. This chapter goes on to interpret household energy use patterns in terms of key household socio-economic variables used in the analysis namely, area, income, household size, gender, age of household, and highest level of education of household, in order to gain insight into how these variables interact and possibly influence these energy use patterns.

5.1 Area

5.1.1 Prevalence of fuels used

A mix of commercial and traditional energy sources meets the household energy demand of both rural and urban households in this study. The study revealed that among rural households the predominant commercial fuels used to meet energy needs were electricity (99% of households), candles (94% of households), paraffin (84% of households), while fuelwood was the main traditional used (82% of households) and to a lesser extent bio-fuels (51% of households) in the form of mainly dung, crop residues and dried plants. These findings corroborate those of Davis (1998), Howells et al (2005), Madubansi & Shackleton (2006) and Thom & Mohlakoana (2001), a body of comprehensive studies on rural energy use by low –income households performed over the last decade. Most rural households who used wood for fuel (62% of households) in the study collected it from the surrounds (such as natural woodlands) instead of purchasing it, hence incurring no cash cost for fuelwood and the value of this wood was not reflected in the household energy expenditure. However there are numerous hidden costs associated with the use of fuelwood. Collecting fuelwood is usually the burdensome task of women in the household, who have to endure as much as 15 hours a week collecting, chopping, bundling and carrying heavy headloads (as much as 35kilograms), further condemning women to the negative health (in the form of neck, back and child bearing difficulties as well as the contribution of fuelwood smoke to respiratory and eye ill health) and social impacts (fuelwood collection is service which is unpaid and undervalued, (Annecke 2001, Eberhard & Van Horen 1995). Fuelwood collection, both a labour intensive and time consuming activity effectively reduces the time that women can devote to other productive and entertaining activities such as farming, education and entertainment (Eberhard & Van Horen 1995, WEO 2002).

The portfolio of fuels most widely used by the urban electrified sample differed slightly from rural households in that a smaller range of fuels were used, they included three of the five fuels used by

rural households, namely electricity (96% of households), paraffin (85% of households) and candles (72% of households). Fuelwood (22% of households) and bio-fuels (5% of households) by comparison were used to a substantially lesser degree by urban households. This is most likely for reasons of availability, cost and convenience (Prasad & Visagie 2006, ITDG et al 2002). The urban sector relative to the rural sector tends to have minimal access to agricultural land or natural woodland and therefore has little opportunity to collect "free" fuelwood. In contrast, the availability of commercial fuels is usually greater in urban areas and there is a striving to improve living standards. These may be further drivers behind the shift from traditional (such as fuelwood and bio-fuels) to commercial fuels (i.e. paraffin) in urban areas.(Banes et al 2005, Eberhard & Van Horen 1995) Within this sphere of commercial fuels, these urban households were rather more heavily reliant on paraffin than electricity to meet the primary and energy intensive needs for cooking and heating, despite them being electrified.

It is also important to note that while coal (4% of sampled rural households and 0% of urban households) and LPG (4% of sampled rural and urban households) were used by a small proportion of households in the study, it does not imply that these fuels are less important. Extensive research has shown that coal plays an important role in the livelihood of low-income households with no access to other forms of energy or even among households with access to electricity, since it is cheapest fuel available for the poor particularly in the Highveld region of the country, where low-income households are in close proximity to the coal fields (Poggiolini 2007, ERC 2006, Wentzel 2006 , Mduli et al 2005, PDC & SCE 2003, Spalding-Fecher 2002, Eberhard & Van Horen 1995). Approximately a million South African households consume one million tonnes of coal annually (Gomes 2005). Low coal and LPG use in this study could possibly be attributed to:

a) Seasonality - households surveys conducted for this study were performed in the warm summer months, when as pointed out by Simmonds and Mammon (1996), low-income electrified households were shown to shift from using coal in the winter to paraffin in the summer,

b) Affordability – study areas may not have been in close enough proximity to the coal fields or oil refineries for coal or LPG to be affordable and accessible,

c) Accessibility – distribution of coal and LPG is usually limited due to the lack of widespread distribution networks for these fuels as well as difficulties in the bulk transportation of these fuels.

On the whole the dominant fuels used by both rural and the urban sample were electricity, paraffin and candles to fulfil basic energy needs. However the rural sample also indicated heavy reliance on traditional and polluting fuels such as fuelwood and bio-fuels in the form of dung to meet energy needs.

5.1.2 Household energy expenditure patterns

Rural households were shown to spend similar amounts on energy (R83.62 per month) when compared with urban households (R79.29 per month). While it may seem that the rural households incur a larger financial energy burden than urban households, it must be cautioned that self-collected biomass fuels (which occurs to a large extent among rural households – 62% households) was not reflected in the average energy expenditure of sampled households, hence cash outlays on energy expressed in this study are lowered. It proved difficult to attribute a monetary value to self- collected biomass fuels for a number of reasons (as outlined in the Methodology Chapter Section 3.4.3) among which was the non-standardised quantities in which they collected. Since per capita expenditure is regarded as a more realistic measure of a household's level of dependency and economic burden as it takes into account variations in household size, the average per capita energy expenditure of the sampled households was examined. It was found in fact that average household energy per capita expenditure for urban households was slightly more than rural households i.e. household average energy per capita expenditure for rural and urban households was R14.75 and R18.05 respectively. Further the energy burden of households expressed as a percentage of total household expenditure amounted to 11% for rural households and as much as 16% for urban households. These figures when juxtaposed against middle and high-income households in South Africa who typically spend between 3-5% of their household expenditure on energy, provide an indication of the significant level of energy burden endured by low-income electrified households. A state of 'energy poverty' is generally considered to prevail when a household spends more than 10% of its cash income on fulfilling basic energy needs such as cooking, water and space heating, lighting, media and keeping food fresh (SEA 2006). It is evident that low-income urban sampled households were experiencing higher levels of energy poverty than rural households. Urban households were likely purchasing useable energy at higher prices than their rural counterparts, particularly in the case where rural households were incurring no cash cost for self-collected fuelwood. However in both the cases of rural and urban households, given their energy burden it is evident that the cost of energy services for the poor is substantially higher than for middle to high income households, largely due to the fact that cooking, heating and lighting with fuelwood and paraffin is cost inefficient (paraffin and wood cooking stoves and lamps are inefficient) relative to cooking heating and lighting with modern fuels such as electricity (Barnes et al 2005, Eberhard & Van Horen 1995). Further low-income households regularly purchase paraffin and fuelwood in small quantities, due to their unpredictable income flows, hence the higher transaction costs of purchasing fuel in small quantities which in turn increases the price. As principal consumers of fuelwood and paraffin, low-income households are faced with the added burden of inconvenience and health costs associated with the use of these fuels (Barnes et al 2005, Annecke 2003, WEO 2002).

