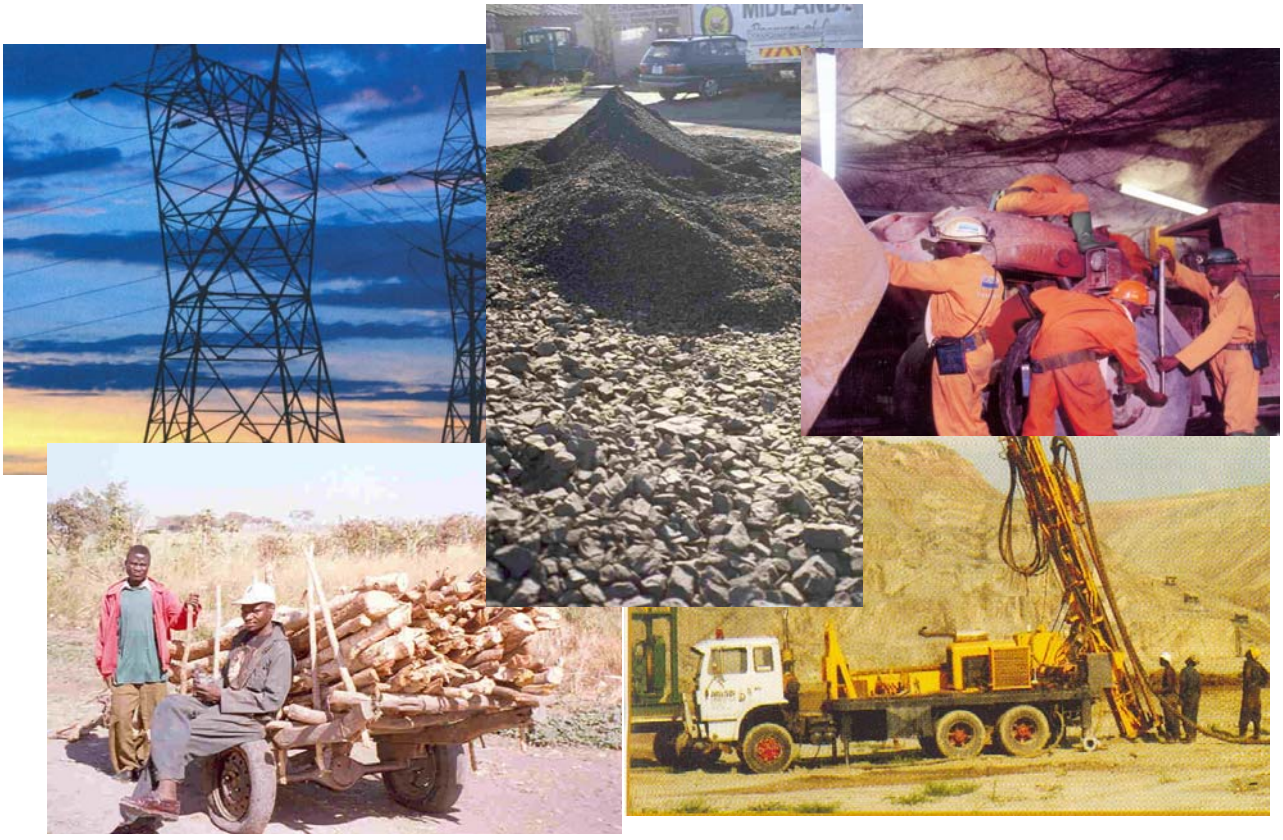
1st Draft

REPUBLIC OF ZAMBIA

## Central Statistical Office

# ENVIRONMENT STATISTICS IN ZAMBIA:

# *Energy Statistics*



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# ENVIRONMENT STATISTICS IN ZAMBIA:

# *Energy Statistics*

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# *Preface*

This publication is the first attempt to collect and compile secondary data on environment statistics. Considering that environmental issues are broad in nature covering many different types of themes, with each theme having many sources of data and in some cases large volumes of data, it was thought wise to cover these themes in separate publications to ensure that every theme is given enough time and attention. In this publication, only energy statistics are presented. Later publications will cover themes such as Water, Wildlife, Land and Agriculture, Mining, Air and Climate, Waste Disposal, Forests, and Minerals and Mining.

Energy is a basic need for human welfare. It is not only used in the production and consumption of goods and services. It is also used in food preparation and preservation, space heating, cooking and lighting, powering of motor vehicles, trains and planes. Like in many African countries, most of the Zambian population live below the poverty datum line, at 68 percent and wood fuel constitute a major source of energy for cooking which accounted for 84percent of the total number of households national wide, (Living Conditions Monitoring Survey IV, 2004). While on one hand, energy is necessary for development; it is on the other hand responsible for the negative impacts in the environmental media. Since meeting human needs overrides the negative impacts human activities have on the environment, a country may concentrate on meeting the needs of its citizens and pay no attention to the impacts the production of goods and services has on the environment. It is for this reason that statistics on the environment are required so that they are incorporated in the planning and development processes. This, in the long run, ensures that the present generation will be able to meet their own needs without jeopardizing the future generations to meet their needs.

In compiling the statistics presented in this publication, the United Nations-Framework for Development of Environment Statistics (UN-FDES) was adopted. The UN-FDES is one of the frameworks that have been developed worldwide to compile environment statistics. This framework does not insist on a one-to-one relationship between a pressure, the resultant stress and the response of government or society. Its purpose is primarily organizational, rather than explanatory. The focus is on identifying and presenting data variables that should be useful in tracing and verifying interrelationships, i.e. cause and effect relationships. In fact, several activities may be the cause of each impact.

Some information on the stated topic may not appear in this publication. This could be because of the unavailability of the information or because the Environment Unit within CSO does not know about that information. It was also not possible to adequately cover all the components of the different energy sources. Gaps in the data will be filled in subsequent publications.

Ms. Efreda Chulu
**Acting Director of Census and Statistics**

# *Abbreviations and Acronyms*

| | |
|---|---|
| As | Arsenic |
| $CaCO_3$ | Calcium Carbonate |
| CEC | Copperbelt Energy Company |
| Cd | Cadmium |
| CSO | Central Statistical Office |
| Cu | Copper |
| DoE | Department of Energy |
| DRC | Democratic Republic of Congo |
| DSR | Pressure-State-Response |
| DSR | Driving force-State-Response |
| DPSIR | Driving force -Pressure-State-Impact-Response |
| Escom | South African Electricity Company |
| ECZ | Environmental Council of Zambia |
| FAO | Food Agriculture Organisation |
| FD | Forestry Department |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| GWh | Gigawatt hour |
| HIV/AIDS | Human Immuno Virus/ Acquired Immuno Deficiency Syndrome |
| LCMS | Living Conditions Monitoring Survey |
| MCL | Maamba Collieries Limited |
| MEWD | Ministry of Energy and Water Development |
| Mg/l | Milligrams per litre |
| MW | Megawatt |
| $M^2$ | Square Meter |
| m/s | Meters per second |
| MTENR | Ministry of Tourism Environment and Natural Resources |
| NISIR | National Institute for Scientific Research |
| NRES | New and Renewable Energy Sources |
| NTU | Nephelometric Turbidity Unit |
| Kmil | Million kwacha |
| KW | Kilowatt |
| Pb | Lead |
| pH | Scale measure for acidity and alkalinity |
| PVs | Photo Voltaic |
| REA | Rural Electrification Authority |
| SADC | Southern African Development Committee |
| SAVCOR | International Forestry Consultancy firm based in Finland |
| STIs | Sexually Transmitted Infections |
| TB | Tuberculosis |
| TOE | Tonnes of Oil Equivalent |
| UN-FDES | United Nations-Framework for Development of Environment Statistics |
| UNDP | United Nations Development Programme |
| UNZA | University of Zambia |
| USD | United States Dollar |
| ZESCO | Zambia Electricity Supply Company |
| Zn | Zinc |

# *Acknowledgments*

Many thanks go to the following government institutions for their contribution in compiling this report; Ministry of Energy and Water Development in particular the Department of Energy, Environmental Council of Zambia, Ministry of Tourism, Environment and Natural Resources.

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The authors wish further to thank the following institutions for providing the secondary data used in this report: the Energy Regulation Board, Maamba Collieries, INDENI Refineries, National Institute for Scientific and Industrial Research, Zambia Electricity and Supply Corporation, the Copperbelt Energy Corporation, Department of Energy, Meteorological Department, University of Zambia and Environmental Council of Zambia.

Special thanks also go to Prof F.D. Yamba, and Prof E.N. Chidumayo from the University of Zambia for taking their time from their busy schedule to provide professional guidance in the compilation of this report.

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# 1 INTRODUCTION

Zambia has a population of 10.2 million, of which 62percent live in rural areas. (CSO Census of population and housing, 2000). Population densities are higher in urban areas as compared to rural areas. Usually, the higher the population density, the higher the environmental concerns in poor countries. This is because the majority of the populations in poor countries depend on the direct exploitation of natural resources for their livelihood. The Human Development Report for Zambia (UNDP, December 1998) has shown that there is a strong correlation between poverty and environmental degradation due to poor people's high dependency on exploitation of natural resources for their survival. Population increase in recent years has resulted in an increasing demand for natural resources such as wood fuel for energy needs because wood fuel is inexpensive and readily available.

Energy plays an important role in human welfare. It is used in food preparation and preservation, space heating, cooking and lighting, powering of motor vehicles, trains and planes. Apart from being a basic human need, energy is also a critical input in many sectors and has the capacity to earn foreign exchange and provide employment for many people in the country. Electricity is one example, which earns foreign exchange through the exports to neighbouring energy defiant countries and the Electricity, gas and water sub-sector contributes about 3 percent of Gross Domestic Product (GDP).

While the use of energy provides enormous benefits to the nation, and therefore to improving the standards of living of the people, the energy sector also contributes significantly to environmental pollution thus causing damage to a wide range of receptors, including human health, natural ecosystems and the built environment.

Even though there is evidence that the production and consumption of goods and services contribute to environmental pollution, and different types of statistics have been collected in the energy sector within the country, these statistics have not been comprehensively analyzed to determine the contribution of the energy sector to the pollutions in the environmental media. In addition, little has been done to document available data on the responses by the government, households or businesses to rectify specific environmental problems as a result of the changes in the state of the environment due to human activities.

Without reliable statistics on the stocks of natural resources, human activities that exert pressure on these resources, the types of impacts produced in the environmental media and what measures have put in place to mitigate the impacts, it would be impossible to plan and/or monitor the sustainable use of natural resources. The importance of reliable quantitative information on energy supply and demand patterns cannot be over emphasized when planning for sustainable economic development.

## 1.1. Objectives

The main objective of this undertaking is to compile environment statistics in Zambia, using the United Nations-Framework for Development of Environment Statistics.

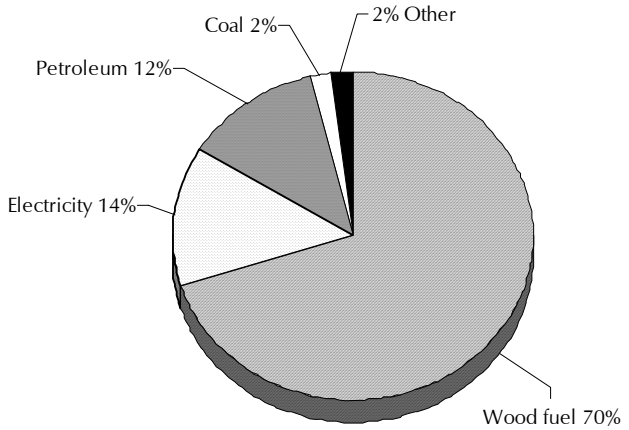
The specific objectives are to

- Determine the different types of energy stocks in the country.
- Determine the social and economic activities in the energy sector that exert pressure on the environment.
- Determine the impacts on the environment as a result of the social and economic activities within the energy sector.
- Identify the responses put forward by the government, private sector and other stakeholders to mitigate these impacts.

## 1.2. Energy Sector Situation in Zambia; an Overview

Apart from petroleum, which is wholly imported, Zambia is endowed with plenty of indigenous energy resources such as woodlands for wood fuel, hydropower, coal and renewable energy. Wood fuel accounts for about 70percent of the total national energy demand while electricity, petroleum and coal account for 14percent, 12percent and 2percent respectively as` shown in figure 1.1.

**Figure 1.1: Total National Energy Demand by Source**

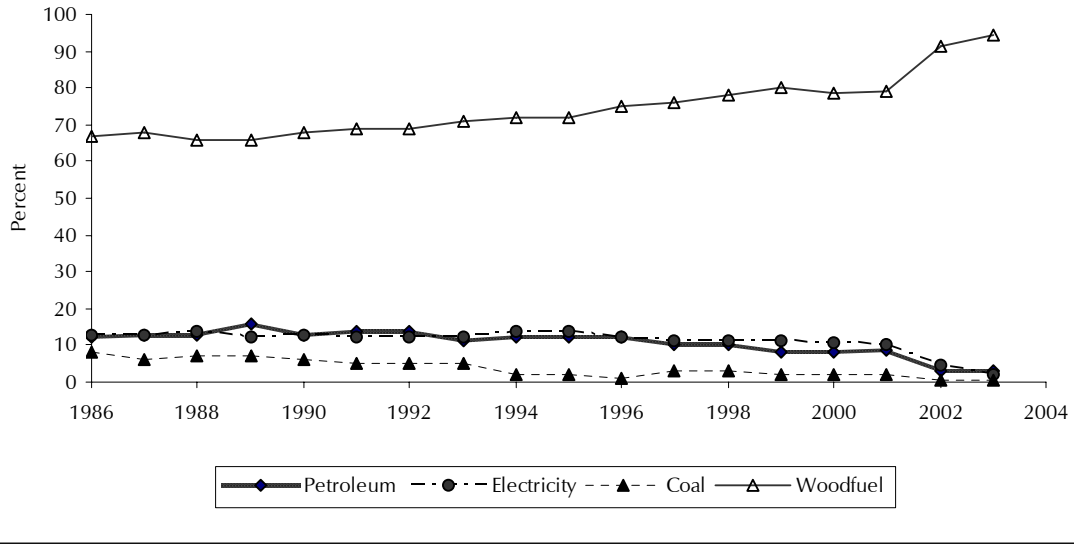



Source: *The Energy bulletin 2000 - 2003*

Figure 1.2 below shows the trend in energy consumption from 1986 to 2003. The consumption of woody energy resource has been increasing due to population increase as a result the rate of exploitation or extraction on forests is higher than the rate of regeneration of the forests. It is important that measures are put in place to cub this trend.

The consumption of petroleum and electricity has remained fairly constant over the years. However the consumption of coal has been declining over this same period.

**Figure 1.2 : Percentage Final Energy Consumption by Source, (1986 to 2003)**




Source: *The Energy bulletin 2000 - 2003*

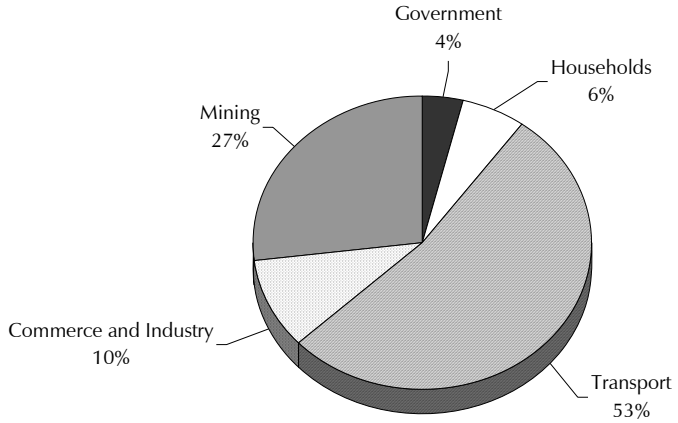
### 1.2.1. Wood Fuel

Traditional wood fuels such as charcoal and firewood dominate energy consumption in Zambia. The main sources of wood fuel are natural woodlands and agricultural lands. According to the *Energy Services Delivery in Zambia Report 2004,* the present consumption of wood fuel exceeds the potential sustainable supply. This is a serious threat to the total forestry land cover, which is currently estimated at 66percent of the total land area.

### 1.2.2. Petroleum

The country's petroleum requirements are wholly imported and accounts for 12 percent of the national energy demand. The import of petroleum dominates all other expenditure and forms a major part of Zambia's import bill *Energy Services Delivery in Zambia, 2004*. Established infrastructure for petroleum import and processing include the 1,704 km TAZAMA pipeline from Dar-es-Salaam port in Tanzania to INDENI refinery in Ndola. As can be seen in figure 1.3 below, the highest consumer of petroleum products in the country is the transport sector accounting for 53 percent, followed by the mining sector with 27 percent. Refined petroleum products are imported into the country by rail through the Railway Systems of Zambia (RSZ) and Tanzania-Zambia Railway (TAZARA) and by road through authorized oil marketing companies and transporters.

**Figure 1.3: Proportion of Petroleum Products consumed by Sector in Zambia**




Source: *The Energy bulletin 2000 - 2003*

### 1.2.3. Coal

Proven coal deposits are estimated at over 30 million tonnes while potential coal resources are estimated to be several thousand tonnes. The main coal company, Maamba Collieries Limited (MCL), currently mines the biggest share of the coal in Zambia. As can be seen in the figure 1.4 in the next page, the consumption of coal in Zambia is confined mainly to the mining industry (54 percent), commerce and industry (37 percent) and the government and service sectors (9 percent). The contribution of coal to the total energy balance has been declining over the years due to operational constraints at Maamba Collieries. However production is likely to go up due to fresh investments in the mine after privatization.

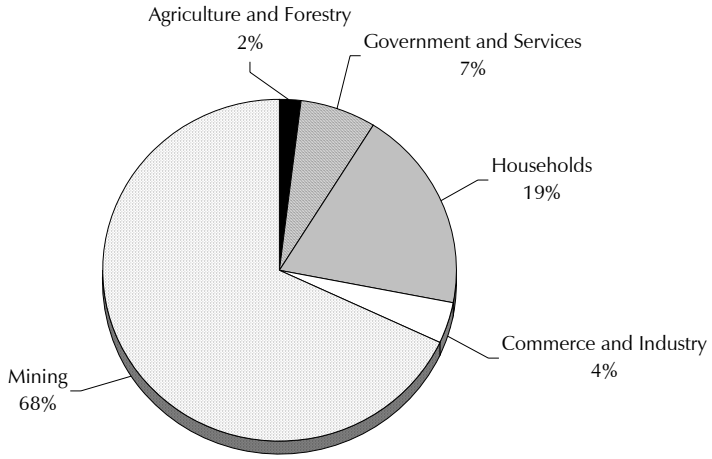
### 1.2.4. Electricity

The hydropower resource potential is estimated at 6,000 megawatts. The installed capacity is only 1,760 megawatts. This contributes about 14 percent of total energy use.

The hydropower stations supply the national grid while the diesel power generating plants supply isolated loads mainly in remote areas not connected to the grid. The gas turbines, located on the copperbelt provide standby supply to the mines.

Figure 1.4 shows the users of electricity in the country. The mines are the major consumers of electricity accounting for 68 percent followed by households, which uses 19percent. The Agriculture and Forestry sector is the least user of electricity in Zambia.

**Figure 1.4: Proportion of Electricity Consumption by User Group**




Source: *The Energy bulletin 2000 - 2003*

### 1.2.5. Renewable Sources of Energy

While wood fuel, petroleum and hydropower will continue to be the major energy sources in Zambia, efforts are being made to develop and expand other energy sources such as solar, mini-hydro and wind. Zambia has a large potential for a variety of renewable energy resources. Table 1.1 below gives a summary of the availability and potential for the utilization of renewable energy sources and technologies.

