RURAL ENERGY DEVELOPMENT IN DEVELOPING COUNTRIES: SOUTH AND EAST SUB-SAHARAN AFRICA

BY

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A dissertation submitted to the Faculty of Engineering at the University of Cape Town in fulfilment for the degree of Master of Science in Engineering.

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DECLARATION

I, Thifhelimbilu Christopher Lithole, submit this thesis in fulfilment of the requirements of the degree of Master of Science in Engineering. I claim that this is my original work and that it has not been submitted in this or in a similar form for a degree at any other University.

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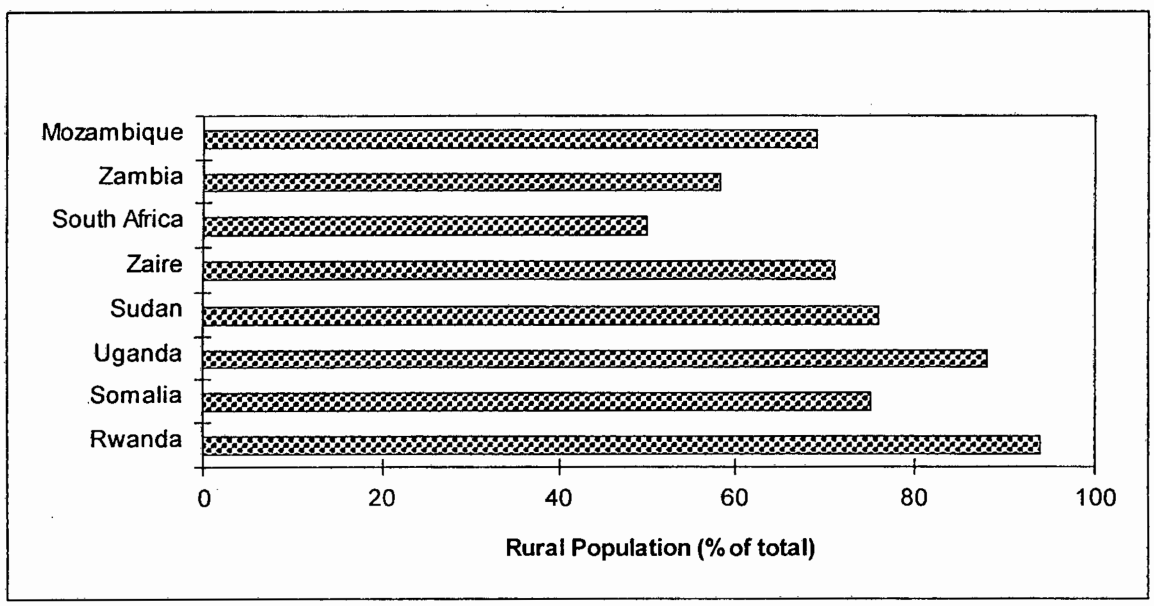
_______ day of _______________ 1997

EXECUTIVE SUMMARY

There are some common characteristics of rural communities throughout the world. They tend to lack a good economic infrastructure, essential social amenities, tourist potential, good road infrastructure, literacy, and most importantly, scarcity of sufficient energy supply to meet basic needs, and deteriorating environments due to increasing pressure on available traditional energy resources.

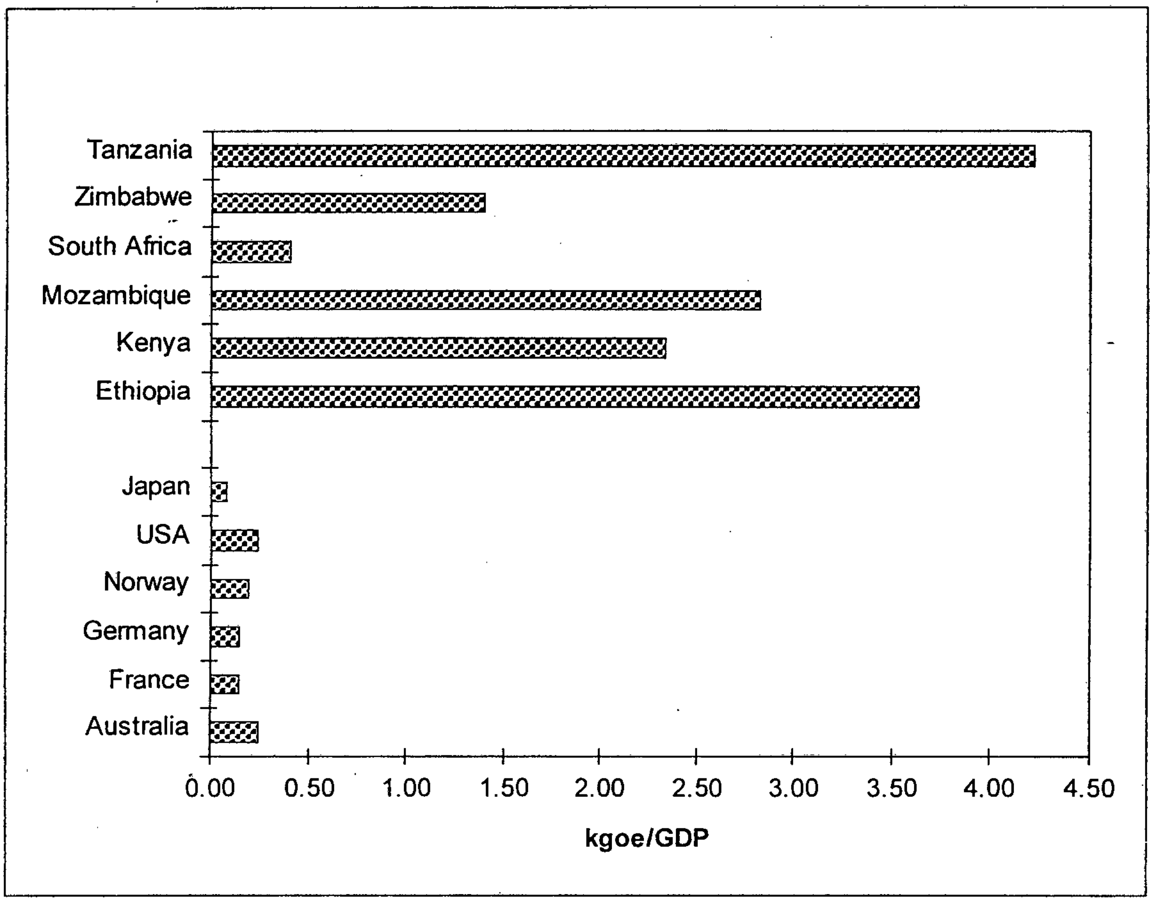
Furthermore, rural areas in the developing countries of South and East Sub-Saharan Africa are characterised by high population ratios, low levels of income, concentration of poverty, significant socio-economic disparities relative to urban area, and a high rate rural-urban migration. According to the figure below, the percentage rural population in the region was over 70% in 1993, with Rwanda and Uganda 94% and 88% respectively.



Rural Population as % of total population for selected countries in the region

The availability of adequate and convenient energy is essential in addressing these priorities of rural development. The development of energy resources for rural areas is, therefore, closely linked to the economic, social and environmental concerns of mainstream rural development. Unlike growth-driven energy development for industrialisation and urbanisation, rural energy development must consider social and environmental development. More importantly, it must be people-oriented.

The result of the study has indicated that the pace of energy transition from traditional to commercial energy in the rural areas of countries in the region has lagged behind that in urban areas, a similar situation to that existing between developing countries and developed countries. Significant rural-urban inequalities in commercial energy supply and consumption exist. Rural communities still continue to rely heavily on traditional energy, mainly biomass resources. The per capita consumption of energy by these countries was found to be generally low, especially when compared with developed countries, whereas a different situation exist with energy intensity, with developing countries consuming more energy per GDP than developed countries as reflected by the figure below.



Energy Intensity of selected developing and developed countries (1993 US$)

Institutions involved in the supply of energy to rural areas have not been successful in keeping data for rural energy demand and supply. This includes government Ministries or Departments, as well as parastatals. Governments are mainly involved in policy issues in most of these countries, with utilities responsible for operational issues, and it appears that the situation will continue like that for a long time, except that some utilities which are parastatals are restructuring with a view to partial privatisation. There is generally a lack of co-ordination between energy institutions and other institutions that are involved in the development of rural areas.

The rural energy demand sector can be categorised into households, agriculture, small industries and institutions like schools and clinics. Households, agriculture and small industries depend on commercial and non-commercial energy supplies that include biomass, coal, oil, gas and electricity. Household energy needs are towards cooking, lighting, space-heating, and the operation of household appliances and devices; the energy needs of agriculture consist of direct energy needs for land preparation, cultivation, irrigation, harvest, post-harvest processing, and the indirect energy needs of agriculture such as fertilisers, pesticides, etc. Energy needs in rural industries differ depending on the nature of the business.

Patterns show that electricity for households, agriculture and small industries is usually from a grid supply. Non-grid electricity is usually targeted for schools and clinics in isolated parts of the rural areas not reached by the grid. Rural electrification is strongly supported by governments in most countries. In keeping with the desire to ensure the basic needs of the rural population, governments have stressed social rather than financial or economic criteria in assessing the feasibility of rural electrification programmes. This is largely why most of the state-owned power utilities have incurred substantial technical and financial losses which are exacerbated by high subsidised tariff structures. The future expansion of conventional energy supply is expected to be constrained by lack of financial resources, technical expertise and the effect that they have on the environment. The role of alternative energy systems, including biomass, solar systems, wind and hydro potential are therefore expected to assume an important role in the overall development of rural energy. It is therefore imperative to make rural people conscious of the crucial role that can be played by these energy resources to their benefit.

Potential for regional co-operation exists. Coal, gas, oil and electricity are energy resources that are traded at regional level. Interconnections of electricity grids already exist between countries like South Africa, Botswana, Zimbabwe, Zambia and Zaire.

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Mr Fayez Malek, Canadian International Development Agency (CIDA), Canada
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NOMENCLATURE

SESSA	South and East Sub-Saharan Africa
WEC	World Energy Council
DCs	Developing Countries
OECD	Organisation for Economic Co-operation and Development
WB	World Bank
IMF	International Monetary Fund
MAI	Mean Annual increment
Mtonnes	Million tonnes
Toe	Tons of Oil Equivalent
AIDS	Acquired Immune Deficiency Syndrome
GDP	Gross Domestic Product
TEC	Total Energy Consumed
FAO	Food and Agriculture Organisation
SADC	Southern African Development Community
OAU	Organisation of African Unity
DME	Department of Mineral and Energy (South Africa)
Eskom	South African Electricity Utility
REFSA	Renewable Energy for South Africa
MEM	Ministry of Energy and Minerals (Tanzania)
MNRT	Ministry of Natural Resources and Tourism (Tanzania)
NGOs	Non-Governmental Organisations
CBOs	Community Based Organisations
UEB	Uganda Electricity Board
MPTC	Ministry of Power, Transport and Communication (Uganda)
ENEC	Ethiopian National Committee
EELPA	Ethiopian Electric Light and Power Authority
NER	National electricity Regulator (South Africa)
REFAD	Renewable Energy for African Development
NDC	Namibian Development Corporation
EPRI	Electricity Power Research Institute
UNIPEDE	International Union of Producers and Distributors of Electrical Energy
CIGRE	Grandes Reseaux Electriques a Tension
ELMS	Environment and Land Management Sector
U/R ratio	Urban/Rural ratio
Trad.EC	Traditional Energy Consumed
ESAP	Economic and Structural Adjustment Programme
PV	Photovoltaic
USA	United States of America
RAPS	Remote Area Power Supply
NRSE	New and Renewable Sources of Energy
ZESA	Zimbabwe Electricity Supply Association
ZESCO	Zambia Electricity Supply Commission
ADB	African Development Bank

UN	United Nations
GEF	Global Environmental Facility
EU	European Union
CIDA	Canadian International Development Agency

1. INTRODUCTION

1.1 Background

Rural Energy supply and demand is one of the contentious issues central to the development of rural areas. There are ongoing debates around the role that rural energy supply can play in the overall development of rural communities. The South and East Sub-Saharan Africa (SESSA) region is one of the developing regions in the world that is still very poor, and lack rural infrastructure in place to support energy supply.

The supply of energy to rural areas, particularly electricity, is believed to have positive spin-offs on the economy of any country. While supplying energy to rural areas is found to be quite costly due to their isolation and a high rate of rural-urban migration, to supply electricity is even more costly. This is even more so if in the short term. However, when one considers the effect that it might have on the long term development of rural communities in terms of education, health, the possibility of promoting rural small businesses and industries, the argument of cost tends to loose its force.

Until today, the dominant source of energy in rural areas of this region is traditional energy, particularly biomass. Biomass energy, unlike commercial energy, is still freely available to people in many rural areas, although the situation is beginning to change in some modernised societies, and due to the decline in biomass supply.

However, urban communities depend largely on commercial energy. Commercial energy is also becoming an important source of energy in rural areas as the population grows and less and less free energy is available. Regrettably, the cost of supplying commercial energy to rural areas is very high due to factors such as:

(a) distance of village settlements from the supplier
(b) lack of resources for rural people to pay
(c) lack of proper infrastructure such as good roads, powerline networks, etc.
(d) lack of confidence by investors to invest in these areas and
(e) lack of competent energy institutions.

As a result, the co-ordinated supply of energy in many developing countries tends to focus largely on urban areas, with rural communities neglected most of the time.

Lack of energy supply is one of the factors causing migration of rural people to urban areas, for the purpose of being closer to employment and proper services, of which electricity is one of them. Current trends show that the situation is unlikely to change unless radical steps are taken by governments to improve rural conditions.

It is generally believed that the supply of energy, particularly electricity, raises people's standard of living, whereby children receive better education and improved health services. Electricity supply in most developing countries is highly subsidised, especially grid electricity.

The effect of the removal of subsidies is not fully known. Efforts to promote adequate supply of alternative sources of energy to rural areas of developing countries, especially in the SESSA region (which happens to be the poorest and underdeveloped), therefore becomes more imperative.

1.2 Purpose of the study

The main purpose of the study is to identify the route for the sustainable development of rural energy. The study will try to identify the major obstacles encountered in rural energy provision and use, taking into account the economic, social and political framework in developing countries, with particular reference to the South and East Sub-Saharan Africa(SESSA) region.

The study will also try to assess the possibility of providing commercial energy to rural populations in terms of planning, availability, financing and consistency with other goals, and give recommendations for rural energy development policies. The recommendations will include proposals for the appropriate costing and pricing of energy in the longer term.

1.3 Research Methodology

An analysis of the problems facing rural communities in their search for energy was made from a literature survey and from direct contact with energy research specialists from research centres in developing and industrialised countries, some of which come from international organisation such as the World Bank (WB), International Energy Agency (IEA) and United Nation Food and Agricultural Organisation (UNFAO) and other organisations having links with the United Nations. A network of informants based on the national committees of member countries of the World Energy Council (WEC) was used. Some of the information was sourced from government officials responsible for energy issues in those countries. In addition, contact was made with existing organisations known to be working in this area, such as CIDA, AFREPREN, SAD-ELEC, etc.

A trip to the United Nation Food and Agricultural Organisation in Rome was undertaken, to assess the work being done by FAO related to the project, followed by a trip to Turkey, during a meeting of the Steering Committee of WEC Rural Energy Study. It was out of this meeting that the WEC Rural Energy Project Steering Committee agreed to appoint Regional Co-ordinators of the project. Seven developing regions were agreed upon, each with a co-ordinator. The regions are:

- South and East Sub-Saharan Africa (SESSA)
- North-West Sub-Saharan Africa
- North and Middle-East Africa
- Latin America and the Caribbean
- South East Asia
- Pacific Rim
- China, which was also decided upon as a region due to its land and population size

In May 1997, another trip was made to Rome, where the WEC Rural Project Steering Committee met on the progress made by Regional Co-ordinators of the project. The SESSA region was one of those that presented a draft report.

Small questionnaires relating to institutional and financial aspects of the energy sector were sent to all countries in the SESSA region. The target of the questionnaires were officials in government departments responsible for energy issues. The questionnaires also requested information on programmes, both successful and unsuccessful, which had either been implemented, were in the process of being implemented, or still in the planning stage. Few countries responded to the questionnaires that were sent out, but this information has been included.

As work progressed, newsletters were sent out to members of the steering committee and energy specialists for the purpose of obtaining feedback during the project, via e-mail and faxes.

1.4 Outline of the Thesis

The focus of this study is developing countries, with special attention being given to the South and East Sub-Saharan Africa region (SESSA).

Chapter 1 gives background information to the study, and the purpose is outlined, as well as the methodology of gathering information. It concludes by citing the limitations of the study.

Chapter 2 details the different characteristics that are common to rural areas in developing countries by looking at a broad spectrum of developing countries. They include poverty, rural population size, energy consumption, etc.

Chapter 3 focuses on the regional summary of energy supply and demand. It looks at the present social and political characteristics in the region, and the overall energy sector. The Institutional aspects and financial considerations involving energy supply and demand are discussed in this chapter. It also touches on environmental issues that result from the production, supply and consumption of energy.

Chapter 4 looks at the short, medium and long term situation relating to the supply and demand of energy in the rural areas. A comparison between developing countries and developed countries, to determine the trends followed by developed countries, is done.

Chapter 5 looks at the electrification needs, traditional fuel usage and regional co-operation in energy issues. The role of organisations such as the World Bank, Aid bodies and the developed world are discussed.

Finally, chapter 6 discusses some recommendations and proposals resulting from the current situation in the energy sector of developing countries. The recommendations are anticipated to provide some possible solutions to the problems experienced by rural communities in accessing energy.

1.5 Limitations

The focus of the study was suppose to be on energy issues relating to rural communities of the developing countries in the region. The study experienced huge difficulties, in that it is not easy to obtain information on rural communities only. Energy demand in many developing countries tends to be obscured by the energy demand in urban communities. There is lack of data on energy consumption in some of the countries in the region, especially in their rural areas.

Lack of finance also hindered the study. Some countries which were supposed to be visited to obtain primary data could not be. Data used in this study was mainly secondary data obtained from previous reports.

2. CHARACTERISTICS OF RURAL COMMUNITIES

This chapter deals with general characteristics of rural areas of all developing countries in the SESSA region. However, a reference will be made to countries of other developing regions.

2.1 Introduction

Rural communities throughout the world have some characteristics which are common in nature. They lack economic infrastructure. Entertainment centres are a luxury to them. Some of them have good tourist potential, but the state of the roads keeps tourists away. The level of illiteracy is high, because of lack of resources and motivation for young children to take education seriously. Most communities do not have good roads, and transporting energy sources such as coal, paraffin and gas to these places is difficult and costly. Many people still depend mainly on woodfuel and other biomass for energy survival.

Energy demands, particularly in the rural areas of the SESSA region, far exceeds supply. The World Energy Council (WEC) reported in 1993 that primary energy requirements in developing countries (DCs) amounted to around 2824 million tons of oil equivalent (mtoe) in 1990, which was only 32% of the world oil requirements, in spite of the fact that DCs represent more than three quarters of the world population. Today, the energy requirements of DCs has increased by more than 2% per annum over the past five years, following the growth in population.

The per capita consumption of energy in DCs was 0.71 tons of oil equivalent (toe) per annum (1990) against a world average of 1.65 toe and 5 toe in OECD countries. In 1993, the per capita consumption of energy in DCs had gone up to .90 toe. This translates to the average individual in DCs consuming less than half world average of energy and only one seventh of that of the OECD per capita[(1)].

However, energy requirements differ from one developing region to another, and from country to country.

It is important to note that there is little written information relating to rural areas only, especially concerning energy consumption. However, this chapter examines the conditions of rural areas in developing countries, particularly those of the SESSA region which are characterised by poor economies, lack of proper services, rural migration to urban cities, different types of energies that are consumed in rural areas, etc. The chapter also addresses problems that rural people of developing countries experience due to lack of adequate energy supplies.

2.2 Ratio rural/urban

Table 2.1 and figures 2.1a and 2.1b compare the urban and rural population of a few selected developing countries, from 1975 to 1995.

According to the World Bank, the majority of the world's population today are found in developing regions. In 1993 the total population in the SESSA region was around 322 million, while the rural population was found to be approximately 72%[6]. The estimations were such that by the year 2010, the rural population as a percentage of the total would have decreased to about 66%, a change of only 6% over 17 years.

The decrease in proportion of the rural population in developing countries is influenced by several factors, of which the more significant are: search for employment, poor infrastructure for development services and lack of energy sources such as electricity. However, this chapter is not going to go into details on factors that promote rural migration.

Table 2.1 %Rural vs %Urban Population[6]

COUNTRY	YEAR									
	1975		1980		1985		1990		1993	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Rwanda	4	96	5	95	5	95	6	94	6	94
Somalia	21	79	22	78	23	77	24	76	25	75
Uganda	8	92	9	91	10	90	11	89	12	88
Sudan	19	81	20	80	21	79	22	78	24	76
Zaire	29	71	29	71	28	72	28	72	29	71
South Africa	48	52	48	52	48	52	49	51	50	50
Zambia	35	65	40	60	41	59	42	58	42	58
Mozambique	9	91	13	87	19	81	27	73	31	69

Table 2.1 show the increase in urban population of some selected developing countries. The countries reflected in the table were picked randomly throughout the region, some with a large total population and others with a small population size. When one looks at the table, it would appear that the % rural population is declining for most of the countries, except for Zaire which reflects an increase in the proportion of the rural population between 1985 and 1993.

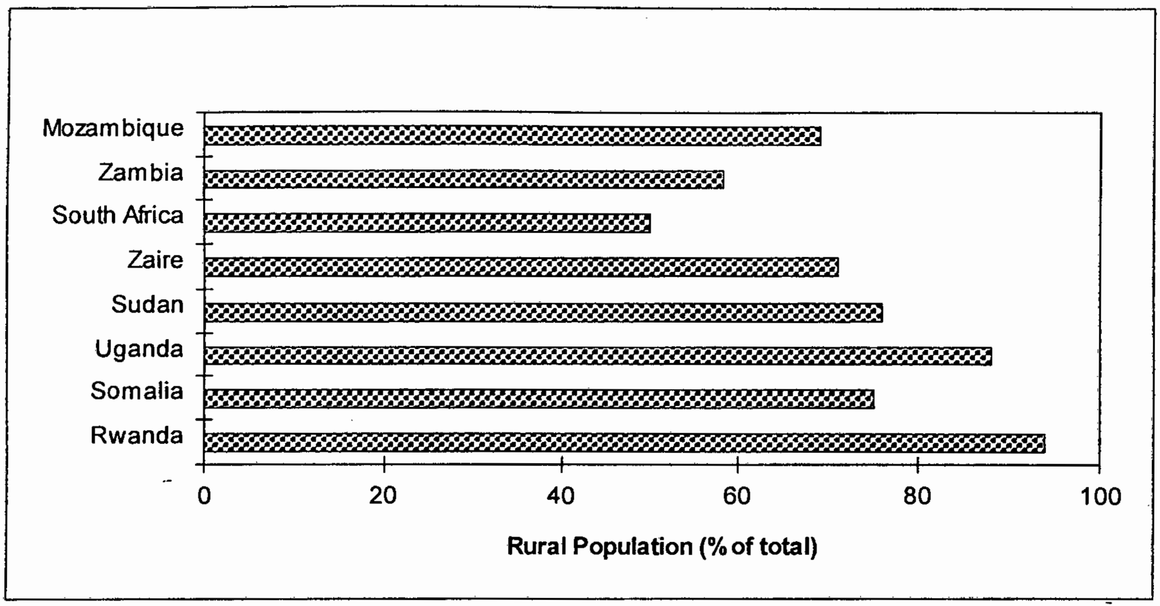

Figure 2.1 **Rural Population as % of total population for selected countries in the region (1993)**

Figure 2.1 shows the rural population of countries in the region, with Rwanda showing the highest percent of rural population at 94%, followed by Uganda at 88%. Amongst the countries selected, South Africa has the smallest proportion of the rural population at 50%. Nonetheless, it is not the smallest in the region: Seychelles' rural population was 47% in 1993.

2.3 Rate of urbanisation

While the rural population is expected to decrease in percentage terms for the next 30 years, the overall population is expected to rise by approximately 1.9% every year.

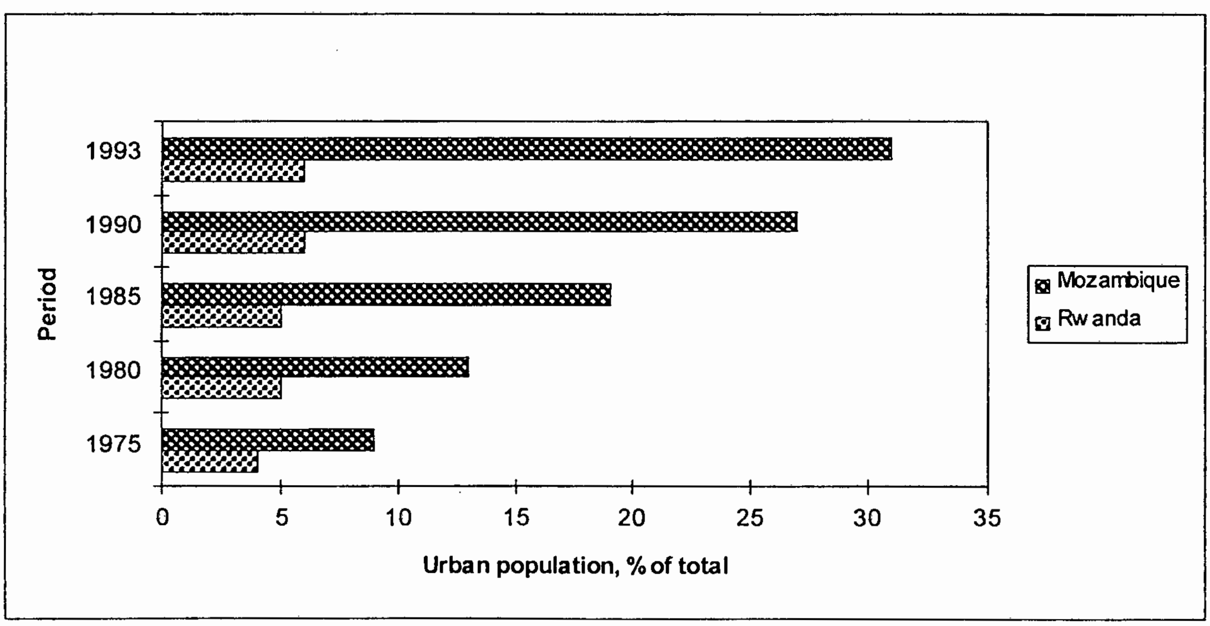

Figure 2.2 **Urban Population as % of total population for selected countries in the region (1993)**

While figure 2.1 shows the percent of rural population of some of the selected countries in the region, figure 2.2 compares the rate at which urbanisation has been taking place between two of the developing countries between 1975 and 1993. The contrast in urbanisation between these two countries is large, with Rwanda's urban population increasing by only 2% from 1975 to 1993, while that of Mozambique increased by 22% over the same period. The two countries were experiencing civil war at some stage during this period, but the result in displacing population was different. Though economic factors are the main driving force behind urbanisation in many developing countries, it would be wrong to draw a general conclusion that urbanisation is caused by similar factors in these countries, as shown by Mozambique and Rwanda.

It is important to point out some of the factors that promote urbanisation without going into details. Many economic institutions that attract labour and professionals are based in cities. The outcome is that people working mainly in the agriculture and some related sectors remain in the rural areas, while all other people, including politicians, move to urban areas. However, in other countries, things have begun to change, with some politicians showing appreciation for the development of rural communities. Political organisations in some African countries use the influence of traditional leaders over their subjects to woo support for their political organisations. Even in situations like these, some political leaders choose to have more than one house, one in the rural area, a place of birth, and one in an urban area. Parents and relatives are left to look after the house in the rural area while the owner spends most of the time in the city, visiting the rural home once in a while.

2.4 Energy Use Patterns and Trends

There are several sources of energy used by households in the region. They include biomass, coal, gas, paraffin and electricity. Almost all the developing countries in the region have found themselves consuming one of the five energy sources as a dominant fuel at one stage, with urbanisation, and depending on the country's economic growth.

Many rural households use different energy sources for different purposes. For example, one family could use fuelwood for cooking and paraffin for light, while another family is using paraffin for both cooking and lighting purpose. Sometimes, the choice for a particular fuel is determined by the availability of the fuel itself, while in other situations, the affordability part of it and the public's perception of the fuel play an important role.

The perceptions of the public are usually motivated by the cleanliness and the convenience of using the fuel. There are fuels which are considered to be dangerous to young children for fear of drinking or inhaling them, or handling them in a manner that will cause damage to the family. Fuels like paraffin are sometimes mistaken for water or soft drinks by young children who may drink it, while on the other hand candles could cause fire to the furniture or roof-thatched houses.

(a) Biomass

Traditional energy, such as fuelwood and other forms of biomass, is the main source of energy in rural communities. It is used in rural households, agriculture and small industries, as will be discussed later in chapter 2. Biomass energy is mainly used for cooking and heating. Sometimes it is also used for lighting where the fire is made outdoors, providing light during the night.

(b) Substitution of biomass fuel

The average rate of fuelwood substitution by other sources of energy in the region has been slow. It is, however, difficult to say for certain how much fuelwood was consumed in rural areas 10 years ago, due to lack of data. Fuelwood energy is replaced by different sources of commercial energy, depending on the availability. For example, gas and paraffin are the first sources of energy in areas where there is no coal supply, depending on the sector of the economy. Unlike urban areas, rural areas with electricity supply use both electricity and fuelwood (i.e. households), with fuelwood used for cooking and electricity for lighting and entertainment. Fuelwood substitution is also very unpredictable at times. For example, there are areas which continue to use fuelwood even after they are supplied with electricity. It is difficult to totally displace fuelwood consumption in rural areas for as long as there is enough supply. It is presumed that people continue to use fuelwood because it is freely available, and in addition, it can be used with less complicated appliances or ones which are easier to obtain.

(i) Coal

According to WEC report(1), coal meets 30 percent of the DCs requirements and is the main fuel utilised by the DCs. Despite the fact that in other regions like China and India, many rural households are using coal for cooking and heating, in this region it is confined mainly to urban households.

The increase in the consumption of coal in the residential sector from 1975 until 1990 for South Africa (the proportion decreased by 1993), little as it may be, can be attributed both to the growing population and the substitution of fuelwood by coal, as the availability of wood and other biomass material became more and more scarce. However, more than 80% of the household consumption is accounted for by urban and semi-urban areas.

(ii) Gas

Gas consumption in rural areas does not necessarily substitute fuelwood or coal, but it does supplement them. This happens mainly in rural areas without electricity. Gas, like coal, is also mainly used for cooking by rural households.

Whilst the contribution of gas to total energy consumption globally was approximately 7% of the primary energy supplies in developing countries in 1985, its contribution in the region was less than 1%.

(iii) Electricity

A dominant feature of energy use patterns in rural communities, particularly rural households is their tendency to include multiple sources of energy to meet their needs[(10)]. The main reason for this is because energy is used not for the sake of being used, but to provide certain services to people. These services include lighting, cooking, space heating, water heating and powering appliances such as radios and TVs.

There are arguments to the effect that multiple fuel is conspicuous mainly in households without electricity. However, this does not seem to be the case in rural areas where people may have access to electricity, but lack electrical appliances. The time spent in warming the place or cooking food also plays a role in the determining which energy source is used.

An interesting observation can be made in areas that have had electricity for many years, and where income levels happen to be higher than average. In this instance, it is proper to talk about electricity displacing other sources of energy like biomass, gas, coal, etc. The advantage is that electricity can be used to provide all the services necessary for energy consumption.

Climate, impacts significantly on household energy consumption. Energy consumption in rural areas may not be influenced strongly by cooling, even in houses with electricity, but the need for space heating plays an important role. Traditionally, people in rural areas prefer sitting around wood fires rather than warming space using electric heaters. Therefore, during winter, even households with above average income levels, and which have enjoyed electricity for many years, would rather heat space using fuelwood fires. This is usually preferred due to the size of rural families, which is above 4 members by average standards.

(iv) Other sources of energy

Rural households also make use of other energy sources besides electricity, coal, biomass and gas. These fuels include paraffin and candles. Paraffin is preferred in some areas for certain needs such as heating of food rapidly or boiling water, while other fuels are more effective for other needs. On the other hand, the main use of candles is for lighting.

2.5 Energy Resources

The energy resources which are going to be covered in this section include coal, oil, natural gas, hydropower, wood, solar energy, and wind energy. Biomass, coal, gas, and oil remain in demand, but only biomass and coal seem to be in abundance in the region. Recent gas discoveries in Namibia have also raised hopes of a brighter future in this field.

Countries such as South Africa and Botswana are rich in coal, while Namibia and Mozambique have shown potential of gas production. Angola is a country that is rich in oil, with Zaire having an abundance of water for hydropower.

(a) Biomass

Biomass resources are classified into two categories: woody and non-woody biomass. The woody resources include natural forests, plantations and woody residues from harvesting or processing, while the non-woody refers to agricultural and animal residues.

Table 2.2 Natural forest Biomass Potential[20]

Country	Forest Area in ha x 10^3	Forest % of Land	Biomass Potential million tons	MAI* Million m^3	Biomass % of Total	Biomass per capita	
						Total tons	MAI m^3
Angola	23074	18.2	2883	4.9	5.0	488	5
Botswana	1427	22.1	7297	3.7	1.3	567	3
Burundi	233	8.7	38	0.4	0.1	7	<1
Comoros	30	66.1	3	0.1	<0.1	5	1
Congo	19865	58.1	4649	82.6	8.1	2331	41
Djibouti	22	1.0	1	<.1	0.0	2	<1
Ethiopia	14165	11.2	2198	26.0	3.8	47	1
Kenya	1187	2.1	224	3.1	0.4	9	<1
Lesotho	519	17.1	2	<0.1	<0.1	1	<1
Malawi	3486	35.2	394	90.2	0.7	46	1
Madagascar	15782	25.3	2288	61.8	4.0	191	5
Mauritius	3	0.4	<1	<0.1	0.0	<1	<1
Mozambique	17330	21.1	1776	23.1	3.1	113	1
Namibia	1256	14.3	556	3.1	1.0	418	2
Seychelles	10	31.9	1	<0.1	0.0	2	<1
Somalia	754	1.2	35	0.1	0.1	5	<1
Sudan	42976	16.8	3991	47.2	6.9	158	2
Swaziland	936	53.9	24	1.1	<0.1	31	1
Tanzania	33555	37.8	3334	56.0	5.8	122	2
Uganda	6344	31.1	1269	13.4	2.2	69	1
Zaire	113275	49.0	29119	557.0	50.6	809	15
Zambia	32301	42.5	3351	62.2	5.8	396	7
Zimbabwe	8897	21.9	638	5.6	1.1	66	1
Total	337425	25.5	57502	1042.0	100.0	5883	89

* MAI: Mean Annual Increment

The data for South Africa is not included here as it was not available. As depicted by table 2.2, the natural forests resource potential in the region seems to be quite impressive. The forest area is approximately 340 million hectares, while the forest cover is around 26% of the total South and East Sub-Saharan Africa region land area. On the other hand, the total biomass estimate was found to be close to 58 billion tons. The per capita total biomass potential is around 6000 tons.

It is, however, imperative to note that the distribution of these resources between the individual countries is uneven. When one looks at the percentage of forest cover for individual countries, it is very clear that there is a high degree of variation, ranging from as low as less than .01% for countries like Seychelles, Mauritius, Swaziland and Lesotho, to as much as 50% for Zaire. More than 70% of the resource potential is found in the northern part of the region

Besides natural forest biomass, the region also has forest plantations that are comprised of industrial plantations and non-industrial plantations. Industrial plantations are usually established mainly for the production of wood for industry. Non-industrial plantations on the other hand are established for more than one reason, some of which are production of fuelwood, production of small wood for domestic consumption and non-wood products and soil protection. Some countries that have forest plantations include Swaziland, Zambia and Botswana amongst others, with Madagascar, which has total land area 310 000 hectares, most of which is covered by forests and plantations.

