ESM C121

ESMAP

Energy Sector Management Assistance Program

Zambia

Urban Household Energy Strategy

Report No. 121/90

Public Disclosure Authorized

Public Disclosure Authorized

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

PURPOSE

The World Bank/UNDP/Bilateral Aid Energy Sector Management Assistance Program (ESMAP) was launched in 1983 to complement the Energy Assessment Program which had been established three years earlier. The Assessment Program was designed to identify the most serious energy problems facing some 70 developing countries and to propose remedial action. ESMAP was conceived, in part, as a preinvestment facility to help implement recommendations made during the course of assessment. Today ESMAP is carrying out preinvestment and prefeasibility activities in about 60 countries and is providing a wide range of institutional and policy advice. The program plays a significant role in the overall international effort to provide technical assistance to the energy sector of developing countries. It attempts to strengthen the impact of bilateral and multilateral resources and private sector investment The findings and recommendations emerging from ESMAP country activities provide governments, donors, and potential investors with the information needed to identify economically and environmentally sound energy projects and to accelerate their preparation and implementation. ESMAP's policy and research work analyzing cross-country trends and issues in specific energy subsectors make an important contribution in highlighting critical problems and suggesting solutions.

ESMAP's operational activities are managed by three units within the Energy Strategy Management and Assessment Division of the Industry and Energy Department at the World Bank.

- The Energy Efficiency and Strategy Unit engages in energy assessments addressing institutional, financial, and policy issues, design of sector strategies, the strengthening of energy sector enterprises and sector management, the defining of investment programs, efficiency improvements in energy supply, and energy use, training and research.

- The Household and Renewable Energy Unit addresses technical, economic, financial, institutional and policy issues in the areas of energy use by urban and rural households and small industries, and includes traditional and modern fuel supplies, prefeasibility studies, pilot activities, technology assessments, seminars and workshops, and policy and research work.

- The Natural Gas Development Unit addresses gas issues and promotes the development and use of natural gas in developing countries through preinvestment work, formulating natural gas development and related environmental strategies, and research.

FUNDING

The ESMAP Program is a major international effort supported by the World Bank, the United Nations Development Programme, and Bilateral Aid from a number of countries including Australia, Belgium, Canada, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States.

FURTHER INFORMATION

For further information or copies of the completed ESMAP reports listed at the end of this document, contact:

Energy Strategy Management and Assessment Division
Industry and Energy Department
The World Bank
1818 H Street N.W.
Washington, D.C. USA 20433

OR

Division for Global and Interregional Programmes
United Nations Development Programme
One United Nations Plaza
New York, NY 10017
USA

ZAMBIA

URBAN HOUSEHOLD ENERGY STRATEGY

AUGUST 1990

Household Energy Unit
Industry and Energy Department
The World Bank
Washington, D.C., U.S.A.

This document has restricted distribution. Its contents may not be disclosed without authorization from the Government, the World Bank, or the UNDP.

ACRONYMS AND ABBREVIATIONS

BCA	Biomass Catchment Area
CH	Contract Haulier
CSO	Central Statistical Office
DOE	Department of Energy, Ministry of Power Transport and Communication
ESMAP	Joint UNDP/World Bank Energy Sector Management Assistance Program
FD	Forestry Department, Ministry of Lands and Natural Resources
FE	Foreign Exchange
FOB	Free on Board (Ship)
GDP	Gross Domestic Product
MLNR	Ministry of Lands and Natural Resources
NCSR	National Council for Scientific Research
OER	Official Exchange Rate
PV	Present Value
SADCC	Southern Africa Development Coordination Conference
SEA	Standard Enumeration Area
TAZARA	Tanzania/Zambia Railways
UNDP	United Nations Development Program
WB	International Bank for Reconstruction and Development - The World Bank
ZESCO	Zambia Electrical Supply Corporation Ltd.
ZR	Zambia Railways

a	annum
a.d.	air dry (15% moisture content dry basis)
Ch	Charcoal
CR	Crop residues
Elec.	Electricity
FW	Fuelwood
b.d.	bone dry (0% moisture content)
GWh	Gigowatt hour
ha	hectare
J	Joule - standard unit of energy
km	kilometer
km^2	square kilometer
M	million
m^3	cubic meter
MW	megawatt
MC db	moisture content dry basis
mm	millimeters
t	metric ton
TOE	metric ton of oil equivalent
tpa	metric tons per annum
WF	Woodfuel (fuelwood and charcoal)

EXCHANGE RATES

There has been a considerable devaluation of the kwacha during the project's lifetime. The following are the exchange rates for specific time periods:

To November 1988	ZK 7.86 = US$1
December 1988 to June 1989	ZK10.00 = US$1
July 1989	ZK16.00 = US$1

Since July 1989 there were gradual unannounced devaluations.