**Table 1.1: Renewable Energy Resources and Technologies**

| Renewable Energy Source/Technology | Opportunities/Use | Resource Availability | Potential Energy Output |
|---|---|---|---|
| PV | Thermal, Electricity (Water pumping, Lighting, and refrigeration). | 6 – 8 sunshine hours. | 5.5 kWh/m $^2$ /day modest potential especially for limited irrigation) |
| Wind | Electricity, Mechanical (Water pumping). | Average 3 m/s. | Good potential, Especially for irrigation) |
| Grid Extension | Electricity | Existing infrastructure | Excess power (approximately 200 MW) |
| Micro – hydro. | | Reasonably extensive | Requires elaboration and quantification |
| Biomass (Combustion and Gasification). | Electricity generation | • Agro wastes<br>•Forest wastes<br>•Sawmill wastes | |
| Biomass (Biomethanation). | •Electricity generation •Heating (cooking). | •Animal wastes.<br>•Municipal and Industrial waste<br>•Wastewater. | Potential requires elaboration. |
| Biomass (Extraction, processing for transport). | Ethanol for blending with gasoline to replace lead as octane enhancer Biodiesel for stationary engines\ | •Sugarcane<br>•Sweat sorghum<br>•Jatropha. | 15,000 Ha to meet current demand 40,000 – 50,000Ha. |
| Biomass (for household energy). | •Improved charcoal production<br>•Improved biomass stove | Sawmill wastes and indigenous trees from sustainable forest management | Reasonably extensive. |

### 1.2.6. National Energy Consumption

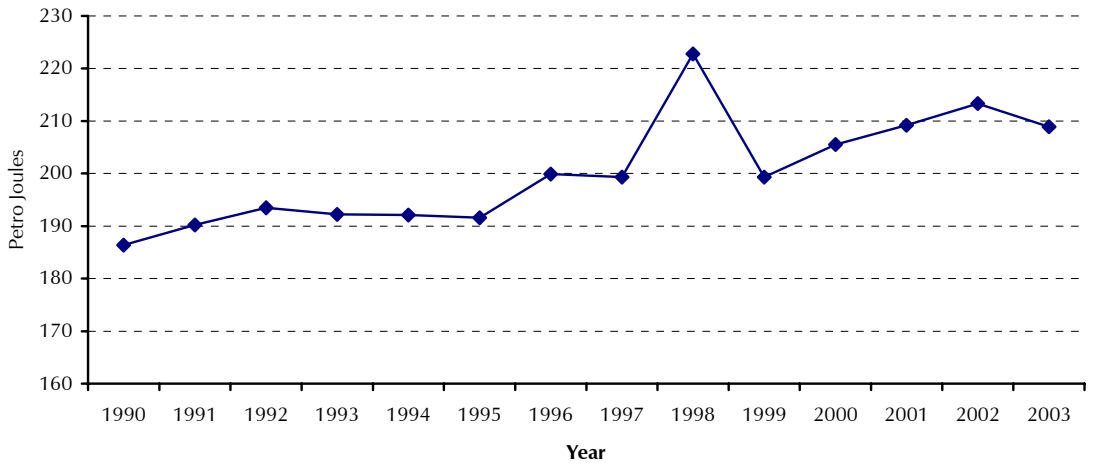
Table 1.2 below shows energy consumption by sector and year in petro Joules from 1990 to 2003. Energy consumption in the country increased from 186.5 in 1990 to 464.8 petro joules in 2003.

**Table 1.2: Final Energy Consumption by Sector and Year in Petra Joules PJ**

| Unit: PJ | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 4.7 | 4.7 | 5.2 | 5.0 | 5.2 | 5.2 | 5.3 | 5.5 | 5.6 | 5.8 | 5.7 | 5.7 | 5.6 | 6.0 |
| Commerce & Industry | 20.2 | 20.7 | 21.4 | 20.1 | 18.4 | 17.0 | 16.8 | 17.4 | 15.0 | 16.4 | 17.0 | 17.3 | 36.5 | 37.4 |
| Government/ Services | 3.6 | 2.8 | 2.5 | 2.6 | 3.0 | 3.8 | 3.1 | 5.3 | 2.0 | 2.1 | 2.3 | 1.6 | 2.5 | 2.7 |
| Households | 116.0 | 119.2 | 122.0 | 125.6 | 129.1 | 128.6 | 136.5 | 139.7 | 166.1 | 146.6 | 150.0 | 155.5 | 162.2 | 170.9 |
| Mining | 28.4 | 27.9 | 27.9 | 28.5 | 23.6 | 23.7 | 23.2 | 24.3 | 24.1 | 20.1 | 20.9 | 19.7 | 16.4 | 2.7 |
| Transport | 13.6 | 15.0 | 14.5 | 10.6 | 12.7 | 13.3 | 15.1 | 7.1 | 10.0 | 8.2 | 9.6 | 9.4 | 9.7 | 9.3 |
| Total | 186.4 | 190.2 | 193.5 | 192.2 | 192.1 | 191.6 | 199.9 | 199.3 | 222.8 | 199.3 | 205.5 | 209.2 | 213.3 | 208.9 |

Source: *The Energy bulletin 2000 - 2003*

**Figure 1.5: Energy Consumption by Sector and Year in Petro Joules Pj**



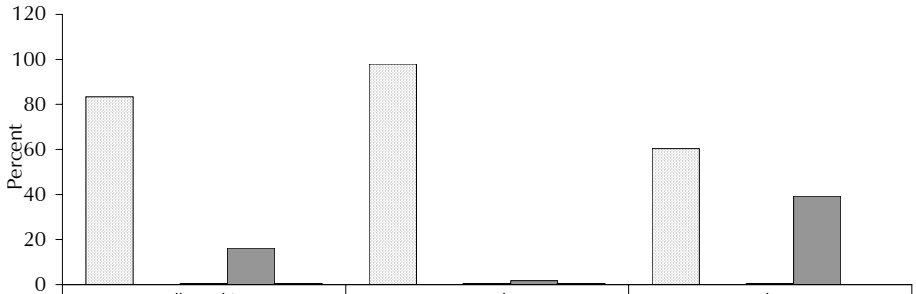

Source: *The Energy bulletin 2000 - 2003*

### 1.2.7. Household Energy Sources

According to the results of the Living Conditions Monitoring Survey of 2004, 83.4 percent of the households in Zambia depend on wood resources for their cooking energy. Only 16.2 percent have access to electric energy for cooking. About 97.9 percent of the rural households solely depend on woody resources for their cooking energy while only 1.7 percent has access to electrical energy.

In urban areas, 60.4 percent of the households depend on wood fuel most of which is charcoal. The most urbanized provinces of Lusaka and Copperbelt are the highest in terms of electric energy as a source of cooking energy at 40.2 and 37 percent respectively. The rest of the provinces have less than 10 percent of their households with access to electricity for cooking. See Figures 1.6 and 1.7 and Appendix 6.

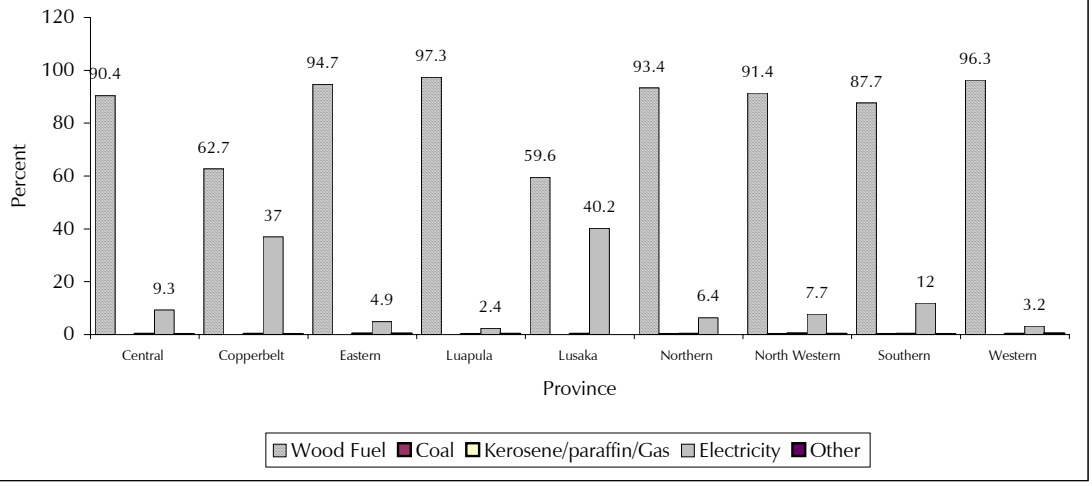
**Figure 1.6: Percentage Distribution of Households by Type of Cooking Energy 2004**




| | All Zambia | Rural | Urban |
|---|---|---|---|
| Wood Fuel | 83.4 | 97.9 | 60.4 |
| Coal | 0 | 0 | 0 |
| Kerosene/paraffin/Gas | 0.2 | 0.2 | 0.2 |
| Electricity | 16.2 | 1.7 | 39.3 |
| Other | 0.1 | 0.2 | 0 |

Source: *CSO, Living Conditions Monitoring Survey, 2004*

**Figure 1.7: Percentage Distribution of Households by Main Type of Cooking Energy by Province,Zambia,2004**




Source: *CSO, Living Conditions Monitoring Survey, 2004*

# 2 METHODOLOGY

## 2.0. Study Design

The study used secondary data scattered across the country in institutions that collect data on energy. This data was further analyzed so that a line of causation, from human activities creating pressure on the environment, which in turn alters the state of the environment and leads to specific response by some part of the society, is meaningful to the users.

## 2.1. Coverage

The study was conducted across the country. Institutions that collect statistics on energy in the country were visited. Most of the data were collected along the line of rail where there is a lot of activities in the production and consumption of energy services. The provinces covered include Copperbelt, Lusaka, Southern and Northwestern.

## 2.2. Selection of a Framework

A number of frameworks,1 used in describing the pressure, state and responses (PRS) on the environment, have been developed worldwide to collect environment statistics. Although no single framework can adequately depict the intricate and constantly changing network of relationships that exist in the environment, each version introduces simplifications, meaning that some aspects of reality are not accurately represented. Even though this is the case, policy makers and analysts can still make rational decisions using information compiled using a particular framework.

In choosing a workable framework for Zambia, the following considerations were made;

- Zambia did not have any experience in collecting environment statistics. Therefore the framework most recommended for countries that do not have previous experience in compiling environment statistics was to be adopted.

- Data collected from the line ministries and institutions dealing in environmental issues, was inadequate, scanty and sometimes unavailable, therefore a relatively simple type of framework was chosen.

The United Nations Framework for the Development of Environmental Statistics (UN-FDES) was the most recommended for reasons given above. This framework has four components namely;

- Stocks and Inventories- This component captures benchmark data on meteorological and/or conditions, geographical background conditions, economic and demographic indicators and stocks of natural resources. This component also provides data that enables appropriate interpretation.

- The Social and Economic activities and natural events- This component captures data on social and economic activities of humans that exert pressure on the environment

- Environmental Impacts of Activities and Events- Captures data on the state of the environment including the changes in the state of the environment over the years as a result of human activities. Impacts presented could either be beneficial or harmful to the environment.

*1 A framework is a system of capturing and presenting environment statistics information to users. Examples of frameworks that have been devised to compile environment statistics are; the PRS, DPSIR, UN-FDES and the DSR frameworks.*

- Responses to environmental Impacts- Comprises of information in mitigating the negative impacts. Improving the monitoring and control of pollutants, development of new technologies by the government as well as Non Governmental Organizations and Individuals can do this.

### 2.3. Selection of Variables

Once a theme has been selected, attention turns to statistical variables2 that appear in the body of the table. Statistical variables enable the theme chosen to be assessed *quantitatively* and they are carefully selected so as to portray the prevailing environmental situation in the country under the chosen theme. In selecting the variables in this publication the following were used as a guide;

1. The United Nations Concepts and Methods of Environment Statistics of the Natural Environment manual of 1991.

2. Various local and international literatures were used to come up with country specific variables in the energy sector in Zambia.

A list of corresponding variables was produced. Although several variables were selected, only some had available data from existing sources while others did not have data and their absence indicates a gap in collection procedures. The selected variables give a sense of direction to the whole process of data collection and they are also important in guiding data providers on the type of data they are required to provide to the national statistical office.

### 2.4. Formulation of Table Frames

Table frames are skeleton tables, which clearly defines the statistical variables, relevant to the theme selected, on which data should be collected, the period it should cover and in which format. Table frames guide the data providers on the required data in compiling environment statistics.

*2 Statistical variables describe priority environmental issues in the country that are used to compile environmental statistics.*

# 3 COAL

## 3.0. Introduction

Coal in Zambia is mined in Maamba in the Southern Province. Mamba Collieries Limited (MCL), a company wholly owned by the Government of Zambia has been the major producer of coal in the country. It is the largest employer in the Southern Province with a labour strength of approximately 830 (as at end of March 2004).

MCL operates two open cast mines at the Kanzize and Izuma basins at the annual capacity of 800,000 Metric Tonnes. Most of the coal mined in Zambia is consumed locally though a small percentage is exported to Malawi, Tanzania and the DRC. The local markets are predominantly the mines on the Copperbelt Province, Chilanga Cement PLC, the breweries and other local manufacturers.

Coal Mining at MCL has been declining since the inception of the mining activity in 1971. The contributing factors to the decline in the production of coal include:

- Depreciation of the mining equipment and lack of re-investments in the coal mining operations to boost production.
- Until recently there have been poor production levels in the mining sector, the major consumers of coal, resulting in low demand for coal.
- Adoption of other heating technologies by the mines and other industries in some areas where coal was predominantly the source of energy.

As at March 2000, there were still about 78 million metric tones of Coal in Maamba area, of which 60 million metric tones were proven reserves.

## 3.1. Stocks and Inventories

**Table 3.1: Coal Production and Reserves per Year in Metric tonnes**

| Year | Production (MT) [a] | Accumulated Production (MT) [b] | Remaining Reserves (MT) [c] | Depletion Index [d] |
|---|---|---|---|---|
| 1990 | 688,929 | 688,929 | 63,836,219 | 0.01 |
| 1991 | 502,150 | 1,191,079 | 63,334,069 | 0.02 |
| 1992 | 517,672 | 1,708,751 | 62,816,397 | 0.03 |
| 1993 | 623,220 | 2,331,971 | 62,193,177 | 0.04 |
| 1994 | 538,640 | 2,870,611 | 61,654,537 | 0.04 |
| 1995 | 302,465 | 3,173,076 | 61,352,072 | 0.05 |
| 1996 | 261,739 | 3,434,815 | 61,090,333 | 0.05 |
| 1997 | 273,900 | 3,708,715 | 60,816,433 | 0.06 |
| 1998 | 326,834 | 4,035,549 | 60,489,599 | 0.06 |
| 1999 | 289,599 | 4,325,148 | 60,200,000 | 0.07 |
| 2000 | 227,160 | 4,552,308 | 59,972,840 | 0.07 |
| 2001 | 231,276 | 4,783,584 | 59,741,564 | 0.07 |
| 2002 | 196,633 | 4,980,217 | 59,544,931 | 0.08 |
| 2003 | 117,295 | 5,097,512 | 59,427,636 | 0.08 |
| 2004 | 233,104 | 5,330,616 | 59,194,532 | 0.08 |
| 2005 | 360,000 | 5,690,616 | 58,834,532 | 0.09 |
| 2006 | 480,000 | 6,170,616 | 58,354,532 | 0.10 |
| 2007 | 600,000 | 6,770,616 | 57,754,532 | 0.10 |
| 2008 | 720,000 | 7,490,616 | 57,034,532 | 0.12 |
| 2009 | 800,000 | 8,290,616 | 56,234,532 | 0.13 |
| 2010 | 800,000 | 9,090,616 | 55,434,532 | 0.14 |
| 2030 | 800,000 | 25,090,616 | 39,434,532 | 0.39 |
| 2050 | 800,000 | 41,090,616 | 23,434,532 | 0.64 |
| 2060 | 800,000 | 49,090,616 | 15,434,532 | 0.76 |

| Year | Production (MT) [a] | Accumulated Production (MT) [b] | Remaining Reserves (MT) [c] | Depletion Index [d] |
|---|---|---|---|---|
| 2070 | 800,000 | 57,090,616 | 7,434,532 | 0.88 |
| 2075 | 800,000 | 61,090,616 | 3,434,532 | 0.95 |
| 2076 | 800,000 | 61,890,616 | 2,634,532 | 0.96 |
| 2077 | 800,000 | 62,690,616 | 1,834,532 | 0.97 |
| 2078 | 800,000 | 63,490,616 | 1,034,532 | 0.98 |
| 2079 | 800,000 | 64,290,616 | 234,532 | 1.00 |
| 2080 | 800,000 | 65,090,616* | -565,468* | 1.01 |

*Note: Annual production column (a), actual production figures from Maamba Collieries

1. The proven reserve of 60.2m tonnes was released by the MCL statement of 31st March 2000. From the production statistics at MCL, a total of 4,325,148 had been extracted during the period 1990-1999. Therefore, there was a total of 64,525,148 tonnes of coal at the beginning of the year 2000.

2. Entries in annual production column [a] are actual production figures between 1990 and 2003. After change of management, there has been a steady increase in production levels, and this report assumes that by the year 2009, production will reach maximum capacity of 800,000 tonnes.

3. The estimation shows that by the year 2080, all the proven reserves of coal in Maamba will have been depleted.

4. Column [b] represents the annual production statistics of coal in Maamba

5. Column [c] represents the initial reserves as at beginning of 1990 (64,525,148 tonnes) less the accumulated reserves.

The Coal production data [1990-2003] was obtained from Maamba Collieries Limited. Initial reserves of the coal were obtained from Investment Centre. Note that the coal production at mamba Collieries has been reducing since inception in the early 1970s. Government however, moved in to save the industry from total collapse, and has put it up for privatization. It is thus assumed that if the mine is privatized, the investor will re-capitalize the industry to enable it produce to its capacity.

### 3.2. Social and Economic Activities

MCL is the major employer in the Gwembe district of the Southern province. The total number of employment levels as a result of the mining activities range between 750 – 850 staff per annum. Establishment of Maamba Collieries in the Gwembe valley has had a lot of positive impacts in the area. The area-surrounding mamba is fairly densely populated as most of the local people have been displaced by the flooding Lake Kariba into the highlands.

When Coal mining operations started in the area, social amenities such as schools, clinics, houses, shops and many more were established. These are accessible by both miners and local communities. The local people also provide unskilled manpower and a number of business activities, a situation that has raised their standard of living.

#### 3.2.1. Coal Sales

Coal has been mainly sold locally though a small percentage has been exported to some neighbouring countries. Coal production has contributed positively to the national economy as well as the generation of foreign exchange. Sales of coal for the period 1996 – 2002 have been as follows:

**Table 3.2: Coal Sales by Customer and Year in metric tonnes**

| Type of Customer | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|
| Mines | 60,578 | 101,825 | 88,806 | 46,892 | 50,560 | 32,801 | 38,232 |
| Chilanga Cement | 51,302 | 50,434 | 72,183 | 55,037 | 79,501 | 63,598 | 64,521 |
| Other Manufacturing | 30,196 | 8,283 | 5,030 | 6,271 | 7,240 | 6,236 | 4,625 |
| Breweries | 15,780 | 15,799 | 14,481 | 13,239 | 15,035 | 11,583 | 4,896 |
| Others | 29,393 | 41,851 | 24,932 | 21,170 | 14,736 | 23,908 | 23,453 |
| Exports | 1,462 | 377 | 1,681 | 6,160 | 10,292 | 12,536 | 0 |
| **Total** | **188,711** | **218,570** | **207,113** | **148,770** | **177,364** | **150,663** | **135,727** |

Source: *Maamba Collieries*

### 3.3. Environmental Impacts

Although Mamba Collieries Limited has had positive socioeconomic impacts in the area, there have also been negative environmental impacts such as land degradation, surface water and air pollution due to the mining activities.

These negative impacts on the environment have remained unaddressed because of not having compelling regulations when mining started. Being a quasi-government body, MCL had a relaxed approach towards addressing, applying and enforcing government environmental laws.

Environmental impacts from the coal mining activities at MCL have two sources. There are impacts, which are as a result of coal extraction activities and impacts from the processing and storage of coal.