Another aspect of household energy expenditure examined in this study was expenditure on individual fuels used by the household as a means to gain insight into how intensively particular fuels were

utilized in the household and the relative importance of individual fuels in the average energy budget of households. Energy sources that were of significant cost to rural households were electricity, paraffin and fuelwood, while for urban households they were paraffin, electricity and candles. It must be noted that a complete picture of household expenditure on fuelwood could not be captured in this study as most of the fuelwood utilised by the household was not purchased at a monetary value. These large energy expenditure items for both rural and urban households are also match the high prevalence of these fuels used by households (Table 4.4). In both samples, household expenditure on electricity and paraffin far exceeded that of other fuels (Table 4.19), and the same trend was observed for the consumption levels of these fuels. Expenditure on paraffin and electricity accounted for well over two thirds of the total cash outlays on energy. These findings are consistent with those found in studies by Madubansi & Shackleton (2006), Cowan & Mohlakoana (2005) and Davis (1998) conducted in a range of rural and urban low-income areas in South Africa. Both fuels accounted for 77% of total household fuel expenditure (42% for electricity and 35% for paraffin) in the rural sample and 92% of total household fuel expenditure (43% for electricity and 49% for paraffin) in the urban sample. It is noteworthy that paraffin and electricity expenditure varied between rural and urban samples. Urban households spent more on paraffin and electricity relative to their rural counterparts to fulfil their energy needs such as cooking (using mainly paraffin) and lighting (using mainly electricity). A possible reason for rural households spending relatively less on paraffin and electricity could be due to the greater extent to which fuelwood is used in rural households. Further most of the fuelwood utilised in rural households was largely self-collected at no cash cost, and therefore not accounted for in the household energy expenditure of rural households. The combination of locally available fuelwood and the low opportunity costs of collection labour time in rural areas could also contribute to reduced use of paraffin and electricity in rural areas (as shown in Table 4.29) and thus reduced expenditure on these fuels relative to urban areas.

Similarly to energy expenditure, the following characteristics were observed for household energy consumption:

1) electricity and paraffin consumption levels well exceeded that of other energy sources, for which consumption levels were measured
2) urban households displayed greater average monthly consumption levels of electricity and paraffin than rural households (see Table 4.29).

It must be noted that the consumption levels of the complete suite of fuels used by households could not be determined owing to the nature of the data collected, hence the absence of the consumption of fuelwood and coal from the discussion.

Greater electricity consumption by urban households (20.8 kWh for urban households versus 16.4 kWh for rural households) could be associated with more modernised lifestyles in urban areas which could involve the use of modern fuels such as electricity and the increased purchase of electricity

appliances. Further the urban sample seemed to be electrified for a longer period of time than the overall rural sample, and this could possibly have resulted in higher consumption levels. Moreover more appliances could be locally available in urban areas than rural areas, which could potentially promote consumption (Barnes et al 2005). In addition, greater consumption of electricity and paraffin in urban areas could be related to higher income levels in the urban areas relative to rural areas (as shown in Table 4.2), resulting in urban households being better able to afford to use modern fuels such as electricity as well as purchase more electrical appliances. A range of comprehensive studies support this theory (Barnes et al 2005, Cowan & Mohlakoana 2005, Dzioubinski & Chipman 1999).

With regard to candle expenditure and consumption, it is interesting to note that although candles were reported to be widely used by both the rural (consumed by 94% of rural households) and urban households (used by 72% of urban households) (Table 4.4), it was not used intensively by both categories of households, as the average monthly per capita household expenditure on candles for rural sample was R0.65 and the urban sample (R1.15). This trend was further confirmed by the small quantities of candles used on a monthly basis (Table 4.26) by both categories of households - an average of 5 candles per month were used by rural and urban households in this study, and with minimal variation between income groups across both categories of households. This relatively low expenditure and consumption of candles by households corresponds with the predominant use of electricity for lighting, which matches findings from a large body of research (ERC 2006, Madubansi & Shackleton 2006, Barnes et al 2005, Cowan & Mohlakoana 2005, Afrane-Okese 1999, Davis 1998, Eberhard & Van Horen 1995).