In October 1989	ZK18.50 = US$1
By February 1990	ZK24.00 = US$1

In April 1990	Window 1	ZK26.65 - US$1
	Window 2	ZK40.00 - US$1

The shadow exchange rate used in this report is: ZK25.00 = US$1

ENERGY CONVERSION FACTORS

Wood charcoal	31.00 GJ/Ton
5% moisture content dry basis, (mcdb) 3% ash content and fully carbonized	
Firewood	16.00 GJ/Ton
15% moisture content dry basis, 1% ash	
Crop residues (Average)	13.70 GJ/Ton
Average: 70% bagasse and 30% maize stalks Bagasse: 15% mcdb, 10% ash: 13.40 GJ/t. Maize stalks: 15% mcdb, 5% ash: 14.30 GJ/t.	
Coal	
5% mcdb, 18% ash content	25.60 GJ/Ton
Kerosene	
with a weight of 0.796 ton per m^3	43.34 GJ/Ton 34.50 GJ/m^3
Electricity	3.60 TJ/GWh 3.60 GJ/MWh
Ton of Oil Equivalent (TOE)	42.74 GJ
1 Petajoule (PJ)	23400 TOE

1 Exa-joule (EJ) = 10^{18} joules	1 Gigajoule (GJ) = 10^9 joules
1 Petajoule (PJ) = 10^{15} joules	1 Megajoule (MJ) = 10^6 joules
1 Terajoule (TJ) = 10^{12} joules	1 kilojoule (kJ) = 10^3 joules

1 Square kilometer		100 ha. (247 acres)
1 Cubic meter		35.3 cubic feet
1 Stacked m^3	(300 kgs wood bone dry (b.d.)	0.55 solid m^3
1 Solid m^3	(550 kgs wood b.d.)	1.82 stacked m^3
1 Cord	(900 kgs wood b.d.)	3.00 stacked m^3

All tons are metric measure of 1000 kgs.

TABLE OF CONTENTS

TABLES

ANNEXES

MAP

I. INTRODUCTION

1.1 This report outlines the first detailed study and comprehensive energy strategy for the urban household sector in Zambia. It identifies an urban household energy sector investment program for the period 1990-1995, reflecting the current economic situation, the condition of the energy supply systems, the most pressing needs of the consumers, the need for foreign exchange saving, the use of renewable indigenous resources, and the boosting of rural employment. The report also recommends a set of energy policies and technical assistance activities designed to facilitate the achievement of the urban household energy strategy's objectives.

1.2 This report is part of an overall energy sector strategy program undertaken by the Government of Zambia and the UNDP/World Bank, Energy Sector Management Assistance Program (ESMAP). Three previous studies have been produced namely The Energy Sector Strategy, Activity Completion Report, ACR No. 094/88, Power Subsector Efficiency Study, ACR No. 093/88, and Energy Sector Institutional Review, ACR No. 060/86. All these reports are related to the same issue, namely the preparation of a comprehensive energy strategy for Zambia.

1.3 This report draws on just over a year's field work in Zambia collecting information on urban household energy supply and demand. A number of surveys were undertaken to collect baseline data on biomass supply, charcoal production, transport and marketing, urban household energy demand, substitution possibilities and energy conservation. With the results of the surveys at hand a strategy was formulated, policy options outlined and an action plan proposed. The major part of the report was drafted in Zambia by a joint team of Zambian energy planners, biomass and charcoal experts and ESMAP staff. Further work was undertaken at the World Bank in Washington, principally to condense the wealth of material generated into this report. The Zambian team members were drawn from the Department of Energy of the Ministry of Power, Transport and Communications, the University of Zambia, the Forestry Department of the Ministry of Land and Natural Resources, the Central Statistical Bureau, the Zambian Electricity Supply Company, and enumerators, supervisors, data entry people etc. from various agencies. There was also a project working group consisting of representatives of all institutions involved in urban household energy which advised the project team and helped develop policy recommendations. This group also provided a basis for future coordination of policy measures amongst interested parties.