Extraction of coal has been carried out through open cast mining method. This type of mining has had profound effects on the environment which include:

- Vegetation removal through bush clearing
- Loose soil removal
- Competent overburden removal
- Waste (overburden) damping

The processing and storage of coal similarly has had some severe impacts on the environment which results in land degradation, air and water pollution.

#### 3.3.1. Vegetation Removal

Huge pieces of land were cleared in the initial development of the mine. This resulted in the loss of biodiversity. The loss of vegetation has made huge pieces of land vulnerable to various agents of erosion, soil weathering and compaction. Since coal and overburden are associated with pyrite, the exposed soil material promotes acid mine drainage that eventually end up in the stream. Vegetation removal has interfaced with normal existence of flora and fauna leading to the migration of wildlife from the affected areas to quieter and less disturbed habitats.

#### 3.3.2. Loose Soil Removal

The loose soil removal has had effects on the environment. The newly exposed surfaces are prone to agents of erosion and runoff from the affected areas, which carry sediments that end up in the surrounding surface water bodies. It also causes destruction of soil by altering its chemical characteristics, which limit its use for agriculture. It also changes the landscape thus creating negative visual impacts.

**(a) Competent overburden (mudstone) removal:**

In addition to land degradation caused by the removal of overburden which results in rugged terrain, it also leads to spontaneous combustion of side caste sulphuric material. This causes fumes such as sulphur dioxide, nitrous fumes and carbon monoxide emissions into the atmosphere. The overburden occurs with pyrite, thus reactions between water, air and the overburden results in the formation of sulphuric acid which eventually ends up into the surrounding water bodies lowering the pH of the water.

**(b) Waste overburden dumping:**

The dumping of overburden and slurry waste in the area has caused major environmental concerns. Waste has taken up large areas of land destroying vegetation and soil suitable for agricultural purposes. The dumped material has resulted in artificial hills, which have created negative visual effects and displaced wildlife. Overburden carries sediments that have silt and clog running water bodies.

### 3.3.3. Environmental Impacts of Coal Processing

Coal preparation produces rejected solid material that is discarded into the dump sites which causes further destruction to land and vegetation. This also causes negative visual effects. In addition the dumped material is high in mineral content, causing spontaneous combustion in the dump sites, resulting in gaseous fumes which pollute the surrounding communities. There is also a danger of contaminating ground water as a result of seepage of acid water from the dumps.

**Table 3.3: Surface Area disturbed as a result of Coal Mining**

| Area Type | Surface Area ($m^2$) | Area in hectares |
|---|---|---|
| Mine Pits | 2,675,343 | 267.53 |
| Overburden Dump sites | 340,008 | 34.00 |
| Slurry Ponds | 64,729 | 6.47 |
| Coal Stock Piles | 109,453 | 10.95 |
| Slurry Dumps (in valleys) | 20,457 | 2.05 |
| **Total Surface Land Disturbed** | **3,209,990** | **321.00** |

Source: *Maamba Collieries*

Washing of coal produces slurry; and because of improper slurry treatment mechanisms, most of it finds its way into the surrounding water bodies. Some of the slurry is pumped into the valleys and these have had severe negative impacts on the environment. The water quality has been severely affected through sedimentation, discharge of acidic effluents into the streams which have lowered the pH hence accelerating the dissolution of the suspended metals like Zinc (Zn), Copper (Cu) Lead (Pb) Cadmium ( Cd) and Arsenic (As).

**Table 3.4: Surface Water Pollution on one of the Streams that passes through the Major Mining and Processing Centre**

| Parameter | P7 | P6 | P2 | P1 |
|---|---|---|---|---|
| pH | 8 | 4.5 | 2.5 | 5 |
| Turbidity (NTU) | 4 | 586 | 109 | 63 |
| Total Dissolved Solids (mg/l) | 210 | 702 | 1090 | 532 |
| Total Suspended Solids (mg/l) | 108 | 894 | 294 | 140 |
| Magnesium hardness (as, mg, $CaCO_3$/l) | 28 | 140 | 268 | 220 |
| Iron (mg/l) | 40 | 103 | 299.5 | 146 |

Source: *Maamba Collieries*

**Note:** P7 is a Sampling Point upstream of Kanzize stream, a major stream that passes through the mining area and the local townships.
P6 Sampling point at the processing plants
P2 is a sampling point after the major mining activities.
P1 is a sampling point after downstream.

### 3.3.4. Air Pollution

There are two major air pollutants in Maamba, which result from the mining operations namely p**articulate coal dust and silica dust.** Both arise from drilling and removal of overburden and coal, blasting and loading operations. Studies revealed that both coal and silica dust concentrations in the air are above the acceptable standards of 900 ppcc and 350 ppcc. (*Impact of Mining activities on miners' health, 1991-2002*)

Miners are subjected to the above mentioned atmospheric contaminants arising from Coal mining activities. Exposure to these high levels of concentrations has resulted into respiration ailments, as recorded by the local clinic. See table 4.5 below.

**Table 3.5: Occurrence of Disease among Miners at Maamba Collieries**

| Disease /Diagnosis | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|
| Respiratory infections | 1503 | 1626 | 1342 | 1652 | 998 |
| Cadio-vascular diseases | 20 | 29 | 14 | 30 | 10 |
| PTB | 3 | 1 | 7 | 11 | 16 |

Source: *Mamba General Hospital*

## 3.4. Responses

### 3.4.1. Responses on Land Degradation

It is estimated that a total of 321 hectares of land has been disturbed by Coal mining operations through;

- Removal of material in open cast areas
- Changing the topology / landscape of the area
- Waste damping and
- Slurry dumps.

There have been attempts to reclaim part of the land used for damping mine waste and overburden in mine pits. However, this has not been adhered to because of added costs of transporting waste to the pits as well as laxity due to absence of compelling forces.

Currently, slurry is damped in the nearby valleys, an arrangement which has caused severe environmental impacts. The initial design was that slurry would be dumped in a pond with 3 compartments for recycling. This method would have served more than 2 hectares of land that has been taken up by dumping slurry in the valleys. It failed to work out mainly due to poor design and rehabilitation costs.

Mining and its associated activities have always been in conflict with the environment. For sustainable development, the mining operations require a good balance between the protection of the environment and economic growth. Mining operation started before the enactment of the Environmental Protection and Pollution Control Act 1990, which was commissioned in 1992. This act comprises a number of regulations, which include:

- Natural Resources conservation
- Waste management
- Water Management
- Air quality etc

Despite the existence of the regulation, environmental impacts at Maamba have remained un addressed mainly due to:

- Lack of resources to embark on rehabilitation works have contributed to increased environmental degradation. The company has not had sufficient equipment to use for both mining activities as well as rehabilitation activities.

- Lack of effective enforcement by Environmental Council of Zambia (ECZ), who have not been consistent in visiting the mining areas. As a result, this has led to a relaxed approach where environmental compliance is concerned.

- Lack of incentives to encourage the mine to embark on programs aimed at environmental protection.

### 3.4.2. Licenses issued by ECZ

To control pollution and ensure that MCL is adhering to environmental regulation, ECZ and environmental regulations enforcing agency have awarded Maamba Collieries 5 licenses. ECZ does not fully monitor compliance to ensure that the company is operating according to the regulations.

The licenses, renewed annually are:

- Transportation of waste, including mine township waste
- Operation of disposal sites
- Air permits
- Discharge of effluent into the local stream. (2 licenses).

# 4 ELECTRICITY

## 4.0. Introduction

At regional level, about 40percent of the waters in the SADC region are in Zambia, while at local level about 6 percent of the land area is covered with water. Due to this fact, the country has a lot of potential for hydropower generation.

## 4.1. Stocks and Inventories

Table 4.1 shows the installed capacity of ZESCO Power Plants in Zambia. Hydro Power accounts for 99.5 percent of the total capacity in the country, while diesel and gas only accounts for 0.5 percent. For the hydro power plants, Kafue Gorge has the highest installed capacity of 900 MW but is currently working under capacity of 600 MW. Kafue Gorge accounts for 56 percent of the main hydro installed capacity, followed by Kariba North Bank with 37 percent and Victoria Falls with 7 percent. The total capacity of mini hydros in Zambia is 23 MW, while the diesel generators have a combined capacity of 8 MW. Below are some potential sites that could be exploited to generate a total of about 6754.9 - 6767.9 MW of hydropower in the country.

**Table 4.1: Installed Capacity of ZESCO**

| Station Type | Station Name | Installed Capacity (KW) | Available Capacity(KW) |
|---|---|---|---|
| Main | Kafue Gorge | 900,000 | 600,000 |
| | Kariba North | 620,000 | 470,000 |
| | Victoria Falls | 108,000 | 40,000 |
| | Sub- total | ***1,628,000*** | ***1,110,000*** |
| Mini | Lusiwasi | 12,000 | 12,000 |
| | Musonda Falls | 5,000 | 5,000 |
| | Chishimba Falls | 6,000 | 6,000 |
| | Lunzua River | 750 | 750 |
| | Sub-Total | ***23,750*** | ***23,750*** |
| Diesel | Mwinilunga | 1,130 | 1,130 |
| | Kabompo | 1,130 | 1,130 |
| | Zambezi | 415 | 415 |
| | Mufumbwe | 760 | 760 |
| | Kaoma | 2,620 | 2,620 |
| | Luangwa | 292 | 292 |
| | Lukulu | 512 | 512 |
| | Chama | 528 | 528 |
| | Kaputa | 665 | 665 |
| | Sub-Total | *8,052* | *8,052* |
| | **Grand Total** | **1,659,802** | **1,659,802** |

Source: *ZESCO Limited, 2005*

**Table 4.2: Installed Capacity by Mines and Private Sector**

| Station | Machine Type | Installed Capacity(KW) | Availability Capacity (KW) | Owner |
|---|---|---|---|---|
| Bancroft | Gas Turbine | 20 000 | 20 000 | CEC |
| Luano | Gas Turbine | 40 000 | 40 000 | CEC |
| Luanshya | Gas Turbine | 10 000 | 10 000 | CEC |
| Mufurila | Gas Turbine | 20 000 | 20 000 | CEC |
| Lunsemfwa | Hydro | 18 000 | 18 000 | PRIVATE |
| Mulungushi | Hydro | 20 000 | 20 000 | PRIVATE |
| Nkana | Thermal | 20 000 | 20 000 | KCM |
| **TOTAL** | | **138 000** | **138 000** | |

Source: *ZESCO Limited, 2005*

Table 4.3 shows some of the potential hydropower sites in Zambia. Zambezi basin has the largest capacity of 4,500 MW, while the most promising site is the construction of Kafue Gorge Lower and Itezhi-tezhi with a current combined capacity of 680 MW.

**Table 4.3: Potential Hydro Electricity Sites in Zambia**

| Basic | Description | Possible Capacity | Remarks |
|---|---|---|---|
| Kafue River | Kafue Gorge Lower | 450 | |
| | Itezhitezhi | 80 | |
| Zambezi River | Kariba North Extension | 300 | |
| | Mpata Gorge | 1200 | Shared with Zimbabwe |
| | Devils Gorge | 1600 | Shared with Zimbabwe |
| | Batoka Gorge | 1600 | Shared with Zimbabwe |
| | Victoria Falls extension | 140 | |
| | Chavuma Falls | 10-20 | |
| Laupula River | Mumbotuta gorge & Mambilima falls | 1188 | |
| | Lumangwe falls | 60 | |
| | Kabwelume | 54 | |
| Luangwa River | Lusiwasi Extension | 40 | |
| Luakela River | Sachibonda | 0.2 | |
| Kabompo River | Chakata Falls | 0.3 | |
| | Kabompo | 30 | |
| | Kabempa | 2-3 | |
| West Lunga River | Mwinilunga | 0.4 | |

Source: *ZESCO Limited, 2005*

## 4.2. Social and Economic Activities

ZESCO Limited is a state owned vertically integrated utility company, which is involved in generation, transmission and distribution of electricity in Zambia.

Table 4.4 shows the total generation by ZESCO Power Plants since 1993. Kafue Gorge continued being the highest in terms of generating electricity with an installed capacity of 900 MW, while Kariba North Bank comes second with an installed capacity of 600 MW. There was a slight increase in generation by 2percent from 2000 to 2003.

**Table 4.4: Electricity Generation by ZESCO Power Plant (GWh)**

| Year | Interconnected Network | | | Isolated | | Total |
|---|---|---|---|---|---|---|
| | Kafue gorge | Kariba North Bank | Victoria Fall | Hydro | Diesels | |
| **1993** | 5,045 | 2,324 | 610 | 69 | 12 | 8,060 |
| **1994** | 5,380 | 2,000 | 695 | 65 | 11 | 8151 |
| **1995** | 4,760 | 2,460 | 636 | 54 | 14 | 7,924 |
| **1996** | 4,767 | 1,696 | 635 | 35 | 16 | 7,149 |
| **1997** | 5,530 | 1,641 | 699 | 37 | 29 | 7,936 |
| **1998** | 4,822 | 2,051 | 673 | 22 | 34 | 7,602 |
| **1999** | 4,899 | 2,146 | 663 | 39 | 16 | 7,763 |
| **2000** | 4,662 | 2,510 | 586 | 24 | 15 | 7,797 |
| **2001** | 5,661 | 2,660 | 641 | 38 | 18 | 9,018 |
| **2002** | 5,001 | 2,746 | 550 | 36 | 16 | 8,349 |
| **2003** | 4,760 | 3,108 | 346 | 48 | 17 | 8,279 |

Source: *Statistical Energy Bulletin, 2004*

Table 4.5 shows the total generation by ZESCO power plants and the private sector. There was a notable increase in generation from 2000 to 2001 by the interconnected network power plants.

**Table 4.5: Electricity Generation by ZESCO and the Private Sector (GWh)**

| Year | ZESCO Generation | | | Private Sector Generation | Total Generation |
|---|---|---|---|---|---|
| | Interconnected Network | Isolated Network | Total ZESCO | | |
| 1993 | 7,979 | 81 | 8,060 | 9 | **8,069** |
| 1994 | 8,075 | 76 | 8,151 | 11 | **8,187** |
| 1995 | 7,856 | 68 | 7,924 | 28 | **7,964** |
| 1996 | 7,098 | 51 | 7149 | 12 | **7165** |
| 1997 | 7,870 | 66 | 7,936 | 5 | **7,941** |
| 1998 | 7,546 | 56 | 7,602 | 1 | **7,603** |
| 1999 | 7,708 | 55 | 7,763 | 1 | **7,764** |
| 2000 | 7,759 | 39 | 7,798 | 0 | **7,798** |
| 2001 | 8,963 | 57 | 9,020 | 1 | **9,021** |
| 2002 | 8,297 | 52 | 8,349 | 1 | **8,350** |
| 2003 | 8,214 | 65 | 8,279 | 4 | **8,283** |

Source: *Statistical Energy Bulletin, 2004*

Table 4.6 shows the total final consumption and total number of exports. The number of exports to Zimbabwe declined drastically since 2000, from 202 GWh to 3 GWh in 2003. The losses continued to be stable, with the highest being in 2000 over the 11 year period. It should also be noted that exports reduced drastically in 2003 probably due to Eskom's decrease in demand for electricity.

**Table 4.6: Electricity Generation and Export (GWh)**

| Year | Total Generation | Export | | | | Total Export | Supply in Zambia (inclusive Losses) | Transmission Loses | Zambia Final Consumption |
|---|---|---|---|---|---|---|---|---|---|
| | | Congo D.R. | South Africa (Eskom) | Zimbabwe | Other | | | | |
| 1993 | 8,198 | -1057 | | 855 | | -202 | 8,400 | 261 | 8,139 |
| 1994 | 8,140 | -903 | | 1,970 | | 1,067 | 7,073 | 280 | 6,793 |
| 1995 | 7,924 | -488 | | 1,468 | | 980 | 6,944 | 224 | 6,720 |
| 1996 | 7,165 | -795 | | 932 | | 137 | 7,028 | 138 | 6,890 |
| 1997 | 7,941 | -38.61 | | 788 | 30 | 818 | 8,759 | 164 | 8,595 |
| 1998 | 7,603 | -3.2 | 196 | 275 | 32 | 503 | 8,106 | 170 | 7,936 |
| 1999 | 7,764 | 0 | 446 | 62 | 37 | 545 | 8,309 | 225 | 8,084 |
| 2000 | 7,798 | 3 | 520 | 202 | 28 | 753 | 7,045 | 425 | 6,620 |
| 2001 | 9,021 | 4 | 1,458 | 12 | 28 | 1,502 | 7,519 | 357 | 7,162 |
| 2002 | 8,350 | 0 | 712 | 3 | 52 | 767 | 9,117 | 224 | 8.893 |
| 2003 | 8,283 | 4 | 148 | 3 | 49 | 204 | 8,146 | 244 | 7,902 |

Source: *Statistical Energy Bulletin, 2004*

**imports from SNELL were inadvertent energy payback (do not involve money transfer)*

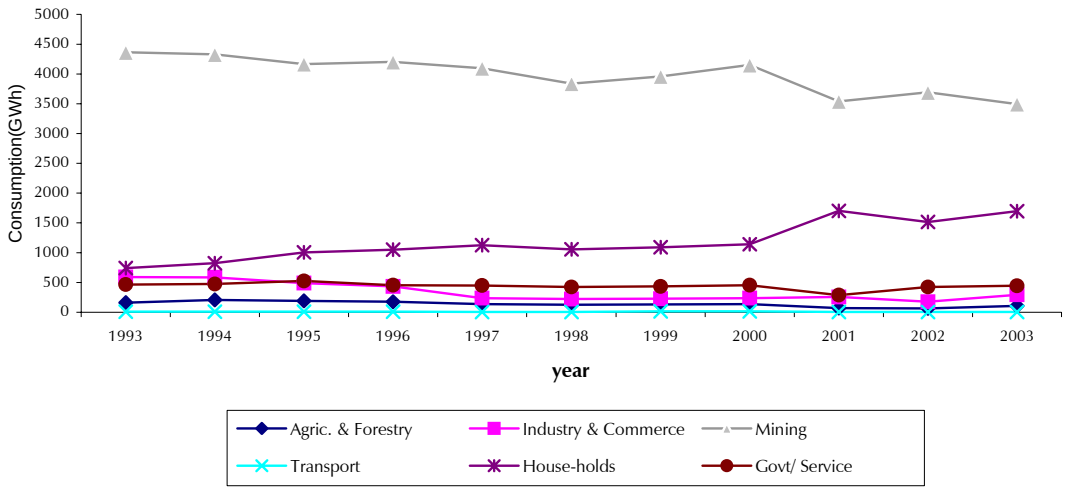
Table 4.7 and figure 4.1 below shows electricity consumption by sector. As at 2003 the mining sector remained the major consumer of electricity but there was a 6 percent drop from 2000 to 2003. In the house hold sector the use of electricity in relation to the total consumption shows a general increase, probably due to the fact that ZESCO had embarked on a project of connecting electricity to the residents, as part of the process of increasing access to electricity. Industry and commerce relatively remained the same.