5.1.3 Household energy end use patterns

Cooking

The demand for energy in a household is largely determined by a range of domestic applications requiring energy such as cooking, water and space heating, lighting, media and entertainment. Cooking forms the primary energy application of a household, as it is a basic human need. In this study a range of fuels were used by both the rural and urban households to meet this energy need. Among the rural sample, the most common fuels used for cooking were fuelwood (consumed by over a third of households), followed by electricity (30% of households) and paraffin (29% of households). The perceived high costs of electricity and electrical appliances possibly serves as a major constraint towards a complete shift from other fuels to the more efficient and less polluting electricity. This is especially the case if fuelwood stocks are 1) locally and sufficiently available, 2) can be purchased at seemingly reduced prices relative to electricity and 3) the opportunity costs of collection labour time are low, especially in rural areas where low level of skills and employment prevail. This was found to be the case in numerous studies conducted on energy use in low-income households in South Africa and internationally (Barnes et al 2005, UNDP/ESMAP 2003, ITDG et al 2002, Mehlwana & Qase 1999, Eberhard & Van Horen 1995).

In the urban sample of this study the most common fuels used for cooking were paraffin used by just under two thirds of the households and electricity consumed by a third of households, with the remaining 6% of household using either LPG or fuelwood. From these figures it appears that there is large-scale substitution of fuelwood (in rural areas) with paraffin (in urban areas).

Lighting

In terms of lighting electricity appeared to be the dominant energy source for rural (96% of households) and urban (86% of household) households (Table 4.36). Studies have extensively shown that the use of electricity for lighting tends to be the preferred option for low-income households with access to electricity, the latter serving to displace the use of candles and paraffin for this purpose, since it delivers a more efficient (reduced energy use) and better quality (increased light output) service and at a cheaper cost than provided by candles and paraffin (Barnes et al 2005, ITDG et al 2002, Thom & Mohlakoana 2001, Eberhard & Van Horen 1995). The literature indicates that the low-income households once electrified tend to use electricity for lighting more extensively than for cooking (Barnes et al 2005, Eberhard & Van Horen 1995). Research has shown that the better quality of light derived from electrical lighting motivates low-income households when they have access to electricity to increase and diversify their household activities such as using light for reading, educational purposes, sewing, and entertainment (Barnes et al 2005, Eberhard & Van Horen 1995).

These findings indicate an advanced degree of 'modernisation' and 'energy transition' with respect to electricity use for lighting across both the urban and rural samples, with the urban households slightly lagging the rural households in this regard.

Water heating

With regard to water heating, similarly to cooking, the fuels used for this application differed between the rural and urban sample. In rural households, fuelwood was the dominant fuel used for this application (44% of households), followed by electricity (31% of households) and paraffin (23% of households). In the urban sample however, over half of all households used paraffin as a main water heating fuel, followed by just over a third of households that used electricity and only 3% utilised fuelwood. Fuelwood use for water heating in the rural areas was widespread, possibly due to greater availability of this resource in these areas and the fact that it could be self collected free of charge. Paraffin use dominated in the urban sample likely due to factors such as availability, cost and convenience. With regard to convenience and availability, the use of fuelwood is time consuming, even if it is available and thus households may prefer to use paraffin and electricity. Paraffin appears to be a preferred option to electricity, possibly due to it being perceived as more affordable by urban households. This perception may be driven by the fixed (administration) cost contained in each

electricity purchase, which makes it less attractive to buy in smaller quantities as compared with paraffin which has less of a financial incentive in bulk purchase.

5.1.4 Multiple fuel use

It was evident from this study that multiple fuel use was widespread across both the rural and urban sample (see Tables 4.4 and 4.49). This finding is consistent with a large body of research on household energy use by low-income households (ERC 2006, Barnes et al 2005, Davis 1998, Eberhard & Van Horen 1995.

From both the rural and urban sample electricity is used as an additional fuel, in combination with other fuels, and does not comprehensively displace other fuels. Electricity serves to rather shift the end-uses of other fuels such as paraffin from lighting to thermal applications such as cooking and heating. This reaffirms similar findings from previous household energy research conducted (ERC 2006, PDC &SCE 2003, Davis 1998).

Widespread use of paraffin prevailed among both rural and urban households alongside electricity in this study, given that a litre of paraffin costs half the minimum cost for an electricity prepayment card, and together with its associated appliances is much more versatile in its range of energy uses particularly for repeated energy intensive tasks such as cooking and heating. Moreover households are able to purchase paraffin in small amounts, depending on their cash income available at any time, thus encouraging greater uptake of paraffin relative to electricity. The preference of paraffin due to the multi-functionality of appliances for the purposes of cooking and heating was identified in White et al 1997.

Biomass fuels (eg. fuelwood and dung) were much more prevalent in the rural sample than in the urban sample, and this is most likely a result of the greater access and availability of these fuels (at no cash cost) in the rural sample. This resulted in a wider range of multiple fuel use amongst rural households.

Lastly with regard to multiple fuel use observed in this study, there was not an extensive display of secondary fuel use for cooking, lighting and water heating, especially so in the urban sample. This suggests predominant use of a single fuel for a particular end use, even though this single fuel varies across households in the rural and urban samples.

The existence of multiple fuel use as described above is a well documented phenomenon in low-income households in South Africa. While electricity has become the dominant fuel source for lighting, it is still some way off with respect to other end uses (probably for reasons of convenience, cost considerations with respect to bulk purchase and multi-functionality of paraffin appliances).

5.1.5 Appliance ownership and use

. In this study both rural and urban households revealed similar levels of ownership of a range of appliances (electric and non-electric) to carry out different end-uses or the same end-use, confirming the pattern of multiple fuel use and appliance use as evidenced by a large body of studies (ERC 2006, PDC & SCE 2003, Eberhard & Van Horen 1995). The types of electric appliances in particular that both rural and urban samples were shown to commonly own and use were related to media, cooking and convenience appliances such as kettles, iron and fridges. The only anomalous finding amongst electrical appliances was that rural households showed a greater than 15% higher ownership and use of electric irons than urban households.