(b) Coal

Of all 24 countries in South and East Sub-Saharan Africa region, proved coal recoverable reserves were identified in only 10 of them. These are Botswana, Malawi, Mozambique, South Africa, Swaziland, Tanzania, Zaire, Zambia and Zimbabwe. The total proved recoverable reserves of bituminous, anthracite, sub-bituminous and lignite in 1995 in the region was around 62 000 Mtonnes, with bituminous (including anthracite) making 98% of the total proved recoverable coal reserves.

It is considered one of the most widely available fossil fuels in the region, as can be seen in table 2.3 below. It covers a considerable proportion of the region's primary energy supply.

Table 2.3 Proven recoverable reserves (Mtonnes)[29]

Country	Bituminous including anthracite	Sub-bituminous	Lignite	Total
Botswana	3500		-	3500
Malawi	2	-	-	2
Mozambique	240	-	-	240
South Africa	55333	-	-	55333
Swaziland	116	999	-	1115
Tanzania	200		-	200
Zaire	88	-	-	88
Zambia	-	55	-	55
Zimbabwe	734	-	-	734
Total	60213	1054	-	61267

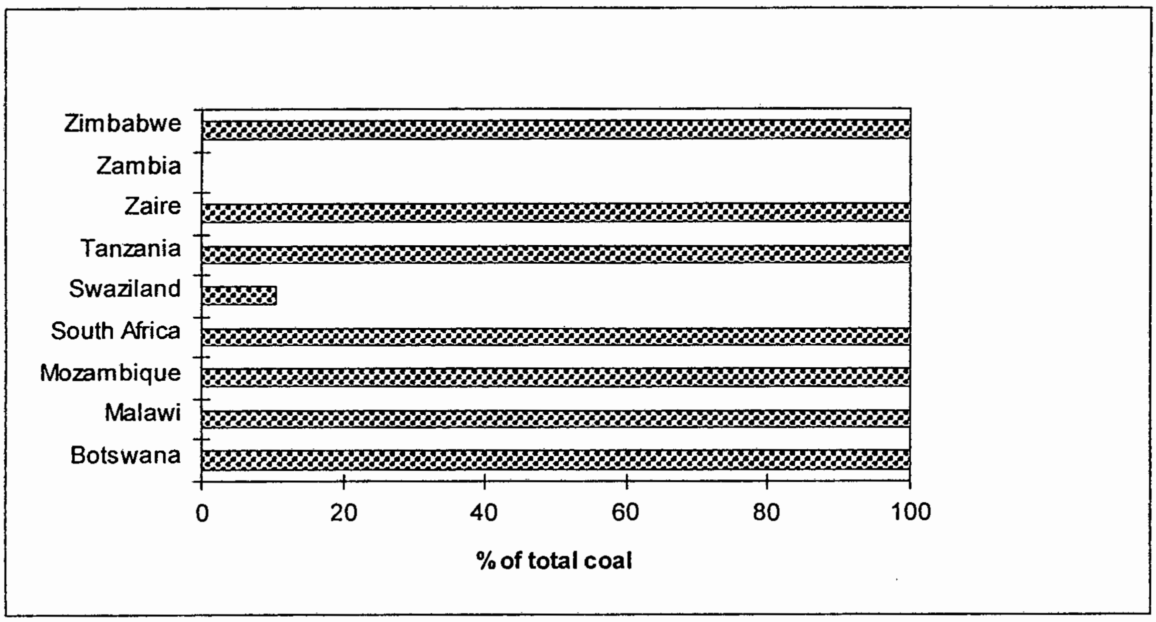

Figure 2.3 Proven recoverable reserves of bituminous coal (% of total coal, 1995)

According to figure 2.3, the type of recoverable coal reserves found in all the countries except Zambia and Swaziland is bituminous coal only. Lignite is not found anywhere in the region.

(c) Oil and Natural Gas liquids

Table 2.4 show the reserves of crude oil in the region, which totals 920 Mtonnes, which is far less than the quantity of reserves found in Nigeria alone. However, the data is not very representative of the present picture as it does not show recoverable natural gas reserves found in Namibia and Mozambique. There are reports claiming more discoveries of crude oil in countries like Angola, the exploitation of which is affected by the civil war. Significant gas reserves are also reported off the southern Cape coast in South Africa.

Table 2.4 Proven recoverable reserves[29]

Country	Crude oil Mtonnes	Natural gas liquids Mtonnes	Total Mtonnes
Angola	736	-	736
Congo	113	-	113
South Africa	6	-	6
Sudan	41	-	41
Zaire	25	-	25
Total	921	-	921

Compared to other regions, this region has very small reserves of crude oil and natural gas. For example, the total recoverable reserves in the whole of the Middle East forms 64 per cent of the total world production, Saudi Arabia dominating the reserves with 25.3 per cent. This makes the world depend largely on the Middle East for oil.

A look into the world picture shows that the world's proved natural gas reserves seem to be increasing significantly, with the markets and the international trade expanding dramatically, and the world's reserves expected to rise from 141 000 billion in 1993 to almost 150 000 billion cubic metres in 1995. An increase in the proved reserves of natural gas was significant in developing countries such as Iran, Qatar, and to a lesser extent, Oman and Yemen. Iran in particular held more than 60 per cent of the Middle East region's total proved reserves. In the Asian region, India and China showed the highest increase in the reserves of natural gas. The three African countries which have shown some increase in natural gas reserves are Algeria, Egypt and Nigeria. Unlike other regions, the growth of oil reserves in Latin America slowing down sharply after the rapid increase of the 1980s, with countries like Mexico and Peru experiencing decline in their reserves. However, there were reports of discoveries in Argentina and the intensification of gas exploration in Venezuela and the Ardine states.

(d) Hydropower

Hydropower is claimed to be the most clean renewable source of energy. It is considered as the third largest source of electrical power after coal and oil/gas, contributing 18.5 per cent of the world's electrical power.

Hydro development is emerging as a central part of a strategy to manage greenhouse gases in some of the developing regions where large hydro resources exist. In addition to the positive environmental effects claimed by hydropower, through the construction of small-scale hydro plants which are locally driven, it is claimed that hydropower offers the fastest way to increase electrification, improve living standards, stimulate industrial development and enhance agriculture in rural areas.

Table 2.5 Hydropower capability[29]

Country		Schemes >10MW	
	Gross theoretical capability (GWh/yr)	Technically exploitable capability (GWh/yr)	Economically exploitable capability (GWh/yr)
Angola	150000	100000	-
Burundi	6605	4000	1445
Congo	>50000	50000	-
Ethiopia	650000	>160000	160000
Kenya	>6000	6000	3500
Lesotho	>2000	2000	-
Madagascar	420000	44370	23061
Malawi	>6000	6000	-
Mauritius	150	110	-
Mozambique	>72000	72000	-
Namibia	12404	8645	8645
Rwanda	>3000	3000	-
Somalia	>600	600	-
Sudan	>1900	1900	1900
Swaziland	3800	560	300
Tanzania	190000	20694	20000
Uganda	>10200	10200	10200
Zaire	1 397000	774000	419210
Zambia	>28753	28753	17233
Zimbabwe	18500	17500	-

Table 2.5 shows the hydro potential that is available in the region. Irrespective of the fact that many of the countries in the region have great hydro potential such as Zaire, Madagascar, Ethiopia, Tanzania and Angola, hydropower is underdeveloped in the region. For example, Cahora Bassa, situated in Mozambique, has been out of action for many years now because of the war in Mozambique. This dam has the potential to supply power to countries like South Africa, Zimbabwe, Malawi and Zambia. Inga dam, based in Zaire' is even bigger than Cahora Bassa.

(e) Solar Energy

Solar Energy is the energy transmitted from the sun in the form of electromagnetic radiation. The earth receives about one-half of one billionth of the total solar energy output. The energy that comes from woodfuel (captured and stored by plants), hydroelectricity, paraffin, and petroleum all originate from the sun.

Apart from the traditional way of consuming energy from the sun by either drying wet clothes in the open, or the energy which it provides to grow crops, the methods of using solar energy to replace conventional sources of energy is still very unpopular in rural communities. There is great potential for solar energy to be used in rural areas of developing countries, except that solar equipment is very expensive for rural people. The negative perceptions that rural people have towards solar energy and the costs of the equipment are two important factors that prevent the growth of the solar energy market.

Despite lack of interest from communities, government authorities do use it. In Tanzania, it is reported that there are some 31 kW of installed solar photovoltaic applications for village electrification, water pumping and flour-making, while a further 12kW is employed for telecommunication systems and 12kW for various water pumping stations[29]. A mean annual total radiation of about 6750MJ/m^2 is reported in Tanzania. Photovoltaic systems are used in many applications like water pumping, lighting, refrigeration and telecommunications. Other countries like Swaziland are also involved in promoting the use of solar energy, and conducting solar pilot projects whereby government funds are used to install solar systems mainly in rural schools and clinics.

2.6 Agriculture and micro-enterprise energy requirements and trends

Agriculture is still the main economic sector that consumes energy in the rural areas of some countries. The sector itself is made up of different kinds of farmers who are characteristic of developing countries. The following are the kind of farmers who can be found in rural areas as described by Auerbach and Gandar,[39]:

- small-scale landholders -their production is below subsistence levels, they generally do not sell any crops or livestock
- small-scale landholders- this group sell some produce and livestock
- market-oriented commercial farmers-such farmers make a living from farming only.

Also apparent is the fact that most rural people who do not have employment depend on agricultural products only. The majority of these rural people happen to have access to small arable land just for their survival. Unfortunately, most of these subsistence rural traditional farmers do not have access to agricultural inputs, implements, markets, research and extension services.

Many small-scale farmers usually survive without depending heavily on commercial energy. Auerbach and Gandar[39] describe the types of energy required by small-scale agriculture as follows:

- draft power - the extent to which rural households use animal draft varies per area. Numerous surveys of subsistence agriculture have shown that most households own insufficient cattle for their basic requirements of draft, even though draft may be the main consideration in keeping the cattle.
- shaft power, for mechanized draught transport, driving pumps, mills and other machinery
- heat, which includes:
- low temperature heat (up to 60 degree C); e.g. incubators, warm water for dairies;
- medium and high temperature heat (60 degrees C upwards); e.g. drying certain crops, sterilizing, welding.
- refrigeration: marketing of perishables, storing veterinary materials.
- lighting: may be used in poultry units for example, but the main need for lighting is in agricultural extension and organisational development and includes audio-visual equipment.

Small-scale agriculture can further be grouped into three categories. The first category is subsistence and sub-subsistence agriculture, done by subsistence farmers as discussed before; which is typically made up of extensive grazing of livestock, dry and arable cropping and gardening on a plot, either in a homestead or in a community garden. The type of energy required here is draft for ploughing and other agricultural operations. When it comes to community gardening, energy is needed for pumping water for vegetables and other garden products, not forgetting drinking water for the livestock. Other farm operations such as food processing (milling) requires energy consumption too.

The second category of small-scale agriculture is that of small-grower schemes, whereby small-grower farmers operate under traditional tenure on their land; and schemes that involve a single crop, often a raw material to be processed like sugar cane, cotton or timber.

The third category involves settler schemes; they usually consist a group of farm and individual plots. These are usually commercial farmers who require a diverse range of energies, for irrigation, feed for livestock, etc.

The agricultural sector's energy share in the developing countries grew from between 2% and 5% in the early 1970's to between 5% and 13 % in 1981. Between 1981 and 1991 it is estimated to have grown by more than 15%. The growth of energy share in agriculture can be attributed mainly to the growth in commercial energy consumption. It should be emphasised, though, that despite the high growth rates of agricultural energy consumption in the rural areas of developing countries, the share of this sector in the total energy consumption of the selected countries is still very low, as shown below in table 2.6.

Table 2.6 Energy shares of Agriculture in some developing countries(Toe)

Year	Coal	Oil	Gas	Electricity	Total
Brazil					
1992		3403		648	4051
1993		3851		688	4539
1994		4358		730	5088
1995		4933		775	5708
India					
1992		234	86	5446	5766
1993		250	99	6080	6428
1994		267	114	6788	7169
1995		286	131	7426	7843
South Africa					
1992	106	829		347	1282
1993	132	1009		350	1491
1994	166	1228		353	1747
1995	209	1498		356	2063
Thailand					
1992		1914		10	1924
1993		1628		11	1640
1994		1335		12	1347
1995		1095		13	1108

Of the selected countries shown in table 2.6 namely Brazil, India, South Africa and Thailand, (table 2.6 reflects commercial energy consumption only) the consumption of traditional energy in small-scale agriculture operations is large. However, there is no reliable estimate of traditional energy consumption in many developing countries. Where the data is available, it tends to capture most accurately those traditional fuels which are traded in some commercial sense, but under-report those which are collected informally.

Brazil and Thailand show a high consumption figure for oil in the agricultural sector. The oil share of energy consumption in the agriculture sector as shown above, is in the form of diesel petroleum products used by tractors in ploughing. Auerbach and Gandar[39] claim that the time taken to plough a hectare by four oxen (the common configuration) is about 18 hours, while a 38kW tractor takes about six and a half hours. Many commercial farmers prefer using tractors for ploughing, while subsistence farmers in rural areas still use oxen because they cannot afford tractors. Tractors save time, compared to oxen. However, the performance of tractors differs depending on their size, and their condition. Some farmers use both tractors and oxen in their field, with oxen used after primary cultivation by tractors, for the purpose of pulling furrows, especially when planting potatoes where ox-drawn cultivators draw inter-row cultivation.

Table 2.6 depicts South Africa as the only country in the table which shows the consumption of coal as an energy share for agriculture. About 106 toe of coal was consumed in South Africa in 1992, and 132 toe in 1993, which translate to 9% of the total energy share of agriculture in the country, as opposed to 8% of coal of total energy consumed in 1992 as a share of agriculture. The coal share was estimated to have gone up by 20% from 1993 to 1995, suggesting that 185 toe of coal was consumed as share of agriculture. The consumption of coal in its primary form in the agriculture sector is mainly in cooking and space heating.

Again from table 2.6 , the column which describes electricity consumption shows clearly that, of the selected countries, only India, with close to 95%, and South Africa, with close to 25%, have done significant work in the supply of electricity to the agriculture sector, much of which is for irrigation pumps. The other countries are still lagging behind, with as little as .5 percent of their agricultural sector electrified. Some of these countries promote the supply of electricity to farmworker houses by giving a farmer a subsidy towards electrification, provided electricity is extended to the worker's households.

India is the only country here which has records of gas consumption in the agriculture sector. However, the consumption of gas compared to that of oil and electricity is low.

Energy, particularly electricity, is an important input in the micro-enterprise sector. Unfortunately, it is difficult to obtain records of energy consumed in the micro-enterprise sector. It is generally accepted that as soon as an area is electrified, small businesses starts getting off the ground.

Typical small businesses that prevail in rural areas of developing countries, some of which use electricity and some not, are retailers, coal and wood yards, garages, panel beaters and shebeens. The retailers vary from small "spaza" traders (informal shops), to general dealers.

A survey done in 1989 in one of the rural areas of South Africa(QwaQwa), shows the average monthly expenditure on electricity and the energy usage and costs in a typical rural business which does not use electricity (see table 2.7 and 2.8 below).

Table 2.7 Electricity expenditure/month in QwaQwa [40]

Rural Settlement	No of businesses	Average monthly electricity bill (Rands)	
		Summer	Winter
Botala	2	60	90
Theseng	1	70	85

Similar to household electricity consumption trends, the amount spent on electricity in winter is higher than in summer. This can be attributed to the fact that heaters are used during cold weather to provide warmth.

The businesses without electricity shows a slightly different picture from those with electricity.

Table 2.8 Alternative sources of energy and associated costs [40]

Energy source	Unit	Usage/month	R/month	% of total
Coal	kg	137.0	21.92	15.3
Firewood	bag	0.3	2.49	1.7
Paraffin	litre	43.0	36.98	26.0
Gas	kg	32.0	53.12	37.2
Candles	pack	3.0	4.62	3.2
Battery	battery	0.9	55.81	4.0
Generator	litre	17.9	12.60	12.6
Total			142.81	100.0

When comparing the two table 2.7 and table 2.8, it is seen that in businesses where there is no electricity, an average of R142.81 was spent on energy, R2.49 spent on wood, R56.00 spent on batteries, compared to R60-R70.00 per month spent on electricity. The results of the two tables show that the amount spent on energy in areas with electricity was less than the amount spent on energy in unelectrified areas.

A further study that was carried out showed that more coal is used in households than in businesses. However, households were found to use less paraffin and gas than businesses. Generator fuel was found to be used more in businesses than in the households. In areas where small businesses had electricity, very little other energy sources were used.

2.7 Food use of energy

Energy plays an important role in the production of food in rural areas. Rural people depend mostly on their cattle for ploughing in the field. Male members of the family, and sometimes neighbours who want to assist, usually wake up during the early hours of the morning, to go and plough the fields. The neighbours, in return, will get their fields ploughed. Ploughing usually takes place every day of the week, sometimes even on weekends. During the week, young men are expected to go to the field first before they go to school.

However, things are changing, and only those who do not go to school and have no formal jobs remain ploughing the fields during the week. During the process of ploughing, it is a custom to make fires for the purpose of warmth. Those who are waiting to relieve others sit by the fire.

During ploughing, female family members collect crop residues for energy purposes from the surrounding areas.

Electricity is one of the energy sources which is very important in the production of food in the rural areas. Electricity in rural communities results in the extension of working hours in the field, small farms, restaurants and other home-based businesses.

2.8 Energy/Food conflict

In the rural communities, a large amount of biomass is lost each year in the form of fuelwood and vegetation which goes towards the preparation of food. The majority of rural people still depend on biomass for cooking food and boiling water. It is also important to note that in the process of ploughing fields for vegetables, maize meal and other agriculture products, the land is cleared of all biomass. In the agricultural sector working in the fields usually go on until late into the night, mainly because there is supply of electricity.

In a study which was done in one African country, Burkina Faso, it was discovered that loss of biomass arising from both man-made and climatic factors could be costing Burkina Faso about 9% of its GNP, with crop productivity losses alone standing at almost 2% of GNP[25]. Most of the waste materials removed from the land in preparation for ploughing are collected again to be used as firewood. Sometimes it is used during the process of ploughing in the field to make fire for warmth as people continue to work, taking turns to sit around the fire. The irony of this is that preparations of land for agriculture production result in the increased use of energy and particularly fuels suitable for driving farm traction and mobile machinery.

2.9 Poverty trap

The majority of people staying in rural areas are poor compared to those in urban areas. Rural areas have no economic centres, except in farming and some small-scale enterprises. These are the main employment sectors of rural people, except in some few instances where there are tourists places and game reserves.

People with formal employment in rural areas prefer to move from rural villages to townships and urban areas. What makes things worse is when literate people choose to migrate to urban centres. These are the people who could serve as vehicles for attracting investment in rural areas by not moving away to already developed areas.

Development projects in rural areas mainly depend on foreign aid that come through non-profit organisations. Local private businesses are usually reluctant to invest in rural areas and therefore turn to direct their investment to urban populations where they are more certain of returns. State resources allocated for rural areas are also limited.

2.10 Effect of non-availability of electricity on health

The lack of electricity in rural communities in many developing countries has significant health effects on people, and more particularly on the poor. Coal is the dominant fuel in many parts of urban communities in South Africa, and sometimes even rural areas. Sulphur, ashes and particulate matters are released into the air from the combustion of coal.

It is common for rural houses not to have smoke-chimneys, nor windows, the door being the only path for smoke to escape. Outdoor exposure to these particulates in the rural areas is not very dangerous as the concentrations are very low. However, during winter, time spent indoors seated around coal/wood fires can be dangerous to health in the long run. It can cause respiratory illness such as bronchitis, asthma and pneumonia. A study by A.A. Eberhard and C. Van Horen, claimed that the chances are 190 per cent higher for children in unelectrified areas to get respiratory illness, than those in electrified areas[10].

Coal is not the only energy source that affect the health of people. Previous studies have reported that wood usage results in the emission of respirable particulates which have been linked to illness and death from respiratory disease, cardiac disease and lung cancer. It is claimed that levels of air pollution in many rural wood-burning homes can reach exceptionally high levels, especially where these dwellings are designed for maximum heat retention, have no chimneys, and few, if any windows, causing serious health problems to the inhabitants, which is exacerbated by the existing poor health conditions in many poverty-stricken rural areas.

Paraffin is one of the fuels widely used in rural communities. A study done in 1995 in one of the unelectrified areas in South Africa, found that 4 per cent of the sample of 1240 rural children and 1 per cent of the sample of 430 urban children had experienced incidences of paraffin poisoning. Again another follow-up survey was conducted amongst over 1600 unelectrified households in one of the rural areas of the same country, where 3.1 per cent of households reported having suffered illness due to drinking paraffin, with ten households claiming death[10]. These incidences usually happen amongst young children, who drink paraffin, thinking that it is water or softdrinks. The problem is that paraffin is usually kept in softdrink bottles in the house. Parents neglect to keep the bottles of paraffin in a safe place.

2.11 Effect of Non-Availability of Electricity on Education

Electricity is generally considered as one of the important basic services for the majority of the people. However, the majority of poor people are found in rural areas, with many of them having no access to electricity.

According to available information, more than 80% of schools are unelectrified in the developing countries. Considering the statistics of rural schools only, the percent of unelectrified schools could be estimated at higher than 95%. Without electricity, the hours used by students for studying is limited. The majority of pupils in rural areas prefer to spend most of their time studying at schools because many of them cannot afford to buy fuels for lighting in order to study during the night. This results in rural schools producing poor academic result.

Another problem is cold seasons that usually keep many students away from schools. During winter, many students miss school and stay at home by the fire, or away from home, under the trees, sitting by the fire, where parents cannot see them. It is difficult for them to concentrate at schools seated in cold classrooms, many of which do not have proper windows. As a result, many students end up failing their exams and sometimes drop out of school completely.

2.12 Transitional Energy Usage

Many rural communities of the DCs still depend on traditional energy sources such as fuelwood and other forms of biomass, including crop residues and dung. This is usually considered as the first phase of energy transition, where every household is entirely dependent on non-commercial energy sources. Usually, people in these communities do not have a choice of what source of energy they should choose. They either do not have enough money to buy commercialised fuels such as paraffin, coal and LPG, or such fuels are not available in their communities.

As the settlement grows, more land is cleared of freely available fuelwood, crop residues and trees. People start building small shops, general dealers, where commercial fuels such as paraffin, coal, kerosene is made available. They do not switch over totally from fuelwood to commercial energy, but start mixing, using wood for cooking and space warming, while paraffin and kerosene is used for lighting.

The experience with newly electrified rural settlements has been different from those in urban areas. Many of the newly electrified rural settlements still continue to use fuelwood for cooking and heating space, while they use electricity for lights, radios, and TVs. It takes many years to accumulate electrical appliances such as kettles, irons, stoves, etc.

2.13 Prices

Energy prices play an important role in energy sector development, through their impacts on the amount of energy used in an economy, the technologies adopted, and in some cases, the direction in which industry develops. The effects of energy prices on the energy infrastructure are long term in nature, and often difficult to reverse. A report to the Congress of the USA, suggested that the energy pricing policy may have several objectives, which are[22]:

(i) efficient allocation of resources,
(ii) provision of affordable supplies to consumers,
(iii) reasonable returns to energy producers,
(iv) substitution of fuels for national security or environmental reasons,
(v) promotion of regional development and industrial competitiveness.

Energy prices in different countries are based on some or all of the above issues. The other characteristics in developing countries that determine energy prices are[10]:

(i) government playing an important role in regulating commercial energy prices because they virtually own the electricity sector, coal, oil or gas sectors;
(ii) social objectives playing an important factor in formulating energy pricing policies. Energy is considered a basic necessity of life, accounting for a substantial part of the total household expenditure. In an attempt to try to provide for the poor, government keeps the prices of household fuels, e.g. kerosene for lighting and cooking and in some cases electricity, as low as possible;
(iii) a belief that policies should be designed to promote rural electrification or keep diesel prices low, in order to encourage key strategic development sectors including transportation and agriculture.

Prices of energy depend on the source. Biomass fuels are usually available as free goods, though that they are generally becoming less easily available, and time-consuming to collect. However, in other developing countries where it is becoming more and more difficult to find wood, people pay young men to climb trees to cut them down for fuelwood. Alternatively, they buy fuelwood from people who fetch it from more remote areas.

Coal prices are sometimes kept below production costs. This is evident in countries like India and China, which together account for 70 percent of all coal consumption in the developing world. This is probably due to the fact that their proven resources are adequate, and evenly distributed in most regions.

Some fuels appear to be cheaper to customers while in actual terms they are expensive. These are fuels which are highly subsidised by the government in an attempt to make them accessible to rural communities. In some cases the government goes to the extent of subsidising the cost of a fuel by up to 50 percent. This sometimes tends to have an adverse effect, in the sense that people tend to consume more they need, leading to shortages. Energy pricing decisions are often motivated by the need to keep energy affordable for large populations of rural households. It is difficult, however, to target needy people only. Sometimes the people for whom the subsidy is intended do not benefit.

Energy pricing is a complicated concept, particularly in situations where the government does not regulate it. Different suppliers charge different prices depending on their customers. It is not uncommon to find more than 50 different types of tariffs in the electricity sector of one country. The prices of energy, particularly electricity, also differ according to customers. Some electricity institutions charge different prices for large consumers per unit of electricity as opposed to small or residential consumers. What makes it more difficult is that the cost of a unit of electricity also differs depending on the time of supply. This discrepancy is evident in electricity, rather than coal, gas or paraffin.

2.14 AIDS and its Effects on Rural Energy

The rate at which AIDS is spreading in developing countries is very high. In South Africa only, it is estimated that 2500 new HIV infections occur daily. What is alarming is that South Africa is one of the few African countries with a small percentage of people infected with AIDS. The spread of AIDS is blamed largely on the ignorance of people. Most people get to hear about the disease AIDS through the media. Rural areas without electricity are a potential high risk community as people do not have TVs. Some rural areas do not have any access to newspapers. They depend mainly on radios for news, and the majority of rural people do not even possess radios. To them, the world is no larger than their own area.

It is believed that it is easy for the young people to get involved in the act of sexual intercourse in the dark. Lack of entertainment facilities to young people also promote such kind of acts from rural youth. This is evidenced by the number of young women who fall pregnant at an early age in rural areas. However, the situation is a bit different in urban areas where there is electricity, with street lights discouraging young people from dark corners. The rate of supplying electricity to rural communities should therefore receive a higher priority.

2.15 Environmental issues

It is reported by the World Bank that today biomass in all its forms (wood, agricultural and forestry residues, and dung) meets about 14 percent of the world's energy demand. More than 80 percent of this is consumed in the developing countries, where it still accounts for more than 35 percent of all energy supplies, with South East and Sub-Saharan Africa region being the main users. In 1993, biomass constituted 55% of all energy sources in Sub-Saharan Africa, and 48% of all energy sources in South Asia.

There is a concern that continued consumption of fuelwood at this rate will cause deforestation, which in turn will cause soil erosion, while the use of dung and crop residues will deplete soil productivity. The continual removal of trees, shrubs and residues for the purpose of biomass fuel causes serious environmental problems. However, the clearing of land for the construction of houses and agricultural purposes has been found to contribute more to degradation of wood resources than fuelwood collection.

When there is transition from biomass to coal, it introduces outdoor pollution on a scale that is very dangerous for people's health. In China, residential and commercial consumption of coal totals more than 200 million tons a year and has nearly doubled in the 1980s[28]. This is their main fuel for industry, electricity production and also many domestic activities. South Africa, one of the main electricity producers in the region, also depends on coal for the generation of electricity. It is reported that coal is the most deleterious of fossil fuels in terms of emissions per unit of useful energy provided, particularly when it is not burned in modern, well-operated plants.

The emission of gases like NO_2 and SO_2 cause acid rain, which poisons plants and grass, and sometimes animals which feed on plants and grass. Because of combustion of fossil fuels, the levels of air pollution in cities in developing countries are among the highest in the world. According to Dutkiewicz, the emissions of carbon dioxide by the developing countries amounts to 19.3 percent of global emission[37]. The emission of gases such as carbon dioxide, methane, nitrogen dioxide and others contribute to global warming.

The Intergovernmental Panel on Climate Change (IPCC) predicted in the late eighties that, under "business as usual" scenario, the global mean temperature will increase at a rate of about 0.3^0C per decade during the next century, a rate at least 10 times higher than any seen over the past 10 000 years, which means an increase over the preindustrial global average temperature of 2^0C by 2025 and 4^0C by 2090[22]. The production of coal also imposes environmental costs, such as the disturbance of lands and aquifers from coal mining.

2.16 Conclusion

The main purpose of this chapter was to try and identify the different characteristics that are found to be common in rural areas, and particularly the rural energy consumption developing countries.

Factors such as proportionately large rural populations in nearly all the developing countries were found to have a profound impact on rural energy development. Though the region is considered to be poor economically, it has enough natural resources to sustain itself for many years, if these resources are well managed. However, the size of rural population which is mainly dependent on natural resources which are freely available like biomass is cause for concern. This is despite the fact that the region boasts of an abundance of natural forests and coal resources.

Agriculture and small-scale industries were found to be the main economic sector for rural communities, except for tourist industries that are generally very weakly developed. For these sectors to prosper, they cannot afford to depend on traditional energy sources alone, hence their poor contribution to the general economy. This results in rural communities being populated predominantly by poor people, most of whom are unemployed. Furthermore, rural communities are usually drained of their potential for economic growth as professionals produced in rural areas migrate to urban cities. It was argued in this chapter that electricity supply to rural areas in developing countries could play an important role in establishing new small businesses and in the process promoting the already existing businesses in the community, creating jobs.

It was further argued that the supply of electricity to rural areas could help protect the environment, and in the process improve the health and the quality of education received by rural people. In addition, it was felt that the rate at which AIDS is spreading is mainly due to people's ignorance, and therefore there is a need to put mechanisms in place to promote the campaign of informing rural people about AIDS. This was felt could be made easier if there is supply of electricity which will enable people to listen to televisions and also promote entertainment facilities which will keep teenagers occupied most of the time.

Rural areas are also characterised by energy prices that are not reflective of their real cost. In an attempt to make energy affordable to rural people, governments of developing countries usually subsidise these energy sources heavily, incurring large debts in the process. Higher energy prices reflecting the true cost would enable the public enterprises to produce energy and earn surpluses.

3. REGIONAL ENERGY SUMMARY FOR THE SOUTH AND EAST SUB-SAHARAN AFRICA REGION (SESSA)

3.1 Introduction

The South and East Sub-Saharan Africa (SESSA) region is made up of 24 countries to the south of Egypt and to the east of Chad, Central African Republic and Congo. The countries of the region include: Angola, Botswana, Burundi, Comoros, Djibouti, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Seychelles, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zaire, Zambia and Zimbabwe. The region is shown in figure 3.1.

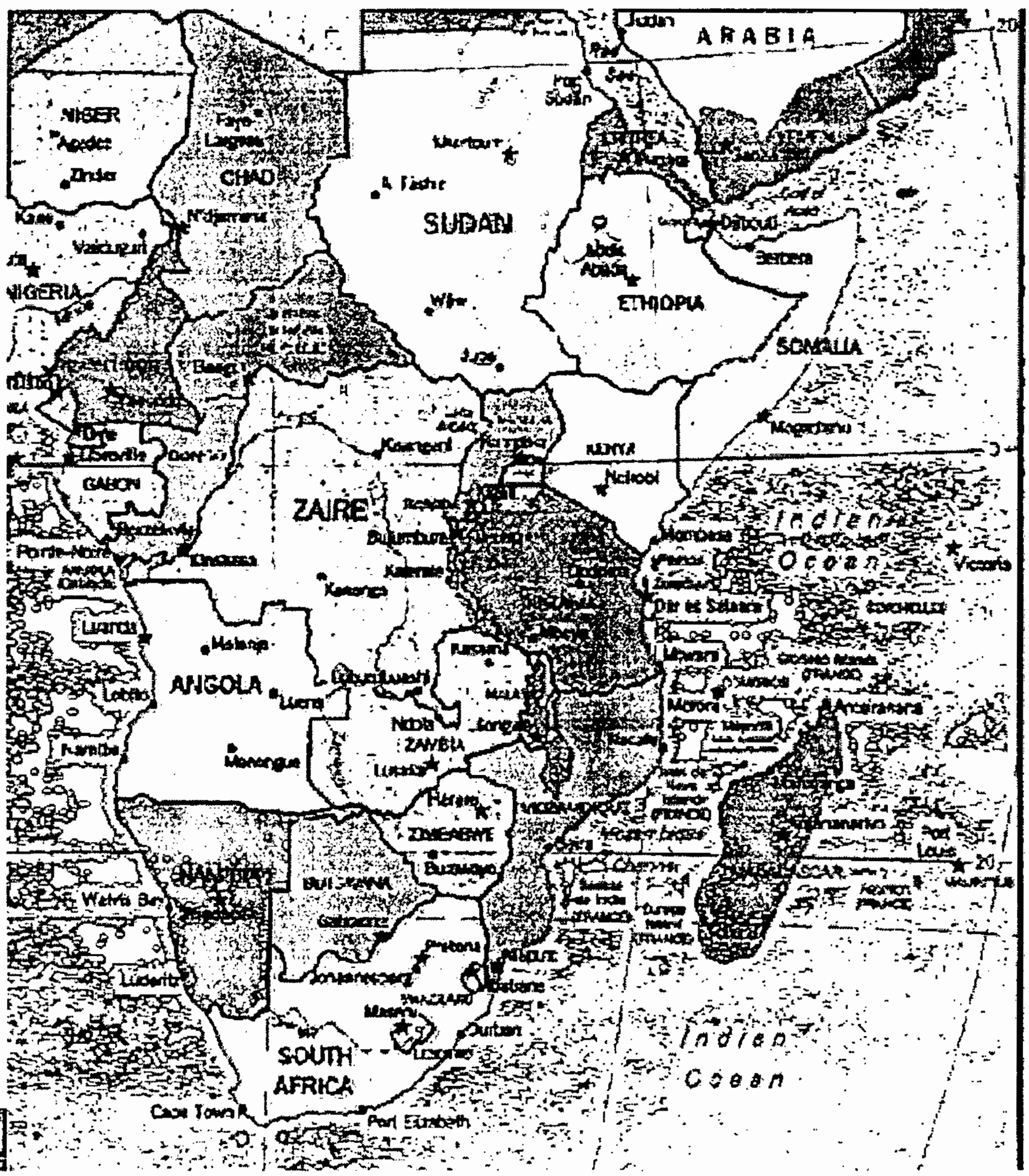

Figure 3.1 Map of the South and East Sub-Saharan African region

The region forms the south-eastern portion of continental Africa and includes the Indian Ocean island archipelagos of the Comoros, Seychelles and Mauritius and the larger island of Madagascar. It is bound by the Atlantic and Indian Oceans.

The topography of the region is diverse, with tropical forests in the equatorial region and more arid savannahs and desert areas further to the north and south. Water resources are abundant in the central equatorial areas, but scarce elsewhere. Other resources such as energy and minerals are generally abundant throughout the area, but varied in type and location. A large portion of the region is plagued by recurrent cycles of drought, and shortages of food are common in many countries.

3.2 Social, Political and Cultural Characteristics

In terms of social, political and cultural characteristics, the region has experienced a massive transition over the past century from an essentially pre-colonial state of localised traditional values, customs and social structures to a post-colonial phase of co-option and integration into a global system of values and systems which have been defined essentially in terms of the values of the predominant economies in the world.