1.4 The Zambian team was led by Mr. Dominic Mbewe, Director of the Department of Energy. Mr. Silvester Hibajene, a household and renewable energy specialist, from the Department of Energy was seconded to the project for its lifetime and acted as project coordinator. Professor Emmanuel N. Chidumayo from the University of Zambia was the biomass specialist and coordinator of the charcoal production study. The World

ESMAP field manager was Dr. Azedine Ouerghi, Mr. Keith Openshaw was the task manager and Mr. Robert P. Taylor was the energy and substitution economist. Ms. Yeshimebet Gonfa (Secretary) was responsible for the word processing in Washington, D.C.

1.5 The team members wish to express their gratitude to the other team members such as supervisors, field assistants, enumerators, the charcoal production teams, data processors, secretaries and members of the working group without whom this study would not have been possible. A final thanks must be given to the householders, woodfuel traders and transporters, food shop owners and charcoalers who gave of their time to answer questions and provide information about the production and consumption of energy.

II. EXECUTIVE SUMMARY

Economic Background

2.1 Copper mining has dominated the economy of Zambia for the last half century. This caused a large population shift from rural to urban areas and now about 40% of the population is urbanized (3.0 million), most of these people living along the line of rail between Lusaka and the Copperbelt. From 1975 there was a persistent decline in the world copper price, over 60% in real terms, and this was coupled with a one-third drop in output resulting in a substantial fall in foreign exchange earnings.

2.2 Over the last decade Gross Domestic Product (GDP) has been growing at a slower rate than population increase, thus the average per capita income has been declining and this has affected all sectors of the economy including the energy sector. The development priorities of the government are to reduce dependency on copper, give high priority to rural development and to promote growth from the country's own resources.

Energy Resources

2.3 Zambia is well endowed with energy resources. Its woodlands have a standing stock of about 4.3 billion tons of wood (69,000 PJ) giving an annual sustainable production of about 130 million tons (2080 PJ). The hydropower potential is estimated to be 4000 MW, equivalent to about 84 PJ per year, assuming 16 hrs/day of production, and proven coal reserves exceed 30 million t (768 PJ). Petroleum products are the only imported energy forms which in 1986 amounted to some 0.55 million tons (24 PJ).

2.4 Total energy consumption in 1988 is approximately 5.13 million tons of oil equivalent (219 PJ) of which woodfuel accounted for 64% (fuelwood 38%, charcoal wood 26%); this is a fraction of indigenous woodland resources. Electricity accounts for 12%, petroleum products for 11%, coal for 7% and crop residues 6% of consumption. The rural and urban household sectors are the largest consumers of energy, accounting for nearly 60% of final consumption. Woodfuel meets about 89% of this demand, making woodfuel the dominant household energy fuel. The urban household sector is the third most important sector accounting for 15% of energy consumption. Rural households account for 43%, the copper mines 18%, industry 12% and agriculture, government and transport the remaining 12%.

Woodfuel and Household Energy Issues

2.5 Despite woodfuel being the dominant energy form and in spite of the household sector being the main end use sector, little attention has been paid to this fuel or this sector. This could be because the fuel is produced by the informal sector using national resources and it fulfills the short term requirements of the household sector. It is a vital fuel for the urban poor and a source of revenue for the rural poor. The principal question is what is the appropriate role of woodfuel in meeting urban household energy needs over the long term?

2.6 Charcoal production puts pressure on wood resources close to large (urban) demand centers and it was thought that this use was leading to wholesale woodland destruction. Because of this, proposals have been made for peri-urban plantations to substitute other fuels for wood and to introduce conservation measures. However, there has been no real assessment of the supply/demand picture for urban areas. Hence the reason for the present study, which sets out to examine:

(a) the biomass resource near urban centers and its use;

(b) charcoal production, transport and marketing and its dynamics;

(c) the energy demand patterns of urban households and the non-household energy consumption that affects the former;

(d) the cost of alternative forms of household energy, both in economic and financial terms;

(e) the costs and benefits to the country of various inter-fuel substitution possibilities; and

(f) the cost and benefits of (woodfuel) conservation options.