Cooking appliances most commonly owned by rural and urban households alike included not only electric appliances but also paraffin appliances. In fact, there was a greater level of ownership of paraffin than electric cooking appliances. Further, it appeared that refrigeration and media appliances were predominantly electric. These patterns reveal that despite access to electricity, households use electricity for specific purposes (such as for media and refrigeration), and continue to use other fuels for energy intensive end-uses such as cooking and heating. These findings are corroborated by those of Madubansi & Shackelton 2006 and PDC & SCE 2003.

5.2 Income

5.2.1 Prevalence of fuels used

There appeared to be no striking income variation for many of the widely used fuels by both rural and urban households in this study, with the exception of fuelwood and bio-fuels. In both types of households, distinct patterns of decreased fuelwood and bio-fuel use with increasing income were observed. This trend was accentuated for bio-fuels, where its use was limited to the poorest households (belonging to Tertile 1). Such findings are also reported in studies by Prasad & Visagie (2006), Banks (2003) and Davis (1998). These trends possibly indicate that poverty is one of the major factors exerting influence on household energy use such as the use of traditional fuels - fuelwood and bio-fuels. Reliance on these fuels impose a major social, health and safety burden on these already economically impoverished households (Barnes et al 2005, ITDG et al 2002, WEO 2002). Further a households' dependence on such fuels could potentially be reduced markedly with income generation opportunities.

5.2.2 Household energy expenditure patterns

A clear trend emerged between income and total household energy expenditure in this study. There was a general increase in the average monthly household expenditure on energy as households' income increased for both the rural and urban surveyed households (Table 4.19). This finding is

corroborated by a large body of research both nationally and internationally (ERC 2006, Prasad & Visagie 2006, Barnes et al 2005, Davis 1998) The poorest rural households (Tertile 1) spent on average R8.34 per capita per month while the least poor rural households spent almost treble this amount i.e. R 22.87. Similarly the urban sample revealed poorest households spending an average monthly per capita amount of R10.56 on energy and least poor household spending just over double this amount i.e. R26.84. It is evident from these figures that average per capita energy expenditure in the rural sample is lower than that of the urban sample. This may be the result of rural households earning lower incomes than urban households as shown in Table 4.2 as well as the cost of self-collected biomass from the local surroundings not being accounted for in the household energy expenditure.

While the above trend of increasing household energy expenditure with increasing income was observed, the poorest households across both the rural and urban sample were found to be spending a higher percentage – up to two to three times as much - of their total household expenditure (14% and 26% of total household expenditure for rural and urban households respectively) on energy than higher income households (8% and 9% of total household expenditure for rural and urban households respectively) (see Table 4.20). This trend of higher energy burden amongst poorer households is consistent with other literature, and is possibly explained by a number of factors. Firstly, poorer households may have access to modern energy sources, as is the case of electricity in this study, but this energy source is perceived to be unaffordable by the poorest of households to fulfil primary and energy intensive tasks such as cooking. Hence the widespread use of the perceived more affordable fuels such as fuelwood and paraffin (for the main energy needs of cooking and heating) as highlighted in previous discussions (see Table 4.4) which also tend to be cost inefficient fuels relative to modern fuels such as electricity and LPG in meeting energy needs (Eberhard & Van Horen 1995, Barnes et al 2005). This perception ignores the fact that while self-collected fuelwood would be expected to have lower associated cash costs, the opportunity (in terms of time spent) and health costs are much higher than would be with the use of electricity. Further, due to poorer households living on unpredictable income streams, they are compelled to buy fuels such in small quantities rather than in bulk, as a result incurring higher transaction costs for these small amounts which in turn inflate the price (Barnes et al 2005, White et al. 1997, Mehlwana & Qase 1996, Eberhard & Van Horen 1995).

In terms of relationships between household income and household expenditure on individual fuels, it was evident that as income improved both rural and urban households in the study spent more on electricity and paraffin relative to other fuels used (see Table 4.19). These findings affirm those of Madubansi & Shackleton (2006), Prasad & Visagie 2006 and Davis (1998). Moreover the above result could also suggest that least poor households in this study were better able to afford these energy forms and the purchase of more appliances. Further, given that household income did not appear to have a distinct relationship with the amount spent by households on the other fuels, this could suggest that the use of electricity and paraffin is reliant on income to a great extent.

It also noteworthy that the largest energy expenditure items across all income groups for rural and urban households was independent of income, these items being electricity in rural households and paraffin in urban households. This is in line with findings by Madubansi & Shackleton (2006), Prasad & Visagie (2006) and Davis (1998).

5.2.3 Household energy end use patterns

Cooking

Electricity was used for cooking by a higher proportion of households in Tertile 3 in both the rural and urban samples. In terms of cooking among the rural sample, fuelwood was predominantly used by the poorest households as a main cooking fuel, with this prevalence of use decreasing with a corresponding increase in electricity use as a main cooking fuel in each of the higher income groups (Tertiles 2 and 3). In the urban sample, there appeared to be a shift away from paraffin to electricity for the least poor households (Table 4.32). This supports the finding of increased use of electricity for high energy consuming activities with increasing income, as per Prasad & Visagie (2006) and is perhaps evidence of some extent of energy transition.

Lighting

There appeared to be no relationship between lighting fuel used and income. Electrical lighting dominated across all income groups, which perhaps suggests that the access to electricity is all that is required for a shift of the fuel used for lighting to be electricity.

Water heating

In terms of water heating, the rural households displayed increased paraffin use with increased income and a corresponding decrease in fuelwood use. In the urban sample it was evident that least poor households displayed greater reliance on electricity relative to paraffin for water heating. Poorest households in the urban sample were dependent on predominantly paraffin for water heating.

