A Synthesis Report on Biomass Energy Consumption and Availability in South Africa

A report prepared for

ProBEC

by

by Dr Oliver Damm and Ralph Triebel

LHA Management Consultants

February 2008

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Programme for Basic Energy and Conservation (ProBEC) is a regional programme implemented by the German Agency for Technical Cooperation (GTZ) in the SADC region. The programme aims to promote and implement projects related to the improved and sustainable use of energy in low-income households, through market development and policy support. It targets both urban and rural households and small businesses that depend on biomass energy such as fuelwood and crop residues for heating and cooking purposes. Some of the ProBEC interventions have included the introduction of more energy efficient appliances (e.g. efficient wood stoves), efficient fuelwood and kitchen management, and conversion to other renewable energy sources such as solar cookers.

A desk top study was conducted of available information with the aim of compiling a synthesis report on biomass energy consumption and availability in South Africa. The main focus was on the domestic consumption of fuelwood, since most rural households depend on this energy source.

The bulk of South Africa's poor are concentrated in the wooded biomes, especially woodlands, in Limpopo, KwaZulu Natal, and the Eastern Cape. Over 80% of these rural households depend on fuelwood as their primary source of energy. Fuelwood supply can be attributed to a number of sources and their contribution to total supply is estimated as follows: natural woodlands (60%), commercial plantations (9%), indigenous forests (2%), woodlots (4%), trees outside forests (13%), processed waste (9%), and clearing of alien invasive species (3%). On a national and regional scale, sustainable annual production of fuelwood is probably sufficient to meet annual demand. However, local shortages can and do arise due to over harvesting and changes in land use.

On the demand side, residential energy consumption accounts for some 18% of national energy demand. The fuelwood market is diffuse and therefore the best estimates of usage are considered to be those from large scale national surveys, i.e. the regular Census and Household surveys conducted by Statistics

SA. Total demand for fuelwood is estimated at 11.2 million tons per annum, which is equivalent to 40% of residential energy demand. The number of households that depend on fuelwood as their main energy source is estimated at 2.3 – 2.8 million, the majority of which are located in rural areas. This represents some 12 – 15 million people or 25 – 30% of the South African population, according to our best estimates.

Fuelwood use is concentrated in the poorer provinces with large rural populations, i.e. Limpopo, KwaZulu Natal, Eastern Cape, and North West. Fuelwood is mainly used for energy hungry activities such as cooking, water heating and space heating. Individual households use between 1 and 7 tons of fuelwood per annum. Based on a study of available localised energy surveys, our best estimate for the average annual fuelwood consumption is 4.5 tons per household. There is a tendency to use more wood in colder areas and during winter compared to summer, but this effect appears to be relatively small, since space heating is largely combined with cooking or water heating.

Fuelwood is a valuable resource and its gross direct use value to rural households is estimated in this study at R4.5 – 5.5 billion per annum. This is somewhat higher than the R3 – 4 billion that is usually quoted in the literature.

An analysis of future demand trends suggests that the rural population has remained fairly stable in recent years due to the combined effects of lower population growth rates, HIV/AIDS, and urbanisation / migration. Therefore, it is concluded that fuelwood demand has most likely peaked and will stabilise and eventually decline in the future.

Electrification is an important driver for rural households to move up the energy ladder, i.e. from fuelwood and other biomass to intermediate energy sources and modern energy, i.e. electricity. However, even recently electrified rural households continue to use fuelwood for years for affordability reasons, as a primary energy source for cooking and heating or as a safety-net in times when money is tight. Moreover, the more sparsely populated rural areas are presently uneconomical to electrify. Therefore, fuelwood will continue to play a dominant role in energy security for rural households.

There is a strong gender dimension to the fuelwood issue. The collection of fuelwood as well as other household chores like cooking and carrying of water are the responsibility of women and children. Therefore, women and children bear the brunt of the negative aspects of fuelwood use, i.e. risk of injury due to the heavy head loads, health risks due to continuous exposure to wood smoke at levels well above international norms, and the opportunity cost related to the time spent in collecting fuelwood and other menial tasks. Any successful intervention to strengthen the role of energy in sustainable development must therefore take into account the particular needs and problems experienced by rural women.

A review of the literature has shown that the fundamental issues regarding fuelwood have not changed. Rural households will continue to depend on fuelwood for decades to come, and therefore the fuelwood resource must be managed actively and with a long term vision. Relatively little is known about the sustainability of present patterns of fuelwood usage and extraction, and further research in this regard would be valuable. Any future fuelwood initiative should also take note of and incorporate the learning from the Biomass Initiative (Department of Minerals and Energy, 1992), which sought to improve the fuelwood supply through community forestry and afforestation pilot projects.

It is recommended that further detailed studies at the local level should receive relatively low priority, since good quality data requires large surveys. Cooperation should be sought with Statistics SA to ensure that the relevant information relating to household energy use, and fuelwood use in particular, is obtained during the regular Census and Household surveys.
Nevertheless, a more rigorous study to better understand the drivers of demand could also be undertaken, as empirical data is scant on this topic. Typical drivers that should receive attention are temperature (i.e. impact on fuelwood use of seasonal and local climate variations), human population densities, and resource availability.

Application oriented research is also required in two areas. On the supply side, research should be conducted on wood species that provide low smoke fuel and, even more appropriate, low smoke fuel combined with other uses such as food security. On the demand side, it is surprising that more efficient technologies such as improved wood stoves and solar cookers have not made greater inroads into rural households. Application oriented research and pilot projects should be conducted on the most effective introduction of these appliances. In this regard particular attention must also be paid to maintenance back-up of the appliances.

1. PROJECT BACKGROUND AND CONTEXT

1.1 General Background

The Programme for Basic Energy and Conservation (ProBEC) is a regional programme implemented by the German Agency for Technical Cooperation (GTZ) in the SADC region. The programme aims to promote and implement projects related to the improved and sustainable use of energy in low-income households, through market development and policy support. It targets both urban and rural households and small businesses that depend on biomass energy such as fuelwood and crop residues for heating and cooking purposes. Some of the ProBEC interventions have included the introduction of more energy efficient appliances (e.g. efficient wood stoves), efficient fuelwood and kitchen management, and conversion to other renewable energy sources such as solar cookers.

In South Africa, the majority of the rural population is poor and depends on low cost biomass fuels and particularly fuelwood for everyday heating and cooking activities. With increasing urbanisation and one of the most aggressive electrification drives in the world, the pattern of household energy use has been changing over the past ten years or so. Nevertheless, it is clear that fuelwood will remain an important energy source in rural areas for decades to come, for reasons of affordability and remoteness from grid electricity supplies. Initiatives to improve the sustainable use of biomass energy resources and to mitigate the associated negative effects such as pollution and health problems will therefore remain relevant and important, although the focus of these initiatives may have to be amended.

Against this background and in preparation for a workshop on low income household energy held towards the end of February 2008, GTZ engaged LHA Management Consultants to conduct a study on the status of biomass fuel use in South Africa, with particular focus on fuelwood.

1.2 Project Objectives and Scope

The primary objective of the project was to compile a synthesis report on biomass energy consumption and availability in South Africa. The scope of work required included:

- Comment on the status of biomass supply and demand in South Africa, related specifically to the household sector;
- Synthesize existing data and extrapolate to provide information on:
  - Household energy consumption patterns;
  - Total household consumption of biomass energy;
  - Consumption of biomass by end-use (i.e. cooking, heating, lighting, etc.);
  - Proportion of South Africans dependent on biomass energy in rural and urban areas;
  - Gender issues related to biomass energy;
  - Indicators of scarcity, e.g. price trends, time spent collecting fuelwood, etc.

2. METHODOLOGY

In terms of the brief, the approach to this work involved desk-top research of existing and available information relevant to the topic. In meeting the required objectives and outputs, the work addressed the following issues:

- Sourcing of information and analysis of relevant previous work done on biomass and fuelwood. Information on other biomass sources such as dung and crop residue was considered where appropriate and available.
- The broader energy sector and trends in the development and use of different energy sources that impact on the current and future supply / demand balance of domestic fuelwood. Issues of particular interest included the apparent developing shortage of wood products as well as

conventional electricity, versus increasing focus by government and the public sector on alternative energy sources (cf. White Paper on Renewable Energy, 2003).

- Demographic trends such as rapid urbanisation, population growth and migration patterns, trends in electrification and housing provision, etc. and their influence on biomass fuel demand.
- Gaps in existing data and recommendations on possible new primary data collection;
- New research required to better understand the role of biomass in the household energy sector; and
- Modelling of key indicators to establish a plausible current biomass consumption level in South Africa.

The present document outlines the findings of the study.

3. BIOMASS IN SOUTH AFRICA'S ENERGY MIX

The White Paper on Renewable Energy (Department of Minerals and Energy , 2003) identified biomass, together with solar, wind, hydro, tidal and other sources, as an important form of renewable energy. Renewable energy is broadly defined as naturally occurring non-depleteable sources of energy, to produce electricity, fuels, heat or a combination of these energy types.

The best known sources of biomass are fuelwood in the rural domestic sector, bagasse in the sugar industry, and pulp and paper waste in the paper sector. Other lesser known types include crops such as maize, sunflowers and the Jatropha tree (there was no reference to Castor beans), organic components in municipal and industrial waste, and landfill gas. Internationally, the use of biomass as a fuel source for sustainable energy systems is growing in importance. In South Africa, about 9% of SA's energy mix is renewable energy, with fuelwood very prominent, particularly in the rural household sector. In the figure below the total potential biomass energy is presented as modelled by the Renewable Resource Database (RRDB). Of particular note are the high energy densities around the commercial plantations, and around sugar, wood and pulp mills.

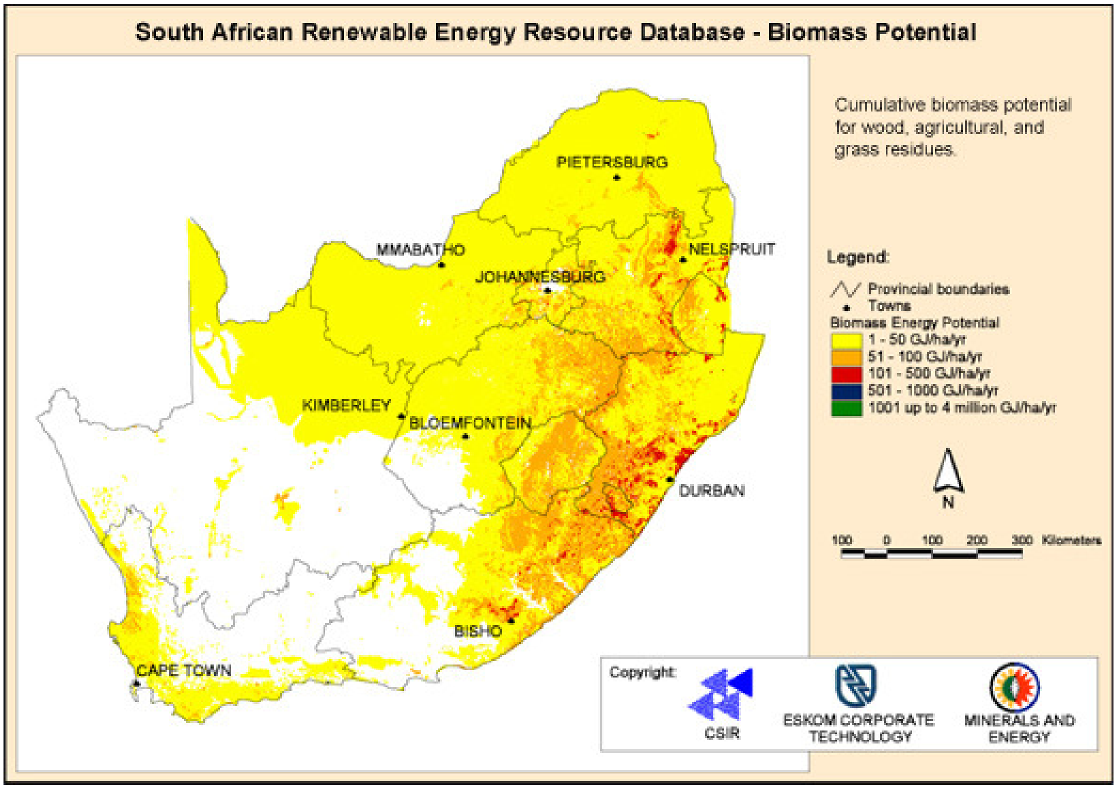


Figure 3.1: Total biomass energy potential for South Africa (DME, Eskom, Centre for Scientific Research , 2001)

The status of fuelwood as a renewable source is debatable, given that in many parts of the country demand exceeds supply, leading to environmental degradation caused by unsustainable harvesting and clearing of land for agricultural and residential purposes. Targeted intervention in these areas to manage the various resources for the benefit of rural households is recognised in the White Paper on Energy Policy, however, this is a difficult task.

Over 80% of rural households use fuelwood as their primary source of energy. Best estimates indicate total use at about 11.2 million tons annually, with the bulk taken from woodlands, commercial plantations and trees outside forests (Shackleton *et al* 2004). This fuelwood has a gross national value of approximately R3 billion annually or, for those using fuelwood, just under R2 000 per household per year (Williams, *et* al, 2002). The likely supply situation of fuelwood in South Africa is highlighted in more detail in the following section.

4. BIOMASS SUPPLY

The prominence of fuelwood in the rural household energy sector is universally recognised. The supply sources are varied, and are discussed in more detail below in order to arrive at an approximation of annual supply. Given that fuelwood harvesting is generally a non-commercial activity and therefore the concept of yield in many cases inappropriate (in commercial forestry yield refers to the annual sustainable availability of timber from a hectare of plantations in rotation), the quantification of supply is at best a broad approximation.

The status of fuelwood energy supply can be summarised as follows:

1. ***Natural woodlands:*** The primary source of fuelwood is from the woodland biome that covers an estimated 42 million hectares or 34% of South Africa (Thompson, *et* al, 2001), of which 11% is partially transformed and 10% totally transformed to agricultural production. Approximately 9.2 million people live in South Africa's woodland areas, and depend upon the goods and services that they provide for some component of their livelihood (Shackleton, *et* al, 2001). Woodlands are characterised by a co-dominance of trees and grasses. Approximately one quarter of the woodland biome is zoned as communal land, and over 70% of the former homelands are in the woodland biome. Virtually all the tree species in woodlands can be used for fuelwood or charcoal manufacture, although there are distinct cultural preference for some species and rejection of others. The smaller-dimension branches are preferred, since they are easier to cut and carry, and dead wood is preferred

to live wood. The majority of preferred species coppice after cutting.