**Table 4.7: Electricity Consumption by Sector (GWh)**

| Sector | Agric. & Forestry | percent | Industry & Commerce | percent | Mining | percent | Transport | percent | House-holds | percent | Govt/ Service | Percent | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 160 | 3 | 590 | 9 | 4,365 | 69 | 12 | 0 | 740 | 12 | 463 | 7 | 6,330 |
| 1994 | 205 | 3 | 585 | 9 | 4,328 | 67 | 8 | 0 | 822 | 13 | 474 | 7 | 6,422 |
| 1995 | 194 | 3 | 491 | 8 | 4,167 | 65 | 11 | 0 | 1,003 | 16 | 527 | 8 | 6,393 |
| 1996 | 179 | 3 | 432 | 7 | 4,203 | 66 | 8 | 0 | 1,053 | 17 | 455 | 7 | 6,330 |
| 1997 | 136 | 2 | 235 | 4 | 4095 | 68 | 7 | 0 | 1,127 | 27 | 450 | 9 | 6,050 |
| 1998 | 128 | 2 | 220 | 4 | 3836 | 68 | 7 | 0 | 1,056 | 19 | 422 | 7 | 5,669 |
| 1999 | 132 | 2 | 227 | 4 | 3960 | 68 | 14 | 0 | 1,089 | 19 | 435 | 7 | 5,857 |
| 2000 | 138 | 2 | 238 | 4 | 4,151 | 68 | 15 | 0 | 1,142 | 19 | 456 | 7 | 6,140 |
| 2001 | 73 | 1 | 260 | 4 | 3,541 | 60 | 6 | 0 | 1,703 | 29 | 288 | 5 | 5,871 |
| 2002 | 65 | 1 | 178 | 3 | 3,692 | 63 | 5 | 0 | 1,516 | 26 | 423 | 7 | 5,879 |
| 2003 | 105 | 4 | 294 | 11 | 3,493 | 62 | 4.05 | 0 | 1,699 | 26 | 443 | 7 | 6,039 |

Source: *Statistical Energy Bulletin Oct 2000 & Dec 2004*

**Figure 4.1:Electricity Consumption by Sector**




Source: *Statistical Energy Bulletin Oct 2000 & Dec 2004*

## 4.3. Environmental Impacts of Activities

Generation and transmission of electricity have had severe impacts on the environment. Even though much of the energy consumption in Zambia is from fuel wood, industries and urban households rely on electricity as a source of energy. As development of the nation continues to grow, more households and industries will use electrical energy, which will in turn, exert more pressure on the environment.

### 4.3.1. Human

#### (a) Physical

Impacts on the physical environment include soil erosion due to cutting of trees to facilitate construction of power lines especially if the trees are uprooted instead of stumping. Soil erosion in urban areas can lead to situation in the rivers and other water bodies. Air quality can also be affected by diesel power stations due to emission of smoke containing carbon dioxide, which has greenhouse effects. Liquid waste discharge, especially used oil from transformers and automobile workshops, can affect water quality and may lead to death of some forms of aquatic life.

Solid wastes such as concrete, steel bars, bolts, nuts, cable drums, paper, plastics, metal and woody vegetation can cause environmental degradation. Projects also generate domestic waste such as leftover foodstuffs and human waste especially at camping sites for workers.

Noise pollution is created during construction especially where heavy-duty equipment is used in excavating, stringing and tower erection. During construction of power stations, blasting is employed to construct the powerhouse and tunnels for various purposes. Noise pollution is, however, limited to the construction period and during routine maintenance. During the operation of the power facilities, noise pollution is minimal.

**(b) Biological**

During the construction of power lines and power stations, some animals, reptiles and birds may be killed accidentally. Poaching of animals, reptiles and birds by construction workers is the major adverse impact especially in places near the national parks. Damming of rivers for power generation purposes can affect seasonal fish migration and breeding, which can lead to diminishing of certain fish species and other forms of aquatic life.

Cutting of trees for construction of power lines leads to the destruction of trees of commercial value and may also open up protected areas (forest reserves and national parks) to charcoal production and poaching.

### 4.3.2. Impacts due to Hydroelectric Power Station Development

Hydropower projects are always associated with construction of barricades or wears, establishment of water reservoirs or the diversion of water from the natural watercourse. This action poses severe impact on the environment such as the disturbance of the natural water flow, alteration to the water levels that in turn affects the biodiversity in the rivers. Environmental effects are on both upstream and downstream of sides of the barricades. On the upstream, the main environmental issues relate to ecosystem changes due to break in natural food chain or circulation of organisms and fish caused by barrier or diversion. Environmental effects on the downstream relate to a changed flow regime towards either very low flows or dry riverbeds, which in turn impacts the aquatic ecosystem with special effects on fish and their food chains. Other effects are erosion of riverbeds especially near the barricades, change in wildlife watering and river crossing habits.

In cases where a dam is created, environmental impacts include loss of vegetation and agricultural land, loss of various natural resources, relocation of people and loss of personal property including houses, disruption of peoples economic activities, social networks and way of life, changes in the scenic beauty and reservoir or water body may become a source of waterborne diseases. These issues are diverse and depend on the nature, size and location of the project. The Kariba dam was constructed primarily to house power stations, which would supply power to both Zambia, and Zimbabwe and nearly 500,000 people were displaced into the highlands. Even though the dam was built more than 60 years ago, environmental effects have never been fully addressed and their effects are still affecting the local people today. People were displaced from the valley with very good agricultural land into the highlands of very poor soil structures. For many years, they have never been able to produce enough crops and the government has to send food supplements to the area.

Projects, especially hydropower stations which usually have a long construction period of at least four year, cause human population influx into the project area to look for jobs and this puts pressure on the existing social facilities in the area as well as on residential and agricultural land. The influx of people in the area also leads to the spread of communicable diseases such as cholera, dysentery, sexual transmitted Infections STIs, including HIV/AIDS.

During the construction of power lines and hydropower stations, houses, shops and other buildings, which cannot be avoided, are demolished and the owners are required to relocate. The owners of the affected property are inconvenienced. Power lines and power station do take up land that can be used for agriculture purposes and this affects agricultural production. Fruit trees and crops in the fields can also be affected by the project

### 4.3.3. Impacts due to Transmission of Hydroelectric Power

The development of transmission lines is characterized by three phases: route selection, construction and operational period. All these have their ecological, visual and socio-economic implications. Main environmental issues related to transmission lines include:

- Clearing of vegetation to facilitate construction of transmission lines and substations
- Relocation of people along line route corridors
- Land use changes
- Wildlife impacts (birds, animals and reptiles etc.)
- Improved access with potential for natural resource exploitation or socio-economic development
- Erosion potentials
- Public safety from high tension conductors or speeding traffic
- Solid and liquid waste management issues.

In general, the impacts of transmission lines occur primarily within or in the immediate vicinity of the way leave. The magnitude and significance of the impacts increase as voltage and length of the line increases. The higher voltages require larger supporting structures and way leave widths. When clearing way leaves, contractors usually resort to burning and uprooting of trees resulting into air pollution and damage to indigenous species, soil erosion and dispersion of wildlife. People in the cleared land get relocated, disturbing their natural way of life. Transmission lines create problems on birds through bird electrocution and collision. It is mainly the larger predatory birds, which are killed through electrocution while other birds are more often killed through flying into wires at high speed. The night active species are more frequently involved in wire strikes

The below table shows that a total of 269.15 $Km^2$ of land have been cleared in Zambia to accommodated power transmission lines. This is about 0.04percent of the total land area in Zambia. The current grid length is at 6,431 Km of electricity transmission lines across the country. Cleared land does not include land taken up by low voltage transmission lines, which are mainly in built up areas. It also does not include land taken up by substations and power stations. It should be noted that the total coverage in transmission lines may grow dramatically in the next few years as the country embarks on the rural electrification program

**Table 4.8**: **Land Cleared and Distance Covered by Power Transmission Systems in Zambia**

| Voltage Line | Distance Km) | Way leave Size (m) | Clearance (m) | Total Way leave (m) | Cleared Land $Km^2$) | Cleared Land (ha) |
|---|---|---|---|---|---|---|
| 330 kV | 2,241.0 | 50 | 5.2 | 55.2 | 123.70 | 12,370.32 |
| 220 kV | 348.0 | 48 | 4.6 | 52.6 | 18.30 | 1,830.48 |
| 132 kV | 201.6 | 32 | 3.4 | 35.4 | 7.14 | 713.66 |
| 88 kV | 817.0 | 30 | 3.2 | 33.2 | 27.12 | 2,712.44 |
| 66 kV | 2,823.0 | 30 | 2.9 | 32.9 | 92.88 | 9,287.67 |
| **Total** | **6,430.60** | | | | **269.15** | **26,914.57** |

Source: *Zambia Electricity Supply Corporation (ZESCO), 2005; Way leave Source: ZESCO Way leaves Guidelines.*

## 4.4. Responses

The Government of Zambia through ECZ has proposed that all power generation and transmission projects be subjected to an Environmental Impact Assessment (EIA). This stipulates the mitigating measures that have to be put in place by the developer to address all anticipated impacts from the project. ECZ would only approve project if it notes that the anticipated impacts have adequately been addressed and attaches conditions of approval. The project would then be monitored for its lifetime.

ECZ is also mandated to license all pollution discharge points at the power stations and enforce corrective measures to be put in place to minimize indiscriminate release of pollutants into the atmosphere:

- Trees are stumped along the proposed power line route
- Diesel power stations are regularly serviced to avoid excessive emission of carbon dioxide.
- Transformer oil should change regularly to avoid contamination.
- Waste oil is put in drums and sold to companies that recycle used oil
- Oil leakages are avoided by keeping good working conditions in the power plant.
- Solid wastes are sorted according to type

In line with this, all the electricity firms have environmental policies, which guide them to mitigate the various impacts, which their operations exert on the Environment. ZESCO has an Environment and Social Affairs unit charged with this responsibility, and the Copperbelt Energy Company has a smaller unit which plays the same role.

# 5 PETROLEUM

## 5.0. Introduction

The term petroleum refers to all products produced from crude oil, which include petrol, diesel, Jet A1, kerosene, butane, bitumen, etc.

Zambia imports all its petroleum requirements, which contribute to about 12 percent of the national energy requirement. The import of petroleum dominates all other expenditures and forms a major part of Zambia's import bill (source). The current infrastructure for import and processing includes the 1,704 Km TAZAMA Pipeline from Dar-Es-Salaam port in Tanzania to INDENI refinery in Ndola.

Previously importation of petroleum feedstock was the sole responsibility of the Zambia National Oil Company (ZNOC) now in liquidation. But with the liberalization of the economy, this role has been taken over by the private sector.

## 5.1. Stocks and Inventories

The TAZAMA Pipeline has a capacity to pump 1,100,000 metric tonnes of crude oil per year feeding into the INDENI oil refinery. The operations of the pipeline solely depends on the operations of the refinery plant as no crude could be pumped if the refinery is not functioning at that particular time for example when the plant was temporally closed due to fire in 2000. There are other inputs, which go into the refinery process.

TAZAMA pipeline is used in the transportation of crude oil while INDENI refinery is used for processing crude oil into refined petroleum products.

### 5.1.1. Refinery

The first refining process is distillation, which aims at separating the crude oil into its constituent hydrocarbons. Crude oil is heated and put into a distillation column and different products boil off and are recovered at different temperatures. The lighter products like liquefied petroleum gases (LPG), naphtha and petrol are recovered at the lowest temperatures. Middle distillates like jet fuel, kerosene and diesel fuel come next.

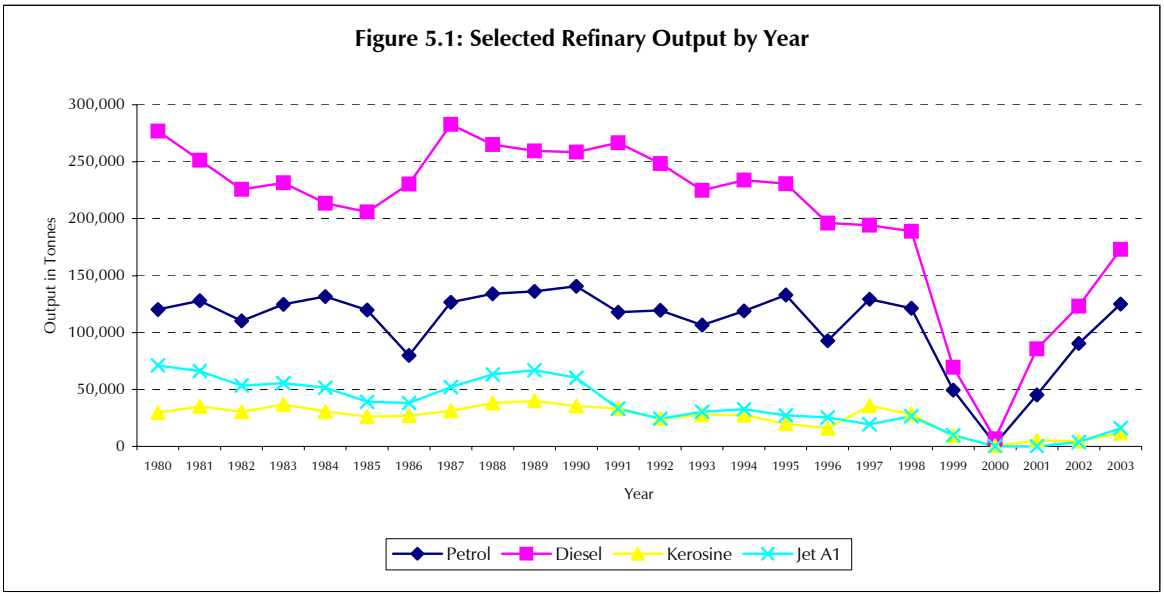
Finally, the heaviest products like the bitumen are recovered at a much higher temperature. Other refinery processes follow what is commonly known as 'down streaming'. These processes involve the breaking or cracking of the molecules of heavier hydrocarbons into the more desired lighter ones either by chemical reactions, under the presence of a catalyst or thermal heating. The refinery inputs that go into the INDENI Refinery are given in Table 5.1 below.

Figure 5.1 shows selected output from INDENI Oil Refinery and it can be noted that there was very low production during the 2000-2001 period when the plant had halted production due to the fire that gutted the part of the infrastructure. The operations of TAZAMA Pipeline solely depends on the production at INDENI as the was very little flow also in the 2000-2001 period as can be observed in Table 5.1 and Figure 5.1.

**Table 5.1: Refinery Inputs by Composition (Tonnes)**

| Year | Slops | Crude | Gas Oil | Kerosene/Jet A1 | Naphtha | Recycled Residue | Fuel Oil | Commingled Feed-stock | Condensate | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 0 | 449,386 | 195,833 | 44,129 | 78,307 | 0 | 0 | 0 | 0 | 767,655 |
| 1981 | 0 | 407,092 | 179,081 | 57,657 | 86,402 | 0 | 0 | 0 | 0 | 730,232 |
| 1982 | 0 | 372,697 | 141,387 | 63,720 | 60,637 | 0 | 0 | 0 | 0 | 638,441 |
| 1983 | 0 | 310,443 | 153,980 | 64,840 | 53,442 | 0 | 0 | 0 | 60,216 | 642,921 |
| 1984 | 0 | 305,570 | 126,611 | 56,172 | 26,448 | 0 | 0 | 0 | 151,196 | 665,997 |
| 1985 | 0 | 246,970 | 117,830 | 27,410 | 8,688 | 0 | 0 | 0 | 163,365 | 564,263 |
| 1986 | 0 | 163,903 | 194,084 | 36,343 | 42,395 | 0 | 44,332 | 0 | 59,096 | 540,153 |
| 1987 | 13,293 | 15,639 | 304,883 | 46,557 | 141,343 | 0 | 152,723 | 0 | 0 | 674,438 |
| 1988 | 0 | 0 | 334,658 | 48,271 | 161,457 | 0 | 143,425 | 0 | 0 | 687,811 |
| 1989 | 0 | 122,383 | 292,031 | 83,520 | 150,243 | 0 | 0 | 0 | 0 | 648,177 |
| 1990 | 0 | 244,929 | 237,746 | 70,134 | 136,862 | 0 | 171,415 | 0 | 61,903 | 922,989 |
| 1991 | 0 | 24,378 | 300,244 | 83,738 | 112,981 | 0 | 25,253 | 0 | 0 | 546,594 |
| 1992 | 0 | 326,238 | 169,223 | 37,000 | 54,217 | 0 | 0 | 0 | 39,379 | 626,057 |
| 1993 | 0 | 131,614 | 186,475 | 46,440 | 390 | 0 | 0 | 0 | 199,939 | 564,858 |
| 1994 | 0 | 95,006 | 179,624 | 28,696 | 0 | 0 | 0 | 0 | 243,291 | 546,617 |
| 1995 | 0 | 297,190 | 148,102 | 54 | 0 | 0 | 0 | 0 | 129,372 | 574,718 |
| 1996 | 0 | 90,199 | 193,022 | 0 | 14,508 | 0 | 0 | 0 | 126,644 | 424,373 |
| 1997 | 0 | 99,908 | 151,665 | 9,723 | 5,184 | 0 | 0 | 0 | 149,324 | 415,804 |
| 1998 | 0 | 118,718 | 181,171 | 26,339 | 37,476 | 33,815 | 0 | 768 | 132,120 | 530,407 |
| 1999 | 0 | 73,297 | 52,072 | 2,592 | 11,988 | 0 | 0 | 0 | 48,174 | 188,123 |
| 2000 | 0 | 8,067 | 3,540 | 932 | 0 | 0 | 0 | 0 | 4,310 | 16,849 |
| 2001 | 0 | 94,533 | 55,759 | 7,345 | 0 | 0 | 0 | 0 | 71,266 | 228,903 |
| 2002 | 0 | 108,897 | 87,460 | 0 | 0 | 0 | 0 | 0 | 105,347 | 301,704 |
| 2003 | 0 | 163,385 | 127,908 | 0 | 0 | 0 | 0 | 0 | 161,893 | 453,186 |

Source: *Department of Energy (Unpublished) and Department of Energy, 2000*




Source: *Department of Energy (Unpublished) and Department of Energy, 2000*

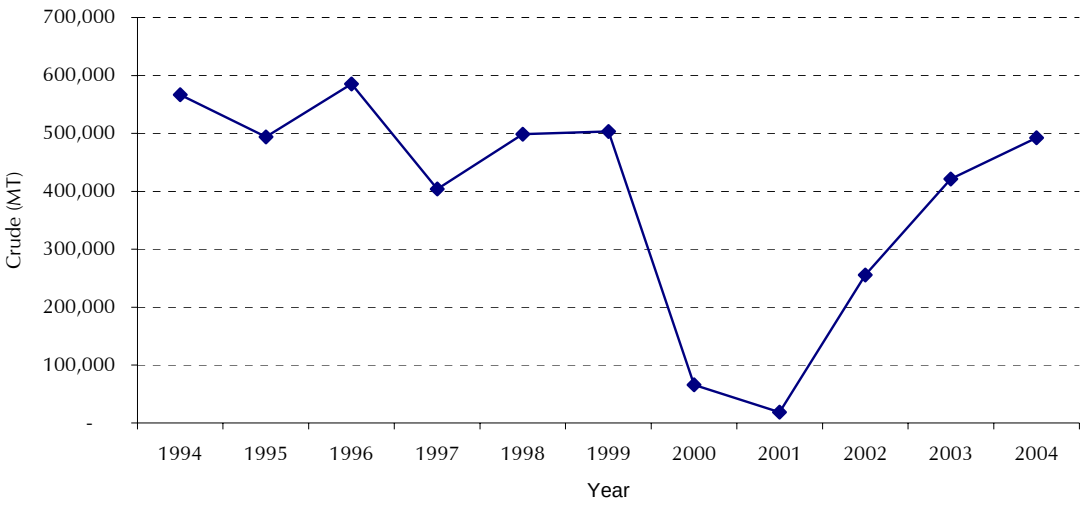
**Derived from Table 5.1**

**Table 5.2: Import of Crude Oil by TAZAMA Pipeline**

| Year | Pumped Crude (Metric Tonnes) |
|---|---|
| 1994 | 566,305 |
| 1995 | 494,068 |
| 1996 | 585,468 |
| 1997 | 404,251 |
| 1998 | 498,743 |
| 1999 | 503,063 |
| 2000 | 65,736 |
| 2001 | 18,774 |
| 2002 | 255,341 |
| 2003 | 421,307 |
| 2004 | 492,135 |

Source: *TAZAMA*

**Figure 5.2: Crude Oil Imports by TAZAMA Pipeline**




Source: *TAZAMA*

**Derived from Table 5.2**

## 5.2. Social and Economic Activities

The table 5.3 below shows the show the consumption of Petroleum by sector and fuel type. This information is compiled by the Energy Department from sales by oil marketing companies.