5.2.4 Multiple fuel use

Income did not appear to have a relationship with multiple fuel use, but this is perhaps because all the households are low-income households and multiple fuel use has been identified as a low-income phenomenon in South Africa.

5.2.5 Electrical appliance ownership and use

Appliance ownership is thought in part to provide some indication of income levels and transition to complete electricity use (Annecke et al 2005). Considering that a dominant trend among all these rural and urban low-income households was the ownership of multiple cooking appliances (Table 4.57 and Table 4.61), over half of both urban and rural samples owned paraffin stoves (Table 4.57). This reflects significant poverty implications. It is apparent from Table 4.57 that the majority of the sampled rural and urban households use “paraffin flame stoves” which are very cheap and unsafe

wick-stoves where the paraffin reservoir of the stove is prone to heat up to levels exceeding the flashpoint temperature, such that when knocked over has the tendency to explode, resulting in often uncontrollable fires (Lloyd 2002). This is particularly detrimental in the situation of densely settled informal areas (typical of the urban sample of this study), where the flammability of the shack building materials and close proximity of the houses encourages the rapid spread of fire through a settlement often razing the entire settlement to the ground (Kruger 2005). The consequences of such fires are severe economic impoverishment through the loss of homes, material possessions and interruption in economic activities (Cowan & Mohlakoana 2005, Kruger 2005). They are also a significant cause of death – nationally burns are the fourth largest cause of death of children under 14 years of age (SEA 2003).

From the data it appeared that electrical appliance ownership and use increased as household incomes rose. Cell phone chargers were among the appliances that revealed increased ownership in the least poor households. Similar findings were identified by Cowan & Mohlakoana (2005) in their study in a Khayelitsha a Cape Town township. Ownership and use could be attributed to low levels of landline availability (or adoption) as well as accessibility of cell phones even with households with relatively low incomes. Cell phones appear to be of a high priority amongst low-income households.

Cell phone charger ownership and use were equally common in the urban and rural samples and this contradicts a finding in Prasad (2005) where the ownership and use was markedly higher in urban households.

5.3 Household size

Even though there is a strong correlation between income and household size, as shown in Figure 6 (Section 4.1.1.1), the interactions with the fuel use patterns examined do not entirely coincide with the corresponding interactions between income and fuel use patterns. This suggests that there are at least some effects of each of these socio-demographic features which are independently (of each other) associated with household fuel use patterns.

5.3.1 Prevalence of fuels used

In this study, household size appeared to show some interaction with some of the energy sources used, namely fuelwood, bio-fuels and dry cell batteries, used by low-income electrified households. Larger households in both the rural and urban sample displayed a higher prevalence for the use of more polluting and less efficient traditional fuels i.e. fuelwood and bio-fuel use than smaller households which showed greater uptake of modern, cleaner and efficient fuels such as electricity and paraffin. Further these households in both samples showed a greater tendency to purchase fuelwood, than smaller households.

Larger households require more energy to fulfil the energy needs of more people, hence apart from the more modern fuels such as electricity and paraffin that they use, they also utilise traditional fuels as they often more affordable than the more modern fuels, especially when per capita income of larger households is lower than smaller households (Figure 5). Another possible reason for greater use of these traditional fuels by larger households is that due to lower incomes, opportunity costs associated with household labour and time required to collect these fuels could possibly be lower. These findings to an extent corroborate those of Barnes et al (2005), who found from a multi-country household energy study that larger urban households more commonly used traditional fuels than smaller households that tended to use more modern fuels. The authors of this study attributed lack of time to maintain cooking fires as one of the reasons smaller households in an urban context choose not to regularly utilise traditional fuels. They also cited lower per capita incomes among larger households and therefore lower opportunity cost of labour as reasons for a greater proportion of large households utilising traditional fuels.

5.3.2 Household energy expenditure patterns

Clear and identical trends emerged for household energy expenditure and household energy consumption in relation to household size (See Table 4.22 and 4.27). Average monthly household per capita energy expenditure and energy consumption showed a sharp decline with increasing size of all households surveyed. This supports the findings of research by UNDP/ESMAP (2003) and Baranzini & Goldemberg (1996) and that indicated household energy use reflects economies of scale with increasing household size. Therefore, while total energy consumption usually increases with household size, per capita energy consumption may lessen. This result may be somewhat exaggerated by the fact that the larger household sizes tend to be poorest households (see Figure 6) which may have a lower demand for energy.

Further, the average household size decreased with increasing per capita income for both categories of households in this study (see Figure 6). Hence smaller households with higher incomes are better able to afford the use of modern fuels such as electricity and paraffin as revealed in this study with smaller households incurring higher energy expenditures.

5.3.3 Household energy end use patterns

Cooking

Among the rural sample where fuelwood, paraffin and electricity were most commonly used fuels for cooking across all household size categories, with distinct variations emerging for paraffin and fuelwood in relation to household size. There was a marked decline in the proportion of households who used paraffin as a cooking fuel as household size increased, while the incidence of fuelwood use for cooking increased with increasing household size. It is therefore evident that larger rural

households which also tend to be the most impoverished (as shown in Figure 6) therefore displayed greater reliance on the cheaper and more polluting fuelwood than modern fuels such as paraffin.

In the urban sample, trends between household size and electricity and paraffin – the latter being the two main cooking fuels used by these households – were clearly evident. There was marked increase in the proportion of households that used electricity as a main cooking fuel as household sizes grew, while a decline in the percentage of households consuming paraffin as a main cooking fuel occurred as households grew in size. From these results (see Table 4.33) there appeared to be a substitution effect of electricity for paraffin to a certain extent as households grew in size. This finding is consistent with the results of a study on household fuel use undertaken in Guatemala (UNDP/ESMAP 2003).