It is estimated that the total annual supply of useable fuelwood ranges between 6 and 7 million tons. This is based on an average figure for annual fuelwood production on natural woodlands of 200 kg per hectare. The range of values that resulted from studies on the annual harvestable production of dead wood and sustainable utilisation of woody vegetation (Shackleton, 1998: Rademan, 2005) lie between 80 kg to 590 kg per hectare per year.

2. ***Commercial plantations:*** Plantations cover approximately 1.35 million hectares of South Africa, mainly in the moister areas (> 800 mm p.a.) Over 80% of them are located in only three provinces, namely Mpumalanga (40%), KwaZulu-Natal (39%) and the Eastern Cape (11%). These plantations produce an estimated 20 million tons annually (LHA, 2004) for commercial production and a further estimated one million tons of fuelwood originate from commercial plantations (LHA, 2007).

3. ***Indigenous forests:*** These forests constitute the smallest biome in South Africa, covering approximately 350 000 hectares. The majority of forest patches are less than 10 hectares, but many rural communities living adjacent to indigenous forests extract fuelwood and other resources from these forests.

4. ***Woodlots:*** A very small area of the plantation resource is managed as woodlots for local consumption, under the nominal control or responsibility of tribal authorities and local government. Best estimates of the extent of woodlots in South Africa are approximately 50 000 hectares and it can be assumed that around 0.5 million tons of fuelwood is supplied from this resource base.

5. ***Trees outside forests:*** They are an often overlooked component of the national forest resource. Trees on farms represent an important asset for many farmers where they may be used for crop shade, fodder, live fencing or fuelwood. Agroforestry systems,

although not specifically identified by the name, are already practised by many farmers.

Trees are a significant feature in villages, towns and cities throughout the country, where they make an important contribution to the well-being of the urban population. Some 75% of households in villages, townships and peri-urban settlements plant trees in their homesteads, with 40% being indigenous trees used for shade and medicinal or spiritual purposes, 40% exotic fruit bearing species and the remainder are exotic trees used for construction and fuelwood, or for ornamental purposes. The scale of active management of such trees is barely known, yet there is no doubting that poor households plant a range of trees – millions of individual plants – to contribute to their various needs (Sesikhona Services, 2005).

6. ***Processed waste:*** Considerable volumes of off-cuts are available from more than 200 sawmills, located mainly in rural areas, and furniture and other downstream timber products manufacturers. Based on an industry log intake of 5 million tons, the waste output could easily range up to 0.5 million tons (LHA, 2007).

7. ***Clearing of alien invasive species:*** The Working for Water Programme has increased short-term supplies of fuelwood in many areas, but in the long run may exacerbate energy poverty in areas reliant in alien species for the bulk of their fuelwood needs.

Given best available estimates, the annual fuelwood supply situation in South Africa is summarised in the following below.

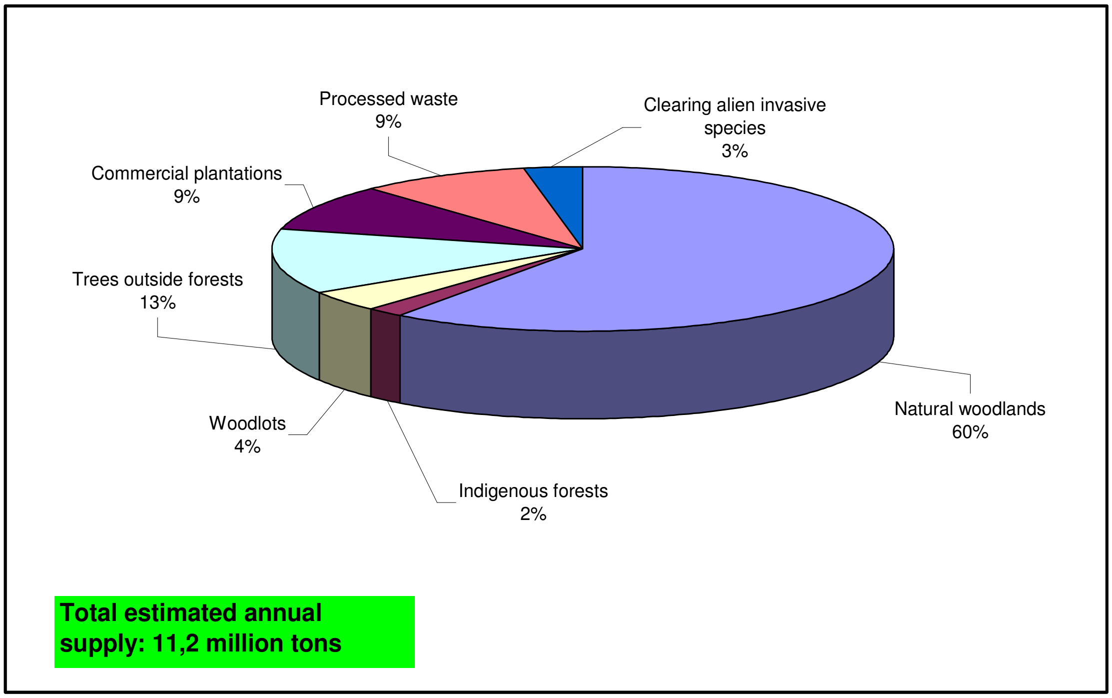


Figure 4.1: Estimated Fuelwood Supply in South Africa (LHA, 2008)

At a national scale sustainable annual production of fuelwood is probably sufficient to meet annual demand. However, at local scales the situation is extremely variable, with some communities and households enjoying adequate supplies within easy collection distance, whilst many rural households have to walk several kilometres to access very meagre supplies and of poor quality species. Others still have no local access to fuelwood supplies and either buy fuelwood and/or substitute it with other fuels such as dung or paraffin.

There is an increasing network of informal fuelwood markets, where small-scale traders harvest and transport wood from areas of adequate or excess supply to areas of shortage. These fuelwood markets help alleviate energy poverty in some areas, and provide local employment. However, in some places these commercial activities undermine local fuelwood security by steadily reducing the biomass resource available to domestic users. Local and traditional institutions are generally weak and unable to manage, guide or police local woody resources and harvesting. There has been a sharp increase in reported incidence since 1994 where non-locals ('outsiders') harvest community biomass resources.

In 1992, the Biomass Initiative was launched by the Department of Minerals and Energy to address the fuelwood problem in rural South Africa, and in response to the objectives of the Reconstruction and Development Programme (RDP). According to the RDP (1995), immediate policies to meet energy needs included improved management of natural woodlands, social forestry programmes, commercial woodlots and support for the transport of wood from areas of surplus to areas of need. The Biomass Initiative was motivated by the need to address the rapidly deteriorating energy situation in rural areas (symptomatic of increasing poverty in which 90% of households are dependent on wood for energy) and to halt the environmental degradation due to pressure on the land (Ngcobo, 2002).

Since 1992, electrification in townships and rural parts of South Africa has increased dramatically, however, there remains a heavy reliance on biomass in the form of fuelwood by households. Wood is used as an energy source due to the cheap cost to use, traditional preference for firewood, and the availability of the resource. The expected benefits of the Biomass Initiative were beyond the stabilised provision of firewood, and included revitalised subsistence farming, provision of food and fodder, improved soil fertility, stimulation of the local economy, improvement in health (particularly of wood collectors), prevention of natural resource degradation, improved water catchment management and greater protection of habitats (Ngcobo, 2002).

The Water and Forestry Support Programme (Department of Water Affairs and Forestry - DWAF, 2005) was instrumental in again focussing on supply-side mechanisms to promote the sustainable management of fuelwood stock, and initiated activities around fuelwood energy and development of a woodlands strategy. A review of the current status of implementation actions is needed in this regard.

The DWAF is the custodian of the nation's wooden biomes, and has a key responsibility in developing and implementing a policy and strategy that support the sustainable supply of fuelwood. At the same time, the Department of Minerals and Energy (DME) is responsible for the management of the country's energy resources and responsible for the management of the Government's programme on Free Basic Energy. These two Departments should jointly lead the development of a policy and strategy on fuelwood.

5. BIOMASS DEMAND

5.1 Residential Household Sector and Key Characteristics

South Africa is a country of extremes where large gaps still persist between rich and poor, urban and rural households. In terms of energy usage, it is known that biomass and particularly fuelwood is dominant in rural areas without access to grid electricity, whereas the use of electricity dominates in urban areas. Biomass use is also determined largely by the availability of a particular biomass resource to consumers. Therefore, the nature and distribution of South Africa's population and households is of interest when considering the demand for biomass fuels.

In 2007, Statistics SA estimated the total South African population at 48.5 million, up from 40.5 million in 1996 and 44.5 million in 2001 (Community Survey 2007). The total number of households was estimated at 12.5 million in 2007. The distribution of the population and households is shown in Table 5.1 below, as estimated in the 1996 and 2001 Censuses as well as the 2007 Community Survey. Gauteng and KwaZulu-Natal are the most populous provinces, both in terms of population and the number of households. Moreover, the data also indicates some migration trends, notably from the Eastern Cape and Limpopo to Gauteng and the Western Cape. This will have an influence on energy and fuelwood demand and will be discussed in more detail in Section 5.4.

Table 5.1: Population and Household Distribution, South Africa (Stats SA, Community Survey 2007)

Province	Population (in '000)			Households (in '000)		
	Census 1996	Census 2001	Community Survey 2007	Census 1996	Census 2001	Community Survey 2007
Eastern Cape	6,147	6,279	6,528	1,303	1,482	1,587
Free State	2,634	2,707	2,773	625	733	803
Gauteng	7,625	9,179	10,452	2,030	2,735	3,176
Kwa-Zulu Natal	8,572	9,584	10,259	1,690	2,117	2,234
Limpopo	4,576	4,995	5,238	909	1,118	1,216
Mpumalanga	3,124	3,366	3,643	670	785	940
Northern Cape	1,012	992	1,058	218	245	265
North West	2,937	3,194	3,272	631	817	911
Western Cape	3,957	4,524	5,279	983	1,173	1,369
South Africa Total	**40,584**	**44,820**	**48,502**	**9,059**	**11,205**	**12,501**

The 1996 Census classified the population into urban and non-urban segments as summarised in Table 5.2 (Statistics SA, 1996 Census). It will be seen that around 44% of South Africa's population lives in rural areas, while KwaZulu-Natal, the Eastern Cape and Limpopo have the largest non-urban and therefore also the largest rural populations.

Table 5.2: Population Distribution into Urban and Non-Urban Regions (Stats SA, 1996 Census)

Province	Population (in '000)		
	Urban	Non-Urban	Total
Kwa-Zulu Natal	3,341	4,331	7,672
Gauteng	6,911	260	7,171
Eastern Cape	2,188	3,677	5,865
Limpopo	490	3,638	4,128
Western Cape	3,703	415	4,118
North West	1,060	1,983	3,043
Mpumalanga	1,014	1,632	2,646
Free State	1,718	752	2,470
Northern Cape	535	211	746
South Africa Total	**20,960**	**16,899**	**37,859**

The average household size has declined since 1996 and in 2007 was estimated at just under four persons per household (Figure 5.1). This trend is continuing under the influence of reduced population growth and increasing urbanisation. The household size is above the national average in KwaZulu-Natal, Limpopo and the Western Cape, which reflects the large rural populations in those provinces (rural households tend to be larger at 5 - 6 persons per household on average).

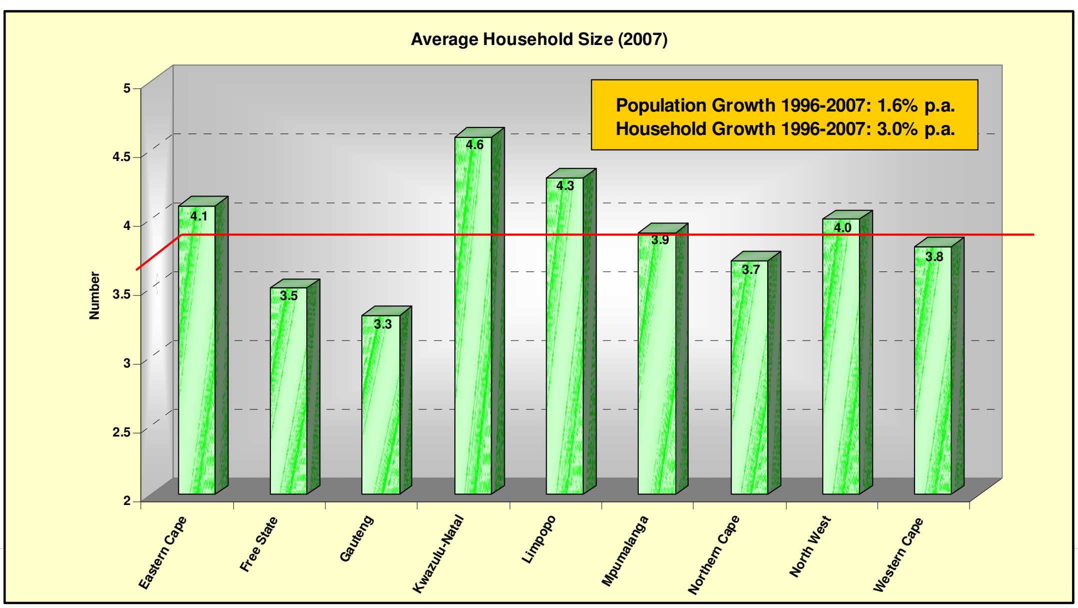


Figure 5.1: Average household size in South Africa.

The majority of households live in formal dwellings (70.5%), whereas some 11.7% of households live in traditional dwellings and a further 17.8% in informal dwellings (Figure 5.2). Traditional dwellings are concentrated in rural areas and have been declining steadily since 1996, under the influence of the government housing programme and urbanisation. Informal dwellings can be found both in urban and in rural areas, and their proportion of the total number of households has remained essentially constant between 1996 and 2007.