Study Findings

2.7 The study found that:

(a) Zambia in general and the household sector in particular rely principally on an indigenous fuel that can meet demand nearly indefinitely if the resource base is protected and properly managed, and if substantial areas of woodlands are not cut down for agricultural development (Table 2.1)

(b) The greatest depletion of woodland resources is caused by agricultural clearing and not by cutting trees for fuelwood, poles and sawlogs. Most areas cleared for woodfuel production regenerate. However, if properly managed these areas would give a greater production of desired species in a shorter time period.

(c) The per hectare standing stock and annual yield of cord wood on measured plots is higher and in some cases considerably higher than previous estimates.

(d) Charcoal production employs about 41,000 people in its manufacture, a further 3500 in transportation and 1000 in marketing. Marketed fuelwood employs about 5000 in manufacture, distribution and trading, so over 50,000 people depend on woodfuel for their livelihood, the bulk being rurally based.

(e) The transport and distribution of woodfuels are relatively inefficient due to poor organization of the producers, bad bush roads, (many of which are impassable during the rains) and unreliable vehicles. Training for producers and improvement in key bush roads could lead to a more reliable all year round supply and lower transport costs.

(f) The shortages of charcoal supply during the rains lead to price increases, up to three times the normal price. These increases place a heavy burden on the low income households who spend about one fifth of their income on charcoal.

(g) Charcoal is the dominant urban household fuel accounting for 58% of final energy demand, fuelwood is second at 26%, electricity accounts for 7%, crop residues 4% and kerosene 5% of demand. Cooking is the dominant end use (Table 2.2).

Table 2.1: ZAMBIA: 1988 POTENTIAL ANNUAL SUPPLY OF ENERGY FROM EXISTING SYSTEMS WITH AN ESTIMATE OF DEMAND a/

Energy type	Units	Quantity	PJ's	1988 Demand PJ'S	Ratio: Annual Supply to Demand (= 1)
Crop residues/Dung	Mill. t. (air dry)	3.10	42.98	13.72	3.1
Wood	Mill. t. (air dry)	130.00	2080.00	162.35	12.8
Coal	Mill. t	0.70	17.92	14.61	1.2
Petroleum products	Mill. t.	1.10	47.01	24.25	1.9
Electricity	GWh	9875.00	35.55	25.45	1.4

a/ Detailed explanation in Table 4.7

Table 2.2: Zambia 1988: Estimated Urban Household Energy Use

Fuel	TOE	(PJ)	%	End Use	TOE	(PJ)	%
Charcoal	372,060	(15.90)	58	Cooking	316,570	(13.53)	50
Firewood	167,850	(7.17)	26	Water heating	100,000	(4.30)	16
Crop residues	21,490	(0.92)	4	Space heating	138,840	(5.93)	22
Electricity	44,920	(1.92)	7	Ironing	39,450	(1.69)	6
Kerosene	33,730	(1.44)	5	Lighting	27,090	(1.16)	4
				Miscellaneous	17,600	(0.74)	2
Total	640,050	(27.35)	100		640,050	(27.35)	100

(h) The use of woodfuel for cooking and other uses of the stove such as water and space heating, account for nearly 80% of total urban household energy consumption. An improvement in this end use efficiency could have a significant positive impact on the househo'd budget.

(i) One fallacy that should be cleared up is that electrification will avoid deforestation. Besides the fact that the use of wood for energy is not the main cause of deforestation, the study found that, in electrified houses, electricity is not the principal cooking fuel; it is mainly an enhancing and illuminating fuel not a substitution fuel for wood.

(j) In economic terms and especially foreign exchange terms, woodfuels are the cheapest fuels, even taking into account the relative inefficiency of the cooking stoves and the relative expensive distribution costs. (Table 2.3).

Table 2.3: ESTIMATED ECONOMIC COST OF COOKING WITH DIFFERENT FUELS MARCH 1989 PRICES

Kwacha per Gigajoule of Useful Energy
Assumed value of foreign exchange ZK25/US$

Fuels	Cooking efficiency (%)	Economic value (ZK)
Charcoal	15 - 30	290 - 145
Kerosene	35 - 50	610 - 430
Electricity:		
Home with connection	60 - 75	285 - 230
Home requiring connection	60 - 75	460 - 370

(k) The bulk of urban household electricity is used by the upper and middle income groups. The price of electricity paid by these groups is about half its economic cost.