Past and existing institutional structures in Africa have been determined to a large extent by prevailing political trends, with ideology and conflict playing major roles. Colonisation has led to the creation of political boundaries, which bear little, if any, relation to the original traditional boundaries. The objective of splitting the different tribes, sometimes creating new boundaries, was to create instability amongst African tribes. Most of the countries in the region gained independence from the colonial powers in the early 1960's. The political development of the region is still in a state of flux. The region is characterised by large cultural and linguistic differences.

3.2.1 Demographics

The total population of the region was 191 million people in 1975, of which 80% were resident in the rural areas. In 1993, the population of the region had increased to over 327 million people, an increase of 40% over the period of 18 years. The rural proportion of the population declined slightly from 80% (153 million) in 1975 to 75% (245 million) in 1993.

Of these countries, Ethiopia had the largest population in 1975 of 32.2 million, which went up to 55 million in 1993, followed by Zaire's population of 41 million, while that of South Africa stood at 40 million.

The percentage change in the rural population in Ethiopia was minimal during this period of 18 years, (between 1975 and 1993), changing from 90.5 percent to 87 percent, which could be attributed to development of industries in urban areas which influenced migration from rural areas. The rural population in Zaire went up approximately 1% during the same period.

Table 3.1 Selected population statistics for the region (1993)[41,27]

Country	Population (M)	Area 000 km^2	Population density per/km^2	% Rural population 1973	1993
Angola	10	1247	8		
Botswana	1	582	2	89	74
Burundi	6	28	207	97	93
Comoros	<1	2	255		70
Djibouti	<1	23	24	34	18
Ethiopia	55	1222	45	91	87
Kenya	26	580	44	88	74
Lesotho	2	30	63	90	78
Madagascar	12	587	21	85	74
Malawi	9	118	77	93	87
Mauritius	1	2	550	57	59
Mozambique	17	802	21	93	69
Namibia	2	824	2	80	65
Rwanda	7	26	281	96	94
Seychelles	<1	<1	257	70	47
Somalia	8	638	13	79	75
South Africa	40	1221	33	52	50
Sudan	27	2506	11	82	76
Swaziland	1	17	52	88	71
Tanzania	26	945	27	91	77
Uganda	18	236	74	92	88
Zaire	41	2345	18	70	71
Zambia	8	753	11	67	58
Zimbabwe	10	391	27	81	69
Totals	330	15125		80	71

Seychelles is the country with the smallest population of 0.07 million people. However, unlike other countries in the region which have populations mainly in rural areas, their rural population was around 47% in 1993. The population densities are low, ranging between 2 and 80 persons per km^2, except for Burundi, Rwanda, Seychelles, Mauritius and Comoros where population densities range between 207 and 550 persons/km[53]. Population growth rates are high, averaging 3,2% per annum, which has resulted in the region having a young population. The majority (approximately 80%) of people live in rural areas.

Although the present levels of urbanisation in the region are low, urban population growth rates are high, far exceeding the average population growth rates. This results in the proliferation of peri-urban squatter settlements with concomitant socio-economic problems, and creates extraordinary demands for housing, services, energy and jobs which are far beyond the capacity of most cities to fulfil.

The lack of employment opportunities in the formal sectors has resulted in a rapidly growing informal sector. The lack of job opportunities at home and the better prospects and living conditions abroad has influenced many of the better educated to emigrate, thus undermining the economy's ability to develop and provide employment. This has undermined the technical, management and administrative skills, resource base of the energy sector.

Life expectancy is low, while infant mortality rates and live birth rates are high. The crude death rate in the region is significantly higher than rates in more developed countries.

Illiteracy rates in the region are very high, especially amongst females. Of particular concern to the energy sector, as well as to the industrial sector, is the lack of suitably qualified and competent technical and scientific personnel at all levels.

3.3 Economic Considerations

The majority of the countries in the region are classified by the World Bank[21] as having low-income economies. The exceptions are: Angola, Namibia, Botswana and South Africa, which are classified as having middle-income economies.

Table 3.2 Summary of economic indicators for the region

Country	GDP	GDP per capita
	(US$M)-1993	(US$)-1993
Botswana	3813	2724
Burundi	850	142
Comoros	248	486
Djibouti		
Ethiopia	5750	111
Kenya	4690	185
Lesotho	610	321
Madagascar	3130	225
Malawi	1610	171
Mauritius	2780	2527
Mozambique	1370	91
Namibia	2110	1407
Rwanda	1360	179
Seychelles	444	6167
Somalia		
South Africa	106400	2660
Sudan		
Swaziland	840	933
Tanzania	2090	75
Uganda	3040	169
Zaire		
Zambia	3685	444
Zimbabwe	5000	467

The region's economy has recorded an average annual growth of 3.4 percent in GDP during the past two decades (since 1961), which is just above population growth. During 1965-95, the average GDP per capita of the countries grew by 2.6 percent per annum, but then stagnated. If inflation is included, the real GDP per capita fell by an annual rate of 2.2 percent from 1980-90.

According to the World Bank, the GDP advanced by 2.2 percent in real terms in 1994. The World Bank estimated that the region's GDP will increase by 3.3-4.1 percent annually between 1995-2005, but given an annual population growth rate increase projected at 3.2 percent, this will result in a growth rate per capita of less than 1 percent.

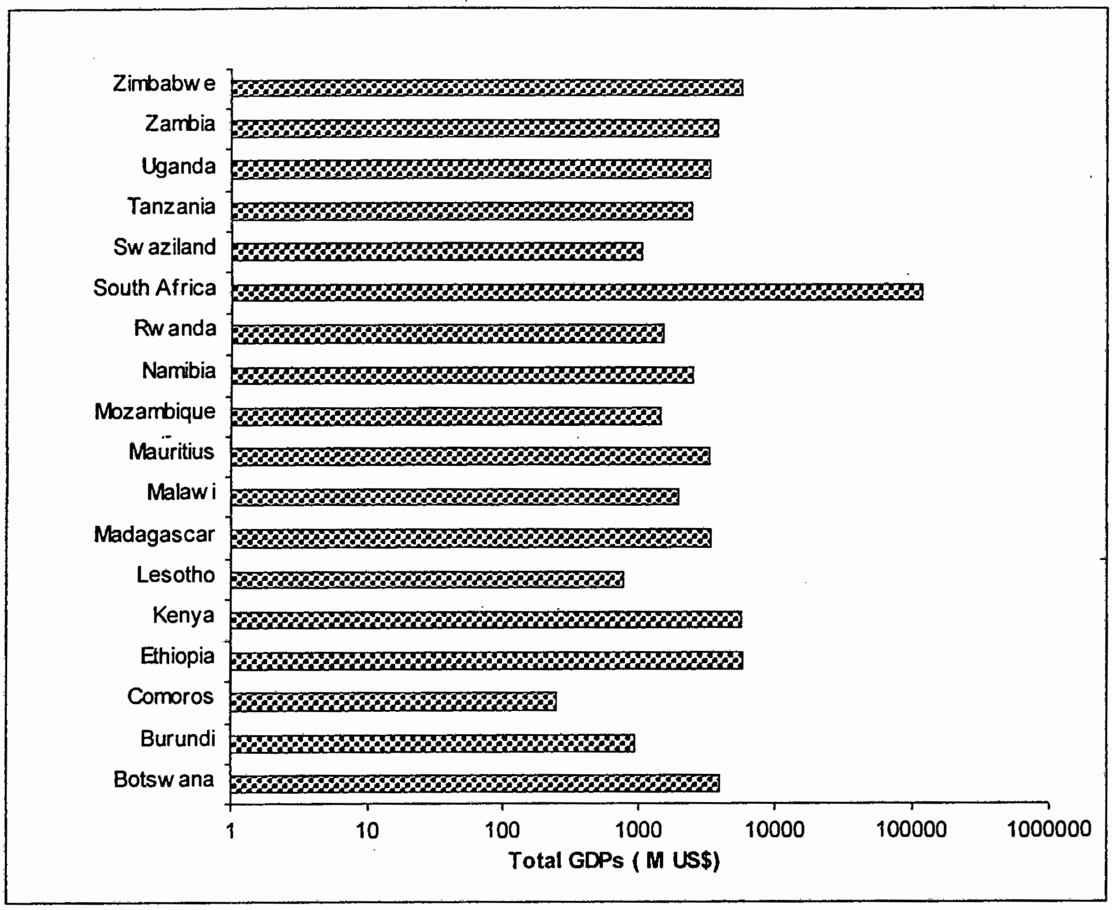

Figure 3.2 GDPs (10^6 US$) of countries in the region (1993 US$)

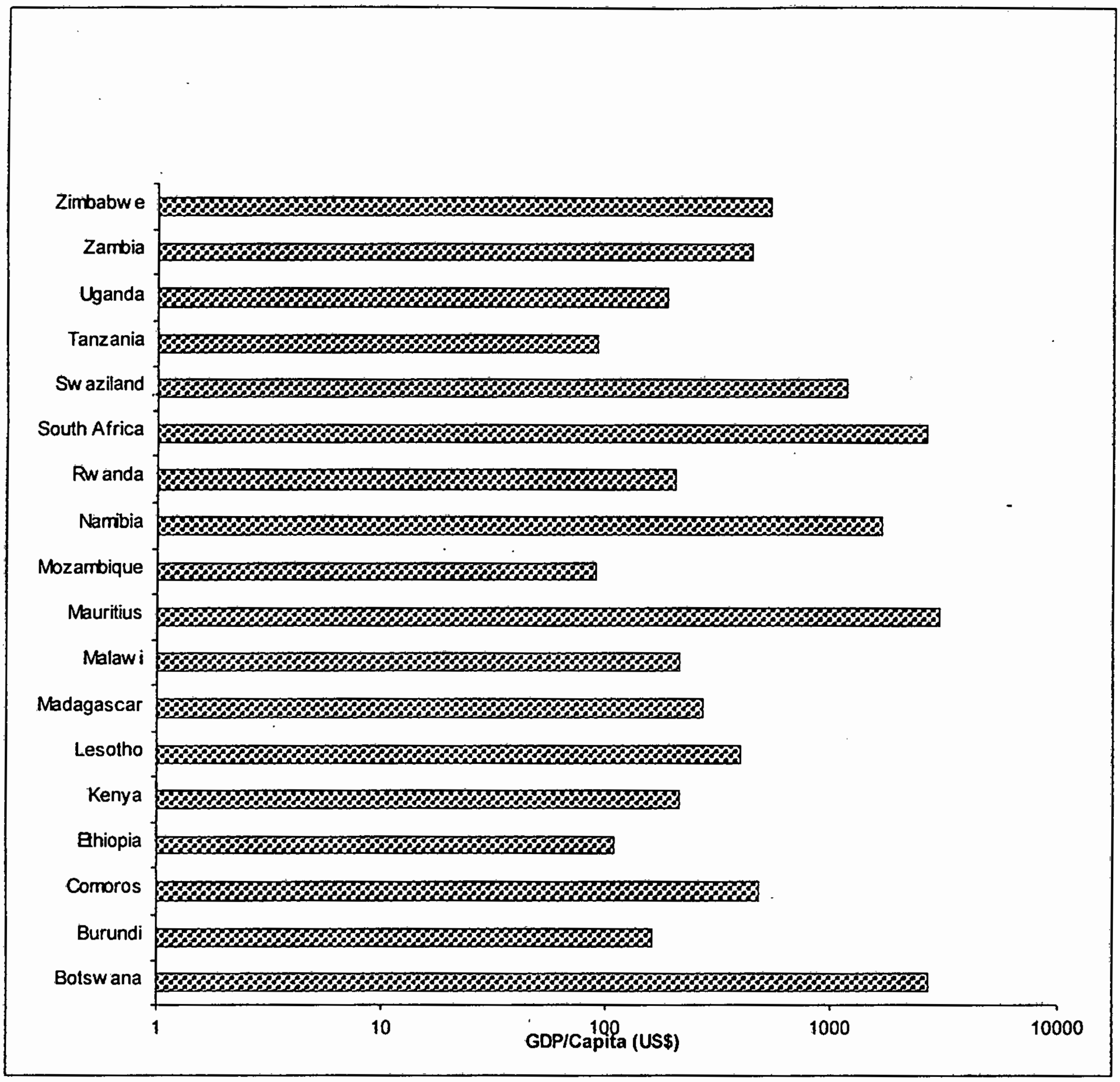

Figure 3.3 GDP per capita of countries in the region (1993 US$)

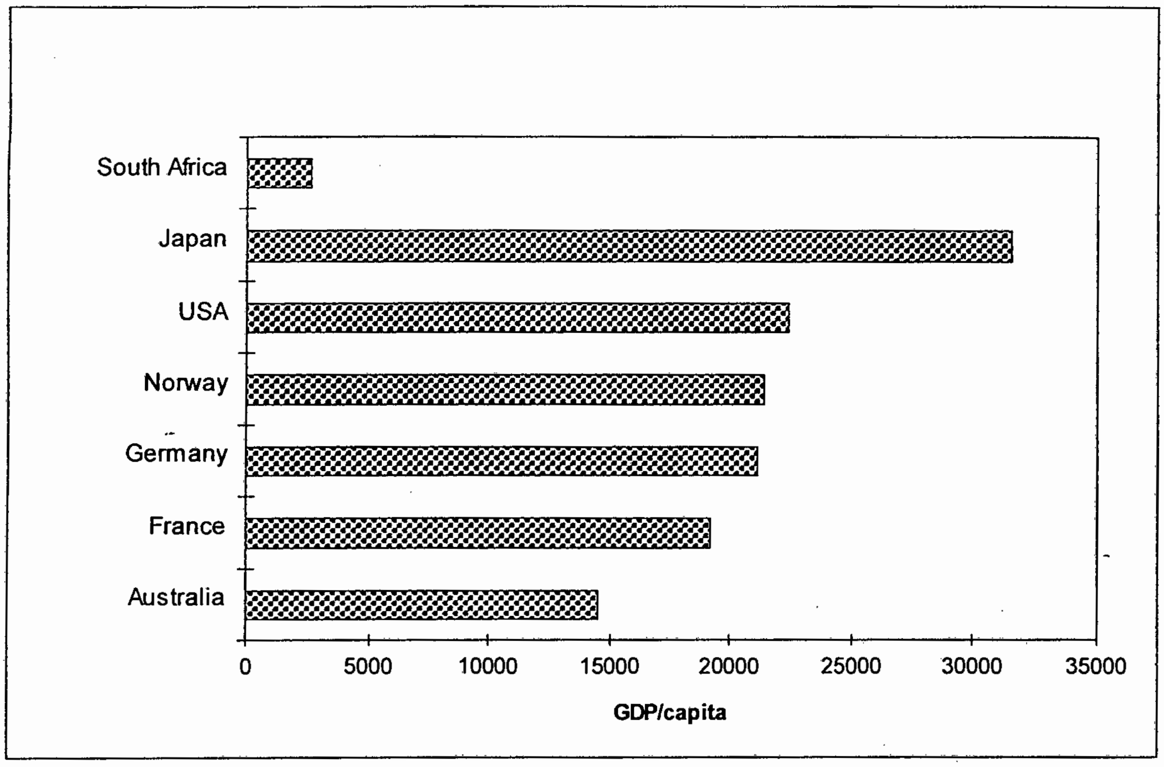

Figure 3.4 GDP per capita of selected developed countries (1993 US$)

The South African economy accounts for approximately 55% of gross domestic product in the region. Figure 3.3 shows that Seychelles, Botswana, Mauritius and South Africa have the highest GDP/capita. Mozambique and Tanzania have the lowest GDP/capita. Figure 3.4 shows comparative GDP/capita data for selected developed countries, with South Africa included, showing the lowest GDP per capita. However, South Africa has the highest GDP per capita in the region. The economies of the SESSA countries are diverse, yet share many common characteristics such as high levels of foreign debt, relatively high ratio of informal / formal sectors, etc.

Some of the issues that are still of concern to the economy of the region are:

- the high rate of unemployment, which has negative results on the economy,
- the main employer is the government;
- level of personal savings are declining,
- interest rates are increasing due to the worsening of the balance of payments, and many development projects depend on foreign capital inflows which are very volatile.

Local currencies are dropping against the US dollar, due to political changes in the region, poor balance of payments, and high local inflation.

3.4 Energy Sector

3.4 1 Overview

Rural development is very important in developing countries. Conditions in rural areas need to be improved in order to achieve real development. For rural conditions to improve, especially living conditions, sustainable energy supply must be considered as a high priority.

The majority of people in the region live in rural areas and have very low incomes. They are essentially dependent on traditional fuels such as biomass. The World Bank's estimates puts the total number of all the people without electricity at over 2 billion. Karenzi and Turyareeba[79], put the figure of people who depend on biomass for their cooking, heating and lighting at 2.5 billion. In many of these countries, biomass energy is important not only for rural and agricultural consumption, but for semi-urban populations, for agroindustry and semi-urban industries, institutions, restaurants, hotels and many other services. However these fuel supplies are diminishing.

Though most people attributed deforestation to woodfuel consumption, the main reason is the clearing of forests for agricultural produce, building houses, cutting of trees for timber and other commercial reasons, and grazing purpose.

Unlike urban areas where biomass is becoming a commercial commodity, biomass fuel is usually freely available in rural areas. As a result, governments of many countries in the region have paid little attention to rural energy development.

In areas far from grid electricity, renewable energy technologies are seen as a possible means of alleviating rural energy problems. Most of the rural areas in developing countries would be ideal places to implement renewable energy technologies. However, there is resistance to these technologies and they have often been rejected by rural people due to what Bhagavan and Karekezi[3] call "the preponderance of technology push" rather than "demand pull" strategy, that ignores local people's energy choice.

3.4.2 Demand/Markets

A high proportion of the energy consumption in the region is derived from non-commercial sources. Since statistics on demand are difficult, if not impossible, to obtain, this energy cannot be readily quantified.

Surveys of household energy consumption have been undertaken in some countries in the region (South Africa, Zimbabwe, Namibia, Swaziland).

Estimates of the total energy consumption are given in table 3.3 below.

Table 3.3 Per capita GDP and consumption of energy for selected countries in the region (1993)(calculated from)[6,41]

Country	GDP/capita (US$)	TEC/GDP (kgoe/US$)	TEC/capita (kgoe)	
			Total	Household
Ethiopia	111	3.63	40	22
Kenya	185	2.34	434	354
Mozambique	91	2.82	255	234
South Africa	2660	0.40	1035	178
Sudan	-	-	250	200
Tanzania	75	4.22	315	292
Zaire	-	-	276	240
Zambia	-	-	486	355
Zimbabwe	467	1.40	648	171

Energy consumption per capita in the region is dominated by South Africa, due to the high levels of energy consumption intensity in the industrial and mining sectors. The average total energy consumption in the residential sector (other sectors excluded) for South Africa was approximately 178 kgoe/capita in 1993, which is low compared to countries such as Kenya, Tanzania, Zambia and Zaire.

The comparative data for energy intensity, kgoe/capita and kgoe (residential)/capita of certain countries, and for some developed countries is shown in figures 3.5, 3.7, 3.8 and 3.9.

It is important to note that energy consumption for the developing countries is very high relative to their GDP. Tanzania, Ethiopia and Mozambique have the highest energy consumption relative to their GDPs. This is due to the fact that these countries depend largely on less efficient energy such as woodfuel.

Few of the countries in the region have adequate statistics of energy consumption. The total energy consumption per capita ranges from 40 kgoe for Ethiopia to 1035 kgoe for South Africa (see table 3.3). Total energy consumption in the residential sector ranges from 22 kgoe per capita for Ethiopia, to 355 kgoe per capita for Zambia, which registers the highest energy consumption in the residential sector. The per capita consumption of energy in the residential sector in South Africa was 178 kgoe (the rural communities accounting for less than one third). Only 9.5% of the total energy consumption in South Africa is consumed by the residential sector, the rest goes to mining, manufacturing, agriculture and commerce.

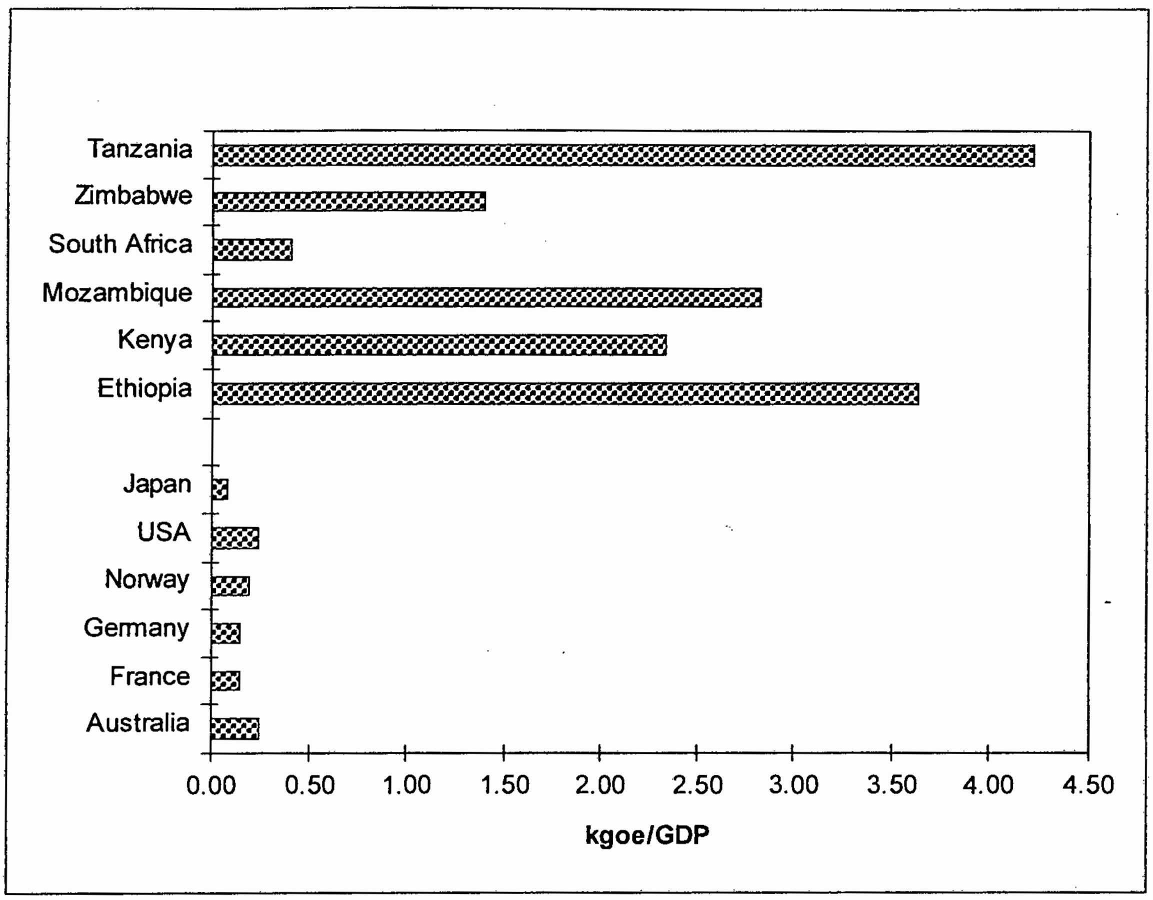

Figure 3.5 **Energy Intensity of selected developing and developed countries (1993 US$)**

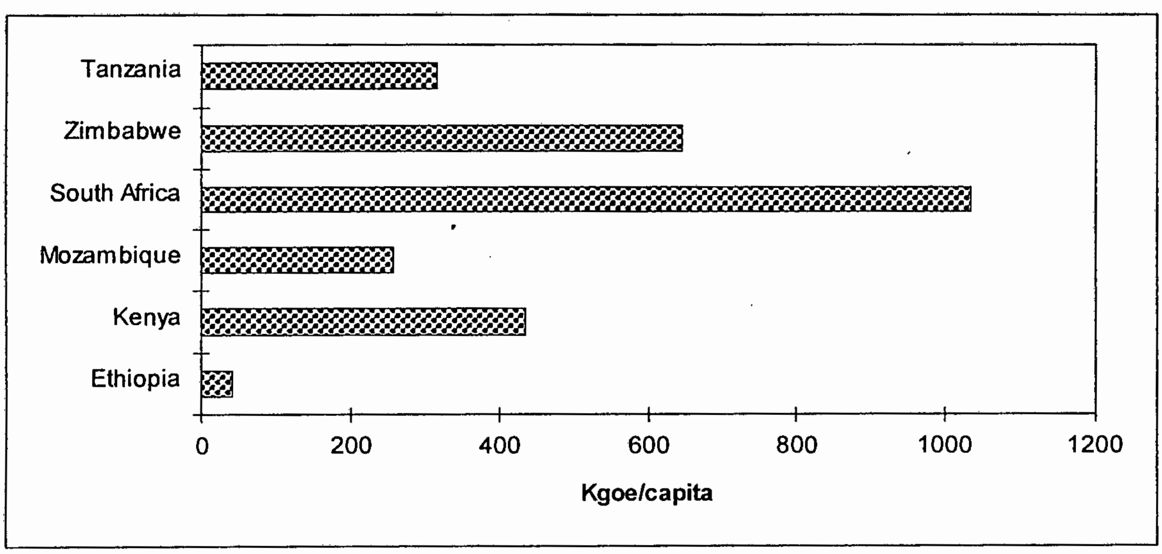

Figure 3.6 **Energy consumption per capita of developing countries in the region (1993)**

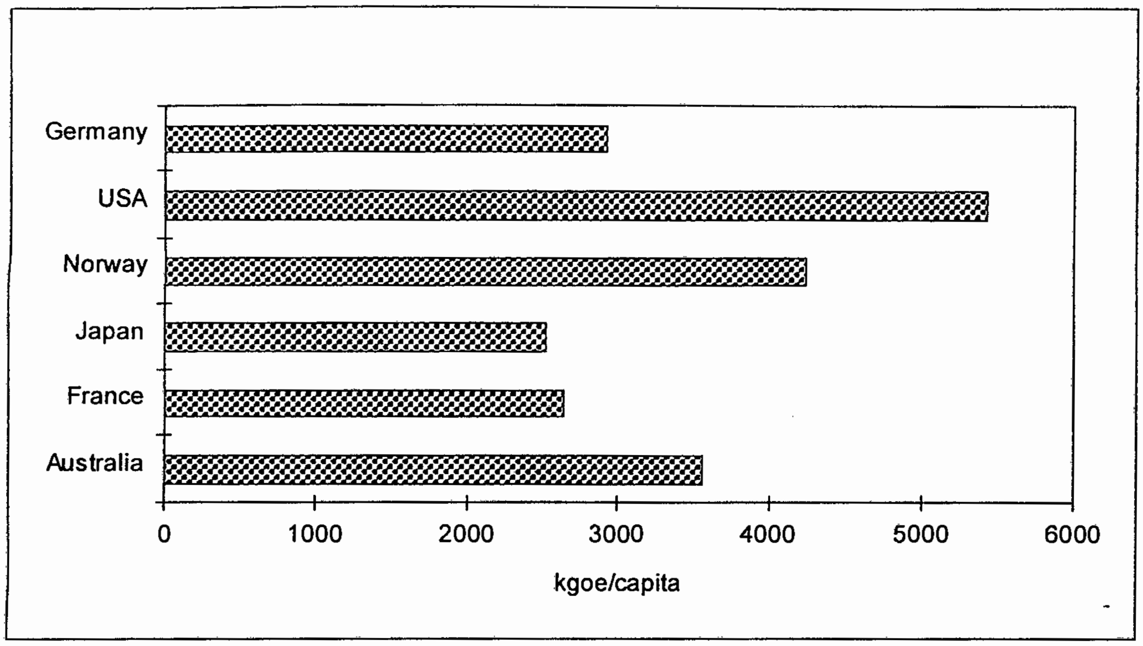

Figure 3.7 **Energy Consumption per capita of selected developed countries**

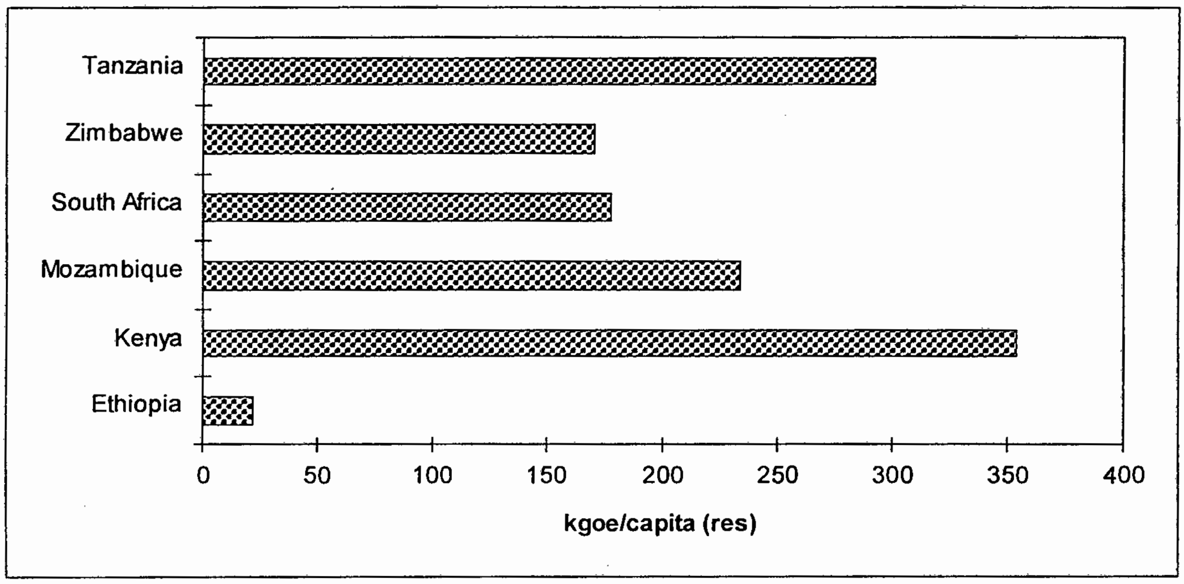

Figure 3.8 **Residential Energy consumption per capita of countries in the region**

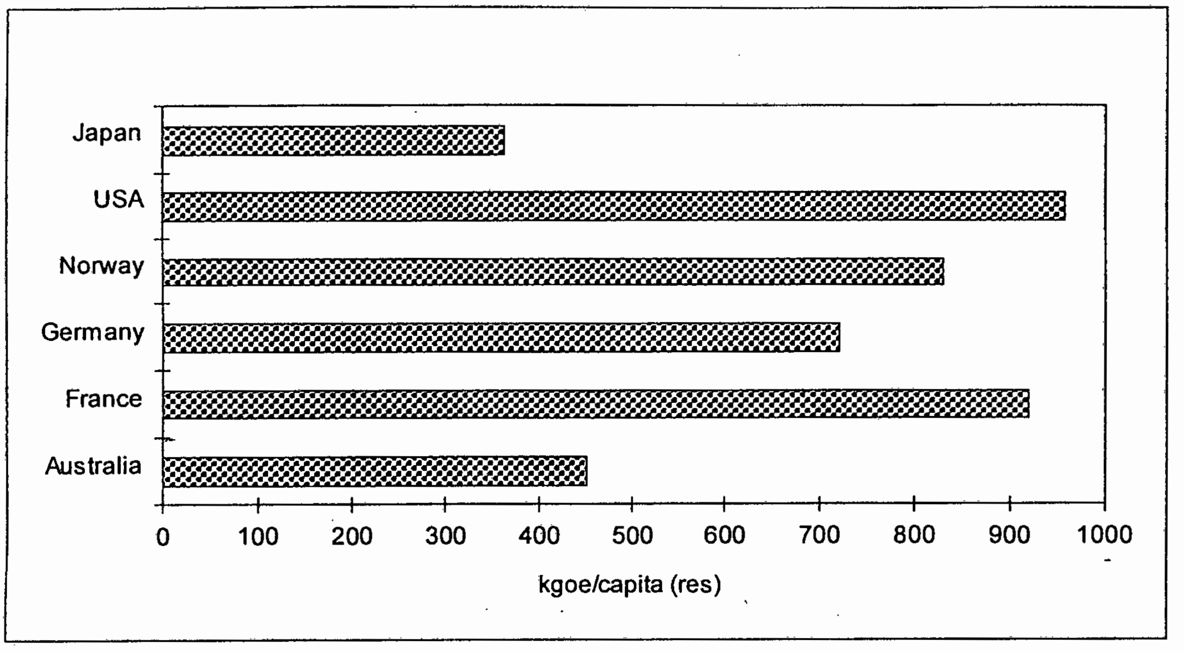

Figure 3.9 Residential Energy consumption per capita of selected developed countries

The demand for different types of energy differs from country to country as shown in table 3.4, depending on the availability of the energy source. Some countries are still highly dependent on traditional energy, particularly woodfuel. There are others, however, which are switching over to commercial energy. For example, traditional energy in countries like Ethiopia, Mozambique and Tanzania still account for more than 90% of total energy consumed (table 3.4). Unlike more developed countries, more than 80% of the total energy consumed in most of the countries in this region is accounted for by the residential sector (see figure 3.8 and table 3.4).

Table 3.4 Total Energy consumption (Toe) in some of the countries in the region, 1993[41]

Country	Total (toe)	Domestic, % of total	Traditional fuel, % of total	Coal, % of total	Gas, % of total	Oil, % of total	Electricity, % of total
Angola	3360	85.5	82.4		07.5	11.8	01.6
Ethiopia	15291	94.1	93.6			05.7	07.0
Kenya	8320	76.7	74.2	01.0		21.6	03.2
Mozambique	6245	93.7	93.2	00.3		05.4	01.1
South Africa	50960	26.4	18.7	28.7	01.3	26.8	24.8
Sudan	3619	63.9	61.3			36.3	02.4
Tanzania	11197	94.8	92.7		<0.1	06.0	01.3
Zaire	11484	87.2	84.4		01.8	10.0	04.0
Zambia	3766	71.3	70.0	06.0	05.9	12.3	11.8
Zimbabwe	7982	63.2	60.4	55.0	17.8	13.2	08.6

3.4.2.1 Demand for traditional forms of energy

Traditional energy, such as biomass, is still a dominant energy source in most developing countries. There is a direct relationship between the size of the rural population and the degree of dependence on traditional energy.

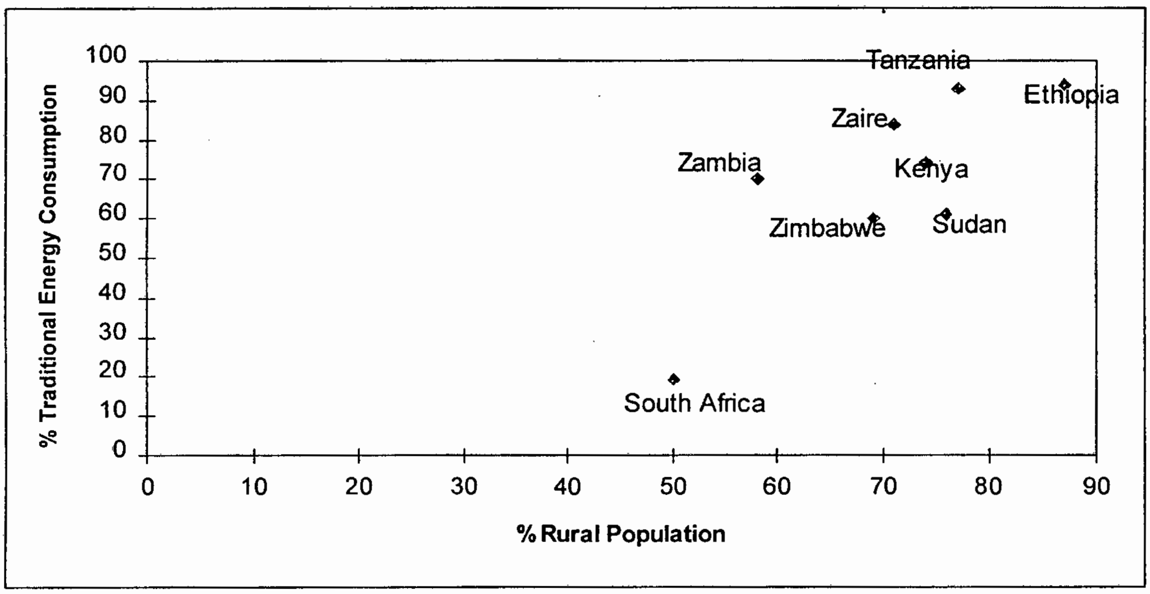

Figure 3.10 Relationship between size of rural population (% of total) and traditional energy (% of total) consumed of the countries in the region

Figure 3.10 shows the relationship between size of rural population and consumption of traditional energy.