**Table 5.3: Total Final Fuel Consumption by Sector by Year**

**Insert different table**

| 1995 | | | | | | 1998 | | | | | | 2001 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** |
| Agriculture & Forestry | 909 | 7,360 | 52 | | 8,321 | Agriculture & Forestry | 1,312 | 8,289 | 266 | 761 | 10,628 | Agriculture & Forestry | 3,322 | 9,529 | 592 | 0 | 13,443 |
| Commercial & Industry | 24,589 | 29,104 | 1,337 | 117 | 55,147 | Commercial & Industry | 3,836 | 25,478 | 637 | | 29,951 | Commercial & Industry | 8,097 | 41,010 | 1,904 | 0 | 51,011 |
| Government & Services | 4,383 | 7,556 | 437 | | 12,376 | Government & Services | 1,355 | 2,265 | 6 | | 3,626 | Government & Services | 2,315 | 1,871 | 114 | 24 | 4,324 |
| Households | | | 69,592 | | 69,592 | Households | | | 18,825 | | 18,825 | Households | 0 | 0 | 14,206 | 0 | 14,206 |
| Mining | 1,038 | 57,350 | 5,434 | | 63,822 | Mining | 772 | 33,566 | 5,441 | | 39,779 | Mining | 754 | 36,880 | 2,949 | 0 | 40,583 |
| Transport | 59,928 | 103,903 | | 23,721 | 187,552 | Transport | 91,093 | 85,867 | 453 | 23,248 | 200,661 | Transport | 89,633 | 90,524 | 855 | 31,970 | 212,982 |
| Total | 90,847 | 205,273 | 76,852 | 23,838 | 396,810 | Total | 98,368 | 155465 | 25,627 | 24,009 | 303,469 | Total | 104,121 | 179,814 | 20,620 | 31,994 | 336,549 |
| **1996** | | | | | | **1999** | | | | | | **2002** | | | | | |
| **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** |
| Agriculture & Forestry | 508 | 8,045 | 58 | | 8,611 | Agriculture & Forestry | 849 | 10,973 | 221 | 2,659 | 14,702 | Agriculture & Forestry | 450 | 8,955 | 147 | - | 9,552 |
| Commercial & Industry | 8,034 | 28,426 | 1,070 | | 37,530 | Commercial & Industry | 5,438 | 27,664 | 1,080 | 0 | 34,182 | Commercial & Industry | 4,707 | 34,109 | 1,051 | 4,334 | 44,201 |
| Government & Services | 2,962 | 3,473 | 1 | | 6,436 | Government & Services | 2,443 | 4,302 | 180 | 0 | 6,925 | Government & Services | 2,173 | 3,133 | 4 | - | 5,310 |
| Households | | | 13,088 | | 13,088 | Households | | | 18,825 | 0 | 18,825 | Households | - | - | 14,206 | - | 14,206 |
| Mining | 1,074 | 53,177 | 6,605 | | 60,856 | Mining | 1,031 | 41,234 | 2,598 | 0 | 44,863 | Mining | 688 | 49,736 | 10 | - | 50,434 |
| Transport | 111,115 | 109,168 | | 24,597 | 244,880 | Transport | 87,215 | 79,395 | 221 | 19,627 | 186,458 | Transport | 96,035 | 99,337 | 8,038 | 21,351 | 224,761 |
| Total | 123,693 | 202,289 | 20,822 | 24,597 | 371,401 | Total | 96,976 | 163,568 | 20,958 | 22,286 | 303,788 | Total | 104,054 | 195,270 | 9,250 | 25,684 | 334,258 |
| **1997** | | | | | | **2000** | | | | | | **2003** | | | | | |
| **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** | **Sector** | **Premium** | **Diesel** | **Kerosene** | **Jet A1** | **Total** |
| Agriculture & Forestry | 943 | 9,367 | 198 | 10 | 10,518 | Agriculture & Forestry | 716 | 8,773 | 722 | - | 10,211 | Agriculture & Forestry | 431 | 11,407 | 552 | 158 | 12,548 |
| Commercial & Industry | 5,696 | 36,063 | 1,268 | 24 | 43,051 | Commercial & Industry | 6,993 | 36,381 | 3,560 | - | 46,934 | Commercial & Indutry | 7,856 | 34,193 | 3,331 | 933 | 46,313 |
| Government & Services | 56,754 | 42,967 | 10,270 | | 109,991 | Government & Services | 2,790 | 2,109 | 114 | - | 5,013 | Government & Services | 2,430 | 3,133 | 8 | 18 | 5,589 |
| Households | | | 6,795 | | 6,795 | Households | 0 | 0 | 13,077 | - | 13,077 | House-holds | - | - | 14,206 | - | 14,206 |
| Mining | 1,423 | 57,759 | 7,576 | | 66,758 | Mining | 756 | 37,470 | 2,944 | - | 41,170 | Mining | 599 | 51,634 | 812 | 939 | 53,984 |
| Transport | 42712 | 60,054 | 505 | 27,276 | 130,547 | Transport | 93,004 | 92,993 | 952 | 31,933 | 218,882 | Transport | 104,850 | 100,046 | 9,076 | 245 | 214,217 |
| Total | 107,527 | 206,211 | 26,612 | 27,310 | 367,660 | Total | 104,259 | 177,726 | 21,369 | 31,933 | 335,287 | Total | 116,167 | 200,413 | 13,779 | 2,293 | 332,652 |

Source: *Department of Energy (Unpublished) and Department of energy (2000)*

### 5.3. Environmental Impacts of Activities and Events

The combustion of fuel in engines and furnaces produce a lot of pollutant gases. The types of emitted exhaust gases are: Carbon Monoxide (CO); Oxides of Nitrogen ($NO_x$); Hydrocarbons; (HCs) and particulates. Carbon Monoxide is a poisonous gas, which can (fatally) reduce the ability of the blood to deliver oxygen to vital organs, as well as causing headaches, dizziness, and comas at lower concentrations. Nitrogen Dioxide plays a principal role in a complex series of chemical reactions in which lower-level ozone or smog is formed, together with acid rain. Smog can cause various respiratory ailments and damages vegetation. Unburnt fuel in exhaust gases usually comprises many different `Hydrocarbons', which are all treated together for present regulation purposes. Many hydrocarbons (VOC) are volatile and responsible for smog formation.

Carbon dioxide is a green house gas that is largely responsible for global warming. The atmosphere has a natural layer of $CO_2$ with a natural thickness, which has been thickening, with the release of more $CO_2$ by activities like burning of petroleum products. Below are the current emission levels in Zambia, which are as a result of consumption of petroleum products. The calculations are derived from the equation below:

**Emissions=Activity (amount of fuel consumed in GJ) x Emission factor (tonnes/GJ)**

The method was adopted from Centre for Energy, Environment and Engineering Zambia report on Climate Change Mitigation in Zambia and the raw data was obtained from the Department of Energy publications. Detailed emissions are in the appendix.

**Table 5.4: Emissions of Carbon Dioxide by Fuels**

| Year | Energy (PJ) | Premium Petrol | Diesel | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Total |
|---|---|---|---|---|---|---|---|---|
| 1990 | 25.6 | 364,701 | 896,042 | 200,948 | 158,238 | 279,742 | 11,275 | **1,910,945** |
| 1991 | 26.5 | 460,522 | 975,215 | 94,172 | 128,480 | 287,814 | 6,939 | **1,953,142** |
| 1992 | 26.3 | 437,293 | 991,359 | 106,775 | 104,675 | 296,197 | 8,673 | **1,944,973** |
| 1993 | 21.6 | 331,309 | 785,822 | 101,524 | 83,320 | 288,435 | 4,915 | **1,595,325** |
| 1994 | 22.8 | 397,512 | 813,145 | 99,0.73 | 77,018 | 286,572 | 4,626 | **1,677,947** |
| 1995 | 24.0 | 423,355 | 851,954 | 94,872 | 95,573 | 301,165 | 3,758 | **1,770,678** |
| 1996 | 23.7 | 367,895 | 987,013 | 88,921 | 75,268 | 226,339 | 2,602 | **1,748,038** |
| 1997 | 19.8 | 320,275 | 653,248 | 98,723 | 95,923 | 215,472 | 80,373 | **1,464,014** |
| 1998 | 18.5 | 327,244 | 588,979 | 105,025 | 106,075 | 220,440 | 24,863 | **1,372,626** |
| 1999 | 15.0 | 286,302 | 511,980 | 80,869 | 74,918 | 142,820 | 10,697 | **1,107,586** |
| 2000 | 16.4 | 310,112 | 562,898 | 115,177 | 76,668 | 150,582 | - | **1,215,438** |
| 2001 | 17.7 | 307,499 | 569,418 | 115,177 | 73,868 | 242,795 | - | **1,308,757** |
| 2002 | 14.5 | 302,127 | 606,272 | 89,901 | 32,383 | 35,488 | 434 | **1,066,605** |
| 2003 | 14.3 | 337,319 | 622,231 | 8,017 | 48,241 | 26,639 | 1,735 | **1,044,182** |

#### 5.3.1. Responses

At the moment they're very few alternatives to petroleum fuels expect research currently going on in Zambia about the possibility of blending diesel with organic fuel or bio diesel which is on going and in its infancy.

# 6 WOODFUEL

## 6.0. Introduction

Wood fuels consist of three main commodities: firewood, charcoal and black liquor. Firewood and charcoal are traditional forest products derived from the forest, trees outside forests, wood-processing industries and recycled wooden products. Black liquors are by-products of the pulp and paper industry.

The amount of Woodfuel use varies considerably among regions, mainly owing to differences in stages of economic development. The use of firewood is especially common in the rural areas of developing countries as the main source of household energy, while charcoal is mainly used by urban and peri-urban dwellers. In general terms, firewood production can be assumed to be more or less equal to firewood consumption within a region. However, the same rule can not apply to the amount of firewood used for charcoal making. In fact, the production of 1 tonne of charcoal requires approximately 6$m^3$ of wood.

Asia is the largest producer and consumer of firewood, accounting for 46percent of the world production. Africa has the second highest share at 30percent, followed by South America and North America, both at around 8percent.

Africa is the most intensive user of Woodfuel in per-capita terms, with an average annual per-capita consumption of 0.77 $m^3$, or 0.18 tonnes of oil equivalent (TOE). In Africa, almost all countries rely on wood to meet their basic energy needs. The share of wood fuels in Africa's primary energy consumption is estimated at 60percent to 86percent, with the exception of North African countries and South Africa. On average, about 40percent of the total energy requirement in Africa is met by firewood.

## 6.1. Stocks and Inventories

Vegetation types in Zambia can be categorized in three wood biomass classes: forest, miombo woodland and savanna woodland. Wood biomass stocks in the three-biomass classes listed above are given in the Table 6.1; Miombo woodland contains two-thirds of the nearly 2,927 million tonnes (oven-dry, OD) of Annual Growth wood biomass; the forest and savanna woodland contains 21percent and 13percent, respectively.

**Table 6.1: Wood Biomass Classes and Standing Stock (oven-dry mass)**

| Biomass Class | Extent (million ha) | | | | Wood biomass (t/ha) | | | Standing stock in million tonnes |
|---|---|---|---|---|---|---|---|---|
| | Total | Dambo Grassland | Crop Land | Actual Extent | Cord wood | Twig wood | Total | |
| Forest | 4.93 | 0.62 | 0.52 | 3.79 | - | - | - | 616.69 |
| Evergreen | 3.93 | 0.49 | 0.43 | 3.01 | 158 | 29 | 187 | 562.87 |
| Deciduous | 1 | 0.13 | 0.09 | 0.78 | 58 | 11 | 69 | 53.82 |
| Miombo woodland | 45.09 | 5.64 | 13.6 | 25.85 | - | - | - | 1919 |
| Wet | 22.2 | 2.78 | 6.66 | 12.76 | 76 | 14 | 90 | 1148.4 |
| Dry | 13.13 | 1.64 | 5.91 | 5.58 | 58 | 11 | 69 | 385.02 |
| Kalahari | 9.76 | 1.2 | 0.98 | 7.56 | 43 | 8 | 51 | 385.56 |
| Savanna woodland | 11.25 | 1.41 | 0.34 | 9.5 | - | - | - | 392.2 |
| Munga | 3.73 | 0.47 | 0.15 | 3.11 | 38 | 7 | 45 | 139.95 |
| Mopane | 4.75 | 0.59 | 0.19 | 3.97 | 38 | 7 | 45 | 178.65 |
| Termitaria | 2.77 | 0.35 | 0 | 2.42 | 25 | 5 | 30 | 72.6 |
| Grassland | 13.01 | 0 | 1.43 | 11.58 | 0 | 0 | 0 | 0 |
| Aquatic | 0.98 | 0 | 0 | 0.98 | 0 | 0 | 0 | 0 |

Note: *Dambo grassland is calculated as 12.5percent of total area (Chidumayo 1992); cropland is based on Schultz (1974); wood biomass in deciduous forest and mopane is calculated on the basis of dry miombo and munga woodland, respectively (Source: Inventory of Wood Used in Charcoal Production in Zambia Prof. Chidumayo)*

### 6.2. Social and Economic Activities and Natural Events

The firewood demand in Southern Africa is growing to unsustainable levels, due to the population increase and the rate at which forests and woodlands are being cleared for agriculture and wood fuel energy. Table 6.2 below shows usage of wood fuel in some selected Southern African countries.

**Table 6.2: Wood Use in Southern Africa ('000 Cubic Metres) (2004)**

| Country | Total Wood Fuel Energy Consumed |
|---|---|
| Angola | 5,539 |
| Botswana | 1,303 |
| Lesotho | 613 |
| Malawi | 7,814 |
| Mozambique | 15,022 |
| Namibia | 1,300 |
| South Africa | 7,078 |
| Swaziland | 560 |
| Tanzania | 32,240 |
| Zambia | 11,565 |
| Zimbabwe | 6,269 |

***Source:*** *FD, Food and Agriculture Organization (FAO) (Year)*

In Zambia, wood fuel (firewood and Charcoal) is the principal source of energy in the country accounting for nearly 80percent of the total energy consumed. Over half of the firewood is converted to charcoal and every year the equivalent of 430 square kilometres of woodland is cleared to produce more than 113,660 tonnes of charcoal.

Wood is the basic fuel for 3.2 million rural households, providing approximately 68percent of their energy needs. Although Zambia's rural electrification programme is reaching increasing proportions, firewood is expected to remain the dominant domestic energy source in rural areas for many years to come. Current consumption levels are estimated to be in excess of 8 million tonnes per annum. The national energy budget in Zambia is dominated by biomass, which accounts for 70percent of the total energy consumption of 4.33 million TOE. (Source: Department of Energy 1992)

In 2004, the forest sector was estimated to contribute 3.7 percent to the country's GDP of which charcoal production generated the largest value added of 2.2 percent. Firewood production accounted for 0.8percent and household production of timber for 0.3percent. (Source: SAVCOR Survey 2004– Contribution of the forest sector to the National Economy and Poverty Reduction in Zambia.)

Forest sector is estimated to provide employment for 161 000 people. Charcoal production offers the largest proportion of employment at 90.4percent while firewood production employs 4.2percent. For details see Table 6.3

**Table 6.3: Employment in Forest Sector in 2004**

| | Production 1 000 $m^3$ or kg | Productivity $m^3$ or kg/employee | Full-time employment # | Proportion of total percent |
|---|---|---|---|---|
| Firewood | 2 383 | 348 | 6 847 | 4.2 |
| Charcoal (kg) | 2 564 484 | 17 585 | 145 831 | 90.4 |

Source: *SAVCOR Survey 2004*

The value added in firewood and charcoal production was estimated based on data from a field survey carried out by Forestry Support Project (FSP) in 2003. A few adjustments to the data set were made to reflect conditions in 2004.

The total volume of firewood production was estimated at 2 838 000 $m^3$, while charcoal production amounted for 2 924 million kilograms. The value added of firewood production stood at K209 123 million (USD 46 million) and that of charcoal production at K569 315 million (USD 127 million).

**Table 6.4: Value Added in Firewood and Charcoal Production in 2004**

| Type of fuel | Consumption | Unit price | Trade value | | Value added | |
|---|---|---|---|---|---|---|
| | | | K mill. | USD mill | K mill. | USD mill. |
| Firewood | 2 383 000 $m^3$ | K 117 000 /$m^3$ | 278 831 | 62 | 209 123 | 46 |
| Charcoal | 2 564 mill. Kg | K 18 500 / 50 kg bag | 948 859 | 211 | 569 315 | 127 |

Source: year??

### 6.2.1. Firewood and Charcoal Production

The estimates on firewood and charcoal production were generated based on a field survey conducted by the Forest Support Project (FSP 2004). The basic data for the year 2003 was as follows:

**Table 6.5: Fuel Wood Production by Type, Residence and Price, 2003**

| Type of wood fuel | Households | | Total | Price |
|---|---|---|---|---|
| | Rural | Urban | | |
| Firewood (1 000 $m^3$) | 9 492 | | 9 492 | |
| Charcoal (1 000 bags) | 22 010 | 27 307 | 49 317 | 16 000 K/bag |

To update the data for 2004, the following adjustments were made:

- Convert bags into kg by assuming that an average bag weighs 50 kg
- Estimates for non-household consumption were generated by applying the proportions of data provided by Department of Energy (2003). With respect to firewood, non-household consumption was 13percent of household consumption, for charcoal the proportion is 4percent.

With these adjustments the following basic table was generated applying to 2004.

**Table 6.6: Fuel wood Production by Type, Residence and Price, 2004**

| Type of wood fuel | Households | | Non-household | Total |
|---|---|---|---|---|
| | Rural | Urban | | |
| Fuel wood (1 000 $m^3$) | 9 681.8 | | 1 258.6 | 10 940.5 |
| Charcoal (1 000 bags) | 1 254.6 | 1 556.5 | 112.4 | 2 923.5 |

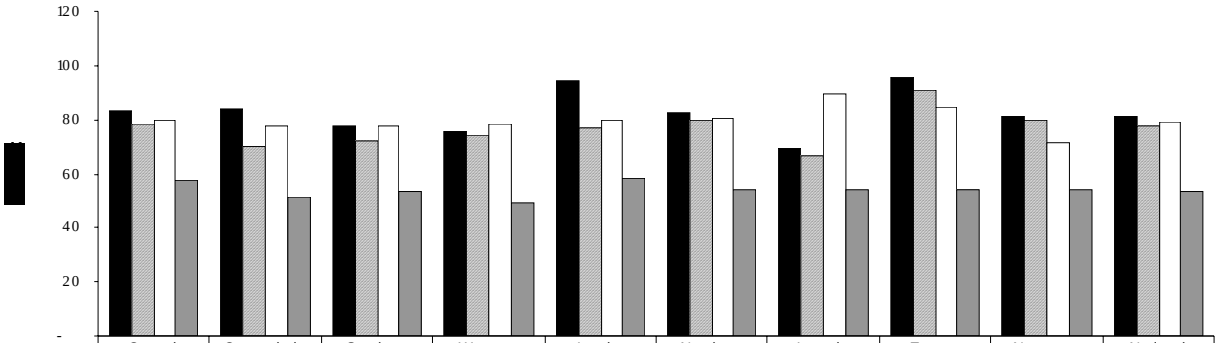
- The original (2003) firewood price was K106 300 per $m^3$ or K1 420 per bundle of 10 kg firewood. Charcoal price was K16 000 per 50Kg bag. Price increase from 2003 to 2004 for firewood was estimated at 10percent and for charcoal 15percent. Thus, the fuel wood price was established at K117 000 per $m^3$ and charcoal price at K18 500 per 50 Kg bag.

## 6.3. Environmental Impacts of Events

The Major environmental considerations in the production and consumption of wood fuel energy (Charcoal and firewood), are: forest clearing, pollution at production site, emission of greenhouse gases (GHG) as a result of burning of wood fuel, which contribute to global warming and climate change. The total annual forest loss is estimated between 700,000 to 800,000 ha country wide which represents an annual loss of about 1.2percent during 1975 – 2003 while 10 percent of this loss is due to clearing of forest for charcoal production while 90percent is due to agricultural purposes.