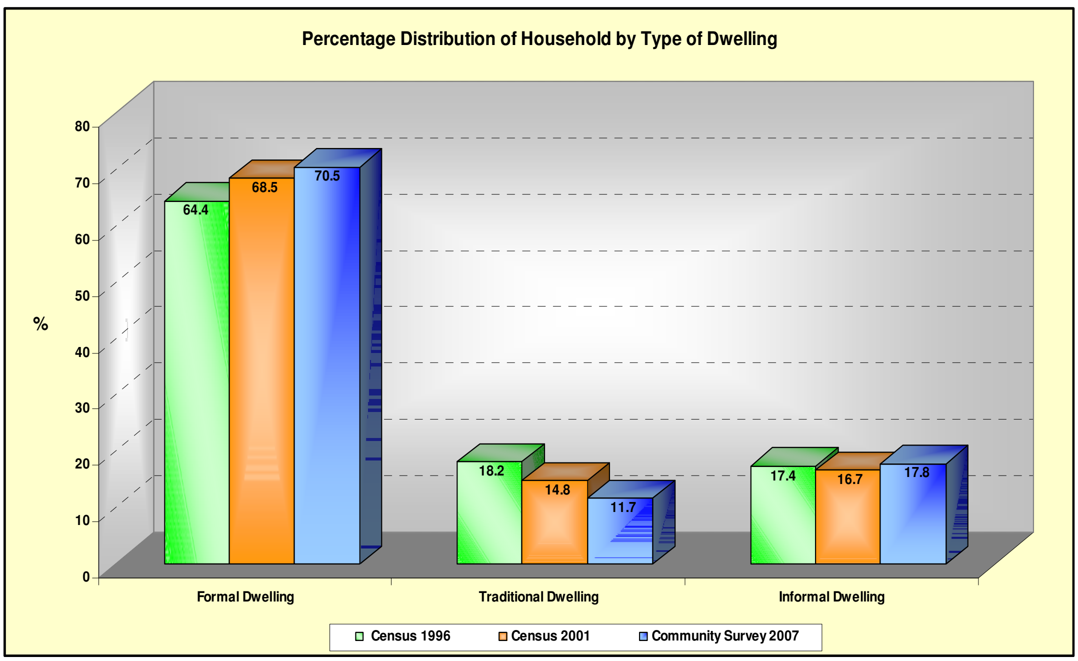
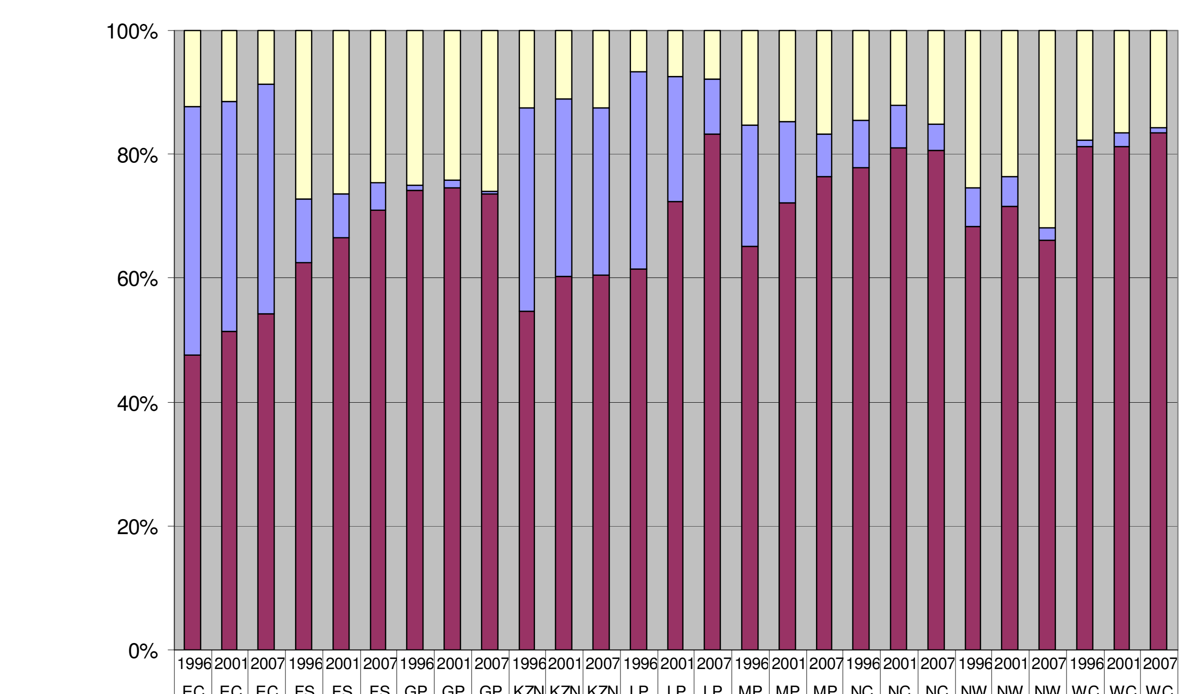


Figure 5.2: Percentage distribution of households by type of dwelling (Stats SA, Community Survey 2007)

The highest percentages of households living in traditional dwellings are found in KwaZulu-Natal, Eastern Cape and Limpopo (Figure 5.3). This is not surprising since these provinces also have the largest rural populations (Table

5.2). These percentages are declining in all cases, with Limpopo showing the largest improvement, from 32% in 1996 to 9% in 2007.

In terms of access to services, it is estimated that some 70% of households have access to electricity (up from 51% in 1996) but only about half of rural households are electrified. Some 88% have access to piped water, but only 55% of households have access to flush toilets.



	1996 EC	2001 EC	2007 EC	1996 FS	2001 FS	2007 FS	1996 GP	2001 GP	2007 GP	1996 KZN	2001 KZN	2007 KZN	1996 LP	2001 LP	2007 LP	1996 MP	2001 MP	2007 MP	1996 NC	2001 NC	2007 NC	1996 NW	2001 NW	2007 NW	1996 WC	2001 WC	2007 WC
Informal Dwelling	12.2	11.4	8.6	27.3	26.4	24.6	25.1	24.1	26	12.5	11.1	12.4	6.6	7.4	7.8	15.4	14.8	16.8	14.5	12	15.1	25.5	23.7	31.8	17.8	16.5	15.8
Traditional Dwelling	40.1	37.1	37.2	10.2	7.2	4.5	0.8	1.3	0.4	33	28.7	27.2	31.9	20.2	9	19.5	13	6.7	7.6	7	4.3	6.2	4.7	2.2	0.9	2.2	0.8
Formal Dwelling	47.6	51.5	54.3	62.5	66.5	70.9	74.2	74.6	73.7	54.6	60.2	60.4	61.5	72.5	83.2	65.2	72.2	76.5	77.8	81	80.6	68.3	71.7	66.1	81.3	81.3	83.4

Figure 5.3: Percentage distribution of households in each province by main dwelling (Stats SA, Community Survey 2007)

5.2 Household Energy Consumption Patterns and Biomass Demand

5.2.1 Introduction

There is a wide range of household types and income levels in South Africa. Moreover, the type of fuels used by households also varies greatly according to their location and socio-economic position. Urban households tend to be wealthier and mainly utilise electricity for most household energy needs. In contrast, more than 70% of rural households are poor and either do not have access to electricity, or are unable to afford electric appliances and energy charges for cooking and heating (DWAF, 2004). Energy usage in these low-income households is characterised by the use of multiple fuels or energy carriers for lighting, cooking and heating purposes (e.g. Palmer Development Consulting, 2001). Examples include fuelwood, dung and other biomass fuels such as crop residues, coal, paraffin, candles, LPG, and, where available, electricity. Charcoal is not commonly used in low-income households, and is largely confined to higher income households for social use. Residential energy sources can thus be classified into three categories:

- Traditional fuels, consisting of biomass sources such as fuelwood, dung and bagasse;
- Transitional fuels, consisting of coal, paraffin and LPG; and
- Modern fuels, consisting of electricity.

The choice and mix of energy sources depends on availability and affordability. Fuelwood is the dominant biomass form used in rural domestic households, although there is evidence that other biomass resources such as dung and crop residues become more prevalent in areas where wood is scarce, either because of a lack of natural woodland or due to unsustainable harvesting of fuelwood, leading to deforestation (Bhatt and Sachan 2004, Shackleton, *et* al, 2004). There is, however, a lack of reliable data on the use of other biomass resources such as dung and crop residues in South Africa.

5.2.2 Total consumption of energy

The three main energy consuming sectors in the South African economy are industry, residential, and transport (DME 2006). As shown in Table 5.3 and Figure 5.4 below, these three sectors together accounted for almost 80% of total energy demand. The residential sector accounts for close to 18% of energy consumption. It will also be seen that the residential proportion has declined slightly from 18.4% in 2003. (The category non-energy use reflects energy carriers such as petroleum products, solvents and lubricants that are not used for their energy content).

Table 5.3: Sectoral energy consumption in South Africa, TJ (DME, 2006)

Sector	2003	in %	2004	in %
Industry	854,793	34.5	983,167	36.3
Commerce	162,272	6.5	183,359	6.8
Residential	455,733	18.4	485,692	17.9
Mining	180,699	7.3	190,274	7.0
Transport	656,520	26.5	689,552	25.5
Agriculture	74,998	3.0	77,988	2.9
Non-specified (other)	64,574	2.6	78,830	2.9
Non-energy use	31,000	1.2	20,000	0.7
Total	**2,480,589**	**100**	**2,708,862**	**100**

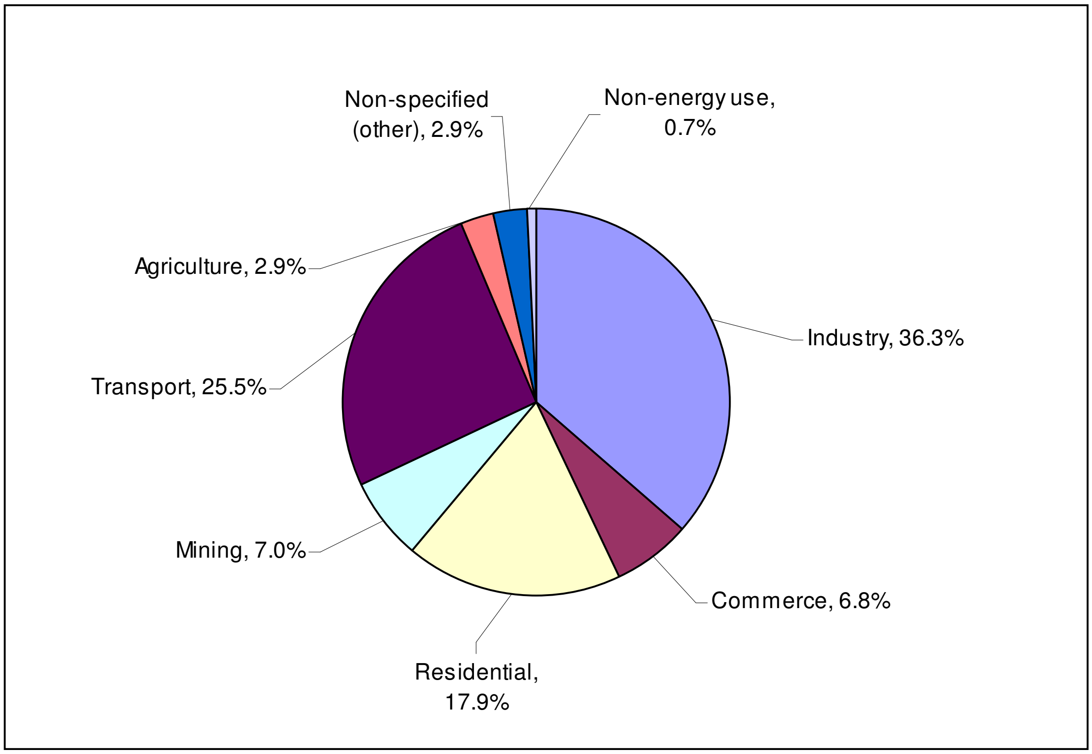


Figure 5.4: Final energy consumption by sector (DME, 2006)

The market for biomass fuels and fuelwood in particular is diffuse, comprising a large number of households distributed over a wide geographical area. An accurate reflection of the household energy demand therefore requires the collection of large amounts of data that identifies energy and appliance usage by household type and income category, and this requires large-scale surveys.

In South Africa, numerous studies have been conducted over the past 20 years into household energy use and fuelwood demand, but these are mostly limited to small samples of between 10 and 100 households, concentrated in a small number of villages. While these are useful to examine energy usage on a micro-scale and will therefore be discussed in a later section of this report, it is difficult to extrapolate such limited data to a regional or national level. The only large-scale surveys that have been conducted are the 1996 and 2001 Censuses, as well as the 2007 Community Survey. All of these sought to elucidate household energy demand, and probably represent the best data on this topic at national level.

The total annual demand for fuelwood in South Africa was estimated at some 13 million m^3 or 9.8 million tons (dry mass) in the mid 1980s (DME, 1996), and this figure is still quoted widely in the literature (e.g. Shackleton, *et al* 2004, DWAF, 2005). A more recent estimate pegs the total annual fuelwood consumption in South African households at ***11.2 million tons*** which is equivalent to190,400 TJ or 52,889 GWh (DME, 2006). This represents approximately ***40% of the total energy consumption*** in South African households.

The total number of households that depend on fuelwood for cooking and heating purposes is generally estimated at around 2.3 – 2.8 million (Census, 2001; DWAF, 2004). In the literature, this has been taken to represent approximately 9 – 11 million people, based on an average household size of around 4, as estimated from Census data. Rural household size on average is larger at 5 – 6 people, however, and so a better estimate would be ***12 – 15 million people or 25 – 30% of the South African population***. A lower estimate of around 1.5 – 1.8 million households has also been reported as part of a study to quantify the value of fuelwood usage in rural households (Williams and Shackleton, 2002). Other surveys have put the figure higher, estimating that fuelwood is used by as much as a third of South Africa's population (Stewart, 2001). The Energy Research Centre at the University of Cape Town (UCT) has estimated that 64% of the households that depend on fuelwood for cooking purposes are in the lowest income brackets, where annual household income ranges from R0 to R9,600 (ERC, 2004), whereas the South African government estimates that 70% of rural households are poor (Government of South Africa, 2000).

There is general agreement that the majority of rural households (80% - 100%, depending on location) still use fuelwood as their primary energy source (Williams and Shackleton, 2002). Households in peri-urban areas and townships are less dependent on fuelwood for their energy needs, with only 38% - 68% of households using fuelwood (Eberhard, 1990).

Table 5.4 below shows the most recent estimate of total residential energy demand for 2004 by fuel type (DME, 2006). It will be seen that electricity accounted for an estimated 27% of total residential demand, whereas coal and fuelwood accounted for 5% and 39%, respectively. Analogous to fuelwood, the high usage of coal is attributable to low-income households which are located close to the coal mines where low cost coal is readily available (Hedon, 2003). Coal is therefore used primarily in urban and peri-urban settlements in Mpumalanga, Gauteng, Free State and KwaZulu Natal to meet domestic energy needs for cooking and space heating and, to some extent, for water heating. Households often combine water heating with either space heating or cooking.