3.4.2.2 Commercial energy demand

Distinguishing between commercial and non-commercial energy sources is sometimes difficult. Though fuelwood is treated as a traded commodity in some areas where competition for energy is high, because of intensive land use or scarcity of arable land, it will be considered as a non-commercial energy source in this report.

Supplying commercial energy in rural communities is costly. Rural people usually travel for many kilometres, sometimes by public transport, to get paraffin, gas or coal. If the cost and time spent on travelling is included, rural people spend more on energy compared to urban people.

In situations where rural people have access to electricity, the consumption is very low, with consumption lower than 5 percent in seven of the 10 countries (see table 3.4). It is only in South Africa that electricity consumption exceeds 20%. However, coal is the dominant energy source in the region, contributing 78 percent of total primary energy consumption in South Africa and 55 percent in Zimbabwe. Domestic consumption of coal in South Africa contributed 14.5 percent of the total domestic energy consumption. A large quantity of coal, however, is consumed in its primary form in informal houses and some of the semi-urban townships. It is possible that the demand for commercial energy in rural areas is lower because of lack of capital and institutions to provide it.

3.4.2.3 Agricultural sector

Statistics on the energy consumption in the agricultural sector is generally poor. Part of its energy consumption is included in other sectors such as fisheries under transport, farming under household and forestry under industry.

Energy is consumed mainly for crop production, fishing and animal husbandry. Crop production requires energy in preparation, harvesting, irrigation and transport. These operations often use both animal and commercial energy. The type of fuel used in irrigation pumps includes diesel, kerosene, gasoline, electricity and wind[(42)].

The majority of people living in rural areas of developing countries depends mostly on agriculture for their economic survival. In many of these countries, the contribution of the agricultural sector to the GDP is significant. For instance in Tanzania in 1993, the contribution of the agriculture sector to the country's total GDP was 56 percent.

According to the data from the IEA statistics[(41)], the percentage commercial energy consumed in the agriculture sector of the total commercial energy consumed in Tanzania the same year was only 4.5%, which is a small portion of the total commercial energy[(8)].

FAO[8] predicted a significant increase in the consumption of electricity, petrol, and diesel in the agriculture sector in Tanzania over the next 15 years. The consumption of fuelwood and crop residue is high at present, compared to other energy sources, but is expected to remain unchanged during the period 1990 to the year 2010. According to FAO[8], large-scale farms accounted for 21% of Zimbabwe's cultivated area and roughly 75% of total production. Their agriculture sector accounted for 15% of the country's total GDP in 1993, and their commercial energy consumption in the agricultural sector constituted 5% of the total commercial energy consumption in the country, which is low considering the contribution of the agricultural sector to the country's total GDP.

The agricultural sector in most countries is divided into communal farms, large commercial farms, small-scale commercial farms, state-run farms and resettlement schemes. The energy demand by the small-scale commercial farms is sometimes equal to the communal energy demand, but less than that in the state-run farms. The energy demand in the agricultural industries of many developing countries has been increasing since 1990. The role played by the state in the agriculture sector has an impact on the quantity of commercial energy used. For example, agricultural energy use in many countries in the region is higher than that of countries in other regions due to the fact that the government policies favour agricultural production[8]. This calls for more government interventions in the agriculture sector to help create more jobs for rural people.

3.4.2.4 Small-scale rural industries

Small-scale rural industries, together with agriculture, form the economic muscle of the rural sectors, but consume less than 10% of the total rural energy budget[8]. These small industries range from shops, restaurants and bottle stores, to agro-industries, manufacturing industries for soap, bricks, metal products and leather goods.

Types of energy sources used in this sector include agricultural residues, paraffin, and electricity. The largest users of residues in the rural industries are the agro-industries, mostly to generate heat using boilers. The supply of electricity plays an important role in the development of small-scale rural industries. A number of people with electricity are able to run their own "village" shops and welding shops in their backyards. They are operated by family members. Sometimes they manage to employ one or two more people in their businesses.

3.4.2.5 Energy for households

Energy in households is determined by their economic standards, size of the family, and the composition of the family. In a family where there are no female members, there is usually no one to collect fuelwood, which is a dominant fuel, and so it is used sparingly. During cold seasons, elderly members of the family spent most of their time before woodfires. Coal consumption in rural areas is not very prominent. The consumption of electricity in rural areas is usually very low for many households, mainly because few houses are connected, but also because those connected consume very little per month. The average consumption of electricity in South Africa (urban and rural consumption combined) is around 80 kWh per month, and is one of the highest in the region. However, consumption in rural areas is lower. Many rural households consume as little as 20 kWh per month mainly because of lack of electrical appliances. The fact that they still use fuelwood and other sources of energy such as coal is another reason why they use little electricity.

3.4.3 Supply issues

The supply of energy sources differs from country to country. Some countries have a surplus of one energy source while others have shortages of the same energy source. For example Angola has an abundant supply of oil products, but no coal resources; Mozambique has natural gas resources, but no oil. In 1993, the average total primary energy supply per capita was approximately 40 kgoe and 1035 kgoe in Ethiopia and South Africa respectively.

The types of energy supplied in the region are renewables, coal, paraffin and electricity. Despite the abundance of natural energy resources in the region, supply to rural areas is affected by lack of proper infrastructure.

3.4.3.1 Renewable energy resources

A considerable amount of research into the possible application of renewable energy sources has been carried out in many of the developing countries, South Africa, Sudan and Zimbabwe being some of those countries. Renewable energy agencies are being formed to heighten public and governmental awareness and to promote research and development of solar, wind, biomass, micro hydro, draught animal power and other renewable technologies.

3.4.3.1.1 Traditional energy sources/Biomass fuels

Most countries in the region are well endowed with biomass, though supply potential differs from region to region, and country to country. The South and East Sub-Saharan Africa (SESSA) is one of the regions with sufficient biomass resource supply potential, and will continue to be well provided if it is well managed.

Biomass resources can be divided into organic wastes (animal and agricultural), natural forests and energy crops (including planted crops). Biomass fuel used comes mainly from natural forest resources. According to a report by the African Development Bank, Sub-Saharan Africa has a forest area totalling 477 million hectares, and its forest cover is 22% of the total land area of the whole region(20). The total biomass estimate is claimed to be 82 billion tons with a Mean Annual Increment (MAI) of 1.7 billion cubic meters. "Expressed in per capita, the resource base (potential) and production are 168.2 tons and 3.9 m^3 respectively, more than enough to cover an average annual per capita fuel-wood demand"(20).

There is, however, an uneven distribution of the resource, varying in production between sub-regions and within countries. In certain areas, there are serious imbalances between supply and demand of fuelwood.

Table 3.5 Natural Forest Biomass for Southern Sub-region (1991)[20]

Country	Forest Area in ha x 10^3	Forest % of Land	Biomass Potential (M) tons	MAI Million m^3	%Total Sub-region	Per capita Biomass tons	Per Capita MAI m^3
Angola	23074	18	2883	5	7	488	5
Botswana	1427	22	729	4	2	567	3
Lesotho	519	17	2	<1	<1	1	<1
Madagascar	15782	25	2288	62	5	191	5
Malawi	3486	35	394	90	1	46	1
Mauritius	3	<1	<1	<1	0	<1	<1
Mozambique	17329	21	1776	23	4	113	1
Namibia	1256	14	556	3	1	418	2
Swaziland	936	54	24	1	<1	31	1
Zaire	113275	49	29119	557	70	809	15
Zambia	32301	43	3351	62	8	396	7
Zimbabwe	8897	21	638	6	2	66	<6
Total	218285	28	41756	813	100	161	4

The total biomass potential and the annual productivity (MAI) of the sub-region (some countries such as South Africa are excluded) as shown in table 3.5, is approximated at 41.76 billion tons and 0.81 billion cubic meters respectively. Zaire represents 70% share of the potential, with Mauritius representing an insignificant figure, showing the variance in the distribution of potential between countries.

Of the total land area in the region, table 3.5 shows that approximately 218 million hectares are classified as forests. The percentage of forest land cover for individual countries varies from <1% for Mauritius to 54% for Swaziland. The percentage of forest land cover does not reflect the production in the country.

Members of the Southern African Development Community (SADC) countries are involved in agroforestry to alleviate the problem of fuelwood. Swaziland, Mozambique, and Zambia are some of the countries involved in the programme of "School tree planting and Woodlots" in the region. Tanzania started the programme of fuelwood plantation many years ago, but the costs were found to be prohibitively high. The plantations were expensive and difficult to manage. They then decided to shift to smaller plantations with a broader market for the wood produce. Kenya's communal plantations are very successful, with various donors and state agencies providing funding.

3.4.3.1.2 Other Renewable energy sources

Governments in the region are conscious of the deteriorating conditions in the supply of fuelwood and are investigating alternative methods of supplying household and small industrial concerns with energy[(54)]. Most of the countries in the region have high solar radiation levels. For example, the insulation in Maputo is above 5 kWh/m^2 per day and there is therefore scope for small scale application of solar systems. Wind speeds are generally low. Wind energy has not been a success story in the region. Some of the windmills (belonging to commercial farmers) failed to operate optimally because they were placed in unsuitable positions and their use as means of cheap water-pumping fell into disrepute because their performance did not meet expectations.

3.4.3.2 Commercial energy sources

There is a general lack of infrastructure for the supply of commercial energy in the region. The type of energy discussed below is coal and electricity. Paraffin is also discussed but not in detail.

(a) Coal

This region has by far the largest share of Africa's known coal reserves. South Africa leads the region with coal production, but the biggest resources still to be explored is found in Botswana, which until now has only one coal mine. The contribution of coal to primary energy supply in South Africa is three quarters of the country's total energy supply. Despite its abundance in the region, its supply to rural areas is very low.

(b) Electricity

The tradition in most of the SESSA countries has been for electricity to be generated and transmitted by one company usually controlled by the state. This monopoly extends to distribution levels, at times. In other instances, other authorities such as Regional Services Councils and Local Authorities are involved at distribution level only.

Table 3.6 Gross Production of Electricity (GWH) 1993[36]

Country	Thermal	Hydro	Nuclear	Geothermal	Total	% of regional
Angola	163	772	-	-	935	0.5
Botswana	1015	-	-	-	1015	0.6
Kenya	81	3246	-	273	3600	2.0
Lesotho	-	1	-	-	1	<0.1
Malawi	2	780	-	-	782	0.4
Mozambique	46	238	-	-	284	0.2
Namibia	27	976	-	-	1003	0.5
S. Africa	147066	1491	7255	-	155812	84.3
Swaziland	3	82	-	-	84	0.1
Tanzania	-	1879	-	-	1879	1.0
Zaire	-	-	-	-	5581	3.0
Zambia	-	6461	-	-	6461	3.5
Zimbabwe	2062	5406	-	-	7468	4.0
Total	150465	21332	7255	273	184904	100.0

Table 3.6 shows that South Africa contributes 84.3 percent of the region's total electricity production. More than 80 percent of electricity produced in the region comes from thermal production. Zimbabwe, which is the second highest electricity producer in the region, contributes 4 percent to the total production. Lesotho's contribution to the total production is insignificant. depending mainly on imports from South Africa.

Despite this high production, less than 20% of the region's rural population have access to electricity. The extension of electricity to rural areas via the grid has been proved to be very expensive. The arguments supporting rural electrification are usually not based on economic feasibility. Social factors, including benefits such as improved quality of education and better health services that are claimed to accompany supply of electricity to rural people are the driving force. It is, however, claimed to be the second most important source of commercial energy in this region, after coal. Its contribution to the region's total energy demand is between 5% and 26%.

3.4.4 Resource carrying capabilities of the region

The region is well endowed with forests and bushes. The level of biomass resources vary from country to country, depending on size of the country and the commitment of state Forestry Departments to controlling and protecting natural forests. Current levels of biomass resource potential in the region is not accurately known.

The region has vast reserves of coal, especially in countries such as Malawi, Botswana, Mozambique and South Africa. In spite of the vast coal reserves found in the region, coal resources are poorly utilised except for South Africa, Zimbabwe and Botswana.

Seismic surveys for gas in Mozambique indicated large gas reserves in the Buzi area near Beira and at Pande. It is estimated that there are about 320 000 million cubic metres of gas in these fields. New gas fields discovered in Namibia are claimed to be adequate enough to be able to supply the whole region.

3.4.5 Distribution

The region has many forests carrying sufficient fuelwood, but the problem is transporting them to where people live. The reason why biomass is becoming a tradable energy source, particularly in urban areas, is to compensate for transport costs. Distribution of biomass is in private hands, where individuals with lorries fetch fuelwood from forests.

The distribution of coal from the production places to the market is well organised. Coal is produced in mines and then transported to harbours for export. Coal that is consumed locally is taken to coal-fired power stations for the generation of electricity, while the remainder is taken to the residential sector, mainly in the urban townships, for consumption. Rural people struggle to access coal because of the lack of transport to these areas. The situation is similar for LPG, paraffin and charcoal. Transport systems for these energy sources are mainly in the hands of private companies that may not operate according to government policies.

The distribution of electricity is mainly in the hands of organisations that are parastatals, in situations where there are not falling directly under the control of government departments responsible for co-ordinating energy issues. Usually, the distribution of electricity to households falls under more than one organisations, i.e., besides the parastatal organisations, municipal bodies also get involved.

3.4.6 Regional Electricity grids

Co-operation in the development of regional electricity grids is at an advanced stage. Several interconnected systems are already in operation in the region, and various extensions and refurbishment's are currently planned. The Southern African region as a whole has an electricity surplus of approximately 12 000 MW in generation capacity. The surplus capacity has given impetus to the creation of the Southern African Power Pool. This is due to the fact that whilst some countries in the region have an oversupply of electricity, others have large deficits.

The technology to establish regional electricity grids is already available. According to Gcabashe[46], the core of a broader African grid would be the Inga Hydro-electric Scheme in Zaire, which is estimated to have a potential output of between 40 000 and 100 000 MW, which is enough to supply the total demand in Africa, with surplus to transmit to Europe and Asia.

The re-commissioning of mothballed plants in South Africa and the development of hydro generation potential at Inga Falls in Zaire is expected to be able to meet future regional electricity demand. The Southern African Power Pool (SAPP) is an agreement between the Southern African Development Community utilities, together with Zaire. Its objective is to create a common market for electricity to provide a reliable and economical supply to consumers in each member state with the best possible utilisation of natural resources, and minimal impact on the environment[46]. Countries that are signatories of the Intergovernmental Memorandum of Understanding that formed the basis of the establishment of SAPP are: Angola, Zambia, Mozambique, Lesotho, Botswana, Malawi, South Africa, Swaziland, Zaire, Namibia, Tanzania and Zimbabwe.

3.5 Institutional Aspects

3.5.1 Introduction

The relationship between the energy sector and the rest of the economy is complex, and requires the linking of the energy sector planning with that of the entire economy, to avoid duplication of programs by different institutions.

Major existing institutions in the region have been determined by prevailing political conditions and the need to protect and promote the regional economy against manipulation by the western countries. Much of the region's energy resources are under-utilised because of the absence of proper institutional structures.

There is no regional energy body in place yet. The establishment of such a body would need the assistance of organisations like the Organisation of African Unity and Southern African Development Community (SADC). A brief description of the two organisations follows below.

Organisation of African Unity (OAU)
The OAU was established in May 1963, after many efforts by some of the members to form it as early as 1958. It is comprised of all African countries, including those that fall under SESSA region. The organisation was formed for the following reasons: (i) co-operation among African states in the following fields: economic and social; education, culture and science; collective defence; (ii) decolonization; (iii) apartheid and racial discrimination (iv) effects of economic grouping on the economic development and other issues related to peace and stability of the continent.

Southern African Development Community (SADC)

SADC was formed in 1979. It was formerly called the Southern African Development Co-ordinating Conference (SADCC), until 1992. Originally, the main purpose of the organisation was to harmonise development plans and to reduce the region's economic dependence on South Africa (that was before South Africa became a member due to its apartheid practices). The activities of the organisation include, among others, joint petroleum exploration, training programmes for the petroleum sector and studies for strategic fuel storage facilities, promotion of the use of coal, development of hydroelectric power, the co-ordination of national electricity grids, new and renewable sources of energy including pilot projects in solar energy, assessment of the environmental and soci-economic impact of wood-fuel scarcity and relevant education programmes, and energy conservation.

3.5.2 Energy Institutions

Institutions are central to the activities of service delivery and economic development of the country. A strong association exists between the availability of services such as telecommunications, safe roads, access to clean water and energy supply. Without telecommunication, it is difficult to contact the electricity authorities in times of power failure. Lack of good roads also prohibits satisfactory distribution of commercial energy to rural areas. Energy supply and demand satisfaction are dependent on the existence and the competencies of their political and administrative structures. This region has few experts on energy issues, and they lack institutional structures to support energy initiatives and programs.

Communities shown a tendency to relocate from areas without a good water supply, even if they have access to adequate sources of energy. As a result, utilities are hesitant to provide services to areas without a proper water supply. The burden is then left to government-related structures to provide such services, which in many cases is driven by central government, without co-ordination with Provincial or local bodies.

3.5.2.1 Sectoral and Institutional barriers in co-ordination and "top-down" flow of targets

The existing approach for planning and implementing energy programmes in the region is typically top-down and sectoral. Different organisations and separate ministries are responsible for the supply of different sources of energy and other developmental services. Some countries have their electricity utilities falling under one or other department/ministry, while the overall co-ordination of energy issues and policy formulation is done by a different department/ministry. A typical example is Eskom in South Africa, which falls under the Department of Public Enterprises, while the Department of Mineral and Energy is in charge of co-ordinating energy matters.

3.5.2.2 Lack of co-ordination between energy demand and supply

There is little co-ordination at national and local levels, between energy supply and demand and other rural development activities, such as housing, water supply, etc. The supply of formal houses to communities should be coupled with water and energy supply, to optimise available resources. For example, electrified communities with adequate water supply use more electricity than those without good water supply systems because of geysers. It is cheaper and more convenient to connect electricity to newly-built houses.

3.5.2.3 Lack of local people's participation

Projects without the approval of local people have little chance of succeeding. Importing labour from outside is more expensive than using local people. Training local people with the intention of involving them in implementing projects is popular in many rural areas. Some unemployed people volunteer to work, with the main intention of accumulating skills and practical working experience. In some instances, people stop supporting projects not because they want to be physically involved, but merely for the sake of being consulted on issues that affect their lives and their communities.

3.5.2.4 Policy formulation

The existing institutions in the region were established to a large extent for economic and political considerations. SADC is one such institution, where member countries share information and expertise. Many national energy institutions in the region were established by acts of parliament, and since then are still wholly or partially controlled by government, either falling under the relevant energy department or Departments of Public Enterprises. The departments involved in energy matters are responsible for drawing up policies on energy issues. They exist at national level as the responsibility of co-ordinating energy matters is left to the central government, with very limited involvement by the Provincial Governments.

To demonstrate how far the state is involved in the running of these institutions, there are some senior appointments such as Chairman and Chief Executives of parastatal bodies which cannot be made without the approval of the government, through the departmental minister concerned. This may not be a very popular concept in the private sector, but it is through such involvement by the state that rural people manage to have access to services such as energy supply.

Many countries in the region are engaged in restructuring energy institutions. South Africa is a good example. Initiated by their governments, the whole process of restructuring is driven by the management board of these institutions. The trade unions are important role players in the restructuring process. In the electricity sector, the trend is to separate generation, transmission and distribution from each other. Generally, the existing energy institutions have the monopoly over generating, transmitting and even distributing to large and small customers. Through restructuring, the generation and distribution sections are being privatised, as in developed countries. The process of restructuring is facing some resistance from the trade unions in South Africa. Such changes are perceived by some of the unions as ways of trying to privatise the enterprise. The trade unions fear that as a result of privatisation, many employees would loose their jobs.

Another option which seems to be receiving support is decentralizing national energy bodies to provincial bodies. The changes being proposed are strongly influenced by political considerations, and would probably follow political provincial boundaries. All the energy organisations in each country's province are expected to form one provincial energy body. It is expected that this approach would help expedite service delivery, as these institutions could be more accountable by being closer to beneficiaries.

3.5.2.5 Implementation

Internal business control, such as short-term plans and the real implementation of programs, is done by the institutions themselves. The government's involvement is at policy level and long-term plans.

However, there are some local authorities, particularly in urban areas, that are also involved at implementation level. These authorities buy energy in bulk, i.e. electricity, coal or gas utilities and sell to their constituencies at a profit. Rural authorities on many occasions do not have the resources to provide services to their people.

There are instances, however, where rural agencies do exist and are responsible for the supply of energy in rural areas. Many such agencies do not survive long due to lack of resources, particularly finance. They depend mainly on funding from international donor agencies. Sometimes, finance meant for providing services to people is squandered by corrupt employees; in some instances it is just lack of accountability to anybody.

3.5.2.6 Some examples of Institutions involved in the energy supply at national level

To have a better understanding of institutions involved in energy issues in the region, it was felt necessary to choose six countries for the purpose of discussion.

Botswana: The overall energy planning is the responsibility of the government. The government has identified energy development as one of the pillars of rural upliftment and development in general. In their master plan, they have integrated energy issues into their wider development planning.

The government is involved in energy matters through the following institutions: Division of Energy Affairs in the Ministry of Mineral Resources and Water Affairs, the Forestry Unit in the ministry of Agriculture, the Ministry of Commerce and Industry. The Energy Division is a small unit. Its responsibilities include co-ordinating energy issues and commissioning energy research studies. There are plans to expand it and make it a fully-fledged department. The management of forests and other biomass is the responsibility of the Forestry Unit. This Unit is said to consist of only one forester stationed at headquarters. Plans to expand the Unit are already in place. The Department of Commerce and Consumer Affairs manages the supply of, and demand for, petroleum products, as well as setting the petrol price. The Department is also involved in the strategic planning of oil facilities in the country.

In addition to the government departments, there is a parastatal called the Botswana Power Corporation which is responsible for the supply of electricity. The Botswana Power Corporation is involved in generating, transmitting and distributing electricity to households, industries, farmers, etc. It is placed under the Ministry of Mineral Resources and Water Affairs. The second parastatal organisation is the Botswana Technology Centre which is responsible for promoting new technologies, under the Ministry of Finance and Development Planning. New and renewable technologies are also promoted by an organisation called Rural Industries Promotion. This organisation falls under the Ministry of Commerce and Industry. Of all the above-mentioned institutions involved in energy matters in the country, this appears to be the only one which promotes direct involvement by local rural people. Its activities are co-ordinated by the Rural Industries Innovation Centre (RIIC) and by the Pioneer Rural Industries.

The other organisations involved in energy matters are the National Institute of Development Research and Documentation at the University of Botswana, which focuses on wood energy production and consumption research programmes; the Forestry Association of Botswana is involved in research on fuelwood and production of natural woodlands, promotion and implementation of fuelwood programme and providing extension on issues related to forestry and the environment in general. Finally, the Brigades have established forestry plantations and woodlots in the country. The Brigades consist of community-based trusts. To cover cost, these community-based trusts combine technical training with production.

South Africa: The Department of Minerals and Energy (DME) is involved in co-ordinating overall energy policies, and supply and demand assessment in the country. This Department only exists at national level. The responsibility of supplying energy is left to national and local bodies. The department is in the process of establishing regional co-ordinators on mineral and energy issues. Plans are already in place to develop woodlots and forestry plantations for the benefit of rural people. The responsibility of managing natural forests and forest plantations is the prerogative of the Department of Water and Forestry. This Department is also only at national level, and does not have representation at provincial level. The co-ordination of Agriculture and land issues is the responsibility of the Department of Agriculture and Land Affairs.

Synthetic oil is produced from coal by SASOL, a semi-private company with issued shares a majority of which are owned by the Government. SASOL is expanding its coal production capacity in order to enter the export market.

Coal is produced, both for local use and export by a number of private mining houses. There is no control of coal prices. These mining houses also supply coal for electricity generation.

Most of the country's electricity (96%) is produced by a parastatal called Eskom. It is accountable to the Minister of Public Enterprise. Eskom is responsible for generating, transmitting and distributing electricity. It supplies electricity to institutions such as mines and municipalities. The responsibility of supplying electricity to rural communities also lies with Eskom. Eskom also exports to other countries in Africa.

To establish an efficient co-ordinating system with rural people in the supply of electricity, through the participation of local people, Eskom established "Electricity Committees". The committees are composed of local people, some of whom are taken for training courses on electricity planning principles.

Renewable Energy for South Africa (REFSA) is a new organisation which was established in 1996. REFSA's responsibility is to promote funding for non-grid electrification of rural regions. It falls under the Department of Mineral and Energy.

In Swaziland: The Ministry of Natural Resources, Environment and Energy is responsible for the co-ordination of energy provision. The Energy section has woodlot projects in rural areas, where local people are encouraged to participate in the planting and management of trees. The Energy section has sought the involvement of external consultants to come up with policy guidelines on a rural electrification project. The Swaziland Electricity Board, which is a parastatal organisation, is responsible for the supply of electricity to consumers in the country. They co-operate with the Ministry in the process of drawing up policy on energy issues.

Besides the Ministry and the Swaziland Electricity Board, there is a private company responsible for the installation of solar systems. This company is called Swazitronix and has existed for some time, but its operation has not been very extensive due to lack of funds. Swazitronix is co-operating with a newly established organisation called Solar International, which intends to raise funds to help people acquire solar systems, paying them off over a period of three years. The arrangement is such that Solar international identifies funding for equipment, and Swazitronix gets involved in the implementation of the systems.

Tanzania: Institutions that are responsible for controlling/administering energy supply and demand in rural areas include:

- Ministry of Energy and Minerals (MEM);
- Ministry of Natural Resources and Tourism (MNRT), through the Forestry and Bookkeeping department;
- Oil Marketing Companies through their retail channels;

- Several NGO's and Community Based Organisations (CBOs) including Women's Groups in the area of improved cook stoves;
- Ministry of Community Development and Women and Children Affairs.

According to Mrindoko of the Ministry of Water, Energy and Minerals, the government intends to put measures in place to assist in solving energy problems in rural areas through:
- introduction of efficient cooking stoves and woodfuel converters including improved charcoal production,
- tax exemption on imported solar energy equipment
- dissemination of biogas technology

Uganda: The main players in the energy sector are the Ministry of Energy, the Forestry Department, the Uganda Electricity Board (UEB), the Geological Survey and Mines Department, and the oil companies. The Energy Department of the Ministry of Power, Transport and Communication (MPTC) was replaced by the Ministry of Energy.

The Forestry Department, under the Ministry of Agriculture and Forestry, is responsible for preserving and managing existing forests. It is also responsible for promoting efficiency in the use of forest products and environmental conservation.

The Uganda Electricity Board is a parastatal and is responsible for the production, transmission and distribution of the public electricity supply in Uganda.

The Woodfuel subsector is accounted for by many local non-governmental organisations, such as Usika Crafts, Joint Energy and Environment Projects, Black Power Ltd, Wildlife Clubs of Uganda, Boy Scouts of Uganda, etc.(57). The energy institutional structure of the country is weak and poorly co-ordinated.

Ethiopia: The Ministry of Mines and Energy is the lead agency in policy formation and development planning for the energy sector. The Ethiopian National Committee (ENEC) was formed by the government in 1979 in order to address the pressing problems of the energy sector in a co-ordinated manner and to assist in policy-making and the setting of priorities(56). The energy parastatals and the agencies established for geothermal and petroleum exploration report to the Permanent Secretary of the Ministry or to the Minister himself.

Electricity is generated under the authority of the Ethiopian Electric Light and Power Authority (EELPA) which was formed in 1956 as a parastatal organisation and since 1976 has been placed under the Ministry of Mines and Energy(56). Although EELPA maintains overall responsibility throughout the country for public electricity generation, transmission and distribution, the supply of power to the northern region is provided by its unconsolidated subsidiary, the Eritrea Region Electricity Supply Agency. Both supply regions are composed of an interconnected system and a series of satellite generation centres.

3.6 Financial considerations

3.6.1 Introduction

The region is one of the poorest in the world, with a population growing very rapidly but slightly slower than economic growth.

The main organisations which have assisted with the funding of development projects in the region are the World Bank (WB) and the International Monetary Fund (IMF). Finance provided by these organisations were in the form of loans. Many countries have not been able to meet their repayments, and they currently owe more than their initial loan, due to interests accumulated throughout the years, and the WB and IMF are pressurising these countries to start implementing liberal economies.

Locally, energy institutions depend mainly on funding from the government, over and above the revenue they generate from their own programs.

3.6.1.1 Existing methods of financing energy infrastructure and tariff systems, energy subsidies and their impact on energy demand

Energy institutions in developing countries rely on organisations such as the World Bank, for financing their projects. Some countries have not been able to honour their loan repayments, resulting in strained relationships with the bank.

The involvement of foreign countries supplying foreign aid is an important means of funding to rural energy projects. Some organisations are sceptical of foreign aid. The conditions attached to some of the aid present difficulties to the recipient countries, and sometimes such funding is rejected.

To reduce capital costs, local people have, on many occasions, offered to be trained so that they could help local projects by providing labour services. This approach has helped to provide employment to local people. In situations where local people are involved actively in projects, people usually pay for their services. Community members are willing to identify and watch against those who choose to avoid payment by stealing or bypassing meters in the case of electricity. Even those who are struggling financially usually borrow money to pay for services.

(a) Government funding

The budget for energy issues is allocated by central government. The budget allocated is generally small compared to other developmental projects. The budget is allocated by the relevant ministry responsible for energy issues. The little funds reserved for energy issues is further divided into urban and rural energy projects, with very little going to rural projects.

(b) Tariffs

The tariffs of different sources of energy differ from country to country. Different suppliers also charge different tariffs for one energy source. For example, in South Africa, there are more than 200 electricity suppliers, charging different tariffs, with prices differing from area to area. Cross-subsidisation of some of the energy sources distorts energy prices. Larger customers are charged tariffs that are designed to subsidise smaller customers.

In countries like Malawi, Zimbabwe and South Africa, municipalities purchase their electricity from the national electricity corporation, and sell it to final end-users at a higher tariff. These municipalities generate much of their income from supplying electricity. As a result, customers purchase electricity at different tariffs, depending on who their supplier is. Those customers buying directly from the producer tend to pay less per unit consumed. However, the government, through the National Electricity Regulator (in South Africa), a statutory body, is planning to rationalise the tariff system.

Electricity is highly subsidised by corporations. The connection fees are very low for rural people, due to the subsidies they receive, and the losses are usually carried by the corporation. There are instances where customers do not pay for their consumption, and as a result, the debt accumulates. Some of these debts are written off, to encourage customers who could no longer afford to pay what they owe, to pay in future.

In Zimbabwe, electricity is supplied under a wide variety of tariffs. The tariffs for urban and rural domestic customers, farming, large and small industrial enterprises and lighting for institutional buildings differ, a situation similar to that in South Africa. The various municipalities also have their own tariff systems(14). The domestic tariffs work on a block system, with the first block of units supplied at a high rate, the price falling sharply for a further block, and falling further for any consumption in excess of the previous one. The standard connection fee was US$ 138 per customer. However, those with special requirements were charged more, a similar situation to that in South Africa.

The connection fee for domestic customers in Swaziland, like many other countries in the region, depends on the distance from the grid system, and the type of supply. The electricity tariffs are cheap and considered to be below the economic cost of providing electricity, especially for domestic consumers.

In Namibia, the government, through the Ministry of Mines and Energy, has established a revolving fund, in conjunction with a United States development organisation, the Renewable Energy for African Development (REFAD), to aid villagers in purchasing solar energy systems. The fund is managed by the Namibian Development Corporation (NDC), which grants loans to interested rural households.

Tanzania uses an incremental system, whereby customers consuming 0-100 kWh per month pay less than those consuming 101-500 kWh per month. Customers consuming more than 501 kWh per month pay a higher tariff[51].

3.7 Environmental issues

In the energy sector, environmental issues need to be considered at every step of the fuel cycle, namely, exploration, extraction, transportation, conversion and consumption. For example, the production, transportation, combustion and conversion of energy affects the environment through pollution. Many reports have been written on the damage caused to the environment by cutting down trees for fuelwood; mining coal, transporting it and the pollution it causes during its combustion.

Desertification is one of the major challenges facing the region. Human activities such as deforestation, unsustainable agricultural practices and overgrazing contribute heavily to desertification. At a workshop of non-governmental organisations (NGO's) involved in implementing the Convention for Combating Desertification (CCD), held in Harare, in 1996, it was mentioned that Botswana and Namibia's food producing capacity is set to decrease if efforts to combat desertification are not implemented as a matter of urgency. According to Madava, Tanzania, Swaziland, Mozambique and Zambia are also faced with the problem of severe land degradation, citing over-population in some areas and deforestation as the major causes. As deforestation continues to deprive rural people of natural forests, the question that most people asks is "Who should control the natural resources"? Should it be the government, private sector or local communities? There are those who feel that it should be the private sector, as the government might lack the capacity, and the local community might lack the legal framework to protect their natural forests. In addition, most local communities in African countries are "poachers" in their own lands, through the collection of biomass fuel. Usually, this happens in situations where projects are implemented without support from local people. It is necessary therefore to set the framework for involving local communities in Africa's sustainable utilisation of natural resources, where the role of the state and its capacity to control, and the authority of local communities will be defined. Utilisation of natural biomass fuel in most rural and communal areas continues without policy guidelines, and sometimes falls in between traditional or indigenous knowledge systems and weak government controls. The result is the depletion of natural forests at an alarming rate.

Coal accounts for more than 80% of the region's electricity generation. The region's contribution to global warming through coal combustion is however still low. As the largest producer and distributor of electricity from coal in the region, South Africa's Eskom activities have a profound impact on the environment and as such, the organisation has undertaken to conduct their business in ways that are environmentally conscientious. In addition the organisation has pledged to[63]:

- comply with environmental legislation
- actively involve communities in decisions on environmental programmes
- support sustainable development

- conduct environmental audits of their operations at regular intervals
- publish their environmental performance results in an annual environmental report to maintain transparency and public accountability
- train their employees to regard environmental considerations as an integral and vital element of their activities
- continually improve environmental performance by:
  - ⇒ conserving and promoting the conservation of energy
  - ⇒ reducing emissions, effluents and wastage
  - ⇒ utilising finite resources efficiently
  - ⇒ promoting the sustainable use of renewable resources
  - ⇒ researching and instituting ways to reduce environmental degradation

In Zaire, the construction of Kariba Dam in 1960, caused the flooding of 5200 sq. km of land, resulting in the loss of species and displacement of the Tonga people of the Zambezi valley, loosing their traditional fishing ground in the process[(52)]. To avoid such an experience repeating itself, discussions on other proposed regional hydro schemes such as Batoka, Kariba II and Epupa are attempting to address this issue.

So far very little has been done at regional level to protect the environment. Internationally, South Africa (through Eskom) participated in the initiative of the E-7, a grouping of the largest vertically integrated electricity utilities in the developed world. The aim is to co-ordinate a capacity building project in environmental management for the utilities in the Southern African Power Pool (SAPP). Subsequently, the SAPP Environmental Subcommittee was established. Collaboration with other African organisations involved in the protection of the environment such as Electricity Power Research Institute (EPRI), International Union of Producers and Distributors of Electrical Energy (UNIPEDE) and Conference Internationale des Grandes Reseaux Electriques a Tension (CIGRE) continued in 1996[(63)].