Figure 7.1 shows the national decrease in forest cover by province. As can be seen, Zambia's forests accounted for a little over 80percent of the total land area by 1975. In Lusaka and Eastern provinces, almost 90percent of the total land areas in those provinces were covered with forests. Ten years later, the forest cover in the country had decreased by 1.2percent. In 1996 however, the forest cover increased by one percent countrywide. A 13percent decrease in forest cover can be observed between 1996 and 2003. Forests presently cover about 58percent of the total land area.

**Figure 6.1: Percentage Change in Total Forest cover by Provice,Zambia 1975 to 2003**




| | Central | Copperbelt | Southern | Western | Lusaka | Northern | Luapula | Eastern | Nwestern | National |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 83 | 84 | 77 | 75 | 94 | 83 | 70 | 96 | 81 | 81 |
| 1985 | 78 | 70 | 72 | 74 | 77 | 80 | 66 | 91 | 79 | 77 |
| 1996 | 80 | 77 | 78 | 78 | 80 | 81 | 89 | 84 | 71 | 79 |
| 2003 | 58 | 52 | 53 | 50 | 58 | 54 | 54 | 54 | 54 | 54 |

Province

Source: *Forest Department*

### 6.4. Responses to Wood Fuel Usage

Although there is no direct policy dealing with this sub sector, there are other regulatory policy statements handling the use and protection of forests in terms of wood fuel, notably in the: 1994 Energy Policy and the Forestry Policy respectively.

The 1994 Energy Policy, which is currently under review, aims to:

- Ensure management and sustainability of the forest resources for wood fuel harvesting.
- Improve the technology of charcoal production and utilization
- Minimize seasonal fluctuations in the supply of charcoal to urban areas
- Improve revenue collection from the wood fuel industry
- Support efforts aimed at finding alternative to wood fuel in order to achieve higher living standards.

The 1998 Forest Policy has the following provisions on biomass resources and energy:

- To ensure the integrity, productivity and the development of potential forest reserves
- To ensure protection of forests by empowering local communities and promoting the development and use of forest and non-wood forest products.
- To ensure sustainable management of forest resources for wood fuel production
- To regulate exploitation and ensure efficient use of forest resources and products

# 7 RENEWABLE ENERGY SOURCES

## 7.0. Introduction

Renewable sources of energy that are available in Zambia and have the potential to be exploited on a wider scale are solar energy, wind energy and biogas. The Government adopted the National Energy Policy in 1994 to guide the development of the country's energy sector. One of the objectives of this policy is to encourage the use of renewable energy sources.

## 7.1. Stocks and Inventories

### 7.1.1. Solar Energy

The Meteorological Department gathers data on solar energy from 8 stations that are spread across the country. Data shows that the sunshine hours range between 2600 – 3000 hours per year and the annual solar isolation is about 5.6 kilowatt hours per square meter (kWh/sq.m) per day. The energy from the sun is at its peak between October and November.

**Table 7.1: Average Annual Isolation by Location**

| Location | Global Radiation/day (KWh/sq.m) | Sunshine hours/year |
|---|---|---|
| Livingstone | 8.9 | 3,249 |
| Kasama | 7.9 | 2,884 |
| Chipata | 7.6 | 2,774 |
| Mongu | 8.8 | 3,212 |
| Solwezi | 7.6 | 2,774 |
| Ndola | 8.0 | 2,920 |
| Mansa | 6.4 | 2,336 |
| Lusaka | 8.2 | 2,993 |
| Kabwe | 8.8 | 3,212 |

Source: *Zambia Metrological Department*

Solar energy is well distributed across the country. With over half of Zambia's population living in rural areas, this energy is especially advantageous as the conventional sources of energy particularly grid electricity is expensive and difficult to supply.

Solar photovoltaics (PVs) provide suitable alternative electricity for heating, lighting, refrigeration etc in rural areas. However, despite the abundance of solar energy the relatively high initial cost of installation is a barrier to the widespread use of this technology. MEWD through the Department of Energy has embarked on a project, the Solar Energy Project to provide electricity to rural institutions for educational and medical purposes etc. (Prof. Chidumayo, 2005). The project is funded by SIDA and so far a total of four hundred systems have been installed and distributed as follows; 150 in Chipata, 150 in Lundazi and 100 in Nyimba.

### 7.1.2. Wind Energy

The Metrological Department also collects data on wind. Wind data is recorded at 10m heights above the ground and wind speeds vary between 0.1 and 3.5 metres per second (m/s). The annual average is 2.5m/s. The use of wind energy in Zambia is basically limited to water pumping and little has been done to develop this technology further. However, recent developments provide great opportunities of exploiting this source of energy. Table 7.2 shows the annual average wind spread at selected locations.

**Table 7.2: Annual Average Wind Speed and Range**

| Location | Annual Average Wind Speed (M/S) | Range Between Different Months (M/S) |
|---|---|---|
| Lusaka | 3.50 | 2.00 – 4.00 |
| Ndola | 2.30 | 1.60 – 3.45 |
| Kasama | 2.50 | 1.95 – 3.60 |
| Chipata | 2.30 | 1.50 – 3.30 |
| Mansa | 1.90 | 1.15 – 3.45 |
| Livingstone | 1.60 | 1.40 – 2.15 |
| Kabwe | 2.70 | 1.85 – 3.65 |

Source: *State of Environment in Zambia 2000*

### 7.1.3. Biogas

Biogas is a fuel that is produced by means of a process of microbiological breakdown of human and animal waste. It is a well-established fuel for cooking in a number of countries such as China and India. In Zambia, the production and use of biogas is relatively new and is being spearheaded by the National Institute for Scientific and Industrial Research (NISIR). The Institute currently runs biogas digesters that use animal waste for cooking purposes in the following areas: Lusaka, Monze, Kasisi, Lealui, Pemba, Chisamba, Maamba, Mukondi and Kabwe.

### 7.1.4. Geothermal Energy

Zambia has more than eighty (80) hot springs. These hot springs are associated with zones of major deep-seated fault and fracture. Water of mainly meteoric origin circulates to great heights and is heated through normal geothermal gradients. Some identified hot springs have not been analyzed in detail. However, interpretations of geochemical data and estimation of subterranean temperature for some of them leads to the existence of worthwhile and potentially exploitable low energy geothermal reserves in most parts of the country.

The earliest publications on Zambian hot springs date as far as 1889. From the 1950's, a number of institutions and individuals have investigated the occurrence of hot springs to various degrees. The Geological Survey of Zambia and the Department of Water Affairs have been among the institutions.

However, little has been done to utilize the hot springs efficiently for industrial and energy purposes. The hot springs are divided into seven (7) geographical groups namely Northern, Western, South –Eastern Luangwa, Choma, Lochinvar, Eastern Luangwa, Mansa and Copperbelt. Table 7.3 provides a summary of geothermal potential sites according to the geographical groups.

**Table 7.3: Possible Geothermal Sites**

| Northern | Western | Eastern | South/Eastern |
|---|---|---|---|
| Kapisya | Lupiamanzi | Chongo | Chinyunyu |
| Kaputa | Lubungu | Nabwalya South | Mafwasa |
| | | Musaope | Chitopolo |
| | | Chikoa | Kampoko |

Source: *Rural Electrification Working Group Report, 2003*

Currently, there is no electricity generation at the identified geothermal sites. There was an initiative with support of the Italian Government in the mid 1980's; Kapisya was developed to the extent that 2 x 120 KW turbines were installed in 1987. The Kapisya installation has never been loaded due to the absence of an infrastructure to provide electricity to the local community.

## 7.2. Social and Economic Activities and Natural Events

### 7.2.1. Solar Energy

One of the positive developments noted with regard to solar energy is the rise in the number of private companies performing a number of services in the solar industry. These services include manufacturing, designing, supply and installation of solar equipment.

### 7.2.2. Biogas

Biogas has great potential especially in areas of high livestock population. It is used for applications in small and medium enterprises. Examples of such enterprises are beer brewing, traditional beverages, space heating for chicks and piglets, small bakeries, firing of pottery products and water heating for utensils used in milk processing.

## 7.3. Environmental Impacts

### 7.3.1. Solar and Wind Energy

The use of solar and wind energy sources does not produce direct emissions into the environment and therefore these sources of energy are not only renewable but are also environmental friendly.

### 7.3.2. Biogas

The operation of biogas digesters/plants poses some potential environmental problems but these can be minimised with proper planning and operation. Biogas composition should be tested and precautions should be taken to prevent leaks and losses. Since biogas is usually odourless and thus difficult to detect surveillance is important as leaking gas could lead to explosion or asphyxiation.

## 7.4. Responses

The Energy Policy recognizes the potential role of Renewable Energy Sources (RES) can play in the energy balance of the country and the constraints to its wider use. It provides for the following:

- Promotion of RES technology
- Promotion of the wider application of RES technology
- Promotion of information dissemination on the use of RES, and
- Promotion of education, research and training in RES at various levels.

In the year 2003, Parliament passed the Rural Electrification Act No. 20. The Act provides for the formation of the Rural Electrification Authority (REA), which would be responsible for implementation as well as mobilization of funds from all possible sources to accelerate the rural electrification programme in the country. One of the functions of the Authority shall be to promote the use of alternative renewable energy sources such as solar power to supply energy to the rural areas.

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# *Appendices*

## APPENDIX 1: LIST OF PERSONNEL INVOLVED IN THE REPORT WRITING

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### REPORT FORMATTING AND ILLUSTRATIONS

| | | |
|---|---|---|
| Mr. Perry Musenge | - | Desktop Publishing Officer |

## Appendix 2: Change in forest area by province and total Zambia

| Province | Forest area HA | | | | |
|---|---|---|---|---|---|
| | Total land Area | 1975 | 1985 | 1996 | 2003 |
| Central | 9,439,448 | 7,829,000 | 7,371,000 | 7,540,000 | 5,430,000 |
| Copperbelt | 3,101,400 | 2,603,000 | 2,163,000 | 2,400,000 | 1,600,000 |
| Southern | 8,528,293 | 6,603,000 | 6,155,000 | 6,640,000 | 4,550,000 |
| Western | 1,263,8595 | 9,539,000 | 9,349,000 | 9,900,000 | 6,267,275 |
| Lusaka | 2,189,571 | 2,065,000 | 1,687,000 | 1,750,000 | 1,280,000 |
| Northern | 14,782,582 | 1,205,000 | 11,843,000 | 11,940,000 | 8,000,333 |
| Luapula | 5,056,681 | 3,523,000 | 3,353,000 | 4,520,000 | 2,736,676 |
| Eastern | 6,910,590 | 6,617,000 | 6,293000 | 5,830,000 | 3,740,011 |
| Nwestern | 12,61,4091 | 10,220,000 | 10,020,000 | 9,000,000 | 6,826,746 |

## Appendix 3: Final Energy consumption By Source, Sector and Year in Tonnes Oil Equivalent ('000) TOE

| Sector | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 4.7 | 4.7 | 5.2 | 5.0 | 5.2 | 5.2 | 5.3 | 5.5 | 5.6 | 5.8 | 5.7 | 5.7 | 5.6 | 6.0 |
| Commerce & Industry | 20.2 | 20.7 | 21.4 | 20.1 | 18.4 | 17.0 | 16.8 | 17.4 | 15.0 | 16.4 | 17.0 | 17.3 | 16.9 | 17.4 |
| Government/Services | 3.6 | 2.8 | 2.5 | 2.6 | 3.0 | 3.8 | 3.1 | 5.3 | 2.0 | 2.1 | 2.3 | 1.6 | 2.5 | 2.7 |
| Households | 116.0 | 119.2 | 122.0 | 125.6 | 129.1 | 128.6 | 136.5 | 139.7 | 166.1 | 146.6 | 150.0 | 155.5 | 162.2 | 170.9 |
| Mining | 28.4 | 27.9 | 27.9 | 28.5 | 23.6 | 23.7 | 23.2 | 24.3 | 24.1 | 20.1 | 20.9 | 19.7 | 16.4 | 2.7 |
| Transport | 13.6 | 15.0 | 14.5 | 10.6 | 12.7 | 13.3 | 15.1 | 7.1 | 10.0 | 8.2 | 9.6 | 9.4 | 9.7 | 9.3 |
| **Total** | **186.4** | **190.2** | **193.5** | **192.2** | **192.1** | **191.6** | **199.9** | **199.3** | **222.8** | **199.3** | **205.5** | **209.2** | 213.3 | 208.9 |

| 1986 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | | | 15.3 | | 0.3 | - | | 8.4 | | 203.3 | |
| Commerce & Industry | | | 27.1 | | 3.2 | 18.6 | 2.3 | 76.6 | 141.5 | 203.3 | 13.5 |
| Government/Services | | | | | 0.3 | 6.0 | | 26.6 | 16.1 | | |
| Households | | | | | 15.9 | | | 42.8 | | 1,908.3 | 548.0 |
| Mining | 1.6 | 1.3 | 71.5 | | 6.1 | 61.8 | | 398.9 | 181.2 | 0.3 | 2.3 |
| Transport | 78.3 | 17.7 | 137.5 | 39.8 | 0.4 | | | | | | |
| **Total** | **79.9** | **19.0** | **251.4** | **39.8** | **26.2** | **86.4** | **2.3** | **553.3** | **338.8** | **2,315.2** | **563.8** |

- Prior to 1986 sectoral breakdown of consumption was not available

| 1987 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | | | 14.9 | | 0.3 | | | 12.8 | | 162.2 | |
| Commerce & Industry | | | 34.5 | | 3.2 | 19.5 | 2.0 | 67.9 | 165.7 | 213.4 | 14.2 |
| Government/Services | | | | | - | 1.1 | | 29.0 | 15.2 | | |
| Households | | | | | 18.9 | | | 46.1 | | 1,962.6 | 567.8 |
| Mining | 1.6 | 1.1 | 76.2 | | 9.5 | 65.4 | | 404.6 | 105.9 | 0.3 | 1.9 |
| Transport | 89.8 | 18.6 | 141.5 | 46.5 | 0.4 | | | | | | |
| **Total** | **91.4** | **19.7** | **267.1** | **46.5** | **32.3** | **86.0** | **2.0** | **560.4** | **286.8** | **2,338.5** | **583.9** |

| 1988 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | | | 12.9 | | 0.6 | | | 10.1 | | 129.4 | |
| Commerce & Industry | | | 40.1 | | 18.1 | 12.1 | 1.5 | 79.0 | 194.7 | 224.1 | 19.1 |
| Government/Services | | | | | 0.1 | | | 63.1 | 29.5 | | |
| Households | | | | | 25.6 | | | 60.0 | | 2,050.0 | 429.9 |
| Mining | 1.8 | 1.0 | 66.0 | | 11.3 | 65.1 | | 396.7 | 102.5 | 0.3 | 1.6 |
| Transport | 110.4 | 17.6 | 161.1 | 18.6 | 0.5 | | | 1.1 | | | |
| **Total** | **112.2** | **18.6** | **280.1** | **18.6** | **56.2** | **77.2** | **1.5** | **610.0** | **326.7** | **2,403.8** | **450.7** |

| 1989 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 2.0 | 0.4 | 20.7 | | 2.4 | | | 15.9 | | 103.3 | |
| Commerce & Industry | 31.2 | 7.2 | 90.7 | | 11.1 | 4.1 | 0.2 | 48.7 | 106.2 | 235.3 | 20.2 |
| Government/Services | 7.8 | 5.0 | 12.3 | | 0.1 | 0.3 | | 39.5 | 27.1 | | |
| Households | | | | | 25.6 | | | 42.5 | | 2,109.1 | 445.4 |
| Mining | 2.2 | 0.8 | 90.6 | | 11.3 | 74.8 | | 377.1 | 171.0 | 0.3 | 1.4 |
| Transport | 82.4 | 15.3 | 147.5 | 52.0 | 0.2 | | | 0.8 | | | |
| **Total** | **125.6** | **28.7** | **361.8** | **52.0** | **50.7** | **79.2** | **0.2** | **524.5** | **304.3** | **2,448.0** | **466.9** |

## Final Energy Consumption by Source, Sector and year in Tonnes of Oil Equivalent ('000) TOE – continued

| 1990 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 1.1 | 1.4 | 9.0 | 0.4 | 0.1 | | | 15.38 | | 82.5 | |
| Commerce & Industry | 6.8 | 1.2 | 36.7 | | 2.3 | 10.0 | 3.8 | 53.18 | 89.45 | 247.1 | 21.2 |
| Government/Services | 6.7 | 3.4 | 11.3 | | 0.1 | 0.7 | 0.1 | 40.12 | 22.71 | | |
| Households | | | | | 34.0 | | | 49.92 | | 2,169.8 | 459.7 |
| Mining | 2.3 | 0.3 | 78.0 | | 8.5 | 74.8 | | 367.05 | 131.31 | 0.1 | 1.2 |
| Transport | 83.8 | 18.5 | 153.6 | 57.0 | 0.2 | 4.6 | | 0.86 | | | |
| **Total** | **100.7** | **24.9** | **288.6** | **57.4** | **45.2** | **90.1** | **3.9** | **526.5** | **243.5** | **2,499.5** | **482.1** |

| 1991 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 1.0 | - | 7.5 | - | - | - | - | 16.15 | - | 85.60 | - |
| Commerce & Industry | 7.6 | 3.0 | 34.2 | - | 1.2 | 12.1 | - | 53.44 | 106.00 | 245.11 | 20.93 |
| Government/Services | 7.0 | 0.6 | 10.7 | - | 0.1 | - | - | 40.90 | 5.61 | | |
| Households | - | - | - | - | 28.0 | - | - | 51.47 | - | 2232.3699 | 477.80 |
| Mining | 2.6 | 0.1 | 76.3 | - | 7.4 | 80.6 | 2.4 | 354.50 | 127.85 | 0.07 | 1.17 |
| Transport | 112.4 | 24.3 | 185.4 | 26.9 | - | - | - | 0.86 | - | - | - |
| **Total** | **130.6** | **28.0** | **314.1** | **26.9** | **36.7** | **92.7** | **2.4** | **517.3** | **239.5** | **2,563.2** | **499.9** |

| 1992 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 1.1 | - | 11.5 | - | 0.1 | - | - | 21.05 | - | 88.86 | |
| Commerce & Industry | 8.0 | 1.4 | 39.6 | - | 3.3 | 11.8 | - | 53.87 | 118.65 | 243.15 | 20.77 |
| Government/Services | 7.4 | 0.6 | 10.0 | - | - | 0.2 | - | 33.16 | 6.98 | | |
| Households | - | - | - | - | 21.0 | - | - | 52.93 | - | 2,296.74 | 484.95 |
| Mining | 2.7 | - | 80.7 | - | 5.4 | 83.4 | 3.0 | 367.22 | 108.11 | 0.07 | 1.17 |
| Transport | 113.6 | 15.8 | 177.5 | 30.5 | - | - | - | 1.20 | - | - | - |
| **Total** | **132.8** | **17.8** | **319.3** | **30.5** | **29.8** | **95.4** | **3.0** | **529.4** | **233.7** | **2,628.8** | **506.9** |

| 1993 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Avgas | Kerosine | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 2.7 | | 7.3 | | 0.6 | | | 13.75 | | 92.3 | |
| Commerce & Industry | 6.6 | | 37.1 | | 2.1 | 5.5 | 0.3 | 50.69 | 105.10 | 241.2 | 20.6 |
| Government/Services | 5.6 | | 7.6 | 0.2 | 0.3 | 1.8 | | 39.78 | 4.53 | | |
| Households | | | | | 19.2 | | | 63.58 | | 2,363.0 | 492.2 |
| Mining | 2.5 | | 78.6 | | 1.6 | 85.6 | 1.4 | 375.04 | 119.92 | 0.1 | 1.2 |
| Transport | 96.7 | | 122.5 | 28.8 | | | | 1.03 | | | |
| **Total** | **114.1** | **-** | **253.1** | **29.0** | **23.8** | **92.9** | **1.7** | **543.9** | **229.5** | **2,696.5** | **514.0** |

| 1994 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.8 | 7.5 | | 0.4 | | | 17.61 | | 95.85 | | 122.2 |
| Commerce & Industry | 6.0 | 31.8 | | 1.4 | 0.5 | 1.3 | 50.26 | 80.52 | 239.23 | 20.46 | 431.5 |
| Government/Services | 5.5 | 11.7 | 0.2 | 0.2 | 4.5 | 0.3 | 40.73 | 7.18 | | | 70.3 |
| Households | | | | 18.5 | | | 70.63 | | 2431.10 | 499.58 | 3,019.8 |
| Mining | 1.2 | 65.1 | | 1.5 | 87.3 | | 371.86 | 24.36 | 0.04 | 1.09 | 552.4 |
| Transport | 123.4 | 145.8 | 28.1 | | | | 0.69 | | | | 298.0 |
| **Total** | **136.9** | **261.9** | **28.3** | **22.0** | **92.3** | **1.6** | **551.8** | **112.1** | **2,766.2** | **521.1** | **4,494.2** |

| 1995 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.6 | 7.5 | | 0.1 | | | 16.67 | | 95.85 | | 120.7 |
| Commerce & Industry | 15.3 | 29.7 | | 1.4 | 7.7 | 1.1 | 42.19 | 39.64 | 239.23 | 20.46 | 396.7 |
| Government/Services | 4.5 | 7.7 | - | 0.5 | - | 0.2 | 45.28 | 31.51 | | | 89.7 |
| Households | | | | 19.7 | | | 86.18 | | 2404.39 | 499.58 | 3,009.8 |
| Mining | 1.1 | 69.6 | | 5.6 | 89.3 | | 358.02 | 30.49 | 0.04 | 1.09 | 555.2 |
| Transport | 124.3 | 159.9 | 27.1 | | | | 0.95 | | | | 312.2 |
| **Total** | **145.8** | **274.4** | **27.1** | **27.3** | **97.0** | **1.3** | **549.3** | **101.6** | **2,739.5** | **521.1** | **4,484.5** |