Table 5.4: Residential energy demand by fuel source, 2004 (DME, 2006)

Energy Source	TJ	in %
Coal	121,582	25.0
Electricity	130,432	26.9
LPG	11,292	2.3
Natural Gas	0	0.0
Paraffin	28,231	5.8
Solar	3,754	0.8
Biomass (Wood)	190,400	39.2
Total	**485,691**	**100**

The high proportion of fuelwood and coal is most likely related to the lower efficiency of these fuels when used in inefficient cooking and heating devices in rural households. Table 5.5 shows energy consumption by activity for 2004, which was estimated on the basis of the total energy demand and the relative percentages as estimated for 2000 (Statistics SA, 2005). In this case, energy consumption for water heating is the second largest segment after cooking, while space heating represents only 12.4%. This is understandable in view of the relatively mild climate in South Africa.

Table 5.5 Estimated residential energy consumption by activity, 2004 (DME, 2006)

Activity	TJ	in %
Cooking	193,791	39.9
Lighting	26,227	5.4
Space Heating	60,226	12.4
Water Heating	154,935	31.9
Other	50,512	10.4
Total	**485,691**	**100**

5.2.3 Consumption by fuel type, province, and household type

The residential energy consumption by fuel types differs significantly among the provinces (Table 5.6). The biomass figures are the most uncertain and have been compiled through estimates and conversions from mass to energy, using an accepted energy density of 17 MJ/kg of dry wood (DME, 2002). It will be noted that these figures seriously underestimate both the fuelwood and the coal demand, compared to the 2004 figures presented in Table 5.4. This could possibly be ascribed to the informal and diffuse nature of these energy sources. Nevertheless, the figures serve to illustrate some important trends. In particular, the data shows that the highest concentration of biomass or fuelwood use occurs in Limpopo, the Eastern Cape, North West, and KwaZulu-Natal. This is understandable since these are the poorest provinces in South Africa with the largest rural populations, and also contain most of South Africa's indigenous forest and woodland biomes. In other words, these provinces represent areas of high demand as well as comparatively good fuelwood availability.

Table 5.6 Residential energy consumption by fuel type and province (DME, 2002)

Sector	Energy Consumption, TJ					Total, TJ	in %
	Coal	LPG	Paraffin	Electricity	Biomass		
Limpopo	682	70.0	2,052	2,758	21,982	27,544	10.3
Eastern Cape	0	471.0	6,363	4,820	14,663	26,317	9.9
North West	682	235.0	2,220	5,389	17,783	26,309	9.9
KwaZulu-Natal	13,640	862.0	5,452	13,079	21,637	54,670	20.5
Mpumalanga	13,640	54.0	1,171	2,318	5,111	22,294	8.4
Free State	12,276	167.0	1,800	4,334	250	18,827	7.1
Northern Cape	0	67.0	302	1,490	0	1,859	0.7
Western Cape	0	294.0	1,445	13,925	0	15,664	5.9
Gauteng	27,280	583.0	4,415	23,461	0	55,739	20.9
Not specified	0	0.0	0	17,111	0	17,111	6.4
Total	**68,200**	**2,803**	**25,220**	**88,685**	**81,426**	**266,334**	**100**
% of Total	**25.6**	**1.1**	**9.5**	**33.3**	**30.6**	**100.0**	

Table 5.7 illustrates the household demand for energy by energy source and activity, in terms of number of households (Census 2001). Note that these

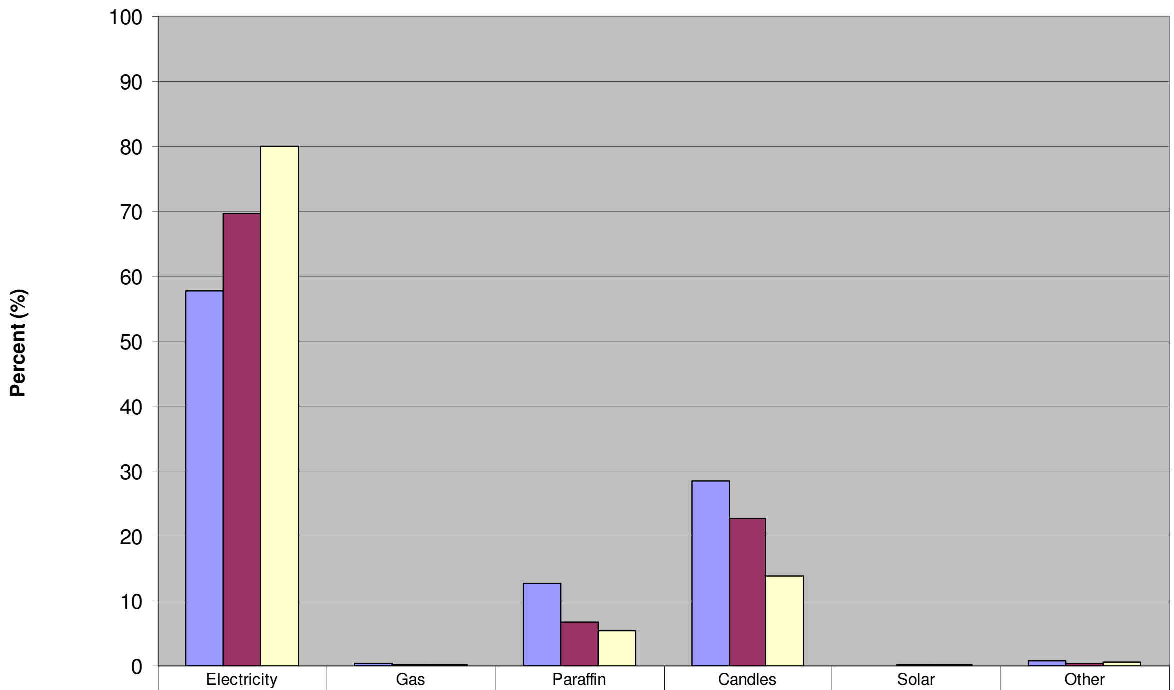
figures are not additive, in other words if a household uses both paraffin and fuelwood, it will be shown under both fuel sources. Electricity clearly dominates in all activity sectors and particularly in lighting, which reflects the high level of electrification that has been reached in South Africa. It is significant that the next highest number of households uses fuelwood for cooking and heating (both space heating and water heating). This reflects the fact that these activities are comparatively energy hungry, which leaves poor and rural households with little choice but to use the cheap traditional biomass fuel. In fact, even electrified poor households tend to use electricity or candles for lighting, but cheaper traditional or intermediate fuels for cooking and heating.

Table 5.7 SA household fuel use by activity (Stats SA, Census, 2001)

Sector	Energy Usage, number of households								
	Coal	LPG	Paraffin	Electricity	Candles	Solar	Fuelwood	Animal Dung	Other
Cooking	310,060	284,293.0	2,394,919	5,761,355	0	24,224	2,292,673	110,969	27,210
Heating	734,454	124,985.0	1,641,457	5,493,022	0	23,507	2,758,863	83,054	346,365
Lighting	0	27,065.0	759,823	7,815,272	2,545,538	24,169	0	0	33,844
Total	**1,044,514**	**436,343**	**4,796,199**	**19,069,649**	**2,545,538**	**71,900**	**5,051,536**	**194,023**	**407,419**

Analysis of the energy use by activity and fuel source over time shows that the energy usage patterns of households is changing. The key drivers for the observed trends are urbanisation, increasing purchasing power of households, and electrification, particularly in rural areas.

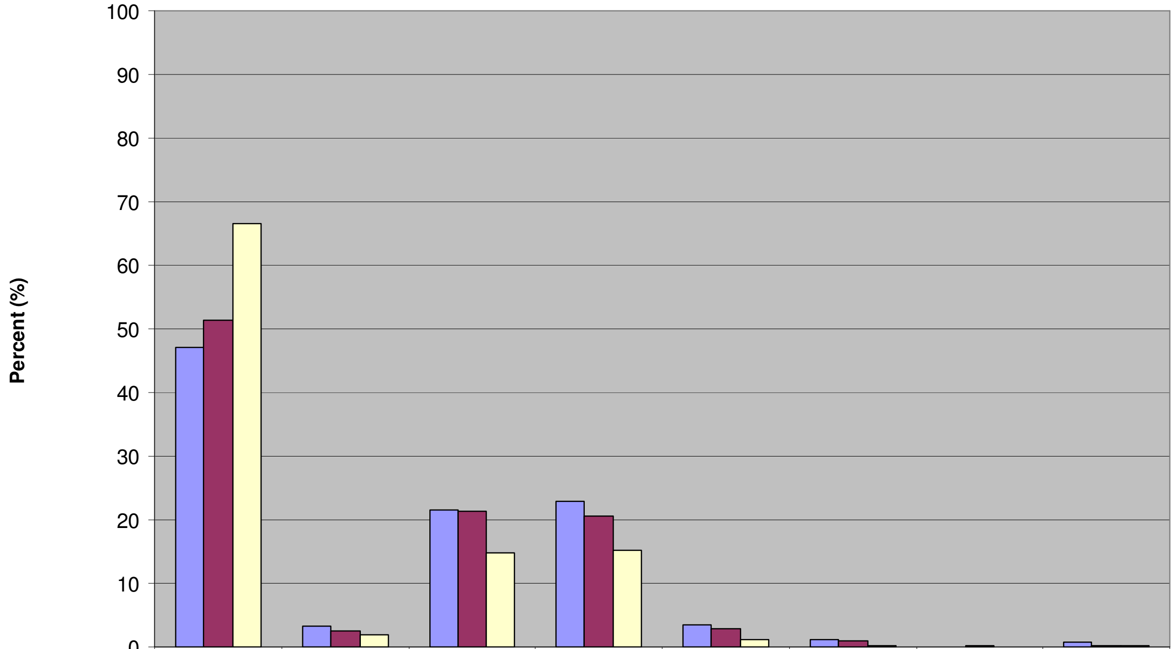
Figure 5.5 shows that in 1996, 2001 and 2007, electricity was the main source of energy for lighting, and has increased in importance over this period. Accordingly, the usage of candles and paraffin has declined over the same period.



	Electricity	Gas	Paraffin	Candles	Solar	Other
Census 1996	57.6	0.4	12.6	28.5	0	0.8
Census 2001	69.7	0.2	6.8	22.7	0.2	0.3
CS 2007	80	0.2	5.3	13.8	0.2	0.5

Figure 5.5: Number of households by type of energy used for lighting (Community Survey, 2007)

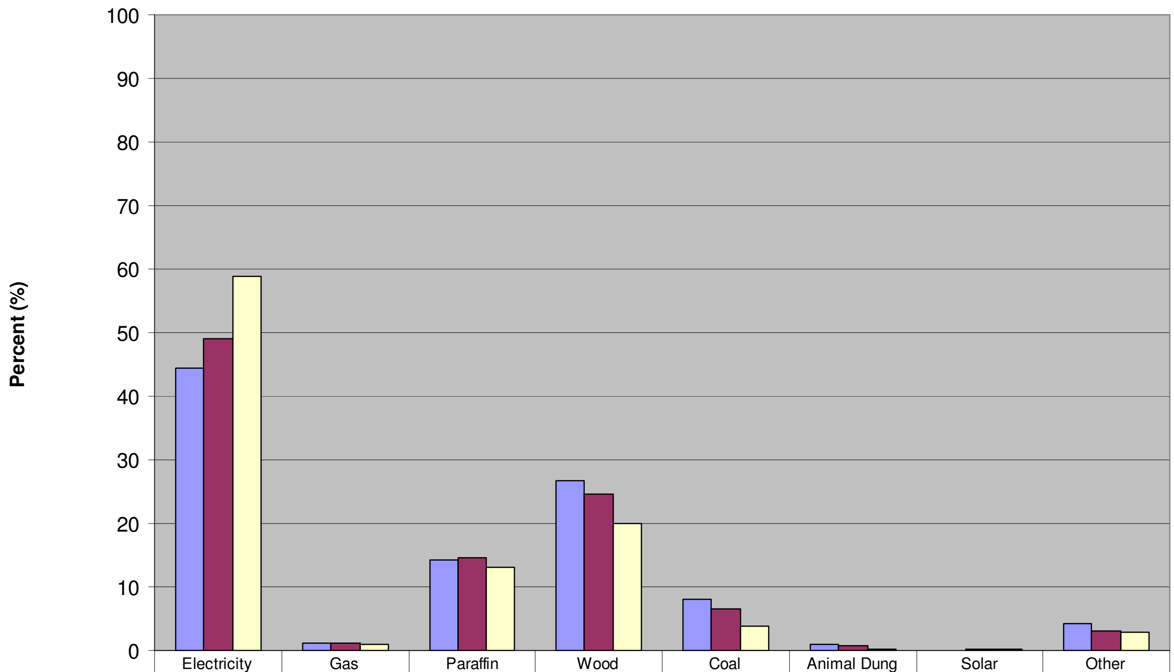
Similarly, most households used electric energy for cooking purposes and again the importance of electricity increased over time, particularly between 2001 and 2007 – see Figure 5.6. By 2007, almost 67% of all households were using electricity for cooking. As might be expected, the use of traditional biomass and intermediate fuels decreased over the same time. Nevertheless, some 30% of households still depend on fuelwood and paraffin, indicating that these fuels remain important in low-income households. This will be elaborated on later in this section.



	Electricity	Gas	Paraffin	Wood	Coal	Animal Dung	Solar	Other
Census 1996	47.1	3.2	21.5	22.9	3.5	1.2	0	0.7
Census 2001	51.4	2.5	21.4	20.5	2.8	1	0.2	0.2
CS 2007	66.5	2	14.9	15.1	1.2	0.2	0	0.1

Figure 5.6: Number of households by type of energy used for cooking (Census, 2001)

Figure 5.7 illustrates that by 2001, almost 60% of households used electricity for heating purposes. The 2001 Census did not differentiate between space heating and water heating. Again, the substantial increase in the percentage of households using electricity is noteworthy, and is attributable to the country's electrification drive as well as increasing household purchasing power, particularly since 2001. Fuelwood remains the second most important energy source with 20% of households using this as their main source of energy in 2007. Paraffin and coal are also important energy forms, and together are used by 17% of households.



	Electricity	Gas	Paraffin	Wood	Coal	Animal Dung	Solar	Other
Census 1996	44.5	1.2	14.3	26.7	8.1	0.9	0	4.3
Census 2001	49	1.1	14.6	24.6	6.6	0.7	0.2	3.1
CS 2007	58.8	1	13.1	20	3.9	0.2	0.1	2.9

Figure 5.7: Number of households by type of energy used for heating (Census, 2001)

The Energy Research Institute (ERI) at the University of Cape Town investigated the energy use patterns by type of household (Haw and Hughes, 2007). They classified households into six categories, namely:

- Urban rich electrified
- Urban poor electrified
- Urban poor non-electrified
- Rural rich electrified
- Rural poor electrified
- Rural poor non-electrified.