3.7.1 Regional initiatives to manage environmental problems

There are moves towards integrating the power sector in Southern Africa. The Rio Conference in 1992 decided that the Environment and Land Management Sector (ELMS) of the SADC should co-ordinate environmental issues amongst member states. A planning workshop was held in 1995 in Lesotho, and guidelines for SADC member states on co-operation on environmental issues were drawn up.

3.8 Conclusion

More than 60% of the region is still living in rural areas. Except for one or two countries such as South Africa and Zimbabwe, the agricultural sector of most countries still makes a significant contribution to the GDP. The region is one of the poorest in the world. Only five of the 24 countries in the region have a GDP per capita of more than US$ 1000.

An overview of the energy sector shows that the supply of commercial energy in rural communities is weak. This results in rural communities depending on traditional energy such as biomass, which they get freely. Some countries were found to have an abundance of commercial energy, but its supply to rural areas is non-existent, or very poor at the least

A closer look at energy institutions reveals poor planning and lack of co-operation with other institutions that are involved in the development of rural communities. In some countries, the governments are actively involved in the policy making, planning and implementation of energy projects, through the relevant departments, except for a few countries that have well established energy institutions. Even in these cases, they still lack institutions that control rural areas. Usually, rural people are not given a chance to participate in the development of their communities, resulting in many problems.

The financial situation of the energy sector reveals that the main funder of rural energy projects is the government, and it happens that the budget allocated by governments for rural energy projects is usually small.

Energy institutions rely mainly on income generated from tariffs, where people are charged for connection fees and what they consume. In order for the supply of rural energy to be sustainable, particularly rural electrification, it is dangerous to continue with subsidies. However, without subsidies, some of the rural people will never get electricity. It is therefore necessary to subsidise the cost of connection, and consumption for a limited period, and thereafter cease subsidy once the consumption is stabilised.

4. FUTURE CONSIDERATION FOR RURAL ENERGY SUPPLY AND DEMAND IN THE REGION

4.1 Introduction

Energy supply and demand depend on many factors; social, cultural and economic, whereas the movement of people from rural to urban areas is influenced by the economy and the type of energy consumed. Most of the countries in the region show similar characteristics. Generally, these countries have poor economies, large rural populations that are scattered over a large area. Moreover, the rural areas lack a commercial energy supply, resulting in them depending mainly on traditional energy. For developing countries, the situation is expected to continue for a very long time, although the rural population in the region is estimated to go down to approximately 68 percent by the year 2000.

Based on the present regional situation, this chapter attempts to examine the future, and how the continual movement of people from rural to urban areas will affect the future energy supply and demand. Will traditional energy supply remain the same in future, despite the movement of people to urban areas? Will the demand for commercial energy increase or decrease? If it increases, are there any future plans to address the growing demand? These are some of the questions that are addressed in this chapter.

The comparison between rural and urban areas, and in developing and developed countries is also covered in this chapter. Is there a particular trend that the developed countries followed during the years of their economic development, which the developing countries might also follow? If there is, will this be to the benefit of these countries?

4.2 Social Implications

4.2.1 Urbanisation

The urban population in the region is quite low, ranging from 6 percent for Rwanda to 53 percent for Seychelles in 1993. The average regional urban population in 1990 was approximately 26 percent. It is estimated to increase to 32 percent by the year 2000, and to 37 percent by the year 2010[53], if one takes into account the present rate of rural migration. By the year 2020, the average percent of urbanisation in the region could reach 42 percent. However, there is a vast difference between individual countries. For example, the urban population in Rwanda and Seychelles are estimated to increase to 8 percent and 60 percent in the year 2000, and 10 percent and 70 percent in the year 2010, and by the year 2020 to reach 19 percent and 80 percent respectively.

In other countries, the urban areas are already experiencing the problem of squatter settlements, in the process raising tensions within communities, particularly amongst people living in new informal settlements and those in formal settlements, as the new settlements usually lack adequate supply of infrastructure. Tensions are also caused by the rate of crime which is usually blamed on the mushrooming of informal settlements which are linked to high levels of unemployment. Though some countries are having ambitious programmes which hope to provide the majority of people with formal houses by the year 2000, there are other countries that do not have budgets for such programmes, and by the year 2020, will still be experiencing acute housing shortages.

During the period of 18 years (1975-1993), the traditional energy consumption in the region decreased, in Tanzania it decreased from 100% to 92%, while that of commercial energy increased by 8%. In South Africa, traditional energy consumption decreased from 6% in 1975 to 5% in 1993[41]. In all these countries, the greater portion of commercial energy was accounted for by the urban population, while the rural population accounted for much of the consumption of traditional energy.

Table 4.1 below shows that the regional rural population is expected to decline by more than 30% by the year 2010. The total demand of energy in the year 2010 is expected to be 3 times higher than it was in 1993. The percentage increase in the demand for commercial energy will be higher than the percentage increase in the demand for total energy, because of the change in conditions of people's lifestyles due to the economic growth, coupled with the increase in the total population. All in all, estimations of energy consumption based on table 4.1 suggests that by the year 2010, average traditional energy consumption would have gone down by more than 5 percent in the region.

Projections of the % urban population to the year 2010 were made based on the urbanisation growth rate shown on table 4.1 above, which could change depending on what strategic policy the government implements during these period. Some countries are already involved in programmes aimed at bringing development to rural areas, which will help in slowing rural migration. Irrespective of developmental rural programmes planned, the urban population in South Africa is probably going to be higher than the figure given in the year 2010. Since the scrapping of apartheid laws, black people from rural areas are migrating in great numbers to the big cities in search of employment. The rate at which informal settlements are increasing is indicative of how the new changes have affected the socio-economic and political situation in the country. As a result, there is a rapid increase in the demand for commercial energy, and many of these settlements are electrified.

Table 4.1 Urban Population Statistics[53]

COUNTRY	URBAN POPULATION AS % OF TOTAL			URBAN POPULATION GROWTH RATE 1975-2010 (% PER YEAR)
	1975	1993	2010	
Botswana	12	28	44	4.0
Burundi	3	7	11	1.0
Comoros	21	30	39	2.3
Ethiopia	10	13	17	1.0
Kenya	13	26	39	3.3
Lesotho	11	22	32	2.7
Madagascar	16	26	35	2.4
Malawi	8	13	18	1.4
Mauritius	43	41	35	-1.0
Mozambique	9	31	31	5.5
Namibia	21	35	50	3.7
Rwanda	4	6	8	0.5
Seychelles	33	53	72	4.8
Somalia	21	25	29	1.0
South Africa	48	50	53	0.6
Sudan	19	24	29	1.2
Swaziland	14	29	45	3.8
Tanzania	10	23	36	3.2
Uganda	8	12	16	1.0
Zaire	30	29	27	-0.2
Zambia	35	42	50	1.9
Zimbabwe	20	31	41	2.5

4.3 Resource Aspects

4.3.1 Future Prospects for Energy demand and supply

4.3.1.1 Demand

Future prospects for energy demand in the region (excluding South Africa) and for South Africa only were shown in table 4.4, showing three economic growth scenarios, for both commercial and biomass energy. Scenario 1 was low growth, scenario 2 was medium growth and scenario 3 was high growth. The role played by commercial energy is going to become more important, while biomass energy will still contribute a large share, but expected to decline in percentage.

Table 4.2a Final consumption of energy in South Africa (1993 and predictions, 000 Toe[1])

Year	Scenario	Commercial	Traditional	Total Energy Consumed (TEC)	Traditional, % of TEC
1993		41413	9547	50960	19
2000	1	51526	7735	59261	13
	2	61651	7735	69386	11
	3	67240	7735	74975	10
2010	1	66729	8011	74740	11
	2	87203	8011	95214	8
	3	111213	8011	119224	7
2020	1	85761	7840	93601	8
	2	117005	7840	124845	6
	3	176376	7840	184216	4

Table 4.2b Final consumption of energy in the region (excluding South Africa 000' TOE)[1], 1993 and predictions

Year	Scenario	Commercial	Traditional	Total Energy Consumed	Traditional, % of TEC
1993		14308	69617	83925	83
2000	1	24507	95782	120289	80
	2	28144	95782	123926	77
	3	30147	95782	125929	76
2010	1	40113	121768	161881	75
	2	49557	121768	171325	71
	3	61342	121768	183110	67
2020	1	63507	149333	212839	70
	2	82369	149333	231702	65
	3	120664	149333	269997	55

Table 4.2c Traditional Energy Consumption (% of Total Energy Consumption) in the region, Predictions to 2020

Year	Scenario	Total Energy Consumed	Traditional, % of TEC
1993		132344	58
2000	1	179550	58
	2	193312	54
	3	200904	52
2010	1	236621	55
	2	266539	49
	3	302334	43
2020	1	306440	51
	2	356547	44
	3	454213	35

4.3.1.2 Supply

The SESSA region as a whole has large commercial energy resources which could, if exploited and managed efficiently, supply most of its commercial energy needs well into the next century[(1)]. Table 4.3 and 4.4 shows a general picture of the resources in the region, though one cannot claim it to be a definitive picture of the resources in the region, due to lack of information on some of the countries.

Wood, coal, natural gas, oil and hydro potential are some of the energy resources that are found in the region. A large portion of the known resources have not yet been exploited in the region due to lack of finance, availability of markets and location. Lack of proper management for biomass energy threatens the future supply of wood. Energy resources are also not evenly distributed throughout the region. Biomass and hydro potential is abundant near the Equator, coal is found in the southern part of the region, while oil and gas have been identified off the east and west coastlines[(53)].

The markets for these resources in the region are limited to local consumers, except for electricity which is traded regionally. Lack of regional energy trading can be attributed mainly to lack of transport, poor infrastructure, and the effect of civil wars in many of the countries in the region. Recent efforts in the region to bring about peace and stability is expected to enhance regional economic relationship.

Table 4.3 Energy Resources of the region(1)

Country	Forests & Woodlands M Ha	Hydro-Potential*		Oil M Ton				Gas (M Metres Cubed)	
		GWh/Year	MW	Estimated	Proven	Total	Proven Recoverable	Estimated	Proven Recoverable
Angola	54	86100	16000	-	156	156	156	30000	9000
Botswana	33	0	0	0	0	0	0	0	0
Burundi	0	1445	289	0	0	0	0	0	0
Comoros	0	50	10	0	0	0	0	0	0
Ethiopia	27	20000	4000	0	0	0	0	6000	24000
Kenya	2	4800	1075	0	0	0	0	0	0
Lesotho	-	2000	450	0	0	0	0	0	0
Madagascar	13	39000	7800	-	-	-	-	-	-
Malawi	4	6300	900	0	0	0	0	0	0
Mauritius	0	325	65	0	0	0	0	0	0
Mozambique	15	60000	12500	0	0	0	0	320000	65000
Namibia	18	-	-	-	-	-	-	28000	-
Rwanda	0	3000	600	0	0	0	0	-	40000
Somalia	9	250	120	0	0	0	0	-	6000
South Africa	1	5550	3500	-	-	-	-	-	28000
Sudan	48	1900	380	-	41	41	41	-	85000
Swaziland	0	3000	600	0	0	0	0	0	0
Tanzania	42	20000	6000	0	0	0	0	26710	163420
Uganda	6	10000	2000	0	0	0	0	0	0
Zaire	178	750000	100000	0.1	24	24	15	-	1000
Zambia	30	21406	3924	0	0	0	0	0	0
Zimbabwe	20	13285	2515	0	0	0	0	0	0
Total	500	1048411	162728	0.1	221	221	212	410710	421420

* Technically Exploitable Potential

Table 4.4 Energy Resources of the region[1]

Country	Coal: Bituminous Mton				Coal: Lignite & Sub-bituminous Mton			
	Estimate	Proven	Total	Proven Recoverable	Estimate	Proven	Total	Proven Recoverable
Botswana	33000	17000	50000	3500	0	0	0	0
Ethiopia	0	0	0	0	-	23	23	11
Kenya	0	0	0	0	0	0	0	0
Lesotho	0	0	0	0	0	0	0	0
Madagascar	1000	173	1173	173	43	11	54	-
Malawi	-	16	16	2	0	0	0	0
Mauritius	0	0	0	0	0	0	0	0
Mozambique	8593	938	9531	240	0	0	0	0
Namibia	-	-	-	-	-	-	-	-
Rwanda	0	0	0	0	0	0	0	0
Somalia	0	0	0	0	0	0	0	0
South Africa	2282	121218	123500	55333	0	0	0	0
Sudan	0	0	0	0	0	0	0	0
Swaziland	1000	549	1549	208	0	0	0	0
Tanzania	1500	304	1804	200	0	0	0	0
Uganda	0	0	0	0	0	0	0	0
Zaire	720	87	807	54	0	0	0	0
Zambia	0	0	0	0	213	69	282	69
Zimbabwe	27008	1535	28543	734	-	965	965	-
Total	75103	141820	216923	60444	256	1068	1324	80

(a) Biomass

The region's total forests and woodland is recorded to be around 500 MHa, with Angola, Zaire and Mozambique having the largest biomass resources still to be exploited. However, many of the forests are situated far from where people stay. Supply of biomass to rural communities is becoming a difficult exercise and new mechanisms to collect wood are needed to be put in place as there is usually lack of transport. Most countries in the region have resorted to establishing woodlots in areas for purposes of fuelwood. Strict measures to control and manage natural forests and use of fuelwood are some of the measures that the authorities are resorting to, in order to sustain the supply of biomass.

There is a general concern about the rate at which forests and trees are being depleted as sources of energy, causing serious damage to the environment. Programmes for planting trees and establishing woodlots are being established to offset the high demand for biomass fuel. Nonetheless, the planting of trees would fail to solve the problem, unless new initiatives are introduced to cope with the growing energy demand. Projections by some researchers in the past showed that by 1995 forests in some parts of West Africa would have been wiped out. Although this is not the case, there are fears that by the year 2010, very few forests would be left, considering the rate at which deforestation is taking place. Between 1981 and 1985, countries like Angola, Zambia and Tanzania had forest areas of 536, 295 and 420 thousands of square kilometres, and their annual deforestation was 0.94, 0.70 and 1.30 thousand square kilometres respectively. The rate of deforestation is expected to increase due to population growth(12), although this can hardly be blamed on fuelwood consumption.

(b) Gas

According to recent discoveries, the SESSA region has large resources of gas. The region boasts an estimate of 410710 million cubic metres of gas and 421420 million cubic metres of proven recoverables. A large quantity of these estimates are reported to be in Namibia and Mozambique. Rwanda, Sudan and South Africa are some of the countries in the region that contribute significant quantities to the region's total proven recoverable reserves. Latest reports claim that in Namibia, Shell E&P Namibia have just finished their tests on the Kudu4-exploration and appraisal well and are expected to announce the results of tests shortly. The tests are said to have focused on the levels that had already been known, and others never previously explored in the gas structure in the southern part of Namibia's coast(49). Indications are that the field holds sufficient reserves to meet local energy demands and also undertake large exports to supply the whole region beyond the year 2005. The discovery of new gas fields in Namibia, added to the productions from Pande gas fields in Mozambique is expected to reduce the region's dependence on coal, which is the main source of primary and secondary energy, as more than 90 percent of electricity produced in South Africa (which is the main electricity supplier in the region) presently comes from coal. The discovery of gas in Namibia has generated discussions around the prospects of generating electricity from their locally produced natural gas, for local and regional consumption.

(c) Coal

According to table 4.4, the total proven coal reserves for the whole region is 142887 Mton, while the total estimated coal is 75359 Mton. The total proven recoverable coal in the region is reported to be 60524 Mton. The total estimated additional amount in place is around 113414 Mt, with Botswana accounting for about 88% of the total estimated. In addition to that, there is approximately 134 Mt of coal that falls under estimated additional recoverable reserves[29]. On average, the region has good prospects for coal production to take it to the year 2010. Although coal resources are in abundance in the region, the consumption in the form of electricity is expected to increase with the increase in the industrial economic sector and the accelerated electrification programmes to households, schools and clinics.

4.4 Changes in energy mix necessary to meet demand

In order to be able to plan for the future, one should be informed of the past and then understand the present. For many years fuelwood has been, and still is, the dominant energy source in rural communities. It is used for heating space, cooking food and boiling water. Households that are still dependent on fuelwood, may use paraffin and candles for lighting. In addition to that, wood fires are usually made outside in the open during the night to provide some light to the house, though this practice is no longer very common. Paraffin is also used both for cooking and for boiling water. Energy mix between fuelwood and paraffin and candles is very common in the region, especially in rural areas.

In countries where production of coal is sufficient, the consumption of coal in the residential sector is ever-increasing. The constrain, however is lack of transportation of coal to rural areas. Coal, like fuelwood, can be used for many purposes in the house, and can also be mixed with other energy sources like wood, paraffin and candles. It is preferred mainly for space heating, cooking, boiling water. At industry level, its main use is the generation of electricity in the region. It is interesting to find that many houses that are electrified still use coal for cooking and space heating, while electricity is used for lighting and entertainment purposes.

With new discoveries of gas fields in Namibia and Mozambique, gas consumption in the region is expected to increase. The price of gas in the region is likely to be maintained at a low level due to the increased production and discovery of gas. Gas is also preferred to other sources of energy such as coal because it contributes less to environmental pollution. The increased supply of gas in the region is expected to offset the increase in demand for coal. Presently there is very little gas consumed in the region, with only Angola showing gas to be 7.5% of its total energy consumption in 1993, while other countries show very little or no gas consumption at all (this might be attributed to lack of data in most countries or might be due to lack of supply). The situation is expected to change once the production of gas in Namibia and Mozambique is increased, and once government departments responsible for drawing up energy policy start putting their energy policy in place.

Electricity is one of the most popular sources of energy in the world. It is a clean form of energy to the final end user and is also considered to be safe. People usually switch from other forms of energy to electricity. Besides being safe and clean, electricity can be used for many purposes in the house. It is the most preferable source of energy for lighting, cooking, warming and cooling space, entertainment, etc. The problem with supply of electricity in many rural areas is lack of finance. Even when the connection costs are subsidised, rural people do not totally abandon other sources of energy such as gas and fuelwood where it is available. In many instances they tend to use electricity for lights as it is cheaper, and continue to use fuelwood, coal and gas for cooking.

In light of the poor economies of rural areas, and their geographical situation, with rural houses situated far from each other, extending grid electricity to some of these areas could be seen as a very expensive exercise in the short term. However, one should see it as an investment in the future, spreading the expense over a longer period. The economic growth of developing regions like South Asia and Latin America have performed well because electricity supply to rural areas was not seen in terms of today's costs, as compared to the SESSA regions during the past years. Rural Electrification in these regions (Latin America and South Asia) was promoted for social and economic reasons, and this, in the long term, seems to be paying off. This region would be well advised to put as many resources as possible into rural energy development projects such as rural electrification, for the benefit of future generations. By the year 2000, more than 40% of the rural community in South Africa is expected to be electrified. This situation is expected to cause a shift from biomass consumption to electricity by rural communities.

4.5 Changes in Traditional/Transitional fuel patterns

Traditional/transitional energy consumption has shown declining trends with changes in the economy of the country[41].

The World Energy Council (WEC) Commission made predictions for future energy consumption (both commercial and traditional) based on three scenarios. Predictions for energy consumption in South Africa were separated from other countries in the region because of its stronger economic position. According to table 4.2, the final consumption of traditional energy in South Africa would decrease from 14% of the total energy consumption in 1988 to 4% by the year 2020. The percentage of traditional energy consumption in other countries of the region is expected to decrease from 83% of total energy consumption to 55%. The share of traditional energy consumption for these countries is still likely to be more than half the percentage of total energy consumption in the year 2020, regardless of the fact that it is decreasing every year. It is, nevertheless, important to note that consumption of energy in some of the countries in the region are not included due to lack of information. Countries such as Botswana, as seen in table 4.5.

4.6 Future Market changes

The region has diverse and sufficient energy resources. Disregarding South Africa, more than 90% of energy consumed in the domestic sector in the rural areas is traditional energy. Fuelwood does not generally have a formal market. In rural areas, it is usually freely available and its supply is done informally. Very little fuelwood is consumed in the commercial sector such as rural industries and the agricultural sector except for countries such as Ethiopia and Tanzania.

Consequently, there are no reliable statistics on the quantity of fuelwood consumed in the rural areas. It is in the urban and peri-urban areas that fuelwood and charcoal are traded on a commercial basis. In some countries community organisations, assisted by the government are busy establishing woodlot projects. Due to the increasing supply shortage, the possibility of trading fuelwood on a commercial basis in rural areas are high. At present, women and children are forced to walk long distances and spend many hours in the forest collecting wood. Those who have lorries make use of the opportunity, collecting wood for sale. It is however, unlikely that fuelwood will become a traded commodity between countries in the near future. There is very little income derived from selling fuelwood, for it to become an internationally traded commodity.

Angola is rich in crude oil products which cannot be exported to neighbouring countries. Civil war also made it difficult for Angola to trade with its neighbouring countries. Fortunately, the war seems to have subsided, and as a result the country is relatively in a better position to resume trade with its neighbouring countries. In Zambia, a project for a $400 million oil products pipeline running from Dar Es Salaam to Mwanza was announced at the Investor's Forum held in Tanzania in November 1996. It was also announced that another project proposal was being studied by BP to build a pipeline that would link Zambia to the Beira-Harare pipeline at Mutare in Zimbabwe. These are some of the initiatives that could open and expand the market for oil in the region.

The discovery of new gas fields in Namibia and Mozambique could see the opening of new gas markets in the region. It is claimed that gas fields discovered in the two countries held sufficient reserves to not only meet local energy demands but also undertake large-volume exports to the region as a whole.

The market for paraffin is strong in rural areas. Its supply in rural areas is reliable, compared to other commercial energy sources. It is one of the affordable energy sources in rural areas due to the subsidy system in the region. Due to the fact that it is the most accessible and affordable fuel, some countries are recommending the improvement in the efficiency of paraffin stoves irrespective of the dangers it poses to children.

The rail network between countries is inadequate to provide a good market for coal in the region. Many rail links were destroyed during civil wars in countries such as Angola and Mozambique. South Africa, inspite of its large coal resources, could not in the past develop its coal market because of economic sanctions. With sanctions lifted and the civil wars in Angola and Mozambique seeming to end, the situation is conducive for the coal market to assume a regional status. Coal trade is expected to increase with the general deterioration in the fuelwood situation of the region, mainly for consumption by big institutions and agriculture, and for the generation of electricity.

Electricity

South Africa's electricity utility Eskom supplies more than half the total electricity consumed in Africa. There are efforts to establish a regional transmission grid to encourage and accelerate economic development in the SADC region. Presently, South Africa exports electricity to Botswana, Zimbabwe, Mozambique, Namibia, Swaziland and Lesotho. Major existing electricity projects in the region are being planned to improve interconnections within the region. These include projects such as Mozambique-Malawi (study), Cahora Bassa North Bank and Mepanda Uncua (study), Songo-Apollo (Mozambique-South Africa)- under construction, Songo-Bindura (Mozambique-Zimbabwe)- under construction, and finally Matimba-Insukamini (South Africa-Zimbabwe)- which has been completed[46].

Many countries in the region are involved in Rural Electrification programmes. Rural Electrification programmes create a bigger customer base for the electricity sector. For example, in South Africa alone, more than three million homes are expected to be connected between the years 1994 and 2004. Indications are that the electricity sector should start looking for new sources of electricity to satisfy the future demand in the region as a whole. There is an excess of generating capacity from coal-fired power stations at present, but this is predicted to be used up by around 2006, especially if the load continues to grow at 4% per annum[58]. By that time, more than 1200 MW of the new generation will be required every year.

There are several options open to meet future demand. One option is to continue building new coal-fired stations in the region. Another alternative is to develop hydro potential in countries like Zaire, whose hydro potential could supply the whole region. Natural gas power stations are also a strong alternative, with the possibility of using Kudu (Namibia) or Pande (Mozambique) gas for the generation of electricity.

The hydro resources from Inga Power station (1750MW) in Zaire and Capanda (600 MW) in Angola are not fully utilised. An urgent exercise is reported to be underway to assess the economic viability of exporting spare power to the rest of the region.

4.7 Institutions

The issue of which institutions are involved in the supply of energy was discussed in the previous chapter. Rural communities are bound to get more and more involved in co-ordinating and influencing the supply of rural energy through non-governmental and community-based organisations. The overall co-ordination of energy is however expected to continue to be controlled by the relevant energy departments, most probably the "Department of Mineral and Energy" and "Energy Ministries" in many countries.

There are however, drastic changes that are expected to take place within the electricity industries. In the electricity sector, the trend is to separate generation, transmission and distribution. Mostly, the existing energy institutions have a monopoly over generating, transmitting and then distributing to large and small customers. Through restructuring, the generation and distribution sections are being separated to be managed independently of each other, as in developed countries. The process of restructuring is, however, experiencing resistance from some trade unions. They interpret such changes as a way of trying to privatise the business. The perception is that many employees would be retrenched if these organisations are privatised.

The other option which affects mainly distribution which seems to be receiving support is breaking national energy bodies into provincial bodies. The changes being proposed, particularly in South Africa, are strongly influenced by political considerations, as the provinces being suggested would follow closely existing political provincial boundaries. All the energy organisations in each province are expected to form one inclusive provincial electricity body referred to as a "Regional Electricity Distributor (RED)", which would be expected to have strong working relations with the alternative energy suppliers. It is hoped that this approach would help expedite service delivery, as these institutions are going to be accountable and will be more closer and accessible to the people on the ground.

The SESSA region is not a homogenous community. Within the region itself, there are other smaller sub-regions, formed around particular issues. For example, all the countries that are members of the Southern African Development Community (SADC), are members of the electricity power pool, called Southern African Power Pool (SAPP), has been firmly established. However, countries like Zaire, that are not members of SADC, are also members of the power pool. The aim of SAPP is to create a mechanism by which member countries can trade electricity among themselves, in particular between those which have vast hydro resources in the north and those which have large loads and thermal plant in the south. To achieve this, high-capacity electrical transmission lines would need to be built, interconnecting the various national networks throughout the region.

Already, there is an existing 400 kV line from Matimba (South Africa) to Insukamini (near Bulawayo) in Zimbabwe which was planned to be in commercial operation since October 1995, making exchange of electricity possible on a significant scale between the northern and southern part of the region. The vision of an integrated southern African grid, shared by many utilities in the region, became a reality with the signing of the Southern African Power Pool (SAPP) agreement which was formalised at governmental and at utility level during 1995[64].

4.8 Financial considerations

The previous chapter went into detail on the issues presently concerning sources of finance for energy projects in many countries in the region. The situation is not expected to change significantly in the future. Governments are expected to continue putting money into local energy projects to advance the supply of energy to rural communities. Clearly, a great deal of money is required for the projects, especially the establishment of the SAPP initiative. It is hoped that, with South Africa accepted as a member of SADC, and being a leading participant in the process, finance may become easier to obtain. A further enhancing factor would be the willingness shown by big electricity industries in the region to act as either a partner in joint venture companies, or as project managers.

4.9 Environmental issues

Environmental issues need greater attention to achieve and maintain sustainable development. The gaseous emission of developing countries which cause global warming is still very low compared to that produced by developed countries. The major energy-related environmental concerns in the region that require some serious attention into the future are:

- environmental degradation likely to result from the expected large-scale future use of indigenous poor quality coal;
- deforestation and loss of soil fertility, which at times is blamed on fuelwood consumption and agriculture-related activities;
- adverse environmental impacts associated with the development of large hydro projects (for example submergence of land and dislocation of population) in countries like Zaire; and
- use of old technology and lack of pollution control devices in the energy sector.

It was mentioned in chapter 2 that the Environment and Land Management Sector (ELMS) of the SADC was given the responsibility of co-ordinating environmental issues amongst member countries. Some of the projects that this subcommittee is expected to co-ordinate are:

- the policy on waste management, whereby Waste Management Forums will be established to co-ordinate reducing, re-using and recycling of waste materials, and to ensure sound management practices
- cleaning the effects of oil spills by electro-chemical technology
- supporting technically and morally initiatives on:
  - clean air environment,
  - community environment projects,
  - nature conservation

Efforts are continuing in some of the countries in the region to investigate the future utilisation of high-efficiency clean coal technologies, renewable energies, and nuclear power technologies to meet future supply requirements. In addition, demand-side management (DSM) programmes are being expanded in some of the utilities in the region. For example, it is estimated that in South Africa, these energy-efficient programmes will avoid the generation of some 12 000GWh of electricity up to the year 2015. In addition to the demand-side management programmes, off-peak load growth of 1500 MW has been targeted for the year 2015[63].

The region's usage of fossil fuels for energy contributes only 1.6% of the world's net additions of carbon dioxide to the greenhouse effect, of which 86% is accounted for by South Africa[1]. Its level of per capita energy consumption is still very low by world standards. Plans to reduce emission of carbon dioxide are still in their infancy. Whilst other countries in the region are already advanced in their plans to protect the environment, the immediate concern of many in the region is to provide adequate energy to meet their socio-economic development requirements and to achieve a higher level of energy self-sufficiency.

4.10 Comparison

While it does not mean that developing countries should copy from developed countries, there are some lessons that can be learnt. Rural communities of developing countries share more similarities. The chances that developing countries will adopt the policies of some of the developed countries are high, because of the financial aid and the technical support they receive from these countries.

4.10.1 Characteristics of rural areas

As discussed in detail in chapter one and two, the situation of biomass in rural areas of developing countries is complex and diverse because biomass production and use are closely linked to many aspects of rural life in many different types of areas. These aspects are related to geography and economy, they are also social and cultural. Furthermore, many groups of different actors are involved in the chain of production and use of biomass: landlords, producers, traders, consumers, etc.

Therefore, great care should be taken before issuing general conclusions in this area, and the observation of real life and actual needs, as perceived by local communities themselves, should be preferred to theoretical and global approaches.

In this respect, the study draws attention to the fact that, so far, most of the statistics produced on developing regions are global. They are usually national figures which do not refer only to rural areas. It is a top-down approach which can be dangerous for reasons previously mentioned. It would be more helpful to produce more localised studies and descriptions.

It should also be noted that the situation with biomass is almost an antithesis of the one for other forms of energy which are normally very independent of these factors for their production, distribution and even their use.

4.10.2 Rural and Urban areas

According to table 4.1, the 1993 figures suggest that only three countries in this region had less than 50% rural population. These three countries are Seychelles with 47.4%, South Africa with 49.8% and Congo with 43%. The rest of the countries in the region had more than 50% rural population, Burundi had 93%, Rwanda 94%, Tanzania 77%, Ethiopia 87% and Kenya 73.9%. The average rural population in the region as a whole was around 70% in 1993, and is expected to be 63% by the year 2010, which is high compared to other regions of the world (except for China). The regional rural population is still expected to be more than 50% by the year 2020, as shown in table 4.1.

What is interesting is the relationship between the contribution of the agricultural sector to the country's overall GDP, and the percentage rural population. The agricultural contribution to the country's total GDP in South Africa in 1993 was 4.6 percent, and that for Zimbabwe was approximately 15 percent. The contribution of the agricultural sector in Ethiopia which had a rural percentage of 87 was around 60 percent, while the contribution of agriculture with other countries was between 30 and 40 percent. By the year 2000 the contribution by the agricultural sector to the total GDP in these countries is expected to decrease by approximately 2 percent.

The average share of the traditional energy consumption to the total energy consumption in the region in 1993, according to scenario 1, as shown in table 4.2c, was 58%, which remains the same until 2000. It was estimated to decrease to 55%, and then to 51% in 2010 and 2020 respectively. According to scenario 2, as shown in table 4.2c, percentage traditional energy consumption of the total energy consumption was estimated to be 54% in 2000, 49% in 2010 and 44% in 2020. Scenario 3 estimated that traditional energy consumption would be 52% in 2000, 43% in 2010 and 35% in 2020.

Table 4.5 Comparison of rural population of different countries (1993)[6, 41]

Country	Rural (% of total)	Urban/Rural Ratio	Total GDP (US&billions)	Agriculture % of total GDP	Traditional energy consumed (%)
Botswana	71.6	0.3			
Burundi	93.0	0.1	0.9	51.9	
Ethiopia	87.0	0.1	5.8	60.5	56.1
Kenya	73.9	0.3	4.7	29.0	82.5
Malawi	87.2	0.1	1.8	39.2	
Rwanda	94.0	0.1	1.4	40.5	
Tanzania	77.0	0.3	2.1	56.0	92.4
South Africa	49.8	1.0	106.0	4.6	5.7
Zimbabwe	69.4	0.4	5.0	15.2	28.2

According to table 4.5 the size of the rural population has an influence on the quantity of traditional energy consumed, showing a bias towards traditional energy by the countries with a high percent rural population. The impression created is that as people move to urban areas, or as the country becomes more urbanised, there is shift from traditional to commercial energy consumption.

The contribution of the agricultural sector to the total GDP of the country also seems to diminish with the shift from traditional to commercial energy, due to a general decline in the rural population. As the country starts to depend more on commercial energy, the percentage contribution of the agricultural sector to the total GDP decreases. It is more probably that GDP/capita increases as the industrial sector increases. Since industry requires commercial energy it is the increase in industrial activity which causes the decrease in traditional energy percent.

4.10.3 Developing countries/regions *vis-à-vis* developed countries/regions

There are major differences in the economic structure of developing and industrialised countries as seen in tables 4.6a, 4.6b and 4.7. These differences are expressed in the GDP per capita for each country, with the average per capita incomes of industrialised countries at more than eight times higher than those of the developing countries. Like economic growth, energy production and consumption for developed countries differs from those of developing countries. The per capita energy consumption in industrialised countries is on average 10 times higher than in developing countries. However, this is not the case for the residential sector as shown in table 4.5. Much of commercial energy in industrialised countries is consumed in the industries, energy, transport and other sectors.

The developed countries are generally believed to account for more than 80 percent of the world's commercial energy consumption. The same applies to rural areas of developed countries, which depend more on commercial energy, unlike rural communities of the developing regions, where energy consumption is more than 90 percent traditional energy, in other countries. Some rural areas in developed countries are 100% electrified, compared to an average of less than 10% in developing countries.

Table 4.6a Developing Regions (1993)

Regions	GDP/capita (US$)	TEC/GDP (kgoe/US$)	TEC/capita (kgoe)	
			Total	Residential
South Asia	300	0.52	180	1000
Sub-Saharan Africa	1000	0.45	850	230
Middle East & North Africa	1120	1.13	1830	150
East Asia & Pacific	1320	1.33	490	260
Europe & Central Asia	1840	0.46	980	240
L. America & Caribbean	2180	0.50	1040	100

Table 4.6b Developing Regions with SESSA region less South Africa (1993)

Regions	GDP/capita (US$)	TEC/GDP (kgoe/US$)	TEC/capita (kgoe)	
			Total	Residential
South Asia	300	0.52	180	100
Sub-Saharan Africa	840	1.37	360	260
Middle East & North Africa	1120	1.13	1830	150
East Asia & Pacific	1320	1.33	490	260
Europe & Central Asia	1840	0.46	980	240
L. America & Caribbean	2180	0.50	1040	100

Table 4.7 Six selected developed countries (1993)

Country	GDP/capita (US$)	TEC/GDP (kgoe/ US$)	TEC/capita (kgoe)	
			Total	Residential
Australia	14489	0.25	3556	452
France	19113	0.14	2646	918
Germany	21103	0.14	2919	720
Norway	21395	0.20	4235	830
USA	22372	0.24	5424	958
Japan	31556	0.08	2524	363

In developed countries, unlike in developing countries, there is very little urbanisation taking place, if any at all. On the contrary, some families seems to be migrating back to the rural areas. However, the rural population is very small, normally less than 20 percent for most developed countries. For example, the rural population in France was 27 percent in 1975 and in 1993 it had increased to 27.2 percent, while in Australia the rural population increased from 14.1 percent in 1975 to 15.1 percent in 1993. However, similar to some developing countries, there is very little economic activity taking place in the rural areas of the developed countries. The contribution of the agricultural sector to total GDP is small. The average GDP per capita in 1993 was US$ 20 000 for the selected countries.