(l) Up to the year 2000, if there are successful initiatives in woodfuel distribution and conservation, th. saving in foreign exchange could be of the order of US$33 million. This is many times more than the foreign exchange required to undertake such initiatives. (Table 2.4).

Table 2.4: THE ESTIMATED CONSUMPTION OF ENERGY IN 1988 - 2000; AND THE FOREIGN EXCHANGE COST OF PROVIDING THIS ENERGY a/

	Improved stove and transportation initiatives									
	(a) Not Undertaken 1988-2000				(b) Undertaken 1988-2000				Saving 1988 - 2000	
	Consumption		FE Cost		Consumption		FE Cost		Consumption	FE Cost
Fuel	PJ	%	Mill US$	%	PJ	%	Mill US$	%	PJ	Mill US$
Electricity	32.29	7	100	23	32.29	8	100	26	-	-
Kerosene	24.49	6	157	37	24.49	6	157	40	-	-
Charcoal	265.89	59	144	34	247.16	58	115	29	18.73	29
Fuelwood	112.26	25	24	6	104.59	25	20	5	7.67	4
Crop resid.	14.80	3	0	0	14.80	3			-	-
TOTAL	449.73	100	425	100	423.33	100	392	100		

a/ The value of the dollar is constant 1988 terms; for more details see Table 6.6.

(m) Even though electricity and kerosene account for under 15% of urban household energy demand, they require about 60% of the foreign exchange spent on urban energy production and distribution (Table 2.4). In spite of taking end use efficiency into consideration these fuels are between 1.4 and five times more expensive in terms of foreign exchange than charcoal.

(n) There is a charge for wood raw material (stumpage fees) for trees on public lands and a tax on some forest products (removal fees) such as charcoal. The fees do not vary according to distance from the market. The stumpage fee on traded wood for fuel ranges from ZK13.9 to ZK1.7 per solid m^3, depending on the unit of purchase, the average charge being ZK4.8 per m^3. The removal fee (tax) on charcoal is ZK0.5 per bag. These fees are less than 5% of the selling price of fuelwood and charcoal and are insufficient to induce private individuals to invest in tree planting.

(o) The collection rate even on the existing stumpage fees is poor. In 1987, fees and taxes on forest products from public lands amounted to ZK2.8 million. If fees and taxes could have been collected from charcoal and traded fuelwood supplying urban areas only, they would have brought in about ZK20 million from stumpage fees and ZK6 million in charcoal removal tax.

(p) The collection rate is low because transport and fuel are lacking, there are poor incentives, inadequate equipment, poor pay and too few people in the field. The budget for the forest service in 1987 was ZK20 million; this has to increase to improve the collection of revenue. Given proper facilities, incentives and more realistic stumpage fees the income from stumpage should more than cover expenditure of all forest service operations.

(q) There is a substantial trade in fuelwood and charcoal for the urban household sector. This is worth in the region of US$65 million (Kwacha 1300 million) per year at present. Very little of this money is captured by the growers of the resource. Yet if there is an equitable distribution of woodfuel revenues, there should be sufficient money to finance the forest service and to encourage private individuals to manage existing tree resources and to invest in tree planting.

(r) The bulk of urban people will rely on woodfuel as their principal energy source for many years to come. This should be viewed as an opportunity for the government to improve its supply, year round availability, end use efficiency, relative price and thus its overall attractiveness as a fuel.

Urban Household Energy Strategy

2.8 The proposed strategy follows directly from the above findings namely:

(a) To ensure that the competing uses of land are assessed in economic and sustainable terms. There are enough areas of woodlands within Zambia both to meet the agricultural expansion plans and the requirements for tree products if the respective needs are properly assessed and adequately planned for by competent land use planners.

(b) To ensure a sustainable supply of woodfuel by reserving sufficient areas of woodlands within economic transport distances of the demand centers and managing these resources properly. The study indicated that there are adequate areas of appropriate woodlands to meet future demand, especially urban demand, but only if they are properly managed and only if they are not looked on as unlimited reserves for agricultural production. Trees should be considered renewable rather than mineable assets and their management undertaken jointly by the forest service and rural people.