In this case, 'poor' households were classified as those with an annual per capita income of less than R4,033. Households falling into the middle income class were grouped together into the 'rich' category due to the similar fuel use and appliance availability. The final energy demand for these household categories in 2001 are shown in Figure 5.8.

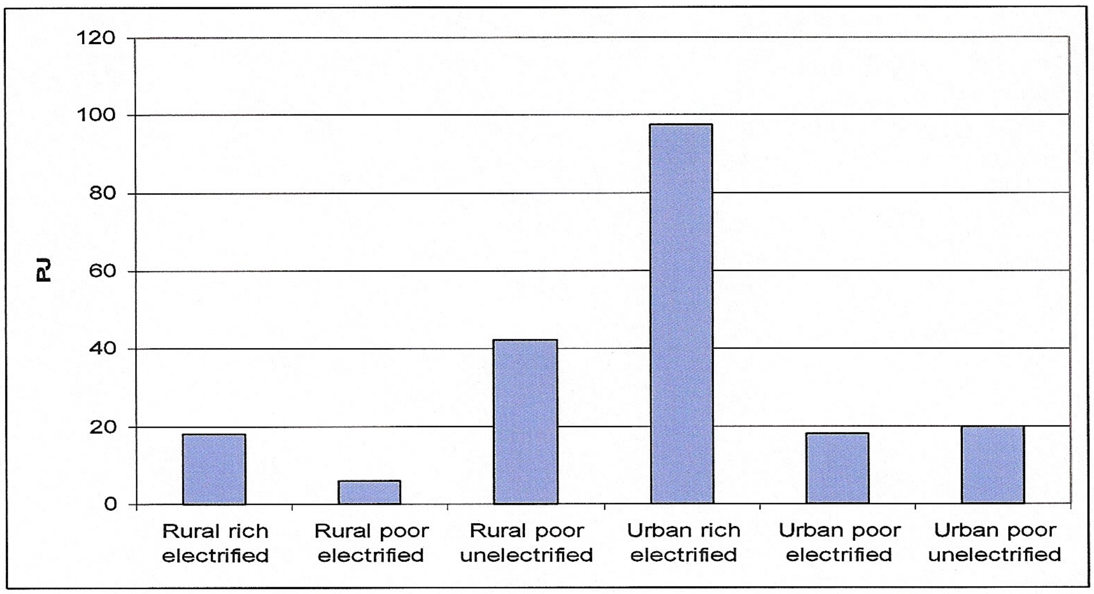


Figure 5.8: Final energy demand by household type (Haw and Hughes, 2007)

The ERI further disaggregated energy usage for these household categories by activity (i.e. lighting, heating, and cooking) as well as by energy carrier. Figure 5.9 illustrates that urban high income households use the most energy, as might be expected. In this diagram, U and R stand for urban and rural households respectively, L and H represent poor and rich households, and E and N stand for electrified and non-electrified, respectively. It is noteworthy that the choice of fuel has a substantial influence on overall energy demand. For example, rural poor non-electrified households have a rather high energy demand, comparable to urban poor electrified households. This is due to the inefficiency that is typically associated with the use of traditional biomass fuels such as fuelwood and dung. As households move away from these fuels towards electricity for cooking in particular, the total household energy demand reduces due to improved efficiencies.

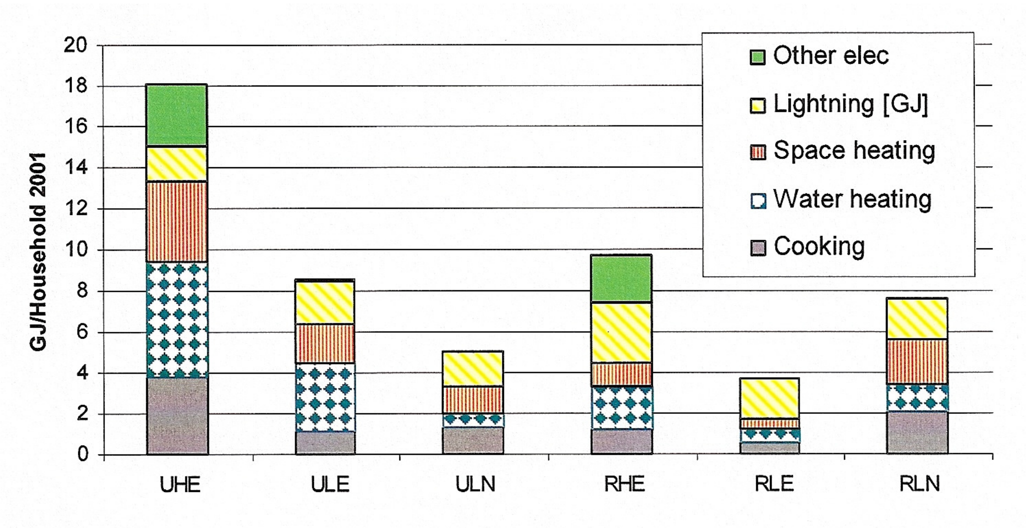


Figure 5.9: Energy use by household type and activity (Haw & Hughes, 2007)

Their analysis of energy usage pattern for cooking involved five different energy carriers (electricity, gas, paraffin, coal, and fuelwood) and eight different appliances (brazier, stove, ring burner [for gas], primus stove, wick [for paraffin], microwave oven, electric oven / hob, and electric hot plate. The usage of these appliances and energy forms by household type is shown in Figure 5.10. In urban electrified households, the electric oven / hob combination dominates by far, which is not unexpected. It is striking to note the dominance of the fuelwood stove in rural poor non-electrified households, however. Note also that these rural households have the second highest overall energy demand, which reflects the inefficiency of the wood stoves that are typically used.

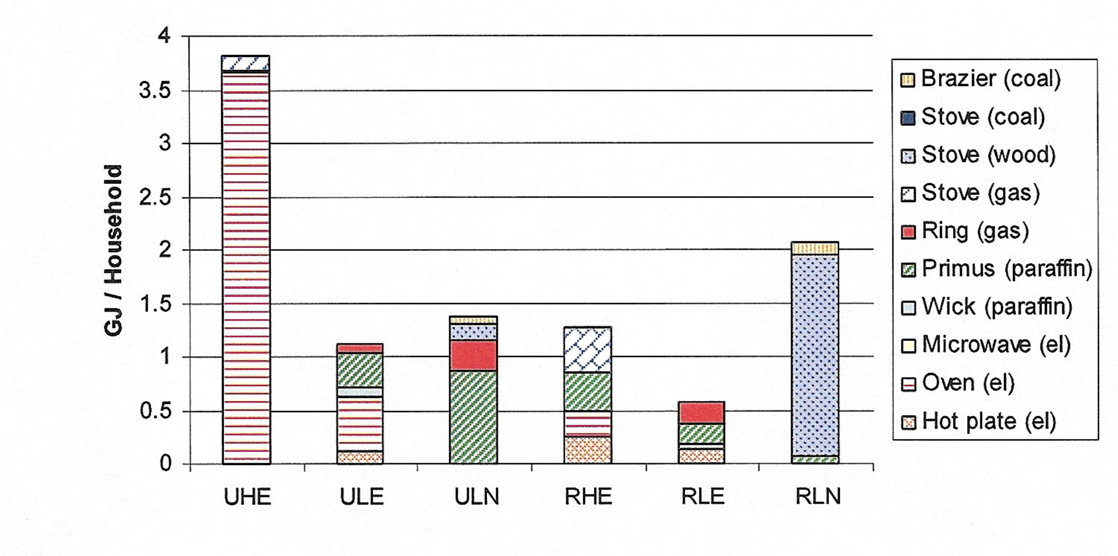


Figure 5.10: Energy use for cooking by energy carrier and household type (Haw & Hughes, 2007)

Figure 5.11 shows the energy demand by energy carrier for water heating purposes. It will be seen that the majority of hot water is supplied by electric geysers. Poor households have a low energy demand for water heating. It is interesting to note that electric lighting is popular in electrified households, and that rural electrified households consume roughly the same amount of energy for electric lighting as for electric water heating, namely around 1.5 – 2.5 GJ/hh per annum (Haw & Hughes 2007). Since water heating is rather more energy hungry than electric lighting, this illustrates the comparatively low demand for water heating among rural households. For non-electrified poor rural households, a coal or wood stove remains the dominant water heating system.

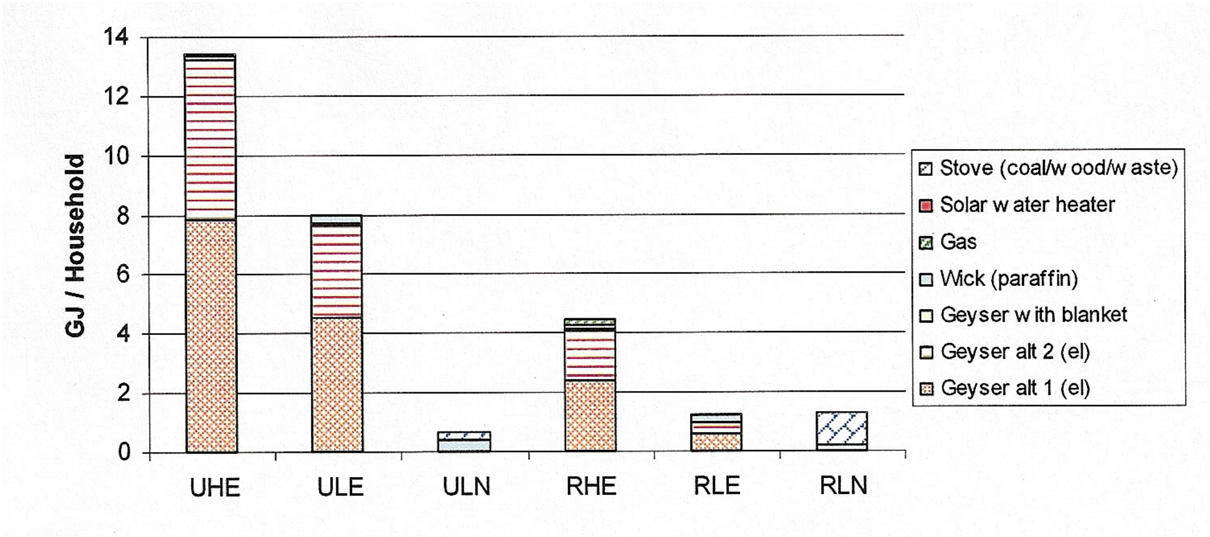


Figure 5.11: Energy use for water heating by energy carrier and household type (Haw & Hughes, 2007)

The energy demand for space heating is shown in Figure 5.12 by household type and energy carrier. Again, the bulk of space heating requirements are met by electric heaters. However, rural poor and non-electrified households rely on open fire pits or wood stoves for heating purposes. As for cooking, these households have the second highest energy demand of all, which again reflects the inefficiency of these traditional heating methods. Therefore, although the traditional fuels such as wood are often obtained by poor households at no or very low cost, a clear opportunity exists to improve energy efficiency in cooking and space heating in these households through the introduction of modern and affordable wood burning technologies.

Energy demand for lighting represents the smallest proportion of total households energy use and is dominated by electricity, candles and other energy sources such as paraffin wick lanterns. Fuelwood and other traditional energy sources such as dung or even coal do not play a significant role in domestic lighting.

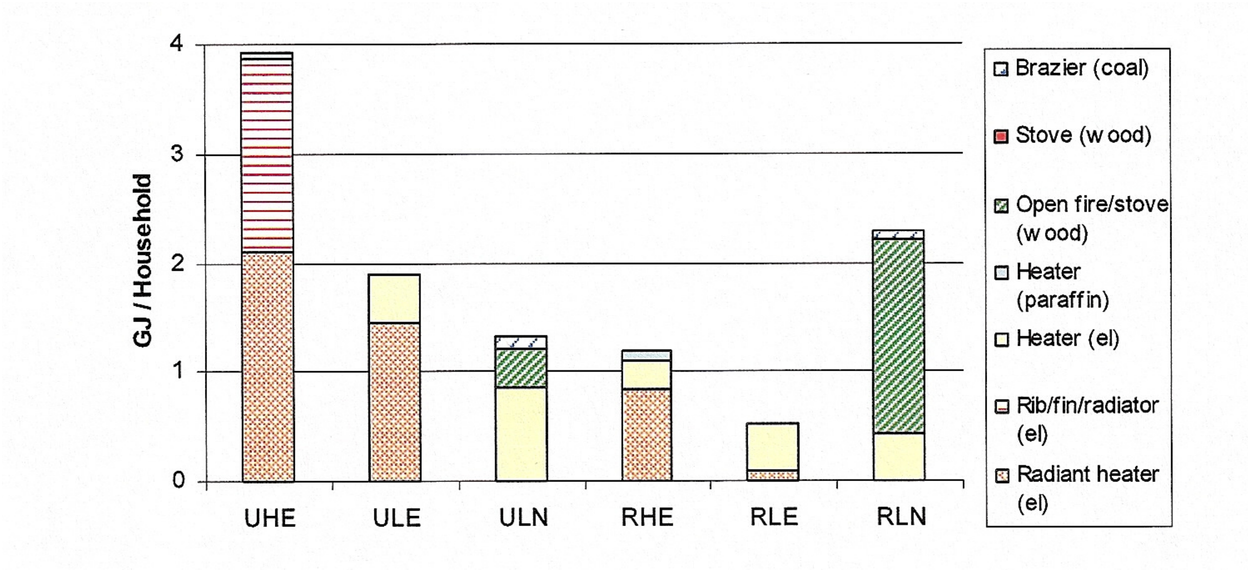


Figure 5.12: Energy use for space heating by energy carrier and household type (Haw & Hughes, 2007)

5.3 Local Surveys of Household Energy Usage

5.3.1 Fuelwood consumption per household

Research into the use of wood and biomass by local communities over the past 15 – 20 years has changed from a focus on documenting and quantifying household's usage in the 1980s to sustainable management of resources in the 1990s, including modelling and approaches to augment existing supplies (Shackleton, *et al,* 2004). The later work has been conducted within a community forestry paradigm rather than an energy shortage paradigm. As a result, only limited empirical data on the usage of fuelwood has been documented in the past 5 – 10 years.

Localised studies have shown that the quantities of fuelwood used per household vary greatly and are dependent on a number of factors, including household size, availability of fuelwood and labour to collect it, access to other fuel sources, and socio-economic standing. Published figures from the earlier studies range from 0.6 – 7.7 tons per annum per household (Gandar, 1981, 1983; Liengme, 1983; Banks, *et al* 1996). Most of these are clustered around a mean of 687 kg per person per year (Shackleton, *et al,* 2004), which at an average rural household size of 5 – 6 people is equivalent to 3.4 – 4.1 tpa/hh. This figure agrees well with the 3 – 4 tpa/hh reported by Williams, *et al* (1996) from a number of studies as part of the Biomass Initiative.