Tables 4.6 and 4.7 show the energy consumption per capita and GDP per capita for developing regions and those of some developed countries. The developed countries, as opposed to the developing countries, project lower energy consumption per total GDP than the developing countries. However, the energy consumption per capita for developed countries is higher than for developing countries. Energy consumption in developed countries is dominated by commercial energy. There is very little traditional energy still available in developed areas. In countries like Norway, it is claimed that the whole country is electrified; in 1993, the consumption of traditional energy in Germany amounted to only 0.5 percent of the total energy consumption, while in France and USA the traditional energy consumption amounted to 2.6 and 3.2 percent respectively in the same year.

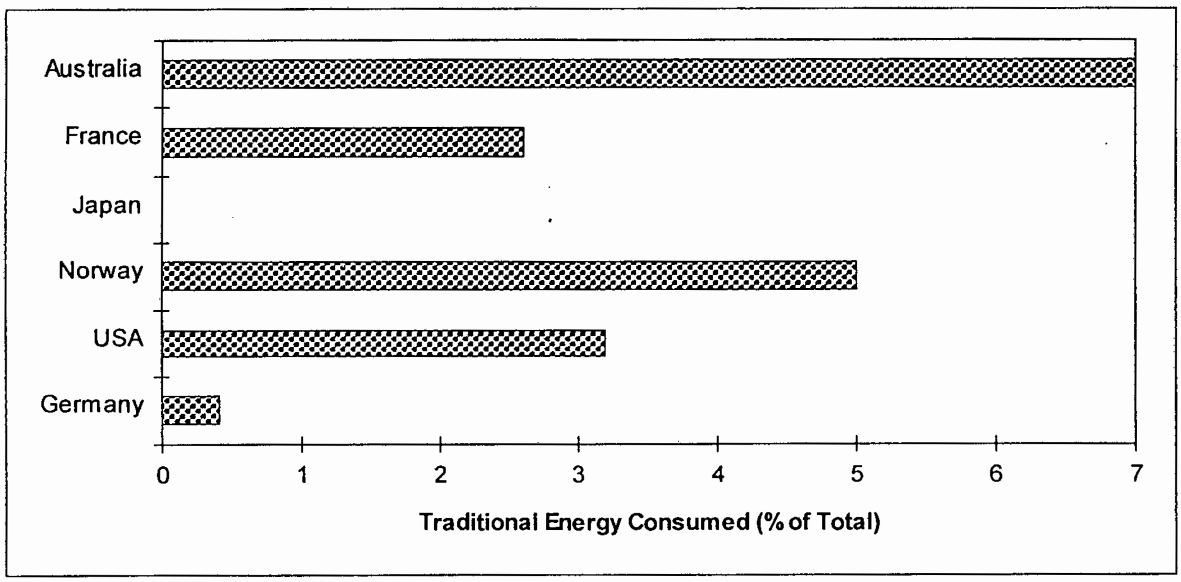

Figure 4.1 Traditional energy consumed in developed countries as % of total energy consumed (1993)

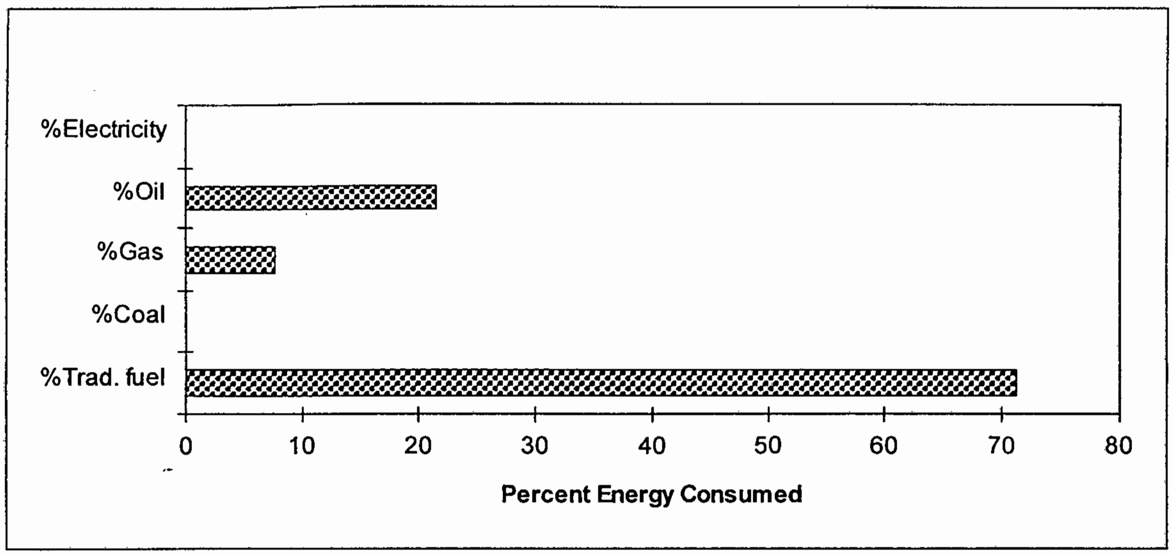

Figure 4.2 **Percentage energy consumption of total energy in Angola, (1993)**

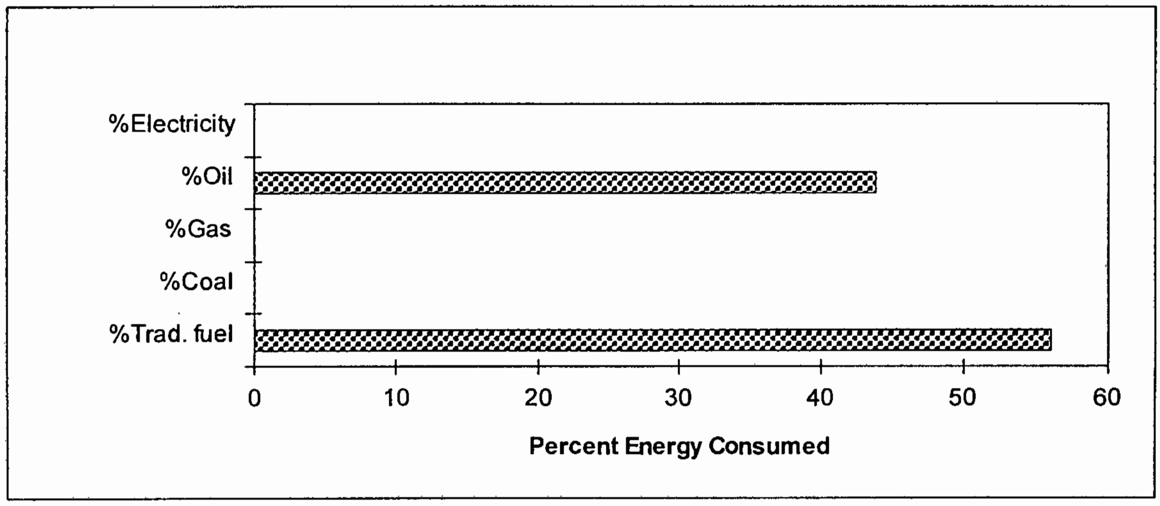

Figure 4.3 **Percentage consumption of total energy in Ethiopia, (1993)**

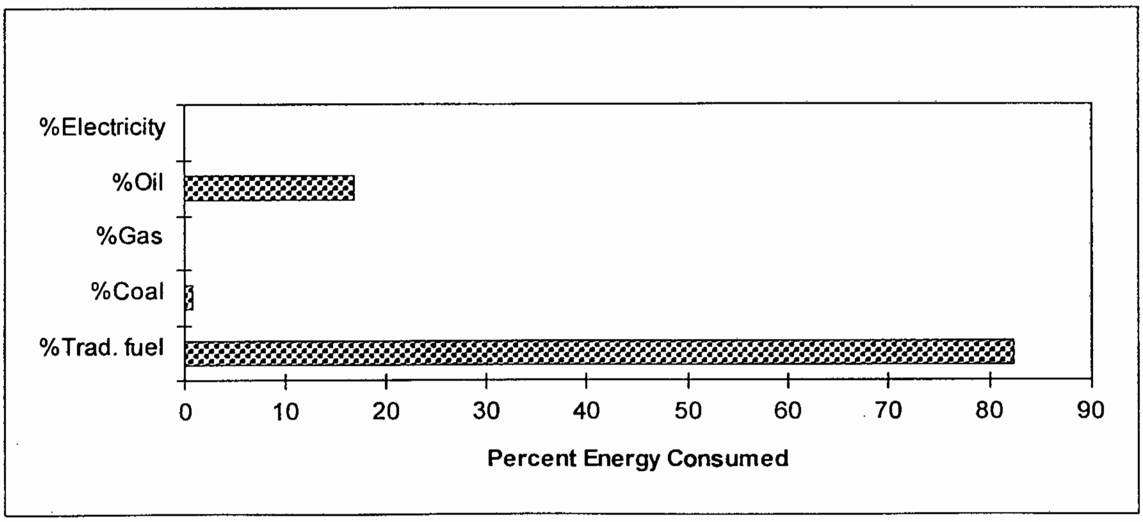

Figure 4.4 **Percentage energy consumption in Kenya, (1993)**

Figure 4.1 shows the consumption of traditional energy as percent of total energy consumed by developed countries, while figures 4.2, 4.3 and 4.4 show consumption of traditional and commercial energy by some of the developing countries in the region.

While developed countries are larger energy consumers, they are also major contributors to global environmental pollution. Their contribution to global warming is alleged to be more than 80 percent. Much of this pollution comes from commercial energy consumption like coal, oil, electricity etc.

Developing countries have a higher population growth than developed countries. This is irrespective of the fact that their economic growth is lower than that of developed countries. For example, the population growth of Mozambique was 2.7 percent between 1980-1989, and is expected to be around 3.1 percent between 1989 and 2000. During the same period the population growth of both France and USA was 0.4 percent. This means that the average total energy consumption per capita is likely to continue to increase for developed countries, while that of developing countries might be affected differently (decrease) due to the high annual population growth. The same applies to the economic growth in these two types of countries.

The SESSA region has a high illiteracy rate by world standards: Zimbabwe is amongst countries which have the lowest adult illiteracy rate in the region, at 26 percent of males and 33 percent of females. All the six developed countries selected have less than 5 percent illiteracy rate for both male and female adults.

4.11 Conclusion

Based on table 4.1, it was estimated that on average the rural population in the region would account for 66% of the population by the year 2010. This assumption was based on the current urban population growth rate, which is influenced by a number of factors, some of which will no longer be there by the year 2000. For example, the level of civil wars in the region is expected to decline.

The level of education and health amongst rural people in this region are the lowest in the world. The interest shown by most countries in the region in the improvement of education and health services in rural areas is encouraging. Indications are that by the year 2010, the region would have programmes in place to reduce the death rate, even in the case of AIDS.

The future prospects of energy supply and demand are promising. There are ongoing projects which are geared at sustaining biomass supply to rural communities. These include the planting of trees. The discoveries of new gas fields in Namibia promise a satisfactory gas supply in the region for at least the next 10 years. In the meantime, further prospecting for gas is going on in countries like Mozambique. South and East Sub-Saharan Africa is one of the regions with adequate reserves of coal for many years to come.

In other regions, traditional energy consumption has declined, with commercial energy penetrating rural communities. Although at present traditional consumption in the region is still close to 80%, predictions, according to table 4.3 show that, one of the scenarios suggests that the consumption of traditional energy would have declined to 55% by the year 2020. Another scenario anticipates a slow decline in traditional energy consumption, and estimates traditional energy consumption will account for 70% by the year 2020. This situation would have an impact on the supply of biomass and the markets of other sources of energy, including commercial energy. However, the market for electricity in the region is expected to increase rapidly, mainly due to potential expansion in the household customer base.

Comparison between rural areas and urban areas showed that the consumption of energy is higher in urban areas than in rural areas, and that consumption of energy is higher in developed countries than in developing countries. In addition, the dominant energy consumed in urban and developed countries is commercial energy, unlike in rural and developing countries.

5. ENERGY NEEDS IN THE REGION

5.1 Introduction

The region's unemployment rate is amongst the highest in the world. The economies of most of these countries were devastated during political turmoil, as liberation movements continue to fight for democratic changes. The rate of unemployment in these countries is increasing, as many of them are in the process of implementing the "Economic and Structural Adjustment Programme" (ESAP).

As a mater of fact, the majority of the people cannot afford to pay for energy consumed. It is a well known fact that most energy projects in the region are highly subsidised to help rural people, the majority of whom are living in poverty, to be able to pay. Unfortunately, because many people do not have jobs, and so cannot afford even subsidised tariffs, subsidies end up benefiting those few people who can afford.

The region is relatively rich in traditional as well as commercial energy resources such as coal, oil, natural and hydropower. However, these resources are not optimally developed and they are under-utilised.

This chapter attempts to look at all issues around energy needs of rural people in developing countries of the region, focusing particularly on rural electrification, current practices employed in the supply of sustainable rural energy, and bodies that are currently supporting energy institutions through providing financial and technical expertise. The chapter also discusses the existing regional interconnections, different roles played by developed countries in assisting developing regions, the role of international donor agencies in the whole process of supporting rural energy development, and particularly rural electrification.

5.2 Rural Electrification

5.2.1 What makes rural electrification happen?

The following issues are considered to be the driving force behind rural electrification in many countries:

- the decision behind electrification is based on both political and economic reasons of varying importance;
- the local availability of resources for the generation of electricity, such as diesel, can determine electrification based on off-grid systems;
- in some instances, off-grid electrification, such as solar PV, has been promoted by donors or governmental sectors only interested in sectoral goals;
- grid extension is only possible when a robust supply of primary energy is available;
- although grid extension is economical in many instances, a solely old fashioned economic approach should not be followed;

- in many cases, the move from candles and/or kerosene to electricity has direct economic benefits to rural populations;
- it would seem that increasingly, social pressures are displacing political pressures as the force behind rural electrification;
- education, awareness, information and actual needs, spark a community's interest in electrification, as will be mentioned later. This triggers action, which sometimes leads to the creation of co-operatives or other forms of social participation;
- the main reasons for extending grids have been economic return and development policies.

5.2.2 Electrification and Rural Development

The impact or not of rural electrification on development has been at the centre of numerous discussions and studies. It has been more or less accepted that, since electricity is a catalyst for development, not a solution in itself, rural electrification efforts need to be part of a broader development plan. In fact, electricity is a necessary component for development but not the sole component. Although priority should be placed on electricity for productive activities (normally linked to food production, agro-industries and cottage industries), household comforts (lighting, heating, water pumping, communications), and social amenities such as cinema, are also important beneficiaries of electricity.

Important opportunities and benefits arise when a "multiservice" scheme is considered, such as a water-telephone-electricity system. In a situation where this system succeeds, the installation costs are shared amongst the three sectors. Unfortunately many countries have experienced problems in trying to implement this system due to lack of co-operation from other sectors.

5.2.3 Institutions involved in Electrification

The role of government in rural electrification is changing. Its role remains critical in the normative and overall policy fields. The responsibility of government to electrifying all houses in a country, a position and goal of many governments in the past, is being questioned in the light of present economic approaches. There seems to be consensus on the prevailing role of governments in promoting development in rural areas, and in that context, to promote rural electrification, both grid and off grid.

Privatisation of utilities is at the core of economic restructuring and liberalisation. The effects of such privatisation on rural electrification need to be monitored closely, since there could be negative impacts. In fact, benefits due to privatisation should be monitored. There is strong consensus to better assess this position.

Co-operatives have proved to work well and serve both as producers and end-users of power. If one might look outside the region, the co-operatives established in Bangladesh with USA support are a good example. Their success is due, among other things, to the establishment of a Board, and the inclusion of women members[55].

Co-operatives can have broader objectives than electrification. They can be effective promoters of rural development, going beyond just rural electrification.

Interconnection of national grids and of rural electrification systems offers large benefits and should be pursued whenever possible.

The following are among the institutions involved in some way in rural electrification: Co-operatives, local development banks, government (ministries, interministerial, committees, provincial governments, local authorities), utilities, regulatory bodies, private investors, industry, international institutions, multi- and bi-lateral institutions, the academic sector, and NGOs.

5.2.4 The role of electricity in rural areas

About 60 percent of the population in the region lack access to modern energy forms and close to 70 percent live in rural areas. Electricity forms a very small fraction of energy supply, particularly in rural areas. More than 80 percent of the total population do not have access to electricity in these countries, while the figure in rural areas is higher than 90 percent households without electricity. The figures differ between countries. For example, in 1995 less than 2 percent of the rural population in Burundi had electricity, while in South Africa, approximately 31 percent of rural people had access to electricity.

The supply of electricity to rural areas has been the central component of many government's energy policies in the developing countries for many years. Electricity is perceived as a vehicle for economic development by many people (there are arguments contrary to this). However, many electrification projects have been found to be economically unviable, but justified to offset pressure from politicians, as mentioned earlier.

5.2.5 Political and economic considerations of rural electrification

Rural electrification is driven mainly by parastatal organisations, in response to the government's energy policy in many developing countries. The economic costs associated with such programmes usually take second field. Political pressure at both local and national level usually serves to promote rural electrification. The rural areas in many of these developing countries are generally remote from the electricity grid, the dwellings are dispersed, and the level of consumption from those rural areas with access to electricity is very low.

The government energy policies with an emphasis on rural electrification tend to have negative financial implications. The average costs per connection in rural areas of many of these countries are double the average costs per connection in urban areas. At the same time, the average consumption of electricity per customer in rural areas is approximately one third that of an average urban customer, prompting a high subsidy for rural customers to break even.

5.2.6 Technology choice

Non-conventional energy programmes are still at an early stage of development in some developing countries, though they were introduced a long time ago. Activities in this area are still limited to research, development and demonstration in many countries. Non-conventional energy has not made any sizeable contribution to rural energy development. According to Foley, renewables tend to be seasonal, unreliable, expensive and limited in their output. As far as he is concerned, people have tended to look at their advantages rather than being realistic about what is involved in attaining large-scale use[(62)]. Foley argues that, all things considered, renewables are at times, not economically justifiable, institutionally unsustainable and locally irreplaceable for poor developing countries. Usually, the external capital costs of such projects are borne by the donor countries with the recipients expected to carry only the local costs. In addition to costs of providing materials, skills, operations, maintenance, other local costs such as transport, including that of the foreign advisers, should be counted, but rarely are[(62)]. In his paper on "Renewable in the Developing World- the road from wishful thinking to practical realisation"[(62)], Foley questions three other issues that are taken for granted when the issue of renewables is considered. These are, first, the financially viability of the project. The government is usually called to bail out poor communities who cannot afford to pay the operating and maintenance costs once the project funding runs out; second, institutional questions that tend to address concerns around the sustainability of institutions to support the operations and maintenance of the project, which on many occasions, are given second place to technical issues when renewable energy projects are being planned; third, the fact that many renewable energy projects are too expensive or complicated for local people, or the recipient governments to replicate on a sufficient scale, defeats the developmental purpose of these projects.

Based on these arguments, rural people seldom support renewable energy. As a result, the majority of rural people prefer electricity from the grid system. The issue of distance from the grid is usually disregarded. The limitation of electricity from non-grid systems in accommodating many electrical appliances also pacts as an impediment.

Despite this, there are reports claiming penetration by non-grid electricity technology to some rural areas in developing countries, due to concerted efforts from the responsible ministries, non-governmental organisations and businesses.

The following are some of the countries that are involved in promoting renewable technologies, particularly solar systems: In Swaziland, the Ministry of Mineral and Energy is directly involved in promoting the development of non-grid electricity to rural areas. Solar system technology is also becoming a popular option for rural people in Botswana and Zambia. Ministries or Departments responsible for the co-ordination of energy issues are getting involved in establishing local organisations to focus on Remote Area Power Supplies (RAPS), with foreign energy organisations, that have necessary expertise.

Examples of some of the countries outside of the region are: first, Bangladesh, where systems like a Solar pumping set used for pumping water, commissioned in 1985; Solar pump commissioned in 1989 used to irrigate the tea garden nursery; Solar PV lighting unit that is planned to charge 100 battery units to be used for lighting; and finally, the Sandwip (Island) solar PV systems that were installed in 1988 for emergency lighting, to operate refrigeration units to preserve essential drugs, and for loud-speaker operations. Secondly, in India, solar water heaters; solar timber kilns, solar air heaters, solar desalination systems and domestic solar water-heaters are made available to users under subsidy schemes. More important is that efforts are being made to establish larger capacity (30 MW) solar thermal power generation plants, with about 50 small decentralised photovoltaic power plants of 1-5 kWp capacity already installed in the country[55]. Thirdly, in the case of Indonesia, the possibilities of utilising solar and wind energy have been explored and appropriate technologies are being developed to make use of these resources.

Fourthly, low prices for conventional energy; lack of technological maturity of many New and Renewable Sources of Energy (NRSE) to be able to compete commercially; lack of awareness among users of the potential for more commercially feasible technologies; the indifference of financing institutions towards NESR projects; inadequate government support for research, development, demonstration and promotion of NESR; and a bias towards large, conventional energy supply systems by large energy decision-makers in Philippines are the main constraints toward the wider application of NESR. However, small-scale photovoltaic applications to provide electrical power for single households, battery charging stations, remote communication facilities, water-pumping and cottage industries have been successfully developed and their operations viably demonstrated[55].

5.2.7 Electrification Projects planning

5.2.7.1 Demographic movements

Very little information exists on the demographic movements of people in these countries. Sometimes it is not clear how many households there are in one village, while some villages' names are either unknown or do not have clear demarcations. Some of the villages have common names, thereby confusing people who are not local residents.

In some villages, the long-term presence of people is not even ensured due to lack of services.

5.2.7.2 Housing and land reform

In situations where the electricity utility is involved in large-scale rural electrification, there is often lack of co-ordination between electrification projects and housing programmes. There is no liaison between the utilities and the housing departments. Information regarding land reform could play an important role in guiding electrification projects. The successful establishment of small scale farmers demands a supply of electricity to expand their farming activities.

5.2.7.3 Community Participation in planning

The approach adopted by utilities in the identification, planning and prioritisation of projects sometimes conflict with the interests of the community. There are situations where projects were resisted by members of communities because they were not consulted. Utilities waste resources by identifying a project which ends up not being accepted by communities.

Electricity utilities differ in their implementation methodology of rural electrification projects. Some connect only customers who have applied and paid connection fees, while others identify a community and then connect everyone who reside in that particular area, irrespective of whether there is deposit paid or not.

There are some projects where members of communities, through community organisations have held employees of electricity supplier organisations hostages, who are in the process of moving away from the project without having connected everyone in that area. Such incidents can be avoided if members of the community were involved from the start in deciding how many customers are going to be connected in an area.

5.2.8 Economics and Financing

It is important to note that there are people in rural areas who can pay for the investment required for electrification (grid or off-grid), for the electricity they use and for the maintenance of the system. Real cost policies and prices should be applied in this case. There are a considerable number of people who are, in fact, willing to pay quite high prices for small amounts of electricity. There is, nevertheless, a large majority of rural dwellers with a very low income which does not allow them to pay for electricity. This poses the obvious question regarding subsidies and the role of government regarding electrification for health, education and economic activity.

Although there is popular support on the need to avoid subsidisation, based on economic sense, the question remains regarding the time frame to eliminate present subsidies. The issue of cross-subsidisation is a sensitive issue, and is often raised, as is the fact that electricity is still subsidised in a number of industrialised countries.

Subsidisation is definitely needed to electrify the poorest sectors of society, in order to initiate a process of development which will break the present poverty trap. Ideally, these subsidies should be well targeted, planned, transparent and temporary. Subsidies can be phased out at the same pace as economic development progresses.

Financing continues to be the main barrier for both grid expansion and off-grid systems. Innovative financing systems exist and should be promoted. Examples of some of these schemes are recorded in some WEC publications. Access to credit is a key issue, and requires an active approach from development banks, agricultural development banks and other financing institutions.

The People's Bank in Bangladesh is a good example of new financing schemes, which could also be implemented successfully in the region. International organisations like IFAD and FAO have given high priority to programmes and projects directed to specific financing of small farmers. Tariff structures for small users, specific loan systems and tax incentives for investments in rural areas are mechanisms which influence rural electrification efforts.

Another scheme useful to consider in the context of electrification (grid or off-grid), is the financing of an energy service, including installation and maintenance, where the end-user pays only for the energy service provided.

5.2.8.1 Direct Project financing

The system of financing rural electrification programmes differs from country to country. In some countries, the customer is asked to pay the total connection cost. This means that, if the cost of supply is US$1000 in rural areas and US$300 in urban areas as is the case with some countries in the region, the full cost will be carried by each individual customer, to be paid in advance or in instalments. An example of such a practice is prevalent in Botswana, where before any connection is made, full payment is expected.

Some utilities charge a lower percentage of the connection cost, and then build the balance into the tariffs, to be repaid over a certain period.

Countries which are involved in full-scale accelerated rural electrification usually have three categories of projects: financially viable, socio-economically desirable and socio-economically non-viable, as explained below:

- Financially viable projects are usually considered first to be undertaken and financed by the utility through normal commercial means. Subsidy to customers is very high.
- Projects that are not financially viable are usually considered on social-economic grounds. They are considered amongst other energy supply options and evaluated as one of a number of services, such as education, health, sanitation, farming etc. Such projects are approved if it is discovered that the socio-economic benefits to be derived outweigh the financial costs in the long run. These projects are financed by government grants, international aid grants, internal cross-subsidies and

concessionaire loans. Projects such as these are often found in areas where there are schools and clinics to be electrified.

- Finally, those projects that are found to be socio-economically non-viable are not approved. These are the kind of projects where the financial costs outweigh the socio-economic benefits to the community.

The above situation applies to small rural household customers, who would not be able to cover the full costs of connections without subsidy from utilities or the government. In cases where the customer is large, like an established farmer, a full deposit is expected to be paid, which sometimes can be as much as more than US$3000 in rural areas, as most of these farmers are very isolated.

5.2.9 The present state of electrification in some of the countries

All countries in the region except Congo, South Africa and Seychelles have rural populations bigger than their urban populations. In addition, electricity is mainly confined to the cities and semi-urban townships. The size of the rural population with access to electricity is very limited.

What is interesting is that the concept of rural electrification was sanctioned many years ago in many developing countries, as an integral part of the energy policy. Lack of resources has been an obstacle in implementing the programme.

In Zimbabwe, for example, it became a policy as far back as 1984, immediately after the country's democratically elected government came into power. The rationale was to widen the availability of electricity to rural areas. The costs of electricity were heavily subsidised by the government. It is reported that in 1988, the customers were paying only 18 percent of the capital costs of electrification. Irrespective of the commitment to the programme by the government and the present utility (ZESA), it is believed that today, ZESA has a backlog of 50 000 or more customers awaiting connection. The average percentage of all the people having access to electricity was estimated to be 14% in 1994, with only 4% of the rural community electrified.

Zambia is one of the countries with a big backlog in the electrification of customers, particularly rural communities. ZESCO has just embarked on an ambitious programme, where they intend to connect 60 000 customers. Table 5.1 shows the level of access to electricity by some of the countries in the region. However, the state of electrification in other countries like Burundi and Rwanda is unknown.

Table 5.1 Rural Population 1993, Access to Electricity, (1995)[2]

Country	Rural Population (% of Total)	Electrified	
		% of Rural Population	% of Total Population
Angola	75*		8.0
Botswana	72	4	10.0
Lesotho	78		3.5
Malawi	87	1	4.0
Mozambique	69	<1	5.0
Namibia	65		13.0
South Africa	50	31	51.0
Swaziland	71		14.0
Tanzania	77		4.8
Zaire	71		6.0
Zambia	58	2	18.0
Zimbabwe	69	3-5	14.0

Most of the countries in the region have made limited progress with rural electrification. Many of these countries have levels of rural access to electricity of around 1 percent or even less. However, there are others, like South Africa and Zimbabwe that have more than 10 percent of their rural areas electrified. The rural areas in South Africa are 31 percent electrified, as seen in table 5.1, the highest in the region.

5.2.10 Benefits of electrification

Many of the benefits that are claimed to accrue from the supply of electricity have been discussed in the previous chapters. The possible social benefits that can be obtained from having electricity in rural areas include improved living standards, reduced urban migration, etc.

The issue of improved standard of education and health was discussed in earlier chapters where it was claimed that areas with access to electricity were found to produce better school results, and offer better health services.

Moreover, the supply of electricity helps promote the establishment of rural small-scale enterprises such as "informal" shops, welding industries and wiring contractors. Many unemployed rural communities are surviving through such small businesses that are strongly dependent on the supply of electricity.

* estimated

5.2.11 Appliances and their impact on consumption

Lack of appliances is one of the issues that determines what source of energy people should use. The majority of rural people continue to use biomass fuel even after other sources of energy are available because of lack of appliances. The gas and electricity tariffs are cheap compared to other energy sources, but it is expensive for rural people to buy gas and electric stoves, kettles, etc.

A newly electrified village usually takes an average of five years before people could start consuming more than 100 units of electricity, due to lack of appliances. The period following supply of electricity to houses is characterised by very low electricity consumption. The majority of families use electricity for lights and entertainment, while they continue to use fuelwood or any other energy source for cooking and boiling water. People take years to accumulate electric appliances like irons, kettles, refrigerators, stoves and geysers. Radios and TVs are some of the first appliances that newly electrified houses posses.

5.3 Sustainable traditional fuel usage

Most developing countries boast significant biomass resources in the form of natural forests; agricultural, animal and wood residues and plantations such as community woodlots. It is estimated that the SESSA region alone carries about eighty billions tons, which translate to 168 tons per capita with an annual sustainable growth capacity of 1.7 billion m[3,20]. The African Development Bank (ADB) report estimated the residue base at an annual potential of 133.5 million TOE.

The distribution of biomass resource potential among these countries is, however, not even. Areas with big populations densities usually contain smaller biomass resources, creating a biomass supply problem. Much of the biomass, besides being used as energy, is cleared away or burned when people put up building structures or prepare the land for agriculture.

The rate of biomass loss in the SESSA region, between 1980-90 according to the ADB was estimated to be 0.6 percent of the potential. This biomass loss was attributed to deforestation alone. Some of the developing countries are involved in woodlot projects to alleviate the problem of deforestation.

5.3.1 Main Issues regarding biomass

The consumption of biomass has both negative and positive consequences, depending on the quantity consumed, resource availability and the type of building materials available.

(a) negative consequences

- Woodfuel consumption increases deforestation.

- It generates low efficiency and bad productivity, especially for women who spend a considerable period of time collecting wood.
- It creates significant health hazards due to emissions.

(b) positive impact

- Woodfuel remains an affordable source of energy for the very poor.
- It does not require foreign exchange.
- It can create local employment and help fight rural exodus.
- It optimises national resources and diversifies rural activities, since it is an added value to existing productions: timber and woodfuel, cattle or crops and residues, etc.
- It has environmental benefits:
  - it does not contribute to net carbon dioxide production,
  - cleaning benefits for the forest and other land of residues.

Furthermore, modern or better, production and use of biomass and woodfuel imply:

- a healthy evolution of ownership and valuation of biomass resources;
- more modern technologies of production and use of energy (production of electricity and biogas, bioenergy in general, better methods of combustion, etc.) increase the range of biomass energy services to be offered to households and also for other needs, accompanying or fuelling economic development of rural areas: agriculture, industry, collective services, etc.,
- improving the quality of life for women.

(c) some more global issues

- Regulations, especially taxes, often have to be adjusted. Taxes on woodfuel and charcoal could be too high. There are countries that tax woodfuel timber, e.g. Senegal in North West Africa. However, no country in this region is known to tax woodfuel.
- Transportation of woodfuel is a complex area where more research should be applied.
- Institutional problems will have to be tackled, particularly in the fields of education, planning and Rural and Development.

The above issues are more relevant to this region than any other developing region, as it is the poorest of the developing regions. Moreover, it is the region with the least electrified rural communities in the world.

5.4 Regional co-operation

The SESSA region is comprised of countries mentioned in Chapter 2. However, according to electricity grids, this region is divided into the SADC region, West Central Africa, the Great Lakes and the Horn of Africa. The potential of energy resources in these countries is different as mentioned in earlier chapters. Some of these countries have energy surpluses while others have a deficit.

Besides the fact that there is an abundance of biomass in the region, a regional market does not exist. Due to differences in resource potential of biomass in individual countries, there could be a possibility of inter-regional biomass trade between various countries, but this could be restricted by the transportation of the biomass products, which is considered to be uneconomic.

Coal is one energy source that is also abundant in the region, and is traded locally, regionally (very little) as well as internationally. Increasing regional coal demand, however, implies that new capacity in more difficult geological conditions will also have to be developed, which will often entail establishing strong regional infrastructure or considerably extending an existing one[29], which has been destroyed by civil wars in many countries. On the basis of availability of coal reserves, profitability of coal deposits, coal types and exportation potential, only a few countries in the region, such as South Africa, Zimbabwe and Botswana, will further increase their importance as exporters, so the regional coal market will continue to be satisfied by a relatively small number of exporting countries.

There are however, environmental problems with the burning of coal that are already raising concern in the international community. The burning of coal releases carbon dioxide that causes global warming. This could reduce the long-term possibilities of coal being used as the main source for the generation of electricity on a large scale, as substantial technological progress in mining techniques and upgrading processes is unlikely in the foreseeable future.

Unlike coal, gas is a limited commodity in the region. This is in spite of the fact that a new gas field was recently discovered in Namibia. Long before gas discovery in Namibia, South Africa was already importing gas from Mozambique. In addition, the South African government is in the process of establishing official ties to access the Namibian gas. The recent developments in Namibia and Mozambique call for a re-examination of regional gas production prospects. Indeed, it now looks as though it could go on rising over the next 5 to 10 years. Irrespective of the recent discoveries, there is little doubt that demand will match this potential supply. Demand is expected to grow in the whole region, particularly now that Southern African countries are renewing regional trade. The increase in gas demand can be attributed to the technical, economic and environmental performance of natural gas, as the pressure on other primary energy sources increases. Sooner or later, the favourable fundamentals of gas will be fully recognised in the region, mainly for electricity generation as is already the case in some developed countries.

The establishment of bilateral and multilateral agreements on cross-border electricity trade has been a common practice between many countries in the region. There are efforts in the region to establish a regional power pool, aimed at increasing co-operation between utilities in such a way that their respective power systems become complementary.

Utilities hope to save through such ventures by promoting exchange in technical information and expertise, optimising energy resources, and selling surplus power to neighbouring countries.

There is sufficient hydro-power potential in Angola, Mozambique and Malawi, which could help reduce overdependence on South African coal for electricity generation, hence the importance of co-operation in the electricity subsector.

5.4.1 Existing Interconnections

Interconnections already exist between the following countries in the region: South Africa, Botswana, Zimbabwe, Zambia and Zaire.

Existing interconnections have experienced problems politically, economically and technically. It is claimed that towards the end of 1992, Zambia and Zimbabwe suffered seriously as a result of drought. It was during this period that Zambia was forced to stop its supply to Botswana, and had to import some of its power from Zaire. As a result, Botswana started importing the shortfall from South Africa, broadening the regional electricity market.

Amongst the already existing power lines, there are 275 kV and 220 kV lines between South Africa and Mozambique and between South Africa and Namibia respectively. These lines have played a very important role during the previous years. The line from Maputo has continued to supply power from South Africa to the city of Maputo after the destruction of lines from Cahora Bassa. The line to Windhoek (Namibia) carries a significant amount of Namibia's electricity.

The 400kV Matimba-Bulawayo interconnection, which comprises of the two largest electricity networks in Southern Africa, is the Eskom-Swawek-EDM system and the SNEL-ZESCO-ZESA system, linked by 132 kV or 220 kV crossing Botswana.