(c) To encourage private individuals mainly to manage existing tree resources but also to plant trees for commercial purposes. The principal means of encouragement will be through the price mechanism for the wood raw material - that is, increasing the price of wood sufficiently to induce private individuals to grow and manage trees. The price of wood should also be such as to make the forest service self sufficient if efficiently organized. A second way to encourage people to plant and tend trees is with training and extension efforts.

(d) To improve the collection of fees from the sale of tree products from public land; this could be done by providing adequate transport and through an incentive scheme with the collectors of the fees receiving a percentage of the income.

(e) To uplift the status of the charcoal producers by recognizing their importance as a major energy producer, providing them with training, market intelligence, access to improved tools, and social services, encouraging them to organize themselves into groups to improve production and marketing of the product and giving them access to loans, etc.

(f) Coupled with the above, woodfuel transport and distribution could be improved by improving key bush roads, better utilizing the existing transport fleet, and the establishment of charcoal stores in towns and on surfaced roads or at rail depots.

(g) To develop and commercialize cheap, efficient, locally produced or assembled stoves, particularly charcoal and electric. In the case of charcoal stoves, the goal should be to increase the efficiency to at least 25% and for electric rings to lower the cost and make spare parts easily obtainable.

(h) To increase the price of fuels to at least their economic cost and to ensure that this price is adjusted when necessary to account for inflation and the economic value of foreign exchange.

(i) As with woodfuel, the metering, billing and cash collection of electricity supply is poor, particularly at the household level. This could be improved by providing incentives to meter readers, reducing illegal connections and improving payments. At the same time, the reliability of supply and voltage stability should be improved considerably.

(j) To monitor the supply, demand and price of energy so that energy accounting, planning and development can be based on a sound footing. To do this the Department of Energy and other related bodies should be strengthened.

Recommendations

2.9 The ten point proposal for Zambia's urban household energy strategy has been outlined above. Such a strategy should satisfy demand for energy at the least economic cost, in a way that is consistent with national development priorities using the available resources.

2.10 This strategy should bear in mind the principal constraint of limited investment resources, both domestic and external. Therefore, the energy strategy seeks to minimize investment requirements by emphasizing improvement in resource management and existing capacity utilization and efficiency.

2.11 To achieve this strategy, recommendations are made both on the supply and demand side and on the organization and strengthening of institutions. Because this study has shown that woodfuel is and will remain the most important household fuel and is the fuel with the least economic cost, most emphasis is placed on the growing, production, distribution and marketing of this renewable resource. Also because this resource is generally used in a very inefficient way, improvement of end-use efficiency must be given equal priority.

2.12 Appropriate fuel choice requires a sound pricing policy reflecting the costs to the nation, especially scarce foreign exchange. To undertake such policy initiatives will require trained manpower at all levels and a full commitment on behalf of government and industry.

2.13 The following recommendations, while listed separately, must be implemented together. Unless they are, a vital link in the chain will be missing.

Biomass Management

2.14 Woodlands do and will supply the bulk of forest products to the people of Zambia and the best way to ensure their survival is by actively managing them. Therefore, the government should establish a Miombo Woodland Monitoring and Management Unit within the Forestry Department, MLNR, to help improve the management of woodlands and elevate their importance. Sufficient areas of woodlands should be reserved to ensure a perpetual supply of woody material especially fuel, for the country.

2.15 Woodland clearing for agriculture is the principal cause of deforestation. Much of the wood resource cleared in this process is burnt in situ. The government should include long term land use planning in the remit of the land use planning division of the Ministry of Agriculture and Co-operatives to ensure that woodlands are put to their most sustainable and economic use. This division should ensure, where possible, the timely use of trees on land to be cleared.

2.16 The present payment system for wood raw material from public lands is weak and needs improving by putting more trained people in the field with adequate resources and sufficient incentives. This is a first priority, because less than ten percent of existing fees are collected and retired to government.