The results obtained from a number of other localised studies in recent years are summarised in Table 5.8 below. It will be seen that sample sizes are quite small, and that fuelwood consumption varies widely between the studies. As noted before, this makes data extrapolation to a regional or national level difficult. The average fuelwood consumption per household determined from the studies below is about 5.5 tons per annum, which is rather higher than the average consumption figures discussed above. However, the result is skewed by at least two outlying results where fuelwood demand seems excessively high, namely Nqutu and Tugela in the province of KwaZulu-Natal (KZN). The small sample size in these areas may have contributed to this effect.

If these areas are excluded together with Mseleni, KZN, which is another high usage area with very low sample size, then the average drops to around 4.5 tons per annum. Recalling that the number of households that depend on fuelwood is 2.3 – 2.8 million, this figure aggregates to a national average fuelwood consumption of around 11.2 million tons per annum, which corresponds to the 11.2 million tons estimate reported earlier. It is thus concluded that a good estimate for the average annual household fuelwood consumption is ***4.5 tons per annum per household***, which is some 30% higher than the 3 – 4 ton per annum reported by Williams, *et al* (1996) as part of the Biomass Initiative.

Table 5.8: Household fuelwood consumption determined by localised studies

Village/Area	Sample Size	Year Collected	Amount used / Household (kg/annum)	Ave. Household Size	Source
Giyani, Limpopo	n/a	2006	2,700	7	Makhado 2006
Nkweletshini, KwaZulu Natal	n/a	2002	4,200	6	Lloyd *et al* 2002
5 villages, Bushbuckridge, Mpumalanga	399	2002	8,974	7	Madubansi and Shackleton 2003
Mbazwana & Siqakatha, KZN	117	2001	2,628	7	Aitken 2001
Kentani, Butterworth, E. Cape	10	2000	3,732		Ham 2000
Mametja, Limpopo	110	2000	5,581		Twine *et al* 2000
Mogano, Limpopo	65	1998	7,707		Shackleton *et al* 1999
Ha-Gondo, Limpopo	54	1998	6,488		Shackleton *et al* 1999
KwaJobe, KZN	31	1998	3,941		Shackleton *et al* 1999
Nqutu, KZN	10	1997	10,502		Beukman *et al* 1998
Mseleni, KZN	10	1997	5,512		Beukman *et al* 1998
Tugela, KZN	10	1997	13,548		Beukman *et al* 1998
Athol, Limpopo	62	1991	3,658		Griffin *et al* 1992
Okkerneutboom, Limpopo	73	1991	3,055		Griffin *et al* 1992
Rolle, Limpopo	70	1991	3,618		Griffin *et al* 1992
Welverdiend, Limpopo	69	1991	4,631		Griffin *et al* 1992
Xanthia, Limpopo	71	1991	3,904		Griffin *et al* 1992
Mean (all studies)			**5,552**		

5.3.2 Seasonal demand variations

It might be expected that fuelwood demand is higher in winter than in summer, due to increased heating requirements. Indeed, studies have shown that more fuelwood is collected in winter than in summer (Liengme, 1983; Cwebe Working Group, 2001). However, a study of households in Ga Maraba and Ga Mogano in the Northern Province has shown that the seasonal effect on actual consumption of fuelwood is rather small, as shown in Table 5.9 below (Palmer Development Consulting, 2001):

Table 5.9: Seasonal variations in energy use (Palmer Development Consulting, 2001)

	Energy Use (% of households)				
	Wood	Paraffin	Electricity	Coal	Gas
Ga Maraba					
Summer	30.7	20.5	46.6	2.3	0.0
Winter	34.1	14.8	36.4	13.6	0.0
Ga Mogano					
Summer	69.0	14.9	11.5	2.3	2.3
Winter	71.3	9.2	6.9	9.2	2.3

This could be due to several factors, such as South Africa's temperate climate, as well as the fact that the use of fuelwood for cooking and heating water in itself also provides heat for the surrounding living space. Comparatively little additional fuelwood would thus be used for space heating only. It is also interesting to note that coal becomes more popular during winter, probably because of its higher energy content and longer burn times.

In summary, more wood is consumed in cooler areas and during winter; however, the seasonal variation in fuelwood consumption is relatively small and probably of the order of 20%.

5.3.3 Economic value of fuelwood

The two main value components of fuelwood are direct value where a market exists and fuelwood is traded, as well as opportunity cost, which is related to the time spent collecting the resource. Relatively little empirical information has been published that translates the amount of fuelwood used into economic value for rural households or the national economy.

Shackleton, *et al* (2004) analysed 12 localised studies between 1992 and 2000 that aimed to quantify fuelwood use and value. Local unit prices determined in these studies varied from zero (i.e. where there was no trade) to R0.57 per kg of fuelwood. The gross direct use value of fuelwood to rural households ranged from R600 to over R4 400 per year, with a mean of approximately R2000. This is equivalent to about R165 per month. Other studies have corroborated this value, e.g. Palmer Development Consulting (2001) found that the average monthly fuelwood expenditure by rural households in Ga Maraba and Ga Mogano ranged from R168 – R175 per month. The total gross direct use value of fuelwood was estimated by Shackleton at approximately R3 billion. However, this estimate was based on 1.53 million rural households. In fact, Census 2001 data showed that 2.3 – 2.8 million households rely on fuelwood. The total gross direct use value of fuelwood in South Africa could thus be as high as R4.5 – 5.5 billion.

If the costs incurred by households in obtaining fuelwood are taken into consideration, these gross values are reduced significantly. The major component in this regard is opportunity cost related to the time spent collecting fuelwood several times per week. Fuelwood is mainly collected by women and girls, who typically walk more than one kilometre and spent between 1 and 5 hours on a given day to harvest the resource (Aitken, 2002; Makhado, 2006; Twine, *et al,* 2003). On a monthly basis, the time spent can range from a few hours to over 80 hours per month, depending on the frequency of collection and the proximity of the fuelwood resource (Williams, 2006). Taking an average of 40 hours per month at R12 per day, the opportunity cost would be of the order of R720 per annum, or 36% of the gross value of fuelwood to rural households (Shackleton, 2004). Deducting this from the gross value means that the net direct-use value of fuelwood is of the order of R1 250 per household per annum, or R3 – 3.5 billion per annum in total.

5.3.4 Concluding remarks on fuelwood supply and demand

Based on the surveys and analyses above, the following summary conclusions can be made regarding fuelwood supply and demand:

i. There is a shortage of research and empirical data on the productivity and yields of fuelwood production from woodlands. However, fuelwood supply has been estimated in this study for a number of plausible sources and aggregated to a total supply estimate of 11.2 million tons per annum.

ii. On the demand side, some 2.3 – 2.8 million predominantly rural households depend on fuelwood. This figure is based on a sample of almost 300 000 households (Census 2001) and is considered the most reliable estimate available. Numerous micro-studies at local level suggest that households use between 1 and more than 7 tons of fuelwood per year. Based on an analysis of a sample of these studies, it is estimated that a good average consumption rate is 4.5 tons per household per annum. By aggregating this figure over the total number of households, our best estimate of the average total consumption of fuelwood is 11 – 12 million tons per annum, which is in line with the estimated supply.

5.4 Trends in Household Energy Use

5.4.1 Future demand growth

The future household energy demand depends on the evolution of the number of households in rural and urban areas, as well as changes in the amount and type of energy used by households. Key drivers of future household numbers are population growth rates and the impact of HIV/AIDS, and migration patters (rural to urban and interprovincial). Changes in energy usage depends on income and changes in fuel use, where a key driver is electrification.

Population growth

The overall population growth rate has been declining over the past 10 – 20 years and is now rather less than 1% per annum. This trend is expected to continue with increasing economic development as well as the influence of HIV/AIDS.

Since fuelwood is mostly used in rural areas, the distinction between rural and urban households is important. South Africa has experienced rapid urbanisation over the past 15 years as rural citizens moved into the cities in search of work and a better quality of life. It is particularly the larger cities such as Johannesburg, Cape Town and Durban that have experienced above average increases in their population (Figure 5.13). Between 2001 and 2007, population growth rates have been highest in the richer and highly urbanised provinces of Gauteng and the Western Cape, whereas growth rates have been well below average in poor and more rural provinces such as the Eastern Cape and Limpopo (Figure 5.14).

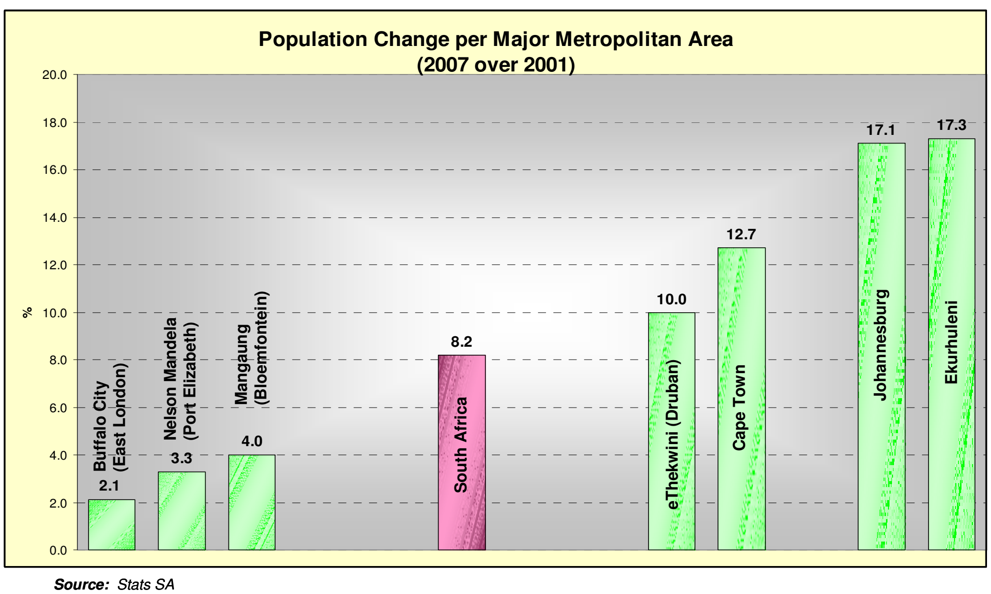


Figure 5.13: Population change per major metropolitan areas 2001 – 2007 (Statistics SA)

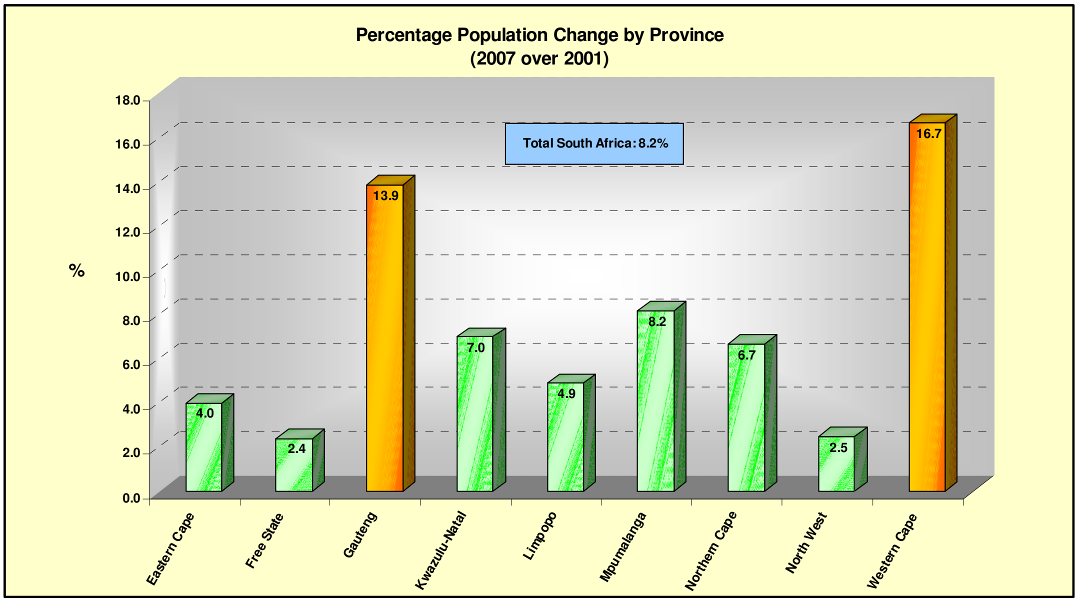


Figure 5.14: Population change by province 2001 – 2007 (Stats SA)

As a result the rural population has remained rather static compared to the urban population, even in highly rural provinces such as the Eastern Cape, KwaZulu-Natal, and Limpopo (Table 5.10).

Table 5.10: The proportion of rural and urban dwellers by province – 1996 – 2001 (Statistics SA, 2003)

		1996		2001	
		Number	%	Number	%
Western Cape	Urban	3,516,007	88.9	4,088,709	90.4
	Rural	440,867	11.1	435,626	9.6
Eastern Cape	Urban	2,304,378	36.6	2,500,234	38.8
	Rural	3,998,148	63.4	3,936,529	61.2
Northern Cape	Urban	588,906	70.1	680,460	82.7
	Rural	251,415	29.9	142,267	17.3
Free State	Urban	1,806,651	68.6	2,052,115	75.8
	Rural	826,853	31.4	654,660	24.2
KwaZulu Natal	Urban	3,628,268	43.1	4,334,642	46.0
	Rural	4,788,753	56.9	5,091,375	54.0
Norht West	Urban	1,171,734	34.9	1,533,768	41.8
	Rural	2,183,091	65.1	2,135,581	58.2
Gauteng	Urban	7,130,277	97.0	8,590,798	97.2
	Rural	218,146	3.0	246,380	2.8
Mpumalanga	Urban	1,094,287	39.1	1,288,434	41.3
	Rural	1,706,425	60.9	1,834,556	58.7
Limpopo	Urban	541,301	11.0	700,459	13.3
	Rural	4,388,067	89.0	4,573,183	86.7
South Africa	Urban	21,781,807	53.7	25,769,619	
	Rural	18,801,765	46.3	19,050,159	

These trends are expected to continue into the future. The migration trends extrapolated by Statistics SA suggest that Gauteng and the Western Cape will experience a net gain in migrants between 2006 and 2011, while the Eastern Cape and Limpopo will experience net losses of 295 000 and 180 000 people, respectively (Figure 5.15). KwaZulu-Natal is expected to remain stable.