The region does not only depend on electricity generated from coal. The system could be predominantly hydro in the north, particularly from infinite reserves in Zaire, and in the south generation is predominantly thermal, from South African coal. The lines linking these systems are considered to be weak. There are plans to build a 400kV line from Matimba in South Africa to Bulawayo in Zimbabwe, which will go through Botswana.

5.4.2 Information sharing

Many countries in the region have very little reliable statistics on energy production and consumption. The formation of a regional energy body to help with the co-ordination of energy issues is long overdue.

5.5 The role of the developed world

The developed countries are involved in many development related projects, of which rural energy projects are a proportion. Their support is offered through funding such projects and transference of skills and expertise.

In some instances, employees from energy institutions are sent abroad to countries like US, Germany and Norway on exchange programs that are designed to equip them with skills and the knowledge of new technologies.

Organisational and management capacity, including human resource skills are areas that are receiving serious attention in many organisations in the region. They are fundamental to every organisation's satisfactory performance and development.

Many countries in the region are dependent on financial aid from developed countries such as Canada and USA, and are usually accompanied with conditions to the effect that technical expertise, sometimes equipment from the donor country, be used in the execution of the targeted projects. Sometimes, these conditions are found unacceptable to the recipient country, resulting in the aid being rejected by the government. But, conditions or no conditions, poor people are the beneficiaries, and if they could have their own way, they would choose to ignore the long-term implications of such conditions to the country as a whole.

5.6 The role of the World Bank

The World Bank is one of the international organisation involved in policies and operations relating to the rural development projects, of which rural energy development forms an integral part. Their support, in the form of finance or technical assistance is passed to the recipients through the relevant government departments, non-governmental organisations and sometimes through partnership with other international (e.g. United Nations) and local non-governmental organisations.

According to a study by the World Bank (1996), the Bank's work on rural energy since the early 1970s has focused on three areas[19]:

Rural electrification
The bank is involved in the financing of rural electrification projects in developing countries. The basis for such support was laid by the Bank's policy paper drawn in 1975[19]. In its policy paper, the bank concedes that economically justifiable investments in rural electrification could be found in regions of the developing world, including SESSA region. The rationale of the support is to promote agriculture development, rural businesses and the rural economy in general. The Bank, however, emphasises the issue of investment on the rate-of return criterion. Only those projects that will allow recovery of costs in the long term are recommended for implementation. An example of an energy project in the region where the Bank is involved is in Kenya, "Kenya Arid Lands Project, 1995". It is a low-cost loans project for purchasing energy equipment. This project encourages a diverse approach, with options that include wind pumping and solar electricity for schools and clinics.

Supply and use of biofuels
The Bank is also involved in the production and use of woodfuels in the region. These include projects such as the planting of trees; support for the development of forestry institutions; technical, research and training assistance; control and proper management of woodlots. It is claimed that the Bank committed US$1.1 billion to sixty projects in thirty-two countries in support of sustainable woodfuel supply and use in rural areas, with Sub-Saharan African countries getting a third, and half going to Asia.

Renewable energy
The Bank started providing support aimed at promoting use of renewables in the 1980s, to offset high prices of oil at the time. It is reported that between 1980-95, the Bank financed approximately thirty renewable energy projects in eighteen countries, including eight projects co-financed with the Global Environmental Facility (GEF). Today, many developing countries are becoming increasingly interested in the use of renewable energy technologies. Rural areas that are far from grid systems are targeted for such programmes.

Advisory capacity-Finally, the Bank gives advice to countries that borrow finance from them. The Bank encourages governments that have loans from them to liberalise their energy markets and to attract private investments.

5.7 Other Aid Bodies

A wide range of funding sources for rural energy exists. Bodies that provide aid support to the region involve such organisations as European Union (EU), US Aid, Norwegian Aid, CIDA and World Bank, and others such as aid from national governments of developed countries, e.g. Japan, France, etc.

For example, CIDA funded the study aimed at increasing access to electricity for households and small businesses in some of the Southern African Countries such as Zambia, Zimbabwe, Mozambique, Malawi and Botswana.

Support comes in the form of concessionary loan, grant or half loan and half grant.

5.8 Regional Political and Economic organisations

Whilst SESSA is referred to as a single region for the purpose of the study, there are other organisations in this region such as Southern African Development Co-operation (SADC), Organisation of African Unity and African Development Bank.

Not all SESSA member countries are members of the organisations mentioned here. The focus of these organisations is broader than just energy related issues. For example, organisations such as SADC look at the following issues:

(i) economic- deeper co-operation and integration, integration on the basis of balance, equity and mutual benefit, providing for cross-border investment and trade;

(ii) common economic, political, social values and systems, enhancing enterprise competitiveness, democracy and good governance and;
(iii) strengthening regional solidarity, peace and security amongst other things.

However, there is a forum established in 1990 focusing purely on energy issues, the Southern and East African Regional Energy Forum. The forum is held under the auspices of World Energy Council (WEC), and is an attempt to bring together the energy experts in the region for discussion on energy matters which are best addressed at regional level.

There is a realisation that some energy related problems in developing countries are quite different from those in the developed countries, and hence the need to find out at regional level, what is being done in the region to enhance more collaborative ventures.

5.9 Conclusion

The picture painted in this chapter about the state of electricity supply in rural areas is worrying. According to the available information, less than 10% of the whole population in the region has access to electricity. Despite the fact that electricity has played an important role in development in other regions, this region is still lagging. Though governments should bear the ultimate responsibility, the blame for failure to supply electricity to the majority of rural people cannot totally be apportioned to them. Many reports on the impact of rural electrification on development have alleged that it does not automatically bring about development. Some of the advice these governments get are from these sectors. What is interesting is that all these claims come from sections of the world that do not have any problem with the supply of electricity. The fact that it plays an important role in the health of people and the quality of education does not seem to be interpreted as promoting development. On the contrary, they seem to emphasise the costs that are incurred on the short-term basis.

Besides lack of commitment by the politicians to promote rural electrification in these countries, lack of technical and financial resources are some of the stumbling blocks. The result is an emphasis by interested parties in promoting the supply of non-grid electricity against the will of rural people. Those few institutions that are committed to promoting rural electrification through grid systems are faced with a mammoth task. Rather than getting demographic information from government departments readily available, they are expected to use their own resources to gather this information.

Regional co-operation within the energy sector is also weak in the region. Few countries show commitment to the process of regional co-operation. Domestic problems within individual countries, which extended to their neighbours, have also played a negative role, with some countries financing the destabilisation of other countries through rebel organisations. Despite historical political problems, recent efforts to form a regional grid are bearing positive fruits.

On the other hand, the role played by the developed world and the donor agencies in rural energy development is commendable, but not enough. The poverty that many countries are subjected to in Africa can be partially attributed to these countries and institutions. Many, if not all, of the countries in the region, were at one stage colonies of some of the most developed countries in the world. Most important is the fact that the debts that most of these countries are subjected to, are due to loans by some of the most influential international financial institutions in the world.

6. RECOMMENDATIONS

6.1 Introduction

The discussions over supply and demand options of rural energy development in developing countries formed the basis of this thesis. It has been shown that many problems relating to the supply of energy in developing countries are related or similar in nature. Some of the common problems found in developing countries are lack of resources to meet the demand, and the unequal distribution or supply of energy between rural areas and urban communities.

This chapter looks at the possible changes that can be recommended for implementation with regard to the utilisation of energy resources, the improvement of financial viability of rural electrification, and energy supply mechanisms to rural areas. Furthermore, the chapter makes recommendations around the optimal utilisation of new renewable technologies in rural areas.

Restructuring of electricity sectors is taking place in many developing countries, with the main aim of introducing business professionalism into the management of the organisations. Some recommendations are made around the restructuring of the electricity sectors. Finally, the chapter recommends some changes around biomass supply sector, to address the use of biomass fuel to make it more sustainable.

It must be noted that most of the recommendations that are going to be made here can only apply at country level, before any attempt to implement them at regional level. As far as some of them are concerned, it may never be possible to implement them at regional level.

6.2 Purpose of Recommendations

Rural energy development planning should form an important part of national socio-economic development planning for developing countries. In most of the countries in the Asia-Pacific region, the energy development programme is closely related to environmental conservation and economic development[55].

The recommendations proposed below are based on the following objectives:

- Efficient utilisation of available natural energy resources in the region
- Improvement of energy supply mechanism to rural areas
- Improvement of the financial viability of rural electrification in the developing regions
- Optimal utilisation of new renewable technology, particularly for scattered rural areas
- Restructuring of electricity supply sector

6.2.1 Efficient utilisation of energy resources

The energy resources in the region are not efficiently utilised. The biomass resources in the region are not efficiently utilised. The state should introduce measures to protect forests against fires.

6.2.2 Improvement in the financial viability of Rural Electrification in the region

The general tariff level of electricity utilities in the region is very low, and needs to be raised in order to make sustainable development of the utilities possible.
There must be a uniform tariff for all customers in one country, regardless of the supplier or the area one stays.

The connection costs should reflect the type of supply a customer is getting, for example, the cost for a single phase line should obviously be less than a three phase line, but should be the same for all customers both in urban and rural areas.

Rural electrification projects which are projected to show losses should not be considered unless under special conditions.

Ranking of projects should be based on the projected economic rate of returns, without considering the profile of customer in the community, as this can create tension within the community.

6.2.3 Improvement of energy supply mechanisms to rural areas

The supply of energy sources in many countries, except for electricity in many instances, is in the hands of private sector, and as a result, done on strictly business terms. Rather than heavily subsidising the supply of electricity to rural communities, which is quite costly for the majority of people, the governments should establish co-operatives to supply a mix of different energy sources that people can afford at market related prices. This could address some of the energy-related problems in rural communities.

6.2.4 Optimal utilisation of new renewable technologies in rural areas

While the government is busy building proper infrastructure for long-term investment, to rural communities, it will be more appropriate to make use of non-grid systems such as photovoltaic systems in the meantime. It is recommended that campaigns to educate people on renewable technologies be implemented to avoid the situation where people reject such technologies due to lack of proper information.

6.2.5 Restructuring of Electricity supply sector

The current trend in the electricity sector in the region is for the separation of generation, transmission and distribution sectors.

Generally, one organisation is responsible for these three functions. The proposals for the separation of the three sections have already been made to the industry in many countries. However, there is resistance to these proposals from the trade unions.

The distribution of electricity is usually controlled by the central body, which allocates finance, sets down plans and co-ordinates the implementation, and in some instances go to the extent of implementing national programmes.

The implementation of developmental programmes such as electrification are best left in the hands of local bodies. Under the local bodies, the implementation of the programmes turns out to be more focused and the pace is faster, due to the support of local people.

It is therefore recommended for the central office to allocate funds to local offices and, only oversee the implementation process, which should be left to the local offices for actual execution.

It is easier for local offices to collaborate with other local structures such as non-gorvenmental organisations, local government structures and other development bodies in the implementation of programmes.

6.2.6 Changes with regard to biomass supply

The ownership and management of forest land and biomass resources by local communities or village co-operatives appear to be one of the key issues and solutions. This would imply in many instances important forest land reforms and in particular the reallocation of huge state owned forest land.

A transitional period in this latter case of joint forest management by the State and the villages should be recommended. The following are the options that could be considered for possible implementation by developing countries:

- The penetration of woodfuel into the world of rational economics and its commercialisation on a large scale will bring tremendous benefits: Bigger incentive to collect and to produce more for better uses; bigger impetus to develop integrated policies among organisations in charge of agriculture, forestry, energy, rural development and the environment. This would include Ministers, public agencies, international organisations, etc.
- Development and modernisation of the production and use of biomass in developing countries should take place within the context of greater liberalisation of energy markets and transparent pricing. In this context, biomass should find its natural and

desirable position in a market where fuel diversity and consumer choice could increase especially when revenue grows in those areas. Subsidies to reduce prices or running costs are not welcome. Often they have too many adverse effects. On the contrary, governments should create conditions for increased competition within energy markets, especially in the oil sector, this sector being dominated by a state enterprise or by private oligopolies.

- Greater attention should be focused on facilitating access to finance, technology and information. Regarding finance, temporary subsidies could be useful if applied to start up costs to finance pilot schemes, to help introduce new products or new equipment (e.g. electrical wiring of a village). Access to small loans has still to be expanded. Small scale industrial energy entities have to be encouraged, in particular with the possibility to sell their excess electricity to the utilities. Concerning technology, governments should make access to technology easier by reducing the tariffs on imported equipment, providing training, information and dissemination of information on best practices. Aid agencies should play the same kind of role in this respect and complement government interventions.
- The impact of the use of biomass on the environment should not be overstated. Deforestation is essentially the consequence of expansion of agricultural land, timber production and urbanisation.

UNFAO estimates that wood-fuel consumption only contributes 7% to deforestation[9]. Better management of forests would reduce this percentage. Governments should focus their attention more on improving air quality (favouring, for instance, the use of chimneys in traditional villages).

6.2.7 Planning of projects

There are many rural energy projects that result in losses because of bad planning, irrespective of the potential of the projects. According to Ramani[55] and others, general principles can be applied, but will be affected by prevailing conditions in the countries as discussed below:

- "a comprehensive and reliable data base on the rural energy situation needs to be developed and regularly updated for rural energy planning. The contents of the data base would include assessments of rural energy needs on an area basis; patterns and trends in traditional and commercial energy consumption, inventories of decentralised renewable energy technologies and costs; and economic, social and environmental indicators of rural development. Substantial financial and human resource commitments have to be made for energy surveys in rural areas, and for establishing information systems that could be accessed by the various agencies involved in rural energy development".
- "rural energy planning may be increasingly delinked from the planning for centralised energy systems and, instead, integrated with the planning for rural development. While centralised co-ordination of the planning effort would be necessary at national level, this may be orientated primarily to seeking policy decisions, establishing

common guidelines for planning at the decentralised level, and mobilising the necessary investment, technology and human resources. Much of the planning effort, in particular the aspects of energy needs identification, resource assessment and technology choice, would need to be decentralised at the level of local governments and local level agencies".

- "an important task of co-ordinated rural energy planning at the national level would be to establish critical links between it and the centralised energy system. Specific attention should be given to rural electrification in order to ensure that the plans and programmes of the electricity utilities are consistent on an area development basis with the plans and programmes for the diffusion of decentralised systems.
- "the area-based approach, which has emerged as a successful paradigm for rural energy development in other regions, should be implemented. As part of this effort, local agencies could be provided with adequate human resources and skills to develop and implement decentralised rural energy plans and programmes. Concrete policies would be needed to ensure the involvement of the rural communities, interested NGOs and the private sector in the planning and programming process with reference to activities such as market potential assessment, site selection and technology evaluation".

However, at the implementation stage, community members should first receive intensive training before they start participating. Their training is crucial to the maintenance of the systems, particularly of decentralised renewable energy systems.

6.2.8 Country profiles on "Rural Energy Systems"

Ramani[(55)] and others have documented Rural Energy Systems in the Asia-Pacific, a survey of their status, planning and management providing a detailed description of energy issues of individual countries in the Asia-Pacific region. The report focuses mainly on rural energy issues, a subject that many reports on energy issues have failed to achieve. The issues covered are: Rural energy Economy, Rural energy Needs, Energy Supplies, Rural Energy Demand-Supply Balance, Rural Electrification, and finally, a detailed picture of the Planning and Management Process that is used in these countries. Under Planning and Management Process, the report addresses the following issues: National Energy Planning and Management, Rural Energy Planning and Management, Energy Pricing and its Impacts, Alternative Energy Technology Diffusion, Public Participation in Rural Energy Programmes, the Role of Financing Institutions and Donor Agencies and finally, Research and Training Infrastructure.

Gathering of such information country by country is costly, however, the work that is produced is worthwhile. It is therefore recommended that such a work on other developing regions be carried out in future to supplement the work already done by WEC. A report at such a level will provide the necessary information on rural areas that is lacking in many developing countries, impacting on planning for rural energy development as a result.

In conclusion, it must be noted that it will only be possible to implement whatever recommendations are made successfully, provided there is reliable data on energy consumption, traditional and commercial, throughout the region. At present, this is far from being the case as many countries do not collect data about their energy production, supply and consumption, let alone energy losses that many institutions are experiencing on a daily basis. This exercise should, however, start at local level, before it could become a regional exercise. It is a fact that some of the countries are poor and because of that would not be able to carry such a costly task, hence the need for financial aid from developed countries and other international financial institutions. In addition, industrialised countries have benefited from poor countries in one way or another, and should plough back their profit to the development of these countries.

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APPENDICES

APPENDIX A

ENERGY RELATED ISSUES ON 11 SELECTED COUNTRIES IN THE REGION

Table A1. Fuelwood supply potential for biomass classes in the SADCC region[12]

Biomass Class	Growing Stock	Annual Productivity	Accessibility
A- Rain Forest/Miombo Woodland Transition	71.22	2.25	Good in places, but restricted by high crowns and reservations
B- Evergreen Miombo Woodland	71.22	2.25	Good in places, but restricted by high crowns and reservations
C- Wet Miombo Woodland forest	71.22	2.25	Good in places, but restricted by high crowns and reservations
D- Seasonal Miombo woodland	19.85	0.49	High crowns
E- Dry Miombo Woodland	16.79	0.49	Tobacco estates & timber operations
F- Cleared Miombo Woodland	33.55	1.01	Some areas have low wood, non-wood ratio
G- Coastal Forest	88.78	4.98	Flooding in mangroves
H- Dry Degraded Miombo Woodland	9.44	0.24	Low productivity and low wood: non-wood ratio in places
I- Mopane Woodland	36.97	1.09	Low wood: non-wood ratio in place
J- a) Commercial Agric. (b) Dry Savannah and Thickets	0.00 11.83	0.00 0.42	Restricted access and low woody biomass Low wood: non-wood ratio
K- Grassland and Bushland	23.36	0.83	Low wood: non-wood ratio
L- Bushland with Woodland & Scrubland	14.22	0.60	Low wood: non-wood ratio
M- Bushy Scrubland and Degraded Open Savannah	7.11	0.30	Low wood: non-wood ratio
N- Dry Scrubby Woodland & Grassland	11.45	0.55	Low wood: non-wood ratio
O- Arid Shrubland	7.11	0.30	Few restrictions
P- Arid Vegetation	0.00	0.00	Few restrictions
Q- Lubombo Hills Woodlands	75.92	2.65	Local access restrictions
R- Grassland with Scrub Woodland	0.50	0.01	Low wood: non-wood ratio & reservations
S- Highveld & Riparian Grassland	0.00	0.00	Few restrictions
T- Alpine & Subalpine Grassland & Heathland			Few restrictions
U- Sublitoral Forest & Bushland	9.44	0.24	Few restrictions
V- Littoral Grassland	0.00	0.00	Few restrictions
W- Highveld Woodland	28.08	0.30	Mostly forest reserves
X- Dense Plantation	39.50	5.16	All commercial forests, no access
Y- Plantations	42.08	8.53	All commercial forests, no access
Z- Irrigated Agriculture	0.00	0.00	All commercial farms, no access

The accessibility of the different classes of biomass shown in the table above differs across countries. Authorities in some countries have put restrictions on the classes of some of these trees for ecological reasons. Examples are the X-dense plantation stands and Z-irrigated agriculture.

Mozambique, Tanzania and Zambia have similar levels of woody-biomass resources. Botswana, in spite of falling in the same size range as the other three countries, has lower resource levels, even lower than Zimbabwe which has a smaller area than the other four countries.

1. ANGOLA[12, 65]

Angola is bordered by Zaire to the north-east, Zambia to the east and Namibia to the south. The country's economic wealth lies in natural resources such as oil and petroleum products.

The country has been caught up in a civil war between the ruling party MPLA and UNITA since independence in 1975. The United Nations and other countries like the US and South africa have tried several times to broker peace between the government and UNITA, but this has been in vain. The war has killed many people and left many crippled and homeless.

1.1 Politics and Economics

The main political parties are the ruling party called the Popular Movement for the Liberation of Angola (MPLA), and National Union of the Total Independence of Angola (UNITA).

In 1992, after the elections which the MPLA won, UNITA refused to accept defeat and went back to an armed struggle. In 1994 after many initiatives mainly by the United Nations, a provisional government was formed, with some UNITA members accepting seats in parliament. This, however, did not mean an end to the war as the leader of the movement, Dr Jonas Savimbi refused to return to Luanda, the capital city of Angola, citing security as the main reason.

Angola depends heavily on its natural resources, such as oil and diamonds, but has been ravaged by the civil war. The country's GDP per capita was estimated to be around US$700 in 1995.

1.2 Biomass supply in Angola

In 1986, the country's total estimated Growing Stock of wood was 4713 million tonnes, while the population size stood at 8.30 million. This translated to an average density of 6.7 persons per km^2, suggesting potential per capita consumption of 560 tonnes of biomass fuel. The total estimated supply potential of MAI was 144.4 million tonnes.

Table A2. Angola: Summary of Growing Stock and MAI data[12]

Biomass Class	Area		Growing Stock		MAI	
	km^2	% of Country	mill t	% of total	mill t	% of total
Trans. Rain forest/ Miombo woodland	159680	12.8	1137	24.1	35.9	24.9
Dense high Miombo woodland	111281	8.9	793	16.8	25.0	17.3
Dense medium-height Miombo woodland	221164	17.7	1575	33.4	49.8	34.5
Seasonal Miombo woodland & wooded Savannah	306946	24.6	609	12.9	15.0	10.4
Dry deciduous Savannah	229657	18.4	386	8.2	11.3	7.8
Dry coastal Savannah & Arid coastal thicket	48484	3.9	57	1.2	2.1	1.5
Dry inland Savannah	26263	2.1	31	0.7	1.1	0.8
Degraded rain forest & Miombo woodland	33220	2.7	31	0.7	0.8	0.6
Degraded dry deciduous Savannah	34987	2.8	82	1.7	2.9	2.0
Bushy arid shrubland	15748	1.3	11	0.2	0.5	0.3
Chanas da borracha grassland	37251	3.0	0	0.0	0.0	0.0
Montane grassland	833	<0.1	0	0.0	0.0	0.0
Coastal & desert vegetation	21184	1.7	0	0.0	0.0	0.0
TOTAL	1246698		4713		144.4	

The rain forest/miombo woodland transition covered 12.8% of the land area, accounting for 24.1% and 25% of the growing stock and mean annual increment (MAI) respectively. On the other hand, 51.2% of the country was covered by the various types of miombo woodland. The growing stock formed 63.1% while MAI constituted 62.8% of the miombo woodland. The degraded woodland and savannah covered 29.9% of the country. This type of woodland accounted for 12.5% of the growing stock and 12.8% of the MAI.

Only 6% of the country was occupied by the grassland, coastal and desert vegetation, contributing very little to the country's woody-biomass resources.

It is claimed that the southern part of Angola, the coastal plain and the Zambian border region are dominated by the savannah vegetation which covered about 30% of the country, contributing around 12% of the country's total standing biomass.

The natural forests in Angola are owned and controlled by the government. According to Millington and Townsend, wood produced from Angola is used largely for industrial purpose, and only 20% of this is believed to be used as fuelwood.

General access to forest woody-biomass resources is restricted by the forest reservations and national parks. The access to woody-biomass resources in Angola is further restricted by the civil war which has been going on for decades. The result is that other areas are subject to increased pressure for biomass supply, especially those which are free of conflict, causing deforestation.

Coal

Angola is one of the few countries in the region which has no record of coal production.

Electricity

The organisation responsible for the supply of electricity in Angola is Empressa Nacional de Electricidade (ENE), which is a governmental organisation. The total nominal installed capacity is 545.5 GWh, of which 98.2% is controlled by ENE. Autoproducers account for the remaining capacity. It is reported that 53.7% of total capacity is hydro powered, while the rest is thermally fired (gas turbine and diesel).

Transmission and distribution of electricity in Angola is divided into the three ENE electricity systems- Northern, Central and Southern. In 1994, 811 GWh of electricity was reported to be sold, 60% of which went to distribution companies, while the remaining 40% went to domestic customers and industry. The total customer base of Angola in 1994 was 80 944.

The amount of diesel generation has been decreasing from 1976 to 1986, while hydro electricity generation is increasing. The proportion of electricity generated from diesel declined from 18,9% to 3,5% between 1972 and 1986, while for hydro electricity generation increased to around 98% of total generation in 1979.

The consumption of electricity increased between the period of 1967 and 1973, but declined immediately after the country's 1974 independence because of the civil war which affected the supply of electricity. Electricity power lines were subjected to sabotage by the resistance movement, and maintenance of the system was very poor.

2. BOTSWANA

Botswana is comprised of 1.5 million people, with a rural population of more than 60%. It is claimed that the population of cattle in Botswana outnumber that of people. It is bordered by Namibia to the West, South Africa to the south, Zimbabwe to the East and Zambia and Angola to the north east and the north respectively.

2.1 Politics and economy

It has had multi-party system since its independence in 1966. The political parties in the country are the ruling party, called Botswana Democratic Party (BDP), the opposition parties called Botswana People's Party (BPP) and Botswana National Front (BNP). Unlike other countries in the region, there is no political infighting in the country.

Cattle farming and subsistence farming is still predominant in the country. The Diamond industry has raised the GDP in real terms by as much as 9.6% per annum between 1980-93.

2.2 Biomass supply in Botswana

Table A3. Botswana: Summary of growing stock and MAI data(12)

Biomass Class	Area		Growing stock		MAI	
	KM^2	% of country	mill t	% of total	mill t	% of total
Dense woodland	33361	5.7	238	18.2	7.5	16.7
Open woodland	83437	14.3	309	23.2	9.1	19.2
Riparian woodland	6297	1.1	45	3.4	1.4	3.1
Woodland & bushland	197664	34.0	462	35.4	16.4	36.4
Fringing palm woodland	3115	0.5	2	0.2	0.1	0.2
Bushland with Scrub woodland and bushy shrubland	106742	18.4	152	11.6	6.4	14.2
Scrubland & bushy shrubland	104093	17.9	74	5.7	3.2	7.1
Hill woodland & shrubland	26502	4.6	30	2.3	1.5	3.2
Salts pans	20584	3.5	0	0	0.0	0.0
TOTAL	581795		1311		45.6	

In 1989, the total Growing stock of biomass in Botswana was 1,311.1 millions tons, while that of MAI was 45.6 millions tons (Table B3). The population in Botswana was estimated to be 1.4 million in 1993.

Botswana is one of the countries in the Southern Africa whose system of rearing cattle is still very strong. Cattle grazing has affected the woody-biomass supply, leading to decreased grass and land cover which promotes water and wind soil erosion.

It is claimed that the biomass classes with the highest Growing stock and MAI levels are situated far from where people live. It is therefore difficult for people to access large quantities of woody biomass for fuelwood purposes. Dense, Open and Riparian woodlands classes together covered 21.2% of the country. According to the research carried by

Millington and Townsend, the populated zone of Botswana is dominated by Woodland and Bushland, Bushland with Shrub woodland and bushy shrubland, and Hill woodland and shrubland classes (table A4). The high resource supply potential per capita of 969 million tonnes would have been affected because a large quantity of forests are far and not easily accessible to people.

The study by Millington and Townsend[26] divided Botswana into three different zones of wood-supply potential. The three zones are:

(i) "Areas with high levels of growing stock and productivity, and low local demand, i.e. Chobe and northern Ngamiland Districts;
(ii) Areas with moderate levels of existing growing stock, restricted productivity and low local demand: south-western Central, Ghanzi, Kgalagadi, western Kweneng, southern Ngamiland and Ngwaketse Districts; and
(iii) Areas with a generally restricted supply base, both in terms of growing stock and productivity, and a high local demand: Barolong, eastern Central, Kgatleng, eastern Kweneng, eastern Nqwaketse and North East District".

In addition to the natural forests abundant in Botswana, a non-governmental organisation called "Kweneng Rural Development Association of Botswana" managed to establish 200 ha of fuelwood and poles woodlots at Kopong. This project is aimed at reducing the depletion of natural biomass resources in the country.

Coal

Botswana has only one coal-mine. The coal production from this mine at present is around 300 000 tonnes per year. The type of coal produced in Botswana currently is only bituminous and anthracite. There is, however, further coal production planned, which will probably place the country in a leading role in future coal production.

There are claims that coal deposits in Botswana have been discovered in ten areas, but this still has to be explored.

Botswana does not have washed coal for industrial and domestic use. It imports coal for domestic consumption from South Africa.

Electricity

The Ministry of Mineral Resources and Water Resources has overall responsibility for power. The Botswana Power Corporation (BPC) generates, transmit and distribute electricity. They are accountable to the Ministry of Mineral Resources and Water Resources. BPC imports electricity from its neighbouring countries, South Africa, Zimbabwe and Zambia.

The installed capacity of BPC was reported to be 197 MW in 1995, of which 78.7% was available for production. Electricity is generated from coal-fired power stations.

Their customer base is comprised of users in the mining, commercial, domestic and governmental sectors. In 1995, domestic customers accounted for 13.2% of electricity consumption.

Institutions

The Ministry of Mineral Resources and Water Affairs, is responsible for the overall coordination of energy. The ministry recognises the difficulties associated with this and in an attempt to improve the situation, a proposal was made to establish a proper assignment of responsibilities and a coordination machinery. Other Ministries to be involved in the process are the Ministry of Commerce and Industry and the Ministry of Finance and Development Planning. The following institutions are presently involved in the energy-related issues:

INSTITUTION	RESPONSIBILITY
Ministry of Mineral resources and Water Affairs	Overall energy coordination
Ministry of Commerce and Industry	Supply pricing and storage of petroleum products
Ministry of Works, Transport and Communication	Supply and control of energy to government institutions
Ministry of Local Government and Lands	The planning of energy supply to households and the design of Botswana Housing Corporation houses, which are supposed to make extensive use of passive solar energy
Ministry of Agriculture	Forests and biomass management
The Botswana Technology Centre	Technology-related issues at national level.
The Rural Industrial Innovation Centre	Rural technologies, including those related to energy
The University of Botswana and the National Institute for Development Research and Documentation. It is based under the Ministry of Education	Participates in energy-related research, especially into woodfuel, forestry and environmental issues.
The Botswana Power Corporation	Generate, transmit and supply electricity

Very few of these institutions have their focus on rural areas only.

3. LESOTHO

3.1 Politics and Economy

Lesotho is a tiny mountain kingdom which is plagued with friction, sometimes leading to violent political conflict in the past. This conflict was between the former ruling party, Basotholand Congress Party (BCP), and the security forces. Several coups have taken place, sometimes resulting in the death of senior officials. At present the ruling party is the newly-formed Lesotho Congress for Democracy (LCD), which is comprised of the leadership of BCP who defected.

The economy has been dominated by the Lesotho Highlands Water Scheme (LHWS) for the past four years. The project involves the construction of a dam, which is anticipated to be completed soon and to start delivering water to South Africa by end of 1997.

3.2 Biomass fuel supply in Lesotho

The total population of Lesotho is around 2 million, of which more than 70% is rural. It is a small country surrounded by South Africa.

Table A4. Summary of Growing Stock and MAI data(12)

Biomass class	Area		Growing stock		MAI	
	km^2	%	1000t	%	1000t	%
Escarpment & Riparian woodland	1371	4.5	1925	81.8	20.5	70.8
Escarpment grassland with shrub woodland	5539	18.2	277	11.8	5.6	19.2
Escarpment grassland with shrub woodland (on small farms)	2987	9.9	149	6.4	3.0	10.0
Highveld and Riparian grassland	5995	19.8	0	0.0	0.0	0.0
Alpine/Sub-Alpine grassland and heathland	14463	47.6	0	0.0	0.0	0.0
TOTAL	30355		2351		29.1	

There are five biomass classes in Lesotho as reflected in table table A4 The total area covered by both Growing stock and MAI was 30,355Km^2 in 1989. The growing stock constituted 2,351,200 tonnes, while MAI constituted 29100 tonnes.

It is assumed that in terms of Growing stock and MAI, Lesotho is the lowest woody-biomass supply base in the whole of the SESSA region. Furthermore, it is one of the SESSA countries whose woody energy resource supply contributes less than 40% of the total energy consumption (i.e. 34% of total energy consumption is supplied by woody biomass). Assuming very little deforestation took place between 1989 and 1993, per capita supply in 1993 would have been 1.25 tonnes per person, which is very low compared to countries such as Angola with 560 tonnes per person and Botswana with 969 tonnes per person.

Access to much of Lesotho woody biomass is restricted in terms of the Forest Act 11 of 1978, which provided the government with the powers to establish forest reserves on all land containing trees planted prior to 1973.

In 1973 the Lesotho Woodlot Project was established jointly by Anglo De Beers Forest Services Lesotho Ltd, the Overseas Development Administration (ODA) and the World Food Programme (WFP), in an attempt to address the problem of wood supply shortage (the project was planned to cover an area of 3,500 ha by 1982, with wood).

The government's Forest Division, established about 10,250 ha of woodlots in over 350 sites, as government Forest Reserves. The establishment of these woodlot, it is argued, has not done much to alleviate the fuelwood crisis. This is because of the poor availability of transport to carry the wood from the woodlots to areas closer to where people live. Nonetheless, it is accepted that woodlots have contributed significantly in protecting the environment.

Coal

Lesotho is the other country which does not produce coal of its own. It imports coal from neighbouring South Africa. It is said that thin and unpersistent seams of coal have been found in the districts of Mohale's Hoek, Mafeteng, Qacha's Nek, Maseru and Leribe. The coal is claimed to vary in quality from poor to low to high grade bituminous. However, there are no prospects of exploiting the deposits in the near future.

Electricity

Power in Lesotho is supplied and distributed by the Lesotho Electricity Corporation (LEC), which was established in 1969 under the Electricity Act No 7 (which authorise it to generate, transmit, distribute and supply electricity).

LEC purchased 312.2 GWh of power from Eskom of South Africa in the 1995 fiscal year.

There is a long term plan to introduce generating capacity at the Lesotho Highlands Water Project which would allow LEC to generate all the power required in the country.

Lesotho produced 3 268 MWh of hydro power in 1993. Electricity is generated from hydro stations in Mantsonyane, Semonkong, Qacha's Nek and Mokhotlong.

Besides hydro, electricity is also produced from diesel. In 1993 the total power from diesel was 1 560 MWh. The areas where electric power is produced from diesel are Qacha's Nek, the LEC headquarters, a 33 kV LEC border substation, Mantsonyane, Semonkong and Mokhotlong. They are all used as either standby or backup to hydro.

The country's total production in 1993/94 was estimated to be 1.18 GWh of hydro. During the same period, 289,23 GWh was supplied by Eskom to LEC. Only 48,49 GWh was supplied to the domestic sector, which is dominantly urban. The total number of domestic customers was 9000.

4. MALAWI

4.1 Biomass fuel in Malawi

Table A5. Malawi: Summary of Growing stock and MAI

Biomass class	Area		Growing stock		MAI	
	km^2	%	mill t	%	mill t	%
Evergreen/Semi-deciduous forest & woodland	35200	30.0	250.7	68.2	7.9	58.1
Seasonal open-canopy Miombo woodland	24697	21.0	49.0	13.3	1.2	8.8
Miombo woodland with extensive tobacco cultivation	16624	14.2	27.9	7.6	0.4	2.9
Dry open-canopy Miombo woodland & cultivation savannah	20252	17.2	19.2	5.2	1.0	3.6
Mopane woodland	864	0.7	3.2	0.8	0.1	0.7
Plantations	4238	3.6	17.9	4.9	2.2	26.3
Swamp woodland & grassland	15539	13.2	0.0	0.0	0.0	0.0
TOTAL	117414		367.8		13.7	

The population of Malawi was estimated at 7.6 million in 1986. Table A5 above shows that in 1986, Malawi had biomass reserves of 367.8 million tonnes of growing stock and 13.7 million tonnes of MAI. In total, this translates to 50.2 million tonnes per person, which is quite substantial, in comparison, for example, to that of Lesotho. The real situation in Malawi does not show sufficient supply of biomass fuel in the country. It is claimed that the distribution of biomass resources is poor in respect to population distribution. The bulk of the country's area is covered by poor biomass reserves, such as the dry open-canopy Miombo woodland and cultivation savanna, and swamp woodland and grassland. About 30.4% of the land area is covered by this poor biomass reserves, accounting for only 5.2% of the growing stock and 3.6% of the MAI.