## Final Energy Consumption by Source, Sector and year in Tonnes of Oil Equivalent ('000) TOE - continued

| 1996 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.5 | 8.2 | | 0.1 | | | 15.38 | | 99.40 | | 123.6 |
| Commerce & Industry | 8.2 | 29.4 | | 1.1 | 2.5 | 0.9 | 37.12 | 55.74 | 237.27 | 20.31 | 392.5 |
| Government/Services | 3.0 | 3.5 | | - | - | | 39.09 | 26.82 | | | 72.4 |
| Households | | | | 13.5 | | | 90.47 | | 2573.33 | 516.23 | 3,193.5 |
| Mining | 1.1 | 63.1 | | 6.8 | 70.4 | | 361.12 | 39.34 | 0.07 | 1.09 | 543.0 |
| Transport | 113.8 | 213.6 | 25.4 | | | | 0.69 | | | | 353.5 |
| **Total** | **126.6** | **317.8** | **25.4** | **21.5** | **72.9** | **0.9** | **543.9** | **121.9** | **2,910.1** | **537.6** | **4,678.6** |

| 1997 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 1.0 | 9.6 | | 0.2 | 0.3 | | 11.68 | | 105.13 | | 127.9 |
| Commerce & Industry | 5.8 | 35.5 | | 1.3 | 16.9 | 27.8 | 20.19 | 39.67 | 240.01 | 21.01 | 408.2 |
| Government/Services | 41.0 | 31.9 | | 7.5 | 0.3 | | 38.66 | 5.67 | | | 125.0 |
| Households | | | | 10.1 | | | 96.83 | | 2625.01 | 536.93 | 3,268.9 |
| Mining | 1.5 | 58.9 | | 7.8 | 50.7 | | 351.84 | 96.35 | 0.07 | 1.09 | 568.3 |
| Transport | 61.0 | 74.5 | 28.2 | 0.5 | 1.2 | | 0.60 | | | | 166.0 |
| **Total** | **110.3** | **210.4** | **28.2** | **27.4** | **69.4** | **27.8** | **519.8** | **141.7** | **2,970.2** | **559.0** | **4,664.3** |

| 1998 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 1.7 | 10.1 | 0.8 | 0.3 | 0.3 | | 11.00 | | 107.21 | | 131.4 |
| Commerce & Industry | 4.7 | 29.5 | | 0.8 | 4.1 | 1.3 | 18.90 | 24.01 | 244.78 | 21.86 | 350.0 |
| Government/Services | 2.0 | 3.0 | | 0.1 | | | 36.26 | 5.34 | | | 46.7 |
| Households | | | | 20.7 | | | 90.73 | | 2677.69 | 1096.88 | 3,886.0 |
| Mining | 1.1 | 48.6 | | 7.8 | 65.6 | 7.0 | 329.58 | 104.06 | 0.07 | 1.09 | 564.9 |
| Transport | 103.2 | 98.5 | 29.2 | 0.6 | 1.0 | 0.3 | 0.60 | | | | 233.4 |
| **Total** | **112.7** | **189.7** | **30.0** | **30.3** | **71.0** | **8.6** | **487.1** | **133.4** | **3,029.8** | **1,119.8** | **5,212.4** |

| 1999 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.9 | 11.2 | 2.8 | 0.2 | - | - | 11.34 | - | 109.72 | - | 136.2 |
| Commerce & Industry | 5.6 | 28.2 | - | 1.1 | 4.6 | 3.4 | 19.50 | 48.34 | 250.44 | 23.73 | 384.9 |
| Government/Services | 1.8 | 2.4 | - | - | - | 0.3 | 37.37 | 7.15 | - | - | 49.0 |
| Households | - | - | - | 17.2 | - | - | 93.57 | | 2739.21 | 580.50 | 3,430.5 |
| Mining | 1.0 | 42.1 | - | 2.7 | 41.4 | - | 340.24 | 42.23 | 0.07 | 1.09 | 470.8 |
| Transport | 89.3 | 81.0 | 20.3 | 0.2 | - | - | 1.20 | - | - | - | 192.0 |
| **Total** | **97.7** | **153.7** | **20.3** | **21.2** | **46.0** | **3.7** | **491.9** | **97.7** | **2,989.7** | **605.3** | **4,527.2** |

| 2000 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.7 | 9.0 | - | 0.7 | - | - | 11.86 | - | 111.90 | - | 134.2 |
| Commerce & Industry | 7.1 | 37.1 | - | 3.6 | 1.1 | - | 20.45 | 48.34 | 255.44 | 24.12 | 397.2 |
| Government/Services | 2.9 | 2.1 | - | 0.1 | - | - | 39.18 | 8.90 | - | - | 53.2 |
| Households | - | - | - | 13.5 | - | - | 98.12 | | 2794.03 | 604.63 | 3,510.3 |
| Mining | 0.8 | 38.2 | - | 3.0 | 47.4 | - | 356.65 | 42.23 | 0.07 | 1.07 | 489.4 |
| Transport | 95.3 | 94.9 | 32.9 | 1.0 | - | - | 1.29 | - | - | - | 225.4 |
| **Total** | **106.1** | **172.3** | **32.9** | **21.2** | **48.5** | **-** | **515.7** | **99.5** | **3,049.5** | **629.8** | **4,675.5** |

| 2001 | Premium Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 3.40 | 9.70 | | 0.60 | 0.20 | | 6.27 | | 114.16 | - | 134.33 |
| Commerce & Industry | 8.30 | 41.80 | - | 1.90 | 1.00 | - | 22.34 | 43.30 | 260.58 | 25.08 | 404.30 |
| Government/Services | 2.40 | 1.90 | - | 0.10 | - | - | 24.74 | 7.97 | - | - | 37.11 |
| Households | | | | 14.60 | | | 146.32 | | 2,849.85 | 628.76 | 3,639.53 |
| Mining | - | 37.60 | - | 3.00 | 77.00 | - | 304.24 | 37.83 | 0.07 | 1.11 | 460.86 |
| Transport | 91.80 | 92.40 | 33.20 | 0.90 | | | 0.52 | | | | 218.82 |
| **Total** | **105.90** | **183.40** | **33.20** | **21.10** | **78.20** | **-** | **504.43** | **89.10** | **3,224.67** | **654.96** | **4,894.95** |

**Final Energy Consumption by Source, Sector and year in Tonnes of Oil Equivalent ('000) TOE - continued**

| 2002 | Leaded & Unleaded Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.45 | 8.95 | - | 0.15 | 0.49 | 0.01 | 5.58 | | 115.12 | - | 130.75 |
| Commerce & Industry | 4.71 | 34.11 | 4.33 | 1.05 | 2.17 | 0.02 | 15.29 | 39.57 | 263.79 | 30.34 | 395.38 |
| Government/Services | 2.17 | 3.13 | - | 0.00 | 0.10 | 0.00 | 36.34 | 17.62 | | | 59.38 |
| Households | - | - | - | - | - | - | 130.25 | | 2,910.15 | 754.48 | 3,794.89 |
| Mining | 0.69 | 49.74 | - | 0.01 | 6.40 | 0.10 | 317.21 | 8.48 | 0.07 | 1.10 | 383.80 |
| Transport | 96.04 | 99.34 | 21.35 | 8.04 | 2.26 | 0.02 | 0.43 | | | | 227.48 |
| Total | 104.05 | 195.27 | 25.68 | 9.25 | 11.43 | 0.15 | 505.12 | 65.67 | 3,289.13 | 785.92 | 4,860.93 |

| 2003 | Leaded & Unleaded Petrol | Diesel/ L.S.G | Jet A1/ Avgas | Kerosene | Fuel Oil | L.P.G. | Electricity | Coal | Firewood | Charcoal | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture & Forestry | 0.43 | 11.41 | 0.16 | 0.55 | 0.38 | - | 9.04 | | 117.42 | - | 139.39 |
| Commerce & Industry | 7.86 | 34.19 | 0.93 | 3.33 | 2.36 | 0.42 | 25.27 | 28.23 | 269.06 | 35.78 | 407.44 |
| Government/Services | 2.43 | 3.13 | 0.02 | 0.01 | 0.08 | - | 38.13 | 18.72 | | | 62.52 |
| Households | - | - | - | - | - | - | 146.01 | | 2,968.36 | 885.24 | 3,999.61 |
| Mining | 0.60 | 51.63 | 0.94 | 0.81 | 3.79 | 0.10 | 1.99 | 1.66 | 0.07 | 1.11 | 62.70 |
| Transport | 104.85 | 100.05 | 0.25 | 9.08 | 1.97 | 0.09 | 0.35 | | | | 216.63 |
| **Total** | **116.17** | **200.41** | **2.29** | **13.78** | **8.58** | **0.60** | **220.79** | **48.62** | **3,354.91** | **922.13** | **4,748.89** |

## Appendix 4: Refinery Outputs by Fuels (Tonnes)

| Year | LPG Liquified Petroleum Gas | Gasolines (Premium) | Kerosenes | Gas Oils | Fuel Oils (Diesel) | Bitumens | Total |
|---|---|---|---|---|---|---|---|
| 1973 | 6,000 | 147,000 | 50,000 | 274,000 | 149,200 | 5,800 | 632,000 |
| 1974 | 6,000 | 175,000 | 57,000 | 341,000 | 176,600 | 5,400 | 761,000 |
| 1975 | 8,500 | 172,000 | 61,000 | 317,000 | 179,500 | 7,500 | 745,500 |
| 1976 | 8,000 | 183,000 | 77,000 | 366,000 | 180,600 | 8,400 | 823,000 |
| 1977 | 10,000 | 162,000 | 84,000 | 315,000 | 178,100 | 7,900 | 757,000 |
| 1978 | 6,000 | 148,000 | 81,000 | 305,000 | 175,300 | 5,700 | 721,000 |
| 1979 | 2,400 | 129,600 | 98,000 | 295,000 | 166,900 | 8,100 | 700,000 |
| 1980 | 2,400 | 112,500 | 97,000 | 309,400 | 171,500 | 8,700 | 701,500 |
| 1981 | 3,400 | 133,700 | 98,400 | 287,800 | 163,000 | 13,900 | 700,200 |
| 1982 | 7,000 | 108,500 | 84,700 | 277,600 | 110,000 | 12,100 | 599,900 |
| 1983 | 7,400 | 136,100 | 95,600 | 251,500 | 125,000 | 14,700 | 630,300 |
| 1984 | 6,200 | 117,400 | 71,600 | 228,600 | 116,100 | 15,100 | 555,000 |
| 1985 | 6,500 | 107,200 | 62,200 | 215,000 | 96,900 | 15,300 | 503,100 |
| 1986 | 5,196 | 108,037 | 76,407 | 278,506 | 93,715 | 16,400 | 578,261 |
| 1987 | 6,639 | 114,656 | 85,353 | 273,528 | 92,339 | 15,243 | 587,758 |
| 1988 | 7,216 | 135,371 | 106,689 | 288,135 | 85,166 | 13,516 | 636,093 |
| 1989 | 3,800 | 145,000 | 109,800 | 277,600 | 93,600 | 10,700 | 640,500 |
| 1990 | 3,870 | 129,866 | 76,679 | 235,559 | 145,044 | 5,922 | 596,940 |
| 1991 | 3,683 | 117,929 | 66,427 | 277,465 | 42,292 | 4,595 | 512,391 |
| 1992 | 2,952 | 119,431 | 48,959 | 258,983 | 137,341 | 5,228 | 572,894 |
| 1993 | 2,665 | 106,592 | 58,214 | 236,167 | 82,964 | 6,485 | 493,087 |
| 1994 | 2,072 | 128,314 | 43,431 | 233,364 | 49,782 | 7,180 | 464,143 |
| 1995 | 1,859 | 95,642 | 41,514 | 180,762 | 85,099 | 3,974 | 408,850 |
| 1996 | 1,777 | 92,796 | 41,288 | 202,841 | 49,205 | 3,642 | 391,549 |
| 1997 | 1,683 | 102,933 | 45,218 | 160,854 | 68,284 | 4,186 | 383,158 |
| 1998 | 4,296 | 121,361 | 54,812 | 199,355 | 96,171 | 5,249 | 481,244 |
| 1999 | 2,881 | 49,523 | 19,018 | 71,968 | 36,371 | 1,739 | 181,500 |
| 2000 | 0 | 2,323 | 487 | 7,218 | 3,611 | 0 | 13,639 |
| 2001 | 1,021 | 45,328 | 5,278 | 85,603 | 53,982 | 1,406 | 192,618 |
| 2002 | 2,058 | 90,281 | 8,159 | 124,820 | 55,758 | 33 | 281,043 |
| 2003 | 2,925 | 125,073 | 27,219 | 174,786 | 75,082 | 21 | 405,064 |
| 2004 | 4,408 | 119,057 | 31,815 | 196,884 | 58,797 | 1,358 | 412,319 |
| 2005 Jan-Oct | 2,290 | 71,101 | 21,672 | 154,880 | 33,498 | 1,869 | 285,310 |

Source: INDENI

## Appendix 5: Carbon Dioxide Emissions by Sector, Source and Year in Metric Tonnes

| 1990 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 7,259 | 23,229 | 29,327 | - | 7,550 | 297,045 | **364,701** |
| Diesel/ L.S.G. | 27,943 | 113,946 | 35,084 | - | 242,174 | 476,896 | **896,042** |
| Jet A1/ Avgas | 1,400 | - | - | - | - | 199,547 | **200,948** |
| Kerosene | 350 | 8,052 | 350 | 119,028 | 29,757 | 700 | **158,238** |
| Fuel Oil | - | 31,048 | 2,173 | - | 232,238 | 14,282 | **279,742** |
| L.P.G. | - | 10,986 | 289 | - | - | - | **11,275** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 345,005 | 87,504 | - | 506,135 | - | 938,644 |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **36,953** | **532,266** | **154,728** | **119,028** | **1,017,854** | **988,471** | 2,849,589 |

| 1991 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2,904 | 30,779 | 22,068 | - | 7,840 | 396,932 | **460,522** |
| Diesel/ L.S.G. | 23,286 | 106,184 | 33,221 | - | 236,895 | 575,628 | **975,215** |
| Jet A1/ Avgas | - | - | - | - | - | 94,172 | **94,172** |
| Kerosene | - | 4,201 | 350 | 98,023 | 25,906 | - | **128,480** |
| Fuel Oil | - | 37,568 | - | - | 250,246 | - | **287,814** |
| L.P.G. | - | - | - | - | 6,939 | - | **6,939** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 408,609 | 21,587 | - | 492,643 | - | **923,225** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **26,190** | **587,340** | **77,226** | **98,023** | **1,020,470** | **1,066,732** | **2,876,367** |

| 1992 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 3,194 | 27,294 | 23,229 | - | 7,840 | 375,735 | **437,293** |
| Diesel/ L.S.G. | 35,705 | 122,950 | 31,048 | - | 250,557 | 551,100 | **991,359** |
| Jet A1/ Avgas | - | - | - | - | - | 106,775 | **106,775** |
| Kerosene | 350 | 11,553 | - | 73,517 | 18,904 | - | **104,675** |
| Fuel Oil | - | 36,637 | 621 | - | 258,939 | - | **296,197** |
| L.P.G. | - | - | - | - | 8,673 | - | **8,673** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 457,179 | 26,984 | - | 416,704 | - | **900,867** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **39,249** | **655,613** | **81,882** | **73,517** | **961,618** | **1,033,610** | **2,845,839** |

| 1993 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 7,840 | 19,164 | 16,261 | - | 7,259 | 280,785 | **331,309** |
| Diesel/ L.S.G. | 22,665 | 115,188 | 23,596 | - | 244,036 | 380,337 | **785,822** |
| Jet A1/ Avgas | - | - | 700 | - | - | 100,824 | **101,524** |
| Kerosene | 2,100 | 7,352 | 1,050 | 67,216 | 5,601 | - | **83,320** |
| Fuel Oil | - | 17,076 | 5,589 | - | 265,770 | - | **288,435** |
| L.P.G. | - | 867 | - | - | 4,048 | - | **4,915** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 405,139 | 17,347 | - | 462,191 | - | **884,677** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **32,605** | **564,787** | **64,543** | **67,216** | **988,905** | **761,946** | **2,480,001** |

**Carbon Dioxide Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 1994 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2,323 | 17,422 | 15,970 | - | 3,484 | 358,313 | **397,512** |
| Diesel/ L.S.G. | 23,286 | 98,732 | 36,326 | - | 202,122 | 452,678 | **813,145** |
| Jet A1/ Avgas | - | - | 700 | - | - | 98,373 | **99,073** |
| Kerosene | 1,400 | 4,901 | 700 | 64,765 | 5,251 | - | **77,018** |
| Fuel Oil | - | 1,552 | 13,972 | - | 271,048 | - | **286,572** |
| L.P.G. | - | 3,758 | 867 | - | - | - | **4,626** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 310,311 | 27,755 | - | 94,057 | - | **432,123** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **27,009** | **436,678** | **96,290** | **64,765** | **575,963** | **909,365** | **2,110,070** |

| 1995 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 1,742 | 44,426 | 13,067 | - | 3,194 | 360,926 | **423,355** |
| Diesel/ L.S.G. | 23,286 | 92,212 | 23,907 | - | 216,093 | 496,456 | **851,954** |
| Jet A1/ Avgas | - | - | - | - | - | 94,872 | **94,872** |
| Kerosene | 350 | 4,901 | 1,750 | 68,966 | 19,605 | - | **95,573** |
| Fuel Oil | - | 23,907 | - | - | 277,258 | - | **301,165** |
| L.P.G. | - | 3,180 | 578 | - | - | - | **3,758** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 143,013 | 112,946 | - | 112,175 | - | **368,133** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **25,378** | **311,640** | **152,248** | **68,966** | **628,324** | **952,255** | **2,138,811** |

| 1996 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 1,452 | 23,810 | 8,711 | - | 3,194 | 330,438 | **367,895** |
| Diesel/ L.S.G. | 25,459 | 91,281 | 10,867 | - | 195,912 | 663,183 | **987,013** |
| Jet A1/ Avgas | - | - | - | - | - | 88,921 | **88,921** |
| Kerosene | 350 | 3,851 | - | 47,261 | 23,806 | - | **75,268** |
| Fuel Oil | - | 7,762 | - | - | 218,577 | - | **226,339** |
| L.P.G. | - | 2,602 | - | - | - | - | **2,602** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 123,354 | 61,677 | - | 52,811 | - | **237,841** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **27,261** | **252,659** | **81,255** | **47,261** | **494,300** | **1,082,542** | **1,985,879** |

| 1997 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2,904 | 16,841 | 119,050 | - | 4,356 | 177,124 | **320,275** |
| Diesel/ L.S.G. | 29,806 | 110,220 | 99,043 | - | 182,872 | 231,307 | **653,248** |
| Jet A1/ Avgas | - | - | - | - | - | 98,723 | **98,723** |
| Kerosene | 700 | 4,551 | 26,256 | 35,358 | 27,306 | 1,750 | **95,923** |
| Fuel Oil | 931 | 52,471 | 931 | - | 157,413 | 3,726 | **215,472** |
| L.P.G. | - | 80,373 | - | - | - | - | **80,373** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 151,108 | 19,659 | - | 372,374 | - | **543,141** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **34,341** | **415,564** | **264,940** | **35,358** | **744,321** | **512,630** | **2,007,155** |