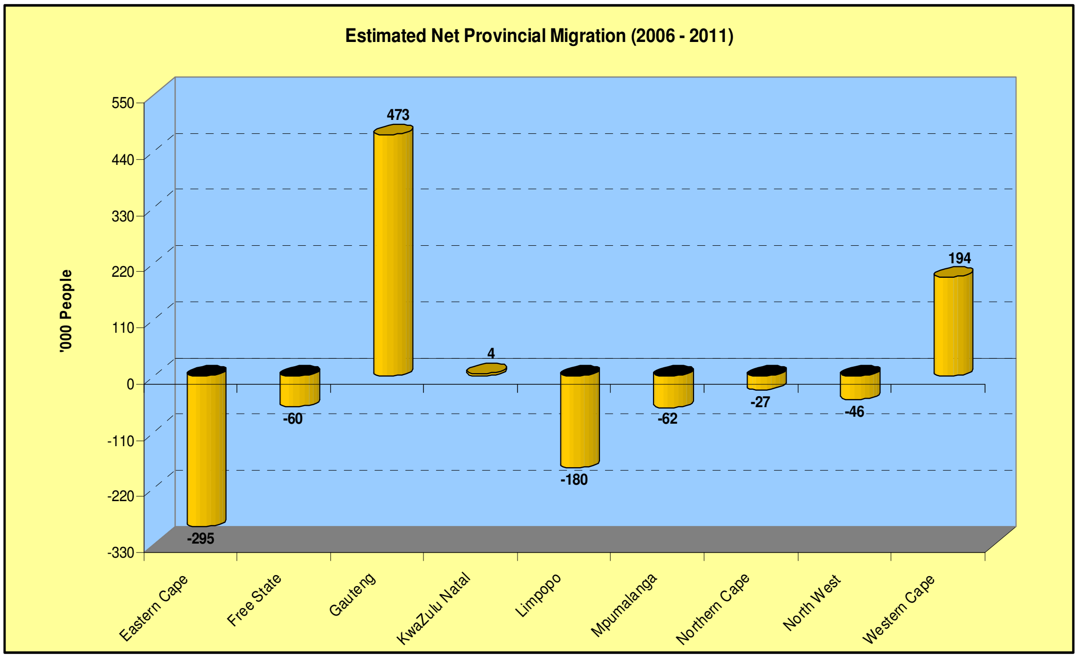


Figure 5.15: Estimated net provincial migration 2006 – 2011 (Stats SA, 2003)

Based on these trends and assumptions, the Energy Research Institute (ERI) at UCT has modelled the growth trends in terms of number of households and access to electricity for various household types from 2001 to 2030 (Figure 5.16). The results show a clear shift towards electrified households and a significant decline in poor urban and rural households without access to electricity.

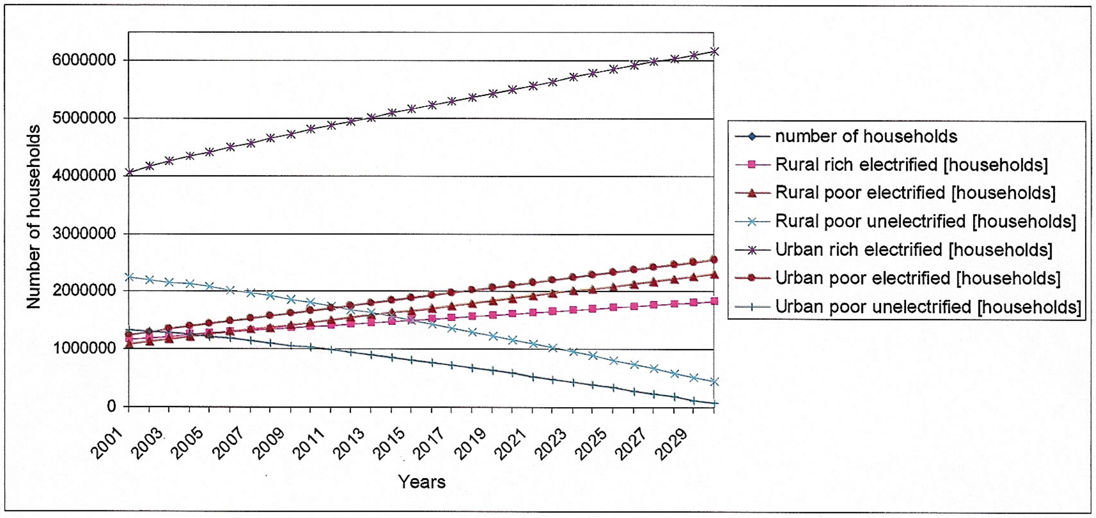


Figure 5.16: Forecast number of households in each subsector 2001 – 2030 (Haw and Hughes, 2007)

Against this background, the following concluding remarks can be made:

i. Overall, the urban population in South Africa will continue to grow relative to the rural population due to a combined influence of urbanisation and inter-provincial migration;

ii. Population growth rates will continue to slow;

iii. The rural population has most likely peaked and will stabilise or even decline, with the result that virtually all the household growth will occur in the broadly defined urban areas;

iv. Household access to electricity will continue to grow as the electrification programme continues. This trend will be supported by the urbanisation trend, since urban areas are more viable for electrification due to higher population densities than rural areas;

v. Most households that depend on fuelwood are poor and located in rural areas in the provinces of Limpopo, KwaZulu-Natal, and the Eastern Cape. With stable rural populations and a continuing migration trend away from some of these provinces, ***fuelwood demand has most likely reached its peak and will probably stabilise and decline over time.***

The impact of electrification

It was noted above the electrification trend is expected to continue. However, the current Eskom limit for viable future grid electrification is 50 households / km^2 (Lloyd, *et* al, 2004). Therefore, many rural households will not receive grid power in the foreseeable future and will either have to rely on off-grid electrification (expensive) or continue to rely on fuelwood and other traditional energy sources.

Moreover, studies have shown that while electric energy is well accepted for lighting in rural households, they continue to use fuelwood for energy hungry activities like cooking and heating. For example, Madubansi and Shackleton (2003) studied five recently electrified rural villages in the Bushbuckridge region of Limpopo and compared household energy use patterns before and after electrification. They found that fuelwood remained the most important energy source even after electrification, and that the amount of wood used per month was little changed, despite increasing scarcity of wood in the local environment.

The reason is of course affordability – of electric appliances and the electric energy required - and many rural households use less than the 50kWh that are provided free per month. This results in a vicious circle since higher usage of electric energy would make the provision of electricity by power producers like Eskom more viable. Even where rural households can afford electricity, fuelwood remains a low cost 'safety net' energy source, which is used whenever money is scarce and not available for electricity (e.g. near the end of the month or in cases of emergency). It has also been shown, however, that the proportion of purchased as opposed to collected wood as well as the mean total number of fuel sources used per household tend to increase with access to electricity. It appears that access to electricity catalyses a move by households up the energy ladder, i.e. from traditional sources like fuelwood to increased use of intermediate sources life paraffin (which are more affordable than electricity for heating purposes) and electricity, initially for lighting.

The following conclusions can be drawn on the influence of electrification:

i. Electrification tends to result in an increase in fuel diversity in rural households, and a shift away from collected fuelwood to purchased fuelwood as well as intermediate energy sources (e.g. paraffin) and electricity. Over time, the proportion of electricity use tends to increase.

ii. Fuelwood will remain a critically important energy source for low income households for decades to come, even where these have access to electricity, and must be managed with a long term vision.

5.4.2 Sustainability of fuelwood

On a national and regional basis, the indigenous forests and savannah biomes produce enough wood to sustain the current fuelwood demand. However, many of these forest resources are inaccessible to poor rural households either because of geographical location or because the resources are privately owned. This together with high rural population densities, which result in over-harvesting of fuelwood resources, and changes in land use for agricultural purposes causes localised shortages in fuelwood. As shortages develop, people begin to use lower quality or less preferred wood species, and to travel longer distances to obtain fuelwood. For example, Madubansi and Shackleton (2003) found that the average fuelwood collection time in five villages in the Bushbuckridge region of Limpopo increased by 12% from 239 minutes in 1991 to 268 minutes in 2002.

Where shortages are sufficiently severe, fuelwood markets have thus developed whereby entrepreneurs harvest fuelwood and transport it for sale to areas where shortages exist. Fuelwood thus has a real and not only a derived economic value, as discussed in Section 5.3.3 above. However, margins on fuelwood trading are extremely tight and the entrepreneurs make little money. As a result, few stay in the industry longer than a few years, and most exit when an unexpected event occurs such as the breakdown of the vehicle used to transport the fuelwood (Shackleton, 2004).

Relatively little is known about the sustainability of present patterns of fuelwood use and extraction, and the implications for sustainable resource management and rural livelihoods (Shackleton and Shackleton, 2004). However, in view of the long term requirement to secure fuelwood supply for rural poor households, there is clearly a need for the sustainable management of fuelwood resources. Attempts in this direction have been made in the past (Biomass Initiative), involving community forestry and reforestation projects. However, many of these projects failed due to inadequate planning and coordination. In particular, Williams *et al* (1996) found that not enough attention had been paid to initial planning of activities so as to obtain maximum learning from the pilot projects. Also, the needs of the intended beneficiaries had often not been adequately determined during the initial planning stages. The Biomass Initiative did contribute positively, however, in that it did provide additional woody resources for local use by rural households, and also enabled researchers and development workers to learn valuable lessons for future interventions. This learning should be re-visited and incorporated into any future interventions as appropriate.

6. OPPORTUNITIES AND CONSTRAINTS IN BIOMASS USE

The Department of Water Affairs and Forestry (DWAF) identified a number of opportunities and constraints as part of the Water and Forestry Support Programme (DWAF, 2005b). These are relevant in light of the present study.

6.1 Opportunities

The opportunities can be summarised as follows (DWAF, 2005b):

i. Fuelwood is an established energy source, with cultural values.

ii. Fuelwood is a renewable resource and has the potential to be harvested and managed sustainably.

iii. The rural poor in South Africa are concentrated in the wooded biomes, especially woodlands.

iv. The national fuelwood resource is valuable, representing R 4 – 5 billion.

v. Fuelwood is abundant in many areas. There is also a significant amount of discarded wood from the State and private lands under plantation forestry and bush clearing, although often not close to areas of demand.

vi. Savanna species generally coppice easily, providing an opportunity for rotational harvesting.

vii. The growth of trees for fuelwood or other purposes is a carbon sink and therefore important as one mitigation of global climate change.

viii. Harvesting and transport of fuelwood offers job opportunities.

ix. Simple technological interventions such as improved stoves with chimneys can improve the efficiency of fuelwood consumption and the health hazards associated with smoke inhalation.

x. There are several national multi-sectoral initiatives that could have a more explicit fuelwood component, (e.g. Working for Water; Extended Public Works Programme, Land Care Programme).

xi. Because fuelwood is a carbon sink, renewable, and has biodiversity benefits, there is a renewed interest in the developed world in biomass energy. This creates opportunities to develop international funding and technology partnerships, including carbon trading.

6.2 Constraints

The constraints associated with the sustainable use of fuelwood resources can be summarised as follows:

i. Diminishing access to local supplies of fuelwood by expanding urban communities.

ii. Localised shortages of fuelwood in many areas.

iii. Fuelwood resources on private and State land are often not close to the areas of high demand, requiring that it has to be transported, which is expensive and cannot be done profitably over long distances.

iv. Gender based power imbalances in the fuelwood sector at household level. Women harvest fuelwood for domestic use, men harvest it for income generation.

v. Uncertainty also exists on the ground with regard to the powers and responsibilities of traditional authorities and local communities in the management and control of woodlands, indigenous forests and woodlots on communal areas post-1994. The emergence of new municipal structures in rural areas and their roles and responsibilities vis-à-vis those of traditional authorities are not well understood and have effectively weakened local control over forest resources in many areas of the country.

vi. Limited access by the poor to training and extension support to effect sustainable woodlands, woodlot and forestry management. It is ironic that traditionally extension support is available for crop farming and animal husbandry, but not for woodlands management.

vii. The permit system around afforestation and water resources hinders the development of woodlots in areas with limited natural woody resources. Also, stringent legislation against alien plants limits the planting of fast growing alien trees in areas with acute fuelwood shortages.

viii. Limited access of nursery programmes in addressing fuelwood shortages. There are at least two reasons for this; (1) People's preference for indigenous species of hardwood as fuelwood and (2) reluctance to plant trees for fuelwood purposes only. Planting of trees becomes attractive if it is done for multiple use – shade, fruit, fuelwood, etc.

ix. Limited funding for fuelwood related research, because it is not seen as a government priority.

x. Local governance and institutions are frequently weak, lacking in skills, capacity, and adequate finances, especially in rural areas, and therefore will be hard pressed to manage any energy security strategies or the fuelwood resource even if identified as a priority.

7. GENDER ISSUES IN ENERGY

There is a strong gender dimension to the fuelwood issue, although this topic has not been investigated in any detail. Traditionally, it is the responsibility of women and children to collect fuelwood and this is still the case today, while the marketing of fuelwood, where relevant, is dominated by men. Women also do the bulk of the household chores such as cleaning, cooking, washing and the like. Therefore, women bear the brunt of all the negative aspects associated with the use of fuelwood. These include the opportunity cost of the time spent in collecting fuelwood, which can range from several hours up to 80 hours per month.

Other hazards include an increased risk of injury due to the heavy loads carried (typical headloads have been measured at 20 – 50 kg), and other health hazards related to the regular exposure to wood smoke. Fuelwood in rural households is often used in simple stoves, the three stone fire and the *iimbawula*, which is a home-made brazier from 25-litre paraffin drums. These devices are popular since they are obtained for very low or zero cost, which suggests that rural households place a low value on women's time and health. Used in poorly ventilated rooms, women and children are typically exposed to particulate emissions well in excess of the World Health Organisation (WHO) limits (DME, 2002). Estimates in South Africa suggest that children aged between 8-12 exposed to wood or coal smoke on a regular basis had a 290% increased risk of developing upper respiratory tract infections and 420% for lower respiratory tract illnesses. The rural communities are well aware of this issue, and many of the local studies into household energy use report that respondents complain about the negative effects of fuelwood use, with the majority reporting that it smoked, made them cough, hurt the eyes, and smelled bad (e.g. Lloyd, *et al,* 2002).

Another health hazard is the risk of burns, particularly to women and children. This hazard can be very considerable, as evidenced by the regular occurrence of severe fires in informal settlements with concomitant loss of life and property. However, anecdotal evidence suggests that many of these fires appear to be caused by paraffin stoves and candles rather than wood fires. The Child Accident Prevention Foundation of South Africa (CAPFSA) has collected trauma injury data at the Red Cross Children's Hospital in Cape Town since 1991. Analysis of this data suggests that in the 12 months from April 1999 to March 2000, some 10% of trauma injuries to children were attributable to burns (a total of 706 cases). However, the dominant cause of burns was fluids such as water (497 cases or 70% of burn cases) while only 117 or 16.6% of burn cases were attributed to flame injuries. Although burn injuries undoubtedly represent a significant risk in informal and rural settlements due to their use of open flames, very little information could be found on the contribution of wood fires in particular to this risk, as opposed to other open flame sources such as paraffin stoves and candles.