Lighting

Again, there was little variation across household size. Electricity was the main fuel used across all household sizes.

Water heating

In the rural sample with increasing household size there appeared to be a shift away from paraffin to largely fuelwood and to a smaller extent to electricity. In the rural areas this shift to mainly fuelwood for water heating as household size increased could be due to affordability constraints, as large households were observed to have lower incomes relative to smaller households. With regard to water heating, within the urban sample, there were signs of a shift away from paraffin to electricity with increasing household size.

5.3.4 Multiple fuel use

Household size did not appear to have a relationship with multiple fuel use.

5.3.5 Electrical appliance ownership and use

In both the rural and urban samples, electrical ironing appliance ownership and use was higher in the largest household size category which is likely an indication of a benefit of economies of scale.

In the rural sample, there was also an increase in electrical ironing appliance ownership and use with increasing size of household, with the largest household size category having the lowest levels of ownership and use of electrical refrigeration appliances.

In the urban sample, on the other hand, increasing household size further predicted higher ownership and use of media appliances, with the largest household size category also showing highest rates of ownership and use of electric kettles and cell phone chargers.

No previous literature was found which examined the interaction between household size and electrical appliance ownership.

5.4 Gender composition of household

Predominant gender composition of a household appeared to have less predictive effect on fuel use patterns than area, income, household size and education level of household. In particular there was only a weak predictive effect with regard to the prevalence of fuels used and electrical appliance ownership and use.

5.4.1 Prevalence of fuels used

Among the range of fuels commonly used by electrified households in the study, the only variations found between fuel use and gender composition of household, were with fuelwood and in particular the gender composition of urban sampled households. There appeared to be no relationship between prevalence of fuelwood use and gender composition of rural sampled households, while in urban households almost three times as many households with a higher proportion of females (26% of households) self –collected fuelwood relative to households comprising predominantly of males. This finding is weak relative to those affirmed by a large body of research pointing to gender playing an important role in household fuel procurement patterns (Annecke 2003, Davis 1998, Eberhard & Van Horen 1995, Makan 1994). Perhaps the choice of variable in this study (splitting only on the 50th percentile) did not sufficiently differentiate on gender composition of household (as perhaps a split into tertiles may have, for example) for these previously identified trends to emerge more strongly. Research has generally shown that women generally manage the household and are the primary end-users of energy, with the result that the arduous task of wood collection falls to women and children. Studies have shown that women spend up to 15 hours a week collecting fuelwood. Despite there usually being no monetary value associated with fuelwood collection from the local surrounds, this undervalued and unpaid service bears an enormous physical and social cost. Although fuelwood is largely collected for 'free', a large opportunity cost is borne, in that opportunities for women to engage in other essential activities such as farming, education, child rearing and entertainment are severely restricted, as fuelwood collection is time consuming. Further there are major negative health impacts associate with fuelwood collection (Annecke 2001).

5.4.2 Electrical appliance ownership and use

In the rural sample, gender composition of the household appeared to have little predictive effect on electrical appliance ownership and use, except that electrical audio media appliance ownerhip and use was higher in in male predominant households. This finding is consistent with that of Eberhard & Van Horen (1995), who showed that media services (radios and television) tend to be largely controlled by men in the household.

In the urban sample, female predominant households showed greater predictive effects of electrical appliance ownership and use of all electrical appliances, with the exception of cell phone chargers and media appliances. This is again consistent with findings from Eberhard & Van Horen (1995).

5.5 Age

The average age of a household appeared to have less predictive effect on fuel use patterns than area, income, household size and education level of household. In particular there was only a weak predictive effect with regard to the prevalence of fuels used.

5.5.1 Prevalence of fuels used

Relationships were found to emerge between average age of the household and the prevalence of fuelwood, biofuels and dry cell battery use. In terms of fuelwood use, the average age of rural households appeared to be independent of fuelwood use, while among the urban households, fuelwood use was found to be more extensive among the 22-27 year average age category of households. This could perhaps be attributed to the age at which members are physically able and were available at the time of the survey in the household to procure fuelwood through self-collection from the local surrounds.

With regard to bio-fuels, a pattern emerged among the rural sample of the study, where a higher proportion of rural households comprising mainly of children reported bio-fuel use relative to rural households comprising of older household members. This corroborates findings of widely documented research indicating that biomass collection tend to be largely the task borne by women and children, (Annecke 2001, UNDP 2000;). Hence rural households in the study, where children are the main presence in the household, serve as a 'free' labour source in gathering bio-fuels for the household.

In terms of dry cell battery use, among the few households using this energy source in both the rural and urban sample, it was found that its use occurred least in households in the youngest average age category of 0-21 years old. This could possibly be due to most of new audio media appliances purchased (which previously in the absence of electrification would have been dry cell battery driven), now being electricity dependent.

5.6 Education

5.6.1 Prevalence of fuels used

Research has indicated that household members with the highest level of formal education could influence decision-making relating to energy consumption in the home (UNDP/ESMAP 2003). Differences in levels of education could influence job opportunities for household members and in turn influence their income, and consequently could be a significant driver in household energy decision making.