Malawi has about 94 woodland reservations. These reservations are divided into 9 Parks and Game reserves (covering 10,700 km^2 of the land), 64 Forest reserves (covering 8,856 km^2 of the land), 21 Publicly-owned and Private plantations (1030 km^2 of the area) and an unknown number of Research plots, (only 15 km^2 of the land is reserved for research purpose). About 17,600 km^2 of the land is retained as accessible woodland or what is generally called customary land.

There are various tree planting programmes in Malawi, including the National Tree Planting Day Programme which started in 1976. The number of trees planted in this programme were estimated at 25 million per annum[(12)]. Another programme is the Carlsberg brewery Company Tree Planting Programme, which it is said, supported the planting of 4 million trees in 1988 and 7 million trees in 1989.

Coal

Malawi's proven recoverable coal reserves were estimated at 2 Mt. in 1985. The coal is of low quality and far from the industrial area. Most of the coal the country uses is imported, to supplement local production. The national coal demand is about 74 000 tonnes per annum.

Electricity

The Electricity Supply Commission of Malawi (ESCOM) was created in 1982 under the Electricity Act of 1963. It is the only body responsible for generating, transmitting and distributing electricity.

In 1987, ESCOM produced electricity from hydro (144.6 MW installed capacity), from gas turbine (15 MW) and from diesel (8.9MW). The hydro plants provided 99.7% of total generation, with the thermal plants, being kept for standby use.

In 1987, 48.1% of total demand came from industrial sector, followed by the agricultural sector at 20.5% and the domestic sector at 16.6%.

A rural electrification project financed by the World Bank commenced in 1981. By 1995, about 4% of households in Malawi had access to electricity, with only 1% of rural households electrified.

5. MOZAMBIQUE

5.1 Biomass fuel in Mozambique

Table A6. Mozambique: Summary of Growing stock and MAI[12]

Biomass class	Area		Growing stock		MAI	
	km^2	%	mill t	%	mill t	%
Evergreen miombo woodland & coastal forest	121002	15.1	862	24.5	27.2	23.8
Wet seasonal forest & woodland	223141	27.9	1589	45.3	50.2	44.0
Seasonal Miombo woodland	190839	23.9	379	10.8	9.4	8.3
Dry Miombo woodland	148545	18.6	140	4.0	3.6	3.2
Mopane woodland	11544	1.4	43	1.2	1.3	1.1
Coastal Forest Mosaic	46908	5.9	416	11.8	19.0	16.7
Dry Riparian woodland	22958	2.9	26	0.7	1.2	1.0
Degraded Agricultural land	19288	2.4	45	1.3	1.6	1.4
Lowland sublittoral forest & bushland	3638	0.5	3	0.1	0.1	0.1
Lubombo hills woodland	1473	<0.1	11	0.3	0.4	0.4
Littoral grassland	10043	1.3	0	0.0	0.0	0.0
TOTAL	799379		35153		114.0	

in 1986, the total area covered by biomass in Mozambique was 799 379 km^2. Large parts of this area were covered by Growing stock, which constituted 3 515.3 million tonnes. Of all SESSA countries, Mozambique has the second largest level of the Growing stock, after Angola. MAI biomass constituted about 114 million tonnes in the country. With the population of approximately 13.7 million at the time, per capita supply potential of biomass was 264.9 tonnes.

Large parts of the forests were inaccessible to people for fuelwood collection because of the ongoing civil war at the time. People were restricted to inhabiting few villages which were relatively safe from the conflict, subjecting their immediate woody-biomass resources to severe pressure.

Mozambique is one of the countries which has taken seriously the issue of involving local people in tree planting programmes aimed at sustaining fuelwood supply. However, the programme of tree planting has been affected by the civil war, limiting it to peri-urban areas. The programme focused on agroforestry as a means of intensifying subsistence farming.

Irrespective of the difficulties in the country, there are some specific areas where farmers are being assisted in individual tree planting. These farmers are assisted by the Canadian University Services overseas (CUSO).

Coal

Mozambique is known to have three major known coal deposits, located in the central west part of the country. Proven coal reserves in Mozambique were estimated to be 938 million tonnes, and in 1994.

There are reports that several other coal seams have been located in different parts of the country. The country appears to have enough coal reserves for its domestic consumption, without considering these other unconfirmed reports of deposits.

Electricity

Electricity supply in Mozambique is undertaken principally by the national utility, Electricidade de Mocambique (EDM). It is presently a state-owned company, but is shortly to be made a public company. The total generating capacity in Mozambique is about 250 MW (diesel 50 MW, gas 90 MW, hydro 100 MW), excluding the Cahora Bassa hydro power station which has essentially not been used to date due to the sabotage of the power lines linking it to South Africa by RENAMO guerillas.

Cahora Bassa is owned by Hidroelectrica de Cahora Bassa (HCB), a company jointly owned by Portugal and Mozambique, and in which EDM has a stake. It has a potential generating capacity of 2075 MW, the largest hydropower plant in Southern Africa.

About 5% of all households in Mozambique have access to electricity. This includes 28% of the urban population and less than 1% of the rural population.

6. NAMIBIA

Renewable Energy

Solar energy has been introduced in rural schools of Namibia. There are mixed reactions from Namibians concerning the use of solar energy in households. It is understood that villagers in the Caprivi area complain about the inadequate strength of the solar power. They claim that solar electricity is useless because it cannot be used for cooking, and that buying the photovoltaic panels is a waste of money. Twenty solar systems have been installed in the Caprivi region and 50 in Oshana.

7. SWAZILAND

There are Community Woodlot Pilot Projects in Swaziland, concentrating on areas with high fuelwood shortages which might serve as a first step towards a country-wide woodlot programme. According to the report by the Economic Planning Office, a tree nursery is already in operation and several demonstration woodlots have been established, with demonstration woodlots still being set up. The project is led by the government through the Ministry of Natural Resources and Energy, with a strong emphasis on the participation of local people.

The research carried out by Millington and Townsend in 1986 established that the total biomass resource in the country is 24.45 million tonnes, providing 33.3 tonnes per person. The total Growing stock and MAI estimated at 24.4 and 1.33 million tonnes respectively. The study indicates that the area covered by the biomass resource was 17,364 km^2.

The total area of biomass resource under Swaziland government control was estimated to be 184,985 ha; with 29,744 ha owned by individuals or by partnerships, and 145,666 ha by registered companies.

The forestry industry generates a large volume of wood wastes which are used for electricity generation within the electricity industry. According to research carried out by the University of Swaziland, there is sufficient excess waste wood to supply the demand in urban and peri-urban markets.

Coal

Swaziland's coal reserves are estimated at 1 billion tonnes. After the closure of Mpaka colliery in August 1992, the coal reserves were not exploited until the mine at Maloma started operating in September 1993. The total coal production of Maloma mine in 1994, was 370,000 tonnes (high quality anthracite, mostly for exportation). It is understood that there are discussions about re-opening the Mpaka mine.

Furthermore, there are plans to open a coal-fired power station to reduce importation of electricity.

Coal for domestic consumption, is imported from South Africa. Coal produced in Swaziland is of poor quality and as a result discourages potential customers who tend to prefer coal from South African. The government, nonetheless, is planning to promote local coal production for local consumption to meet existing demand and potential new users in order to cut down on coal imports.

Electricity

A parastatal body, Swaziland Electricity Board (SEB), is responsible for the supply of electricity in Swaziland. Their electricity is generated from hydro and diesel power. In the year ending March 1994 sales to domestic, commercial, industrial and agricultural (irrigation) consumers decreased by 1.7% to 546 GWh. Nine major establishments in the sugar, timber, mining and irrigation agriculture industry generated approximately 247 GWh of electricity. The balance of these industries' needs were provided by the SEB, much of which is imported from South Africa.

Of total electricity consumption in 1994 51% was used in the industrial sector, 20.2% in the domestic sector, 20% in the agricultural sector and 0.8% in the commercial sector. The total number of customers that SEB had in 1994 was 25 807.

Renewable Energy

The government of Swaziland is supportive of the installation of solar systems in the rural villages. Solar power has become popular in Swaziland, to the extent that people are resorting to stealing equipment that is already installed. Only 10% of the population has access to grid electricity, fuelwood is disappearing, and as a result more and more solar power is being used.

About seven rural schools and 11 clinics have solar installations.

Solar water pumps have been installed at three villages. This helps to enhance agricultural activities as people can now set up vegetable gardens.

The government, the University of Swaziland and technical colleges are carrying out further research projects on solar systems and their applications.

8. SOUTH AFRICA

South Africa has the largest coal reserves in the region. The recoverable reserves in South African coalfields is estimated to be around 58 billion tonnes, with the two Highveld coalfields in Witbank accounting for 11 000 Mt. each. About 95% of South Africa's coal reserves consist of bituminous coal, anthracite comprises only 2% of the reserves.

In 1993, the total coal production in South Africa was reported to be 182.1 million tonnes, of which 178.9 million tonnes was bituminous coal and only 3.2 million tonnes was anthracite. Of the total coal produced, 28.4 percent was exported. With the population of the country standing at 39.7 million in 1993, the coal production per capita was 4.59 toe, which is quite high, particularly for a developing country.

Electricity

South Africa is the greatest single producer of electricity in Africa; more than 50% of the total electricity consumed on the continent is supplied by Eskom of South Africa.

Eskom is responsible for generating and transmission of electricity in the country. It is a parastal organisation. The distribution of electricity to end-users is the responsibility of Eskom and many other municipal organisations and local authorities which purchase their power from Eskom.

Table A7. Electricity Output 1993[36]

Total electricity produced in SA,	155812 GWh
Total Eskom electricity production as a % of South African total	97.9%
Total Electricity for Eskom system (Eskom stations and purchased)	154361 GWh
Total produced by Eskom stations	154260 GWh
Subtotal from coal-fired stations	145514 GWh
Subtotal from hydroelectric stations	146 GWh
Subtotal from pumped storage stations	1345 GWh
Subtotal from diesel and gas-turbine stations	0
Subtotal from nuclear power stations	7255 GWh
Total purchased for Eskom system	101 GWh
Total consumed by Eskom power stations	1898 GWh
Total available for distribution	152463 GWh
Electricity sales	143800 GWh

Eskom produced 145514 GWh of electricity from 11 coal-fired power stations. It has two hydroelectric power stations, from which 146 GWh was produced. 1345 GWh was produced from the two pumped storage power stations. There is only one nuclear power station, which produced 7255 GWh of electricity. Only 0.07% of the total electricity supply in South Africa is purchased externally from other organisations. There are three gas turbine power stations which have a capacity of 368 MW but are presently not used to generate electricity.

Table A8. Eskom Electrification Progress[36]

Number	Jan 1991-Dec 1992	1993	Inception to date
Direct domestic connections	176557	208801	385358
Farmworker connections	12698	16074	28772
Incentive indirect connections	22622	69756	92378
Total connections	211877	294631	506508

The total number of customers connected by end of 1993 (excluding customers belonging to municipalities without records) was 506508. This figure includes connections for farmers, of which 5.7% of the houses connected are farmworker houses. Eskom has an incentive scheme which encourages every farmer with electricity to extend the supply to the households of the employees.

9. TANZANIA

In Tanzania, the Forestry Department is involved in tree planting. The government does this for demonstration purposes and to test the performance of new tree species. Other institutions, like schools and prisons, are also claimed to plant trees for their own fuelwood demand.

The study by Millington and Townsend[(26)] found that Tanzania has high levels of woody-biomass potential supply, both in terms of growing stock and productivity. The area covered by forests excluding small farm cultivation and lakes was around 840 097 km^2. Of this area covered by the forests, 3 361.1 million tonnes were found to be Growing Stock, while MAI accounted for 107.4 million tonnes.

Coal

Tanzania is estimated to have 304 million tonnes of proven coal reserves. The coal ranges from bituminous to sub-bituminous, and is non-coking and weakly coking in character. It has low sulphur and phosphorus content.

Electricity

Tanzania Electricity Supply Company (TANESCO) is responsible for generation, transmission and distribution of electricity in Tanzania. Of the total installed capacity in the country, 66% is hydro powered. It is estimated that Tanzania has 3 800 MW of exlpoitable hydro potential capacity.

The total electricity demand by domestic customers in 1994 was 37% of total demand. Of 232 595 customers in the country, 75.7% were domestic customers.

10. ZAMBIA

The total area covered by forests in Zambia is approximately 726 853 km^2. The supply potential was 2 744.6 million tonnes of Growing stock and 83.3 million tonnes of MAI, as reported by Millington and Townsend. As in other countries, it is said that the distribution of woody biomass resources is not even. National and local forests are protected by the government.

In Zambia, the International Committee for Research in Agroforestry (ICRAF) is supporting the programme of tree planting both financially and technically. It is claimed that between the years 1985/86 and 1988/89 a total of 2.8 million trees were planted in Zambia.

Non-governmental donor agencies based in Zambia, such as the Children's Christian Fund, are also involved in tree planting projects. The other organisations involved in tree planting projects are: SIDA, IDRC, the Commonwealth Development corporation (CDG) and the Danish Development Agency.

Coal

The total coal reserve in Zambia was estimated at 280 million tonnes. According to reports, there are several coal deposits in the country, which if exploite can increase coal supply in the country. So far, coal supply comes from only one mine called Maamba Colliery, based in Siankondobo.

Electricity

The body responsible for the supply of electricity is called Zambia Electricity Supply Corporation Limited (ZESCO). It produces electricity from hydro power plants, such as the Kariba Dam power plant, the Victoria Falls plant and the Kafue Gorge. According to Dutkiewicz, the Kariba Dam complex consists of the Kariba South plant of 666 MW (commissioned in 1960), and the Kariba North plant of 600 MW (commissioned in 1976). Zambia shares the capacity of this dam equally with Zimbabwe, entitling them to 633 MW.

The 1993 Eskom Statistical report gave the total production of electricity from the interconnected system as 6 412 GWh in 1993, with the total from isolated systems given as 49 GWh.

Almost all electricity is generated and distributed by ZESCO, the state-owned utility. All national grid electricity is hydro generated, and to date only one quarter of the national hydro potential has been developed.

Access to electricity in Zambia is mainly concentrated amongst wealthier urban households, while low-income and rural households have low levels of access. It is estimated that 18% of all households in Zambia have access to electricity, 37% urban and 2% rural.

Renewable Energy

Zambia has more than 1000 solar powered systems installed throughout the country. Unfortunately, very little has been done to teach people how to maintain and back up the systems.

Most of the people using solar panels are eager to learn how to maintain the systems. Donors are also reluctant to spend more money on the systems because of lack of maintenance.

Without ignoring the difficulties experienced with solar systems, Zambia is still looking to solar power to provide more of its energy needs as wood becomes scarce; electricity production from hydro is threatened by falling water levels in dams, and coal fired stations are still costly to operate.

Zambia has an adequate solar resource. It has a daily average of between seven and eight peak sun hours. Some private companies supply and install systems, and report that there is continuing heavy demand mainly in the rural areas.

11. ZIMBABWE

11.1 Biomass fuel in Zimbabwe

Table A9. Summary of Growing stock and MAI data(12)

Biomass class	Area		Growing stock		MAI	
	km^2	%	mill t	%	mill t	%
Dense savannah woodland	18907	4.8	134	9.2	2.2	8.9
Open savannah & baikiaea woodland	117790	30.2	839	55.9	26.5	55.7
Seasonal savannah woodland	3144	0.8	6	0.4	0.2	0.3
Dry savannah woodland	47717	12.2	45	3.0	1.2	2.4
Mopane woodland & escarpment thicket	68565	17.5	254	16.9	7.5	15.7
Dry bushy savannah	91656	23.5	214	14.3	7.6	16.0
Degraded bushy savannah	2380	0.6	2	0.1	0.1	0.1
Wooded grassland	6653	1.7	8	0.5	0.4	0.8
Intensive commercial agriculture	33918	8.7	0	0.0	0.0	0.0
TOTAL	390734		1502		47.6	

According to table A9, Zimbabwe had a Growing stock of 1 501.7 million tonnes and MAI of 47.55 million tonnes in 1986. Zimbabwe's population stood at 8.7 million people in 1986, and that translates into a potential supply of 178.1 tonnes per person. Approximately 10 years later, the population had risen to around 11 million, and it is estimated that the supply potential of woody biomass had declined by no less than 10%. As in other countries, woody biomass resource is distributed unevenly throughout the country.

There are specific trees which people prefer for fuelwood supply. This preference creates a problem of supply for certain biomass classes.

Coal

Zimbabwe's energy needs are met largely by coal. Proven coal reserves were estimated to be 2 194 million tonnes. In 1991 there were about 24 coalfields in the country, located in the Zambezi and Sabi Limpopo region.

Electricity

The body responsible for the supply of electricity is the Zimbabwe Electricity Supply Authority (ZESA), which was established in 1986 to replace the Electricity Supply Council (ESC). ZESA has taken over the operations of the municipal power stations of Harare, Bulawayo, Umniati and Wankie.

The largest power station was built in Kariba dam under the control of the Central African Power Corporation. This consists of the North Bank Power Station, which has four 150 MW sets, and the South Bank Power Station, with six generating sets of 111 MW each, bringing the total output to 1266 MW. Half of this output became the property of Zambia after the breakdown of the federation.

After independence, a thermal power station was constructed. The main purpose of this was to reduce reliance on imported power from other countries. This power station has an overall sent-out capacity of 876 MW. It is understood that the sent-out capacity of all power plants is now 1827 MW, of which 633 MW is hydro and 1194 is thermal. There are about six thermal power stations, which produced 5 406 GWh in 1993. Hydro electricity production was 2 062 GWh.

The Zambezi Basin has a potential hydro capacity of 2515 MW for Zimbabwe. There are speculations that, depending on the increase in demand, there might be further expansions based on coal-powered generation.

In addition to the local production, ZESA imports a further, 2348 GWh, of which 9.8 GWh comes from South Africa. ZESA's largest foreign supplier is the Botswana Power Corporation. There is more capacity imported from Zambia and South Africa. Agreements between Zimbabwe and Mozambique to import power from Cahora Bassa Dam as soon as it is rebuilt are already finalised.

Table A10. Sales of electricity by Category Zimbabwe[36]

Category	1993 (GWh)	1992 (GWh)	Change %
Mining	1306	1550	-15.7
Industrial	3079	4147	-25.7
Farming	593	810	-26.8
Commercial & lighting	1036	1141	-9.2
Domestic	1719	1621	6.1
Total National Sales (GWh)	7733	9268	-16.6

As can be seen from the table, mining accounted for 16.9% of total consumption; industry 39.8%; agriculture 7.7%; commercial and lighting 13.4%, while domestic consumption was 22.2%. The consumption of electricity in all sectors apart from the domestic sector decreased by an average of 20% between 1992 and 1993. The domestic consumption increased by 6.1%.

The total number of domestic customers connected by end of 1993 was 294246, and the majority of these are in the urban area. The total number of farming customers connected stood at 9576, the majority being commercial farmers.

Electricity is considered important, but not as essential a service as water or sanitation, which are automatically provided to new houses as soon as they are built. The fact that householders have to pay a high connection fee contributes to the situation of many people not having access to electricity. There are also instances where the connection are made but consumption tends to be very low- electricity is used only for lighting.

One major reason for the unwillingness to use electricity in poor rural areas is the fact that many people perceive it is an expensive energy source, compared to paraffin and coal.

Renewable Energy

The potential for the utilisation of solar energy for crop drying, heat production and water pumping is high. According to the report by Dutkiewicz the country is in a high solar radiation belt with some 2 800 sunshine hours per year and an insulation figure of 5,7 $kWh/m^2/day$[3].

A solar support programme, supported by the Global Environment Facility (GEF) in its three years of operation, has provided low cost solar systems to hundreds of Zimbabwean households, clinics and schools. The systems are imported with no customs duty or surtax charges (as an incentive).

The programme is being implemented through the United Nations Development Programme (UNDP) and the government of Zimbabwe as a pilot project. The GEF project is expected to install 9000 solar lighting systems during the first phase from 1993 to 1997. According to

Mandisana (the GEF Manager) the project is gaining momentum in coordinating its functions with those of the national electricity utility, installers, end-users, manufactures, finance houses, NGOs, donors and district councils. The project's current activities have been focused on the installation of solar rural household systems, development of industry capacity among solar companies, and importation of solar components.

According to Makoni of Development Dialogue, solar home lighting in Zimbabwe's rural areas is improving living standards, and its promotion could support further development taking place in the country. Some energy experts in Zimbabwe claim that its introduction has resulted in the increased job opportunities and a better quality of life which in turn will reduce rural-to-urban migration.

In an article by Mr Makoni, it is claimed that the local solar electric industry has so far install 9000 systems, and there are 50 solar companies that are qualified to sell and install systems under the market driven GEF project.

APPENDIX B

ENERGY CONSUMPTION AND GDP OF DEVELOPING COUNTRIES IN THE REGION

Table B1. Energy consumption and GDPs of developing countries

	1993								
Country	**Tr.EC**	**TFC**	**%Tr.**	**GDP**	**Pop.**	**GDP/ Capita**	**TFC/Pop.**	**TFC/GDP*10^3**	***GDP (M.P)**
	M toe	**M toe**		**US$ M**	**M**	**US$**	**Toe**	**kgoe/US$**	
Angola	1.33	1.92	69.3		10.0		0.19	-	
Botswana				3813	1.4	2724			
Burundi				855	6.0	143			
Comoros				248	0.5	496			*
Congo	0.54	0.80	67.5	2250	2.4	938	0.33	0.36	
Ethiopia	10.59	11.56	91.6	5750	51.9	111	0.22	2.01	
Kenya	8.84	10.99	80.4	4691	25.3	185	0.43	2.34	
Lesotho				609	1.9	321			
Madagascar				3126	13.9	225			
Malawi				1810	10.5	172			
Mauritius				2780	1.1	2527			
Mozambique	3.52	3.95	89.1	1367	15.1	91	0.26	2.89	
Namibia				2109	1.5	1406			
Rwanda				1359	7.6	179			
Seychelles				444	0.0	6346			*
Somalia					9.0				
South Africa	9.52	50.93	18.7	105640	39.7	2661	1.28	0.48	
Sudan	5.25	6.65	79.0		26.6		0.25		
Swaziland				843	0.9	937			
Tanzania	8.00	8.82	90.7	2086	28.0	75	0.32	4.23	
Uganda				3037	18.0	169			
Zaire	9.79	11.58	84.5		41.2		0.28		
Zambia	3.16	4.29	73.7	3685	8.9	414	0.48	1.27	*
Zimbabwe	1.75	4.91	35.6	4986	10.7	466	0.46	0.98	

* = GDP at market prices

Table B2 Indicators: Population, distribution of income and forests

	1993							
Country	**Pop. (M)**					**Area**	**Gini Ind.**	**Pop/ha**
	Total	**Urban**	**Rural**	**U/R**	**RP (%TP)**	**10^3 km^2**		**/km^2**
Angola								
Botswana	1.4	0.4	1.0	0.4	71.6	582		2.41
Burundi	6.0	0.4	5.6	0.1	93.0	28		214.29
Comoros	0.5	0.1	0.4	0.3	70.5			
Congo	2.4	1.4	1.0	1.4	43.3	342		7.02
Ethiopia	51.9	6.7	45.2	0.1	87.0	1097		47.31
Kenya	25.3	6.6	18.7	0.4	73.9	580	57.5	43.62
Lesotho	1.9	0.4	1.5	0.3	78.4	30	56.0	63.33
Madagascar	13.9	3.6	10.3	0.3	74.2	587	43.4	23.68
Malawi	10.5	1.3	9.2	0.1	87.2	118		88.98
Mauritius	1.1	0.4	0.7	0.6	59.4			
Mozambique	15.1	4.7	10.4	0.5	68.8	802		18.83
Namibia	1.5	0.5	1.0	0.5	64.8	824		1.82
Rwanda	7.6	0.4	7.2	0.1	94.1	26	28.9	292.31
Seychelles	0.07	<0.1	<0.1	1.3	47.4			
Somalia	9.0	2.3	6.7	0.3	74.5			
South Africa	39.7	19.99	19.8	1.0	49.8	1221	58.4	32.51
Sudan	26.6	23.7	2.9	8.2	76.2			
Swaziland	0.9	0.3	0.6	0.5	70.7			
Tanzania	28.0	6.4	21.6	0.3	77.0	945	38.1	29.63
Uganda	18.0	2.2	15.8	0.1	88.0	236	40.8	76.27
Zaire	41.2	11.8	29.4	0.4	71.3			
Zambia	8.9	3.7	5.2	0.7	57.9	753	46.2	11.82
Zimbabwe	10.7	3.3	7.4	0.4	69.4	391	56.8	27.37

APPENDIX C

ENERGY CONSUMPTION BY END USE: SOUTH AND EAST SUB-SAHARAN AFRICA

1. ANGOLA

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	1644	874	992	1361	1929
Vegetal fuel	1560	830	940	1310	1330
Coal					
Gas					141
Oil/Petrol					398
Electricity	979	506	604	598	690
Electricity ("000 toe)	84	44	52	51	60
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	1560.059	830.0304	940.0363	1310.037	1330.038
Vegetal fuel	1560	830	940	1310	1330
Coal					
Gas					
Oil/Petrol					
Electricity	686	354	422	434	439
Electricity ("000 toe)	0.058996	0.030444	0.036292	0.037324	0.037754
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					
Electricity					
Electricity ("000 toe)					

2. CONGO

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	309	344	412	559	800
Vegetal fuel	300	330	380	510	540
Coal					
Gas					
Oil/Petrol					214
Electricity	104	162	368	570	540
Electricity ("000 toe)	9	14	32	49	46
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	300	330	380	510	549
Vegetal fuel	300	330	380	510	540
Coal					
Gas					
Oil/Petrol					9
Electricity	50	78	142	293	285
Electricity ("000 toe)	0.0043	0.006708	0.012212	0.025198	0.02451
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel	-				
Coal	-				
Gas	-				
Oil/Petrol	-				
Electricity	-				
Electricity ("000 toe)					

3. ETHIOPIA

	1975	1980	1985	1990
Total Energy ("000 Toe)	716	845	1010	1097
Vegetal fuel	670	790	940	1020
Coal				
Gas				
Oil/Petrol				
Electricity	537	635	809	891
Electricity ("000 toe)	46	55	70	77
Conversion factor	0.000086	0.000086	0.000086	0.000086
Residential (total)	670	790	940	1020
Vegetal fuel	670	790	940	1020
Coal				
Gas				
Oil/Petrol				
Electricity	89	151	216	280
Electricity ("000 toe)	0.007654	0.012986	0.018576	0.02408
% Houses electrified				
% Schools electrified				
% Clinics electrified				
Agriculture				
Vegetal fuel				
Coal				
Gas				
Oil/Petrol				
Electricity				
Electricity ("000 toe)				

4. KENYA

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	5012	6245	8162	8488	10989
Vegetal fuel	4890	6100	7930	8160	8840
Coal	27	10	55	93	81
Gas					
Oil/Petrol					1801
Electricity	1104	1567	2060	2729	3103
Electricity ("θ00 toe)	95	135	177	235	267
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	4890	6100	7930	8160	8963
Vegetal fuel	4890	6100	7930	8160	8840
Coal					
Gas					
Oil/Petrol					123
Electricity	234	458	598	780	927
Electricity ("000 toe)	0.020124	0.039388	0.051428	0.06708	0.079722
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					
Electricity					71
Electricity ("000 toe)					

5. MOZAMBIQUE

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	2310	2970	3360	3520	3857
Vegetal fuel	2310	2970	3360	3520	3520
Coal					
Gas					
Oil/Petrol					337
Electricity					
Electricity ("000 toe)					
Conversion factor	<1	<1	<1	<1	<1
Residential	2310	2970	3360	3520	3529
Vegetal fuel	2310	2970	3360	3520	3520
Coal					
Gas					
Oil/Petrol					9
Electricity					
Electricity ("000 toe)					
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					
Electricity					12
Electricity ("000 toe)					

6. SOUTH AFRICA

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	49816	60848	87196	95829	109131
Vegetal fuel	2800	2750	6350	6000	5430
Coal	41059	49455	69455	76572	76193
Gas					
Oil/Petrol					13638
Electricity	69266	100499	132458	154147	161276
Electricity ("000 toe)	5957	8643	11391	13257	13870
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	3487	3571	7233	7092	7135
Vegetal fuel	2800	2750	6350	6000	5430
Coal	687	820	882	1091	1032
Gas					
Oil/Petrol					671
Electricity	9991	13522	16395	22443	25700
Electricity ("000 toe)	0.859226	1.162892	1.40997	1.930098	2.2102
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					132
Gas					
Oil/Petrol					1009
Electricity					350
Electricity ("000 toe)					0.0301

7. SUDAN

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	3203	3762	4549	5173	6655
Vegetal fuel	3150	3690	4450	5080	5250
Coal					
Gas					
Oil/Petrol					1313
Electricity	622	832	1150	1077	1074
Electricity ("000 toe)	53	72	99	93	92
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	3150	3690	4450	5080	5327
Vegetal fuel	3150	3690	4450	5080	5250
Coal					
Gas					
Oil/Petrol					77
Electricity	151	175	230	190	200
Electricity ("000 toe)	0.012986	0.01505	0.01978	0.01634	0.0172
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					124
Electricity					2
Electricity ("000 toe)					0.000172

8. TANZANIA

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	4789	5353	6409	7707	8812
Vegetal fuel	4730	5270	6330	7590	8000
Coal					
Gas					
Oil/Petrol					669
Electricity	689	961	915	1360	1666
Electricity ("000 toe)	59	83	79	117	143
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	4730	5270	6330	7590	8183
Vegetal fuel	4730	5270	6330	7590	8000
Coal					
Gas					
Oil/Petrol					183
Electricity	186	257	295	418	540
Electricity ("000 toe)	0.015996	0.022102	0.02537	0.035948	0.04644
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					31
Electricity					6
Electricity ("000 toe)					

9. ZAIRE

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	5249	6122	7111	8853	11379
Vegetal fuel	4920	5780	6730	8460	9790
Coal					
Gas					
Oil/Petrol					1141
Electricity	3830	3978	4427	4572	5204
Electricity ("000 toe)	329	342	381	393	448
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential	4920	5780	6730	8460	9903
Vegetal fuel	4920	5780	6730	8460	9790
Coal					
Gas					
Oil/Petrol					113
Electricity		866	1654	1401	1725
Electricity ("000 toe)		0.074476	0.142244	0.120486	0.14835
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					
Electricity					
Electricity ("000 toe)					

10. ZAMBIA

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	2721	2905	3333	3358	4323
Vegetal fuel	1750	2030	2490	2780	3160
Coal	480	353	278	220	233
Gas					
Oil/Petrol					464
Electricity	5710	6070	6565	4164	5423
Electricity ("000 toe)	491	522	565	358	466
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential	1756	2033	2493	2780	3160
Vegetal fuel	1750	2030	2490	2780	3160
Coal	6	3	3		
Gas					
Oil/Petrol					
Electricity	427	437	453	598	571
Electricity ("000 toe)	0.036722	0.037582	0.038958	0.051428	0.049106
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					
Gas					
Oil/Petrol					14
Electricity					100
Electricity ("000 toe)					

11. ZIMBABWE

	1975	1980	1985	1990	1993
Total Energy ("000 Toe)	3046	3636	4217	5622	6934
Vegetal fuel	1160	1420	1650	1760	1750
Coal	1361	1608	1862	3055	3405
Gas					
Oil/Petrol					1055
Electricity	6101	7073	8192	9385	8419
Electricity ("000 toe)	525	608	705	807	724
Conversion factor	0.000086	0.000086	0.000086	0.000086	0.000086
Residential (total)	1169	1429	1684	1791	1827
Vegetal fuel	1160	1420	1650	1760	1750
Coal	9	9	34	31	35
Gas					
Oil/Petrol					42
Electricity	821	928	1278	1528	1719
Electricity ("000 toe)	0.070606	0.079808	0.109908	0.131408	0.147834
% Houses electrified					
% Schools electrified					
% Clinics electrified					
Agriculture					
Vegetal fuel					
Coal					216
Gas					-
Oil/Petrol					73
Electricity					51
Electricity ("000 toe)					0.004386

APPENDIX D

SELECTED INDUSTRIALISED COUNTRIES

1. GERMANY

	1993
Total Energy ("000 Toe)	**235560**
Vegetal fuel	1080
Coal	21330
Gas	46040
Oil/Petrol	128750
Geotherm. solar etc.	
Electricity ("000 toe)	38360
Residential	**58120**
Vegetal fuel	960
Coal	3410
Gas	19020
Oil/Petrol	23890
Geotherm. solar etc.	
Electricity	10840
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	**2990**
Vegetal fuel	
Coal	290
Gas	220
Oil/Petrol	1730
Geotherm. solar etc.	
Electricity	750

2. USA

	1993
Total Energy ("000 Toe)	**1399480**
Vegetal fuel	44150
Coal	30530
Gas	365950
Oil/Petrol	711700
Geotherm. solar etc.	
Electricity ("000 toe)	247150
Residential	**247060**
Vegetal fuel	15940
Coal	1420
Gas	115550
Oil/Petrol	28700
Geotherm. solar etc.	
Electricity	85450
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	**16150**
Vegetal fuel	
Coal	
Gas	
Oil/Petrol	16150
Geotherm. solar etc.	
Electricity	

3. NORWAY

	1993
Total Energy ("000 Toe)	**18210**
Vegetal fuel	910
Coal	820
Gas	
Oil/Petrol	7730
Geotherm. solar etc.	
Electricity ("000 toe)	8750
Residential	**3570**
Vegetal fuel	420
Coal	
Gas	
Oil/Petrol	330
Geotherm. solar etc.	
Electricity	2820
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	**250**
Vegetal fuel	
Coal	
Gas	
Oil/Petrol	190
Geotherm. solar etc.	
Electricity	60

4. JAPAN

	1993
Total Energy ("000 Toe)	**313010**
Vegetal fuel	
Coal	33580
Gas	17900
Oil/Petrol	193020
Geotherm. solar etc.	
Electricity ("000 toe)	68510
Residential	**44960**
Vegetal fuel	
Coal	120
Gas	8930
Oil/Petrol	18310
Geotherm. solar etc.	
Electricity	17600
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	**7230**
Vegetal fuel	
Coal	
Gas	
Oil/Petrol	7110
Geotherm. solar etc.	
Electricity	120

5. FRANCE

	1993
Total Energy ("000 Toe)	**152170**
Vegetal fuel	4000
Coal	8120
Gas	28190
Oil/Petrol	83280
Geotherm. solar etc.	
Electricity ("000 toe)	28580
Residential	**52790**
Vegetal fuel	3410
Coal	1310
Gas	8060
Oil/Petrol	1840
Geotherm. solar etc.	
Electricity	9590
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	**2950**
Vegetal fuel	
Coal	
Gas	210
Oil/Petrol	2550
Geotherm. solar etc.	
Electricity	190

6. AUSTRALIA

	1993
Total Energy ("000 toe)	**62590**
Vegetal fuel	4350
Coal	5540
Gas	9410
Oil/Petrol	31470
Geotherm. solar etc.	60
Electricity ("000 toe)	11760
Residential (total)	**7950**
Vegetal fuel	1830
Coal	10
Gas	2140
Oil/Petrol	410
Geotherm. solar etc.	60
Electricity	3500
% Houses electrified	
% Schools electrified	
% Clinics electrified	
Agriculture	
Vegetal fuel	
Coal	
Gas	0
Oil/Petrol	1180
Geotherm. solar etc.	
Electricity	230