The fact that rural women spend the majority of their time on survival activities such as cooking, fuelwood collection, water carrying and food preparation, represents a high social and economic cost to the households. Providing relief from these chores through providing more efficient and accessible energy options would allow rural women to use more time for higher level activities such as adult literacy, permaculture courses and skills training, which could contribute towards breaking the cycle of poverty.

Any intervention to strengthen the role of energy in sustainable development will need to pay attention to women's participation to be successful. Cecelski (2000) argued for an integrated approach towards developmental initiatives, where the particular energy needs and problems experienced by women receive particular attention.

8. RESEARCH GAPS AND OTHER REQUIREMENTS

This study has revealed a number of knowledge gaps that would benefit from further research.

1. Reliable empirical data on biomass and fuelwood use remains relatively scarce, particularly on a national level. However, research done on a macro level (i.e. national surveys) and micro-level (localised studies) together indicate that:

   - fuelwood is a substantial part of the South African household energy landscape, and around 2.3 – 2.8 million households or 12 – 15 million people depend on it (LHA estimate, 2008);
   - poor households continue to rely on or revert to fuelwood for energy hungry activities like cooking and heating, even where they have access to electricity;
   - although there is a definite trend away from traditional energy sources towards transitional and modern energy forms, fuelwood will remain an indispensable source of energy for poor households for decades to come, especially in rural areas.

   Therefore, it is suggested that further detailed and localised research in this field aimed at enumerating the use of fuelwood should have a low priority, with the exception of the regular national Censuses and household surveys, which are large enough to provide meaningful energy usage data at household level. Cooperation with Statistics SA should be sought to modify the Census and Household survey questionnaires to provide the required information (e.g. it would be important to include questions on the amount of fuel used per household).

2. A review of the literature on fuelwood use in South Africa shows that the key issues have not changed since the 1980s. Rural communities

continue to depend on fuelwood for the majority of their energy needs, and thus greater effort should be expended to address the supply situation. This should include research on wood species that (i) provide low-smoke fuel or multi-use species that provide less smoky fuel with other benefits such as assisting with food security; (ii) mechanisms / incentives to facilitate the planting of trees in rural habitats. There is some resistance in communities towards planting trees for fuelwood use only (Lawes, *et al,* 2004), and so a multi-use strategy may be more appropriate.

3. Little is known about the sustainable use of fuelwood in South Africa and the implications for sustainable resource management and policy interventions. Further research on the supply / demand balance is required to address this issue and map areas of fuelwood shortage and areas with an oversupply.

4. The lessons learnt from the Biomass Initiative should be re-visited and incorporated into any fuelwood initiative.

5. A more rigorous study could be done to better understand the drivers of demand, addressing issues such as temperature (seasonal and geographical variations), human population densities, and resource availability (i.e. local availability of fuelwood and its influence on usage).

6. It is surprising that despite the availability of more modern energy conversion technologies like smokeless fuels, more efficient wood burning stoves, and solar cookers, these have not made greater inroads into poor South African households. Herein lies a significant research (and application) gap – the need is there, although the absolute scale may be somewhat uncertain, but what is lacking is information on how best and most effectively these improved technologies can be introduced to poor households to reduce the demand for fuelwood and benefit health and environment. The following is proposed:

- conduct research to consolidate worldwide experience in the introduction of improved energy technologies like wood stoves and solar cookers, and identify key success and failure factors;
- select appropriate technology(ies) and design implementation strategy – this will most likely require the inclusion of an element of subsidisation to make the appliance(s) more affordable. It will also – critically – have to include a strategy for providing an after-sales maintenance and support structure for the appliances, to sustain their use for a long period of time (i.e. if the thing breaks, someone must be there to fix it - cf. the solar cooker study where after 5 years about half of the cookers required some repairs and maintenance and were out of action for that reason. After repair, the rural households went back to using them…). The support and participation of relevant government departments will have to be secured;
- launch pilot implementation project(s) in selected key rural areas. Monitor usage of technologies over a period of not less than 5 years. Measure benefits using a selection of measures which could include time saved, reduced fuelwood use, reduced environmental pollution and respiratory health problems, etc.

9. CONCLUDING REMARKS

i. The bulk of South Africa's poor are concentrated in the wooded biomes, especially woodlands, in Limpopo, KwaZulu Natal, and the Eastern Cape. Over 80% of these rural households depend on fuelwood as their primary source of energy.

ii. Fuelwood supply can be attributed to a number of sources and their contribution to total supply is estimated as follows: natural woodlands (60%), commercial plantations (9%), indigenous forests (2%), woodlots (4%), trees outside forests (13%), processed waste (9%), and clearing of alien invasive species (3%). On a national and regional scale, sustainable annual production of fuelwood is probably sufficient to meet annual demand. However, local shortages can and do arise due to over harvesting and changes in land use.

iii. Residential energy consumption accounts for some 18% of national energy demand. The fuelwood market is diffuse and therefore the best estimates of usage are considered to be those from large scale national surveys, i.e. the regular Census and Household surveys conducted by Stats SA.

iv. Total demand for fuelwood is estimated at 11.2 million tons per annum, which is equivalent to 40% of residential energy demand.

v. The number of households that depend on fuelwood as their main energy source is estimated at 2.3 – 2.8 million, the majority of which are located in rural areas. This represents some 12 – 15 million people or 25 – 30% of the South African population, according to our best estimates.

vi. Fuelwood use is concentrated in the poorer provinces with large rural populations, i.e. Limpopo, KwaZulu-Natal, Eastern Cape, and North West.

vii. Numerous micro-studies at local level suggest that households use between 1 and more than 7 tons of fuelwood per year. Based on a study of available localised energy surveys, our best estimate for the average annual fuelwood consumption is 4.5 tons per household.

viii. Seasonal variations in fuelwood use are related to temperature and there is a tendency to use more fuelwood in winter compared to summer. However, the effect is relatively small (estimated at around 20% of demand) since space heating is largely combined with cooking or water heating.

ix. Fuelwood is a valuable resource and its gross direct use value to rural households is estimated in this study at R4.5 – 5.5 billion per annum. This is somewhat higher than the R3 – 4 billion that are usually quoted in the literature.

x. An analysis of future demand trends suggests that the rural population has remained fairly stable in recent years due to the combined effects of lower population growth rates, HIV/AIDS, and urbanisation or migration. Therefore, it is concluded that fuelwood demand has most likely peaked and will stabilise and eventually decline in the future.

xi. Electrification is an important driver for rural households to move up the energy ladder, i.e. from fuelwood and other biomass to intermediate energy sources and modern energy, i.e. electricity. However, even recently electrified rural households continue to use fuelwood for years for affordability reasons, as a primary energy source for cooking and heating or as a safety-net in times when money is tight. Moreover, the more sparsely populated rural areas are presently uneconomical to electrify. Therefore, fuelwood will continue to play a dominant role in energy security for rural households.

xii. There is a strong gender dimension to the fuelwood issue. The collection of fuelwood as well as other household chores like cooking and carrying of water are the responsibility of women and children. Therefore, women and children bear the brunt of the negative aspects of fuelwood use, i.e. risk of injury due to the heavy head loads, health risks due to continuous exposure to wood smoke at levels well above international norms, and the opportunity cost related to the time spent in collecting fuelwood and other menial tasks. Any successful intervention to strengthen the role of energy in sustainable development must therefore take into account the particular needs and problems experienced by rural women.

xiii. A review of the literature has shown that the fundamental issues have not changed. Rural households will continue to depend on fuelwood for decades to come, and therefore the fuelwood resource must be managed actively and with a long term vision. Relatively little is known about the sustainability of present patterns of fuelwood usage and extraction, and further research in this regard would be valuable. Any future fuelwood initiative should also take note of and incorporate the learning from the

Biomass Initiative, which sought to improve the fuelwood supply through community forestry and afforestation pilot projects.

xiv. It is recommended that further detailed studies at the local level should receive relatively low priority, since good quality data requires large surveys. Cooperation should be sought with Statistics SA to ensure that the relevant information relating to household energy use and fuelwood use in particular is obtained during the regular Census and Household surveys.

xv. A more rigorous study to better understand the drivers of demand could also be undertaken, as empirical data is scant on this topic. Typical drivers that should receive attention are temperature (i.e. impact on fuelwood use of seasonal and local climate variations), human population densities, and resource availability.

xvi. Application oriented research is also required in two areas. On the supply side, research should be conducted on wood species that provide low smoke fuel and, even more appropriate, low smoke fuel combined with other uses such as food security. On the demand side, it is surprising that more efficient technologies such as improved wood stoves and solar cookers have not made greater inroads into rural households. Application oriented research and pilot projects should be conducted on the most effective introduction of these appliances. In this regard particular attention must also be paid to maintenance back-up of the appliances.

REFERENCES

Aitken R (2002). Socio-economic survey of the Northern KwaZulu Natal Area; The prospects for off-grid energy services, Rural Area Power Solution (Pty) Ltd.

Banks DI, Griffin N, Shackleton CM, Shackleton SE & Mavradonis J (1996). Wood supply and demand around two rural settlements in a semi-arid savanna, South Africa. Biomass and Bioenergy 11: p 319 – 331.

Bhatt BP and Sachan MS (2004). Firewood consumption pattern of different tribal communities in north east India; Energy Policy 32, p 1 – 6.

Cecelski E (2000). Enabling equitable access to rural electrification: Current thinking and major activities in energy, poverty and gender. Energy, Environment and Development (EED).

Census (1996). Statistics SA.

Census (2001). Statistics SA.

Community Survey (2007). Statistics SA.

DME (1996). Energy in South Africa. Pretoria, Department of Mineral & Energy Affairs.

DME (2002). Energy outlook for South Africa, 2002.

DME (2006). Digest of South African Energy Statistics.

DWAF (2004). Forestry and Poverty in SA. Working paper 3.

DWAF (2005). Forest Policy Briefing Note: Towards a fuelwood energy strategy for SA.

DWAF (2005b). Key issues paper on fuelwood energy, p 11 – 12.

DWAF (Department of Water Affairs and Forestry) (1997). South Africa's national forestry action programme. Pretoria: DWAF.

DWAF (Department of Water Affairs and Forestry) (2004). Policy and strategic framework for participatory forest management.

Eberhard AA (1990). Energy consumption patterns and supply problems in underdeveloped areas in South Africa. Development South Africa 7, p 335 – 346.

ERC (Energy Research Centre) (2004). Energy for sustainable development: South African profile, Energy Research Centre, University of Cape Town, South Africa.

Gandar M (1981). Tree utilisation in KwaZulu Natal, Unpublished progress report, Pretoria, CSIR, as cited in Lawes MJ et al (ed) 2004. Indigenous forests and woodlands in South Africa: Policy, People and Practice.

Gandar M (1983). Wood as a source of fuel in South Africa. South African Forestry Journal, June, p 1 – 9.

Government of South Africa (2000). Integrated rural development strategy. Pretoria, Government Printer, p 53.

Ham C (2000). The importance of woodlots to local communities, small-scale entrepreneurs and indigenous forest conservation: A case study. Instruments for sustainable private sector forestry.

Haw M and Hughes A (2007). Clean energy and development for South Africa: Background Data. Energy Research Centre, University of Cape Town, South Africa.

Hedon (2003). Country report synthesis: South Africa.

Lawes MJ, Obiri JAF and Eeley HAC (2004). The uses and value of indigenous forest resources in South Africa. In Lawes et al (ed). Indigenous forest and woodlands in SA: Policy, People and Practice.

LHA Management Consultants (2004). Roundwood supply and demand to 2030. Report prepared for the WFSP (Water and Forestry Support Programme), Department of Water Affairs and Forestry.

Liengme CA (1983). A study of wood use for fuel and building in an area of Gazankulu, Bothalia 13: p 501 – 518.

Lloyd PJ, Dick A & Howell M (2002). The energy profile of a rural community, Journal of Energy in Southern Africa, Aug 2004.

Madubansi M & Shackleton CM (2003). Changing energy profiles and consumption patterns following electrification in five rural villages, South Africa.

Makhado R (2006). Wood: primary source of energy in rural areas, Science in

Africa, www.scienceinafrica.co.za.

Palmer Development Consulting (2001). Energy baseline survey in Ga Maraba and Ga Mogano in the Northern Province (South Africa). ProBEC.

Rademan LK (2005). An ecological assessment of the sustainable utilisation of the woody vegetation in the Lowveld Bushveld, Mpumalanga province. Centre for Wildlife Management, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria.

Sesikhona Services (2005). Trees in gardens and homesteads; a review of the livelihoods importance of non-forest trees and their institutional and policy drivers. Report prepared for the WFSP (Water and Forestry Support Programme), Department of Water Affairs and Forestry.

Shackleton CM (1998). Annual production of harvestable deadwood in semi-arid savannas, South Africa. Forest Ecology and Management 112: 139 – 144.

Shackleton CM and Shackleton SE (2004). Use of woodland resources for direct household provisioning. In Lawes et al (ed). Indigenous forests and woodlands in South Africa: Policy, People and Practice.

Shackleton CM, Grundy IM, Williams A (2004). Use of South Africa's woodlands for energy and construction. in Indigenous Forests and Woodlands in SA: Policy, people and practice. Lawes MJ et al, p 337.

Statistics SA (2003). Urban/Rural discussion document.

Statistics SA (2005). Energy accounts for South Africa, 1995 – 2001.

Stewart G (2001) (ed). Women, energy and poverty, in Energy Scan vol. 9, No 1 2001, edited by JJ Doppegieter, G Stewart and E van Vuuren of the Institute for Futures Research, University of Stellenbosch, p 33 – 46.

Twine W, Moshe D, Netshiluvhi T and Siphungu V (2003). Consumption and direct use values of savanna bio-resources used by rural households in Mametja, a semi-arid area of Limpopo Province, South Africa, Research Letters, S.Afr. J. Sci 99 p 467 – 473.

Williams A & Shackleton C (2002). Fuelwood use in South Africa: Where to in the 21st century? Southern African Forestry Journal, 196: 1 – 7.

Williams A and Shackleton CM (2002). Fuelwood use in South Africa; Where to in the 21st Century? Southern African Forestry Journal, 196, p 1- 7.

Williams A, Eberhard AA & Dickson B (1996). Synthesis report of the biomass initiative, Pretoria. Chief Directorate Energy, Department of Mineral and Energy Affairs.