**Carbon Dioxide Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 1998 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 4,936 | 13,647 | 5,807 | - | 3,194 | 299,659 | **327,244** |
| Diesel/ L.S.G. | 31,358 | 91,591 | 9,314 | - | 150,893 | 305,822 | **588,979** |
| Jet A1/ Avgas | 2,801 | - | - | - | - | 102,224 | **105,025** |
| Kerosene | 1,050 | 2,801 | 350 | 72,467 | 27,306 | 2,100 | **106,075** |
| Fuel Oil | 931 | 12,730 | - | - | 203,674 | 3,105 | **220,440** |
| L.P.G. | - | 3,758 | - | - | 20,238 | 867 | **24,863** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 94,057 | 17,347 | - | 403,212 | - | **514,616** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **41,077** | **218,584** | **32,818** | **72,467** | **808,517** | **713,777** | **1,887,242** |

| 1999 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2,613 | 16,261 | 5,227 | - | 2,904 | 259,298 | **286,302** |
| Diesel/ L.S.G. | 34,774 | 87,555 | 7,451 | - | 130,712 | 251,488 | **511,980** |
| Jet A1/ Avgas | 9,802 | - | - | - | - | 71,067 | **80,869** |
| Kerosene | 700 | 3,851 | - | 60,214 | 9,452 | 700 | **74,918** |
| Fuel Oil | - | 14,282 | - | - | 128,538 | - | **142,820** |
| L.P.G. | - | 9,830 | 867 | - | - | - | **10,697** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 82,107 | 23,900 | - | 206,232 | - | **312,239** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **47,889** | **213,886** | **37,445** | **60,214** | **477,838** | **582,553** | **1,419,825** |

| 2000 | Agriculture & Forestry | Commerce and Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2,033 | 20,616 | 8,421 | - | 2,323 | 276,720 | **310,112** |
| Diesel/ L.S.G. | 27,943 | 115,188 | 6,520 | - | 118,603 | 294,645 | **562,898** |
| Jet A1/ Avgas | - | - | - | - | - | 115,177 | **115,177** |
| Kerosene | 2,451 | 12,603 | 350 | 47,261 | 10,502 | 3,501 | **76,668** |
| Fuel Oil | - | 3,415 | - | - | 147,167 | - | **150,582** |
| L.P.G. | - | - | - | - | - | - | **-** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 186,341 | 34,308 | - | 162,788 | - | **383,398** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **32,426** | **338,163** | **49,599** | **47,261** | **441,384** | **690,042** | **1,598,837** |

| 2001 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 9,872 | 24,100 | 6,969 | - | - | 266,557 | **307,499** |
| Diesel/ L.S.G. | 30,116 | 129,780 | 5,899 | - | 116,740 | 286,883 | **569,418** |
| Jet A1/ Avgas | - | - | - | - | - | 116,228 | **115,177** |
| Kerosene | 2,100 | 6,652 | 350 | 51,112 | 10,502 | 3,151 | **73,868** |
| Fuel Oil | 621 | 3,105 | - | - | 217,335 | - | **242,795** |
| L.P.G. | - | - | - | - | - | - | **-** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 166,913 | 30,723 | - | 145,827 | - | **343,463** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **42,710** | **330,550** | **43,941** | **51,112** | **490,405** | **672,818** | **1,652,219** |

**Carbon Dioxide Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 2002 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 1,307 | 13,676 | 6,301 | - | 2,004 | 278,868 | **302,127** |
| Diesel/ L.S.G. | 27,788 | 105,904 | 9,718 | - | 154,432 | 308,430 | **606,272** |
| Jet A1/ Avgas | - | 15,159 | - | - | - | 74,743 | **89,901** |
| Kerosene | 525 | 3,676 | - | - | 35 | 28,147 | **32,383** |
| Fuel Oil | 1,521 | 6,737 | 310 | - | 19,871 | 7,017 | **35,488** |
| L.P.G. | 29 | 58 | - | - | 289 | 58 | **434** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 152,534 | 67,922 | - | 32,689 | - | **253,145** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **31,170** | **297,745** | **84,251** | **-** | **209,319** | **697,262** | **1,319,749** |

| 2003 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 1,249 | 22,823 | 7,056 | - | 1,742 | 304,450 | **337,319** |
| Diesel/ L.S.G. | 35,426 | 106,153 | 9,718 | - | 160,300 | 310,634 | **622,231** |
| Jet A1/ Avgas | 560 | 3,256 | 70 | - | 3,291 | 875 | **8,017** |
| Kerosene | 1,925 | 11,658 | 35 | - | 2,836 | 31,788 | **48,241** |
| Fuel Oil | 1,180 | 7,327 | 248 | - | 11,767 | 6,116 | **26,639** |
| L.P.G. | - | 1,214 | - | - | 289 | 260 | **1,735** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 108,821 | 72,162 | - | 6,399 | - | **187,420** |
| Firewood | - | - | - | - | - | - | **-** |
| Charcoal | - | - | - | - | - | - | **-** |
| **TOTAL** | **40,340** | **261,252** | **89,289** | **-** | **186,624** | **654,123** | **1,231,603** |

## Appendix 6: Methane gas Emissions by Sector, Source and Year in Metric Tonnes

| 1990 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 10 | 34 | 42 | - | 11 | 429 | **526** |
| Diesel/ L.S.G. | 1 | 3 | 1 | - | 7 | 13 | **24** |
| Jet A1/ Avgas | 6 | - | - | - | - | 840 | **846** |
| Kerosene | 0 | 3 | 0 | 38 | 10 | 0 | **51** |
| Fuel Oil | - | 1 | 0 | - | 6 | 0 | **8** |
| L.P.G. | - | 0 | 0 | - | - | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 45 | 11 | - | 66 | - | 122 |
| Firewood | 173 | 518 | - | 4,546 | 1 | - | **5,237** |
| Charcoal | - | 44 | - | 967 | 3 | - | **1,014** |
| **TOTAL** | **190** | **647** | **55** | **5,551** | **102** | **1,282** | 7,828 |

| 1991 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 4 | 44 | 32 | - | 11 | 573 | **665** |
| Diesel/ L.S.G. | 1 | 3 | 1 | - | 6 | 16 | **26** |
| Jet A1/ Avgas | - | - | - | - | - | 396 | **396** |
| Kerosene | - | 1 | 0 | 32 | 8 | - | **41** |
| Fuel Oil | - | 1 | - | - | 7 | - | **8** |
| L.P.G. | - | - | - | - | 0 | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 53 | 3 | - | 64 | - | **120** |
| Firewood | 179 | 513 | - | 4,678 | 0 | - | **5,371** |
| Charcoal | - | 44 | - | 1,001 | 3 | - | **1,047** |
| **TOTAL** | **184** | **660** | **36** | **5,710** | **100** | **985** | **7,675** |

**Methane gas Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 1992 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 5 | 39 | 34 | - | 11 | 542 | **631** |
| Diesel/ L.S.G. | 1 | 3 | 1 | - | 7 | 15 | **27** |
| Jet A1/ Avgas | - | - | - | - | - | 449 | **449** |
| Kerosene | 0 | 4 | - | 24 | 6 | - | **34** |
| Fuel Oil | - | 1 | 0 | - | 7 | - | **8** |
| L.P.G. | - | - | - | - | 0 | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 60 | 4 | - | 54 | - | **118** |
| Firewood | 186 | 0 | - | 4,813 | 510 | - | **5,509** |
| Charcoal | - | 2 | - | 1,016 | 44 | - | **1,062** |
| **TOTAL** | **192** | **110** | **38** | **5,852** | **639** | **1,006** | **7,837** |

| 1993 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 11 | 28 | 23 | - | 10 | 405 | **478** |
| Diesel/ L.S.G. | 1 | 3 | 1 | - | 7 | 10 | **21** |
| Jet A1/ Avgas | - | - | 3 | - | - | 424 | **427** |
| Kerosene | 1 | 2 | 0 | 22 | 2 | - | **27** |
| Fuel Oil | - | 0 | 0 | - | 7 | - | **8** |
| L.P.G. | - | 0 | - | - | 0 | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 53 | 2 | - | 60 | - | **115** |
| Firewood | 193 | 505 | - | 4,951 | 0 | - | **5,650** |
| Charcoal | - | 43 | - | 1,031 | 2 | - | **1,077** |
| **TOTAL** | **206** | **635** | **30** | **6,004** | **89** | **840** | **7,803** |

| 1994 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 3 | 25 | 23 | - | 5 | 517 | **574** |
| Diesel/ L.S.G. | 1 | 3 | 1 | - | 5 | 12 | **22** |
| Jet A1/ Avgas | - | - | 3 | - | - | 414 | **417** |
| Kerosene | 0 | 2 | 0 | 21 | 2 | - | **25** |
| Fuel Oil | - | 0 | 0 | - | 7 | - | **8** |
| L.P.G. | - | 0 | 0 | - | - | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 40 | 4 | - | 12 | - | **56** |
| Firewood | 201 | 501 | - | 5,094 | 0 | - | **5,796** |
| Charcoal | - | 43 | - | 1,047 | 2 | - | **1,092** |
| **TOTAL** | **205** | **614** | **31** | **6,162** | **34** | **943** | **7,990** |

| 1995 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 3 | 64 | 19 | - | 5 | 521 | **611** |
| Diesel/ L.S.G. | 1 | 2 | 1 | - | 6 | 13 | **23** |
| Jet A1/ Avgas | - | - | - | - | - | 399 | **399** |
| Kerosene | 0 | 2 | 1 | 22 | 6 | - | **31** |
| Fuel Oil | - | 1 | - | - | 7 | - | **8** |
| L.P.G. | - | 0 | 0 | - | - | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 19 | 15 | - | 15 | - | **48** |
| Firewood | 208 | 497 | - | 5,240 | 0 | - | **5,945** |
| Charcoal | - | 43 | - | 1,064 | 2 | - | **1,108** |
| **TOTAL** | **211** | **627** | **35** | **6,326** | **41** | **933** | **8,174** |

**Methane gas Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 1996 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2 | 34 | 13 | - | 5 | 477 | **531** |
| Diesel/ L.S.G. | 1 | 2 | 0 | - | 5 | 18 | **27** |
| Jet A1/ Avgas | - | - | - | - | - | 374 | **374** |
| Kerosene | 0 | 1 | - | 15 | 8 | - | **24** |
| Fuel Oil | - | 0 | - | - | 6 | - | **6** |
| L.P.G. | - | 0 | - | - | - | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 16 | 8 | - | 7 | - | **31** |
| Firewood | 208 | 497 | - | 5,240 | 0 | - | **5,945** |
| Charcoal | - | 43 | - | 1,064 | 2 | - | **1,108** |
| **TOTAL** | **211** | **594** | **21** | **6,319** | **33** | **869** | **8,047** |

| 1997 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 4 | 24 | 172 | - | 6 | 256 | **462** |
| Diesel/ L.S.G. | 1 | 3 | 3 | - | 5 | 6 | **18** |
| Jet A1/ Avgas | - | - | - | - | - | 415 | **415** |
| Kerosene | 0 | 1 | 8 | 11 | 9 | 1 | **31** |
| Fuel Oil | 0 | 1 | 0 | - | 4 | 0 | **6** |
| L.P.G. | - | 1 | - | - | - | - | **1** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 20 | 3 | - | 49 | - | **71** |
| Firewood | 220 | 503 | - | 5,499 | 0 | - | **6,223** |
| Charcoal | - | 44 | - | 1,125 | 2 | - | **1,172** |
| **TOTAL** | **225** | **598** | **186** | **6,636** | **75** | **678** | **8,398** |

| 1998 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 7 | 20 | 8 | - | 5 | 432 | 472 |
| Diesel/ L.S.G. | 1 | 2 | 0 | - | 4 | 8 | 16 |
| Jet A1/ Avgas | 12 | - | - | - | - | 430 | 442 |
| Kerosene | 0 | 1 | 0 | 23 | 9 | 1 | 34 |
| Fuel Oil | 0 | 0 | - | - | 5 | 0 | 6 |
| L.P.G. | - | 0 | - | - | 0 | 0 | 0 |
| Electricity | - | - | - | - | - | - | - |
| Coal | - | 12 | 2 | - | 53 | - | 67 |
| Firewood | 225 | 513 | - | 5,610 | 0 | - | 6,347 |
| Charcoal | - | 46 | - | 1,170 | 2 | - | 1,218 |
| **TOTAL** | **245** | **594** | **11** | **6,803** | **78** | **872** | **8,603** |

| 1999 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 4 | 23 | 8 | - | 4 | 374 | **413** |
| Diesel/ L.S.G. | 1 | 2 | 0 | - | 4 | 7 | **14** |
| Jet A1/ Avgas | 41 | - | - | - | - | 299 | **340** |
| Kerosene | 0 | 1 | - | 19 | 3 | 0 | **24** |
| Fuel Oil | - | 0 | - | - | 3 | - | **4** |
| L.P.G. | - | 0 | 0 | - | - | - | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 11 | 3 | - | 27 | - | **41** |
| Firewood | 229 | 525 | - | 5,739 | 0 | - | **6,493** |
| Charcoal | - | - | - | 1,217 | 2 | - | **1,219** |
| **TOTAL** | **276** | **563** | **11** | **6,975** | **44** | **680** | **8,548** |

**Methane gas Emissions by Sector, Source and Year in Metric Tonnes - continued**

| 2000 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 3 | 30 | 12 | - | 3 | 399 | **447** |
| Diesel/ L.S.G. | 1 | 3 | 0 | - | 3 | 8 | **15** |
| Jet A1/ Avgas | - | - | - | - | - | 485 | **485** |
| Kerosene | 1 | 4 | 0 | 15 | 3 | 1 | **25** |
| Fuel Oil | - | 0 | - | - | 4 | - | **4** |
| L.P.G. | - | - | - | - | - | - | **-** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 24 | 4 | - | 21 | - | **50** |
| Firewood | 234 | 535 | - | 5,853 | 0 | - | **6,623** |
| Charcoal | - | 52 | - | 1,265 | 2 | - | **1,319** |
| TOTAL | 239 | 648 | 17 | 7,134 | 38 | 893 | 8,969 |

| 2001 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 14 | 35 | 10 | - | - | 385 | **444** |
| Diesel/ L.S.G. | 1 | 4 | 0 | - | 3 | 8 | **15** |
| Jet A1/ Avgas | - | - | - | - | - | 489 | **485** |
| Kerosene | 1 | 2 | 0 | 16 | 3 | 1 | **24** |
| Fuel Oil | 0 | 0 | - | - | 6 | - | **7** |
| L.P.G. | - | - | - | - | - | - | **-** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 22 | 4 | - | 19 | - | **45** |
| Firewood | 239 | 546 | - | 5,971 | 0 | - | **6,756** |
| Charcoal | - | 54 | - | 1,316 | 3 | - | **1,372** |
| **TOTAL** | **255** | **662** | **14** | **7,303** | **34** | **882** | **9,147** |

| 2002 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2 | 20 | 9 | - | 3 | 402 | **436** |
| Diesel/ L.S.G. | 1 | 3 | 0 | - | 4 | 8 | **16** |
| Jet A1/ Avgas | - | 64 | - | - | - | 314 | **378** |
| Kerosene | 0 | 1 | - | - | 0 | 9 | **10** |
| Fuel Oil | 0 | 0 | 0 | - | 1 | 0 | **1** |
| L.P.G. | 0 | 0 | - | - | 0 | 0 | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 20 | 9 | - | 4 | - | **33** |
| Firewood | 652 | 1,494 | - | 16,481 | 0 | - | **18,627** |
| Charcoal | - | 82 | - | 2,032 | 3 | - | **2,116** |
| **TOTAL** | **655** | **1,683** | **18** | **18,513** | **15** | **734** | **21,618** |

| 2003 | Agriculture & Forestry | Commercial & Industry | Government & Services | Households | Mining | Transport | Total |
|---|---|---|---|---|---|---|---|
| Premium Petrol | 2 | 33 | 10 | - | 3 | 439 | **487** |
| Diesel/ L.S.G. | 1 | 3 | 0 | - | 4 | 8 | **17** |
| Jet A1/ Avgas | 2 | 14 | 0 | - | 14 | 4 | **34** |
| Kerosene | 1 | 4 | 0 | - | 1 | 10 | **16** |
| Fuel Oil | 0 | 0 | 0 | - | 0 | 0 | **1** |
| L.P.G. | - | 0 | - | - | 0 | 0 | **0** |
| Electricity | - | - | - | - | - | - | **-** |
| Coal | - | 14 | 9 | - | 1 | - | **24** |
| Firewood | 665 | 1,524 | - | 16,811 | 0 | - | **19,000** |
| Charcoal | - | 96 | - | 2,384 | 3 | - | **2,483** |
| **TOTAL** | **671** | **1,688** | **20** | **19,194** | **26** | **462** | **22,061** |

**Appendix 7: Percentage Distribution of Households by Main Type of Cooking Energy by Rural/Urban, Stratum and Province, 2004**

| Residence/ Stratum/ Province | Type of Energy for Cooking | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Collected Firewood | Purchased Firewood | Own produced Charcoal | Purchased Charcoal | Coal | Kerosene /paraffin/Gas | Electricity | Other | Total | Total Number of Households |
| All Zambia | 54.2 | 1.9 | 3.5 | 23.8 | 0 | 0.2 | 16.2 | 0.1 | 100 | 2,110,640 |
| Rural | 84.9 | 1.7 | 4.7 | 6.6 | 0 | 0.2 | 1.7 | 0.2 | 100 | 1,287,490 |
| Urban | 5.6 | 2.2 | 1.5 | 51.1 | 0 | 0.2 | 39.3 | 0 | 100 | 823,150 |
| **Province** | | | | | | | | | | |
| Central | 68.2 | 1.8 | 1 | 19.4 | 0 | 0.2 | 9.3 | 0.1 | 100 | 207,243 |
| Copperbelt | 16 | 1.4 | 3.6 | 41.7 | . | 0.2 | 37 | 0.1 | 100 | 311,712 |
| Eastern | 76.9 | 2.7 | 0.5 | 14.6 | . | 0.3 | 4.9 | 0.3 | 100 | 290,224 |
| Luapula | 45.8 | 3.1 | 24 | 24.4 | . | 0.1 | 2.4 | 0.2 | 100 | 171,659 |
| Lusaka | 10.7 | 0.8 | 0.8 | 47.3 | 0 | 0.2 | 40.2 | 0 | 100 | 309,949 |
| Northern | 75.2 | 1 | 3.2 | 14 | 0.1 | 0.2 | 6.4 | 0 | 100 | 275,395 |
| North Western | 71.7 | 1.5 | 2.3 | 15.9 | 0.1 | 0.5 | 7.7 | 0.2 | 100 | 125,814 |
| Southern | 71.1 | 2.5 | 0.7 | 13.4 | 0.1 | 0.2 | 12 | 0.1 | 100 | 252,423 |
| Western | 88.3 | 3.8 | 0.6 | 3.6 | . | 0.2 | 3.2 | 0.4 | 100 | 166,219 |