In terms of variation of the range of fuels commonly used by low income electrified urban and rural households with highest level education of household members, fuelwood emerged as the only fuel

showing some relationship with education levels of households in the study. Fuelwood use appeared to be independent of highest level of education for urban households, while for rural households its use appeared to be closely associated with those of lower levels of education. The latter relationship could possibly be attributed to household members in the rural areas with lower levels of education finding it less likely to find employment in the formal economy on a regular basis and with little and infrequent income are consequently unable to afford modern energy sources. Moreover lower levels of education mean low skill levels and therefore fewer available opportunities for employment (and income) which all contribute to low opportunity costs of fuelwood collection labour time, hence greater uptake of fuelwood relative to modern commercial fuels. Household members with low levels of education could imply that these households were composed mainly of children, who would in turn serve as 'free' labour (low opportunity cost) in collecting 'free' fuel from the local surrounds. Hence for the above reasons these households remain heavily reliant on fuelwood, which is much more accessible in rural areas than urban areas in that they can gather it for 'free' (at no cash cost) from the local surrounds.

The corollary of the above finding implies that households in the rural sample with the highest level of highest level of education displayed a higher incidence of being non-woodusers, possibly signalling that a shift away from biomass fuels such as fuelwood towards cleaner and more efficient modern fuels such as paraffin occurs with higher levels of education.

However no clear relationship emerged between electricity and education, since all surveyed households were electrified through the national electrification programme.

5.6.2 Household energy expenditure patterns

Across both the rural and urban sample, total household energy expenditure appeared to increase with increasing levels of education of households. This could possibly be attributed to higher education levels of household members yielding greater opportunities for formal employment and income generation, resulting in households having improved incomes and therefore better able to afford the use of modern fuels such as electricity and paraffin and associated appliances and to a greater extent. Further higher education levels could have the effect of rising opportunity costs of fuelwood collection time, motivating households to use more expensive fuels such as electricity and paraffin for meeting their energy needs. Higher education levels could also play a part in changing fuel preferences i.e. households with higher education preferring to use cleaner and more efficient modern fuels (UNDP/ESMAP 2003).

5.6.3 Household energy end use patterns

Cooking

Among the urban households in this study, variations were evident between levels of education of a household and the main cooking fuels used by the households i.e. paraffin and electricity. With regard

to electricity, prevalence of use increased almost two fold between household in the lowest (24% of households) and highest education (42% of households) categories. Paraffin however showed a slight decline in use between education categories, with close to 10% fewer households consuming it for cooking in the highest education (55% of households) category relative to the households in the lowest education category (64% of household). These patterns as explained for expenditure patterns could possibly be attributed to the benefits of higher levels of education, yielding greater awareness, resourcefulness and perhaps even opportunities for improved income, thereby rendering households with higher levels of education more likely to use modern and efficient fuels such as electricity.

Lighting

In terms of lighting, among the rural sample there appeared to be no clear trends between highest level of education and main lighting fuel except that the highest use of electrical lighting occurred in the households with highest education category. In the urban sample, however clear trends were evident indicating increasing use of electrical lighting with increasing level of education of the household. In general among both the rural and urban sample, it appeared that there was shift way from other fuels to electricity for lighting among households with higher levels of education.

With regard to water heating fuels used, in the case of the rural households, while fuelwood use was widespread across all education categories of households, electricity use increased and paraffin use decreased concomitantly with increasing level of education of household. This possibly suggests that fuelwood was most preferred given that it was most affordable in the sense that it could be collected free of ‘charge, and these were low-income households. However increased education levels could have prompted a change in fuel preferences in favour of a cleaner and more efficient modern fuel in the form of electricity for water heating.

Water heating

In the urban sample clear trends emerged with respect to education levels of households and water heating fuels used. Use of electricity as a main water heating fuels increased with increasing level of education of household, while paraffin use declined with increasing education levels of households. This again could possibly be related to higher education levels possibly resulting in a change of fuel preference to clean and more efficient modern fuels such as electricity. Further households with higher education levels possibly also have higher incomes, resulting in being able to afford greater use of electricity and related appliances.

None of the literature reviewed contained as detailed an analysis of the interactions between level of education of a household and fuels used for each end use.

5.6.4 Multiple fuel use

Level of education of household did not appear to have a relationship with multiple fuel use for these low-income rural and urban households.

5.6.5 Electrical appliance ownership and use

The ownership and use of electrical irons increased with increasing highest level of education and the highest education level category showed the highest levels of electrical cooking appliance and cell phone charger ownership and use, while electrical kettle ownership and use was lowest in the households with the lowest level of highest level of education.

None of the literature reviewed contained as detailed an analysis of the interactions between level of education of a household and fuels used for each end use.

CHAPTER 6: CONCLUSIONS

Household energy use patterns differ greatly between rural and urban areas.

The most striking difference in the prevalence of fuel use was that fuelwood use is substantially more widespread in rural areas. This is likely due to wood being more available and cheaper, the latter being mainly as a result of it often being self-collected at no cash cost. This pattern of use of 'cheap' (in monetary terms) fuel is further reflected by the markedly higher prevalence of bio-fuel (mainly dung and crop residues) in rural areas. These patterns may explain why the energy burden (the proportion of household expenditure spent on energy) borne by urban households was higher than for those in rural areas. In both cases though, the energy burden was significantly higher in these low income households than is experienced by middle and high income households in South Africa.

While the prevalence of electricity and paraffin use (across households) is similar in rural and urban areas, the per capita consumption was higher for both in urban areas. Again, this probably reflects the substitution of fuelwood for these fuels, chiefly paraffin, in rural households.

This substitution effect is further illustrated by the fact that while almost all of the urban households use electricity and paraffin as their main fuels for cooking and water heating, a slightly lower proportion of rural households use electricity for these end uses, with paraffin being used by a substantially lower proportion. This decrease in the proportions of households using electricity and paraffin corresponds to the very large increase in the proportion of households using firewood in rural areas for these end uses.

Electricity is almost totally dominant as the fuel used for lighting in both the electrified rural and urban households in this study.

Multiple fuel use is widespread in both rural and urban areas, although to a larger extent in the rural areas because of the cheap availability and use of biomass fuels. This larger incidence of multiple fuel use in rural areas is further illustrated when looking at secondary fuels used for the main end-uses, where for all of cooking, lighting and water heating there was a considerably higher prevalence of second fuels being used for these end-uses in rural areas.

In spite of much higher electricity and paraffin consumption in urban areas, there is no large scale difference in electrical and paraffin appliance ownership and use across the rural and urban samples. This possibly suggests that access to appliances is not a major driver of fuel use patterns in low-income households.

Household energy use patterns also show significant variation with household income. The least poor households are less likely to use fuelwood and bio-fuels than poorer households in both rural and urban areas.

Even though the prevalence of electricity and paraffin use show little variation across income groups, the expenditure and consumption of these fuels increases greatly with increasing income. Moreover, while energy expenditure and consumption both increase with increasing household income, the energy burden in fact decreases.

The increasing paraffin and electricity consumption with increasing income is further reflected in the choice of main cooking fuel in rural areas, with electricity and paraffin becoming more frequent choices in least poor households. In urban areas electricity is used more by least poor households than paraffin for cooking. These patterns of increasing choice of paraffin in rural areas and decreasing choice of paraffin in urban areas with increasing income persist with respect to households' choice of main water heating fuel.

Multiple fuel use has very little relationship with income (extent of poverty) in low-income households.

Appliance ownership and use, as one might expect, has a close relationship to household income. Even if not true for every type of appliance, the overall trend is an increase in ownership and use with increasing household income.

Household energy use patterns display significant variation by household size. The smallest households are less likely to use fuelwood and bio-fuels than larger households. While the prevalence of electricity and paraffin use shows little variation across household size categories, economies of scale result in the per capita expenditure and consumption of these fuels decreasing considerably as household size increases. Choosing fuelwood as a main cooking or water heating fuel in rural households increases with increasing household size. This increase is mostly balanced by decreasing choice of paraffin (and to much less of extent, electricity) for these end-uses with increasing household size. In urban areas the electricity is chosen more by larger households for cooking and water heating, with corresponding drops in the choice of paraffin for these end uses. The increase in the use of electricity with increasing size of households for these end-uses only in the urban areas may reflect some combination of a better ability to achieve economies of scale in these areas as well as a lack of fuelwood resources. These explanations are further supported by the tendency for increased ownership of electrical appliances in larger households.

Average age of household bears little relationship with household energy use. One relationship that emerges is that rural households of younger age categories report higher prevalence of bio-fuel use than households with older average ages. The only other pattern that is evident is that the choice of fuelwood as a main cooking fuel decreases with increasing average age, with the corresponding increase in the choice of paraffin for this application.

Household energy use does not show a strong interaction with the predominance of one gender in a household. However there is some variation in electrical appliance ownership and use by gender

composition of household, with urban households where females are in the majority showing higher levels of ownership of electrical appliances (to a substantial degree in the cases of cooking, ironing and refrigeration appliances), with the notable exceptions of media appliances and cell phone chargers.

As part of the South African government plan to redress inequities and promote sustainable development in the country, numerous policies and strategies to increase access of low-income households to electricity and to make the use of electricity more affordable have been a high priority.

This study and other literature show that despite being electrified and hence having better quality and safer lighting, poor households continue to use and direct a large proportion of their energy budget towards other fuels such as fuelwood and other biomass fuels and paraffin for their thermal energy needs.

The continued reliance on fuelwood across all income groups in low-income rural households (and especially amongst the most poor households) remains an issue of grave concern, especially because the combustion of fuelwood gives rise to indoor air pollution which negatively impacts the health of women and children.

Thus, energy policy planning should adopt an integrated approach rather than solely focussing on electricity i.e. it should accept that other fuels (especially fuelwood and paraffin) will for the foreseeable future still play an important role in low-income household energy use and that this begs for resources to be directed at improving the safety and efficiency with which these fuels are used. It is imperative that government's means and efforts also focus on interventions that address the thermal energy needs of low-income households. In the absence thereof, the critical issues of poverty, health, safety and household energy security will not be adequately addressed.

Another key conclusion of this study is that while there is detailed reasearch (such as this) giving insights into localised situations and household fuel use patterns, there is not a comprehensively national energy use surveillance system to inform policy and measure it's success with sufficient accuracy.

Finally, it is most evident from this study that household demographic and socio-economic characteristics appear to be good predictors of household energy use patterns. Designing energy policy and interventionist strategies to effect changes in these patterns to enhance the energy welfare of low-income households should include a good understanding of these interrelated patterns. Such understanding may be further enhanced by determinant studies which would allow an exploration of the interaction of these factors with each other and with fuel use and may identify any causal relationships.

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APPENDIX 1

Glossary of Terms

Energy poverty – A lack of choice in accessing adequate, reliable, good quality, safe and environmentally benign energy services to sustain economic and human well-being.

Energy burden – The share (%) of total household expenditure on energy, which gives an indication of the amount of money spent on different sources of energy in comparison to other household expenditure items.

Poverty line – A threshold level of money income required to achieve a basic minimum standard of living satisfy i.e. enough to purchase nutritional food and to provide for other basic needs. A poverty line of R322 per capita per month (in 2000 prices) has been estimated for South Africa, below which all individuals are considered to be living in poverty.

Compact ready boards – Low cost electrical unit comprising a bulb or bulb holder, sockets and circuit breaker, used to install electricity in households without the necessity of wiring.

Pre-payment meter – Meters enabling consumers to purchase electricity in advance from vending stations, with payment balances decreasing as electricity is consumed. Most meters have display units that show the amount of electricity available.