2.17 However, there is a strong case for increasing the resource charge (stumpage fee) for government owned wood raw material to about ten percent of product price to cover the economic cost of growing woodland trees. This should be sufficient to pay for proper management and to finance an efficient forest service. Such fees should set a standard for charges to be levied by the private sector thus encouraging private individuals to plant and/or tend trees. A review of the fee structure should be undertaken immediately and its imposition and adjustment be divorced from government control. At present the Forestry Department (FD) has to seek cabinet approval for fee changes and this may take up to seven years. The FD should be able to increase fees without cabinet approval and be governed by market forces such as the price of alternative fuels. The strengthening of the fee collection system is paramount in ensuring that the forest service will have sufficient funds to cover its expenses. Coupled to this, is the proposal to establish a revolving fund from fee collection which will be kept by the forest service to finance itself.

2.18 The tasks of such a Miombo Woodland Monitoring and Management Unit would be to:

(a) Check and map all areas of woodlands noting their present condition and possible future status;

(b) In coordination with the Land Use Planning Section of the Ministry of Agriculture, list in order of priority areas that should be reserved for water catchment, wood and other resources production, species protection, agricultural production, etc.;

(c) Establish permanent and temporary management plots to measure and monitor tree growth and woodland production;

(d) Draw up management plans for the areas that will remain under woodlands;

(e) Meet with local people and decide who will manage the woodlands;

(f) Organise training courses and train extension workers from forestry and agriculture to teach woodland management;

(g) Recruit and train people to undertake the various tasks;

(h) Draw up plans for the woodland resources that are going to be cleared owing to a change of land use;

(i) Establish stumpage fees that are to be charged by the forest service. Ideally these fees should decrease with increasing distance from the market and vary according to end use. Such fees should set a standard for charges to be levied by private individuals on trees they manage;

(j) Establish sets of rules concerning resource payments, rewards and penalties;

(k) Start pilot projects to test management practices and fee collection systems;

(l) Ensure that there are sufficient resources available to undertake the tasks;

(m) Modify management and fee collection schemes as a result of pilot study experiences; and

(n) Put into operation the modified schemes on areas designated for management.

Charcoal Production

2.19 Charcoal is the second largest source of energy supply in Zambia today, firewood being the first. These two woodfuels are obtained from indigenous resources which if properly managed, can last indefinitely. It is the government's interest to encourage the use of charcoal, for in economic terms it is the cheapest purchased urban household fuel. It also requires very little foreign exchange to market it and provides considerable rural employment.

2.20 First and foremost the status of the charcoal producers should be improved. Basic services should be provided for them, and they should receive courses and on-the-job training to improve their skills, both on the production side and in the management of the resource.

2.21 Also, because shortages occur every year during the rainy season, strategic supplies should be built up by traders and producers to counter these shortages; again, access roads could and should be improved to mitigate these shortages and to reduce transport costs. The abolishing of gazetted charcoal prices has removed one large obstacle to building up stocks.

2.22 The government should encourage the charcoal producers to form active producer organizations so that it can channel help through these organizations. The proposed Miombo Monitoring and Management Unit under the FD, MLNR, should have a charcoal production section to provide training in woodland management, the use and maintenance of correct tools and ways of improving charcoal production, transport and marketing. Charcoal production is a large business (currently about 16 million bags are produced annually) so this industry, by paying a realistic fee for the wood raw material could provide a considerable amount of revenue to the forest service, the principal managers of the wood resource, as well as encouraging villages to manage woodlands and plant trees.

Woodfuel Transportation

2.23 The transportation of woodfuel and in particular charcoal is relatively disorganized and expensive, because of poor bush roads, dilapidated vehicles and poor organization. The government should improve selected bush roads, help charcoal associations establish stores on accessible roads, look into ways of reducing transport costs and encourage competition between all transport sectors. In order to pay for these services, the removal fee 1/ on charcoal should be enforced and possibly revised and a similar fee should be imposed for firewood.

Energy Conservation

2.24 Cooking is the principal end-use of household energy and together with water heating on the stove, accounts for about 66% of household energy use. The efficiency of charcoal and firewood stoves are low and kerosene moderately low. The cost of kerosene and in particular electric stoves are high. More efficient woodfuel stoves are commercially produced in other countries, as are cheaper electrical units. The greatest saving of energy should result from concentrating on this end use. Therefore a stove unit under the National Council for Scientific Research should be established in cooperation with artisans and industry, to design and market improved stoves, (especially fuelwood and charcoal stoves), to assist industry in production techniques, and to monitor the industry to ensure that quality is maintained.

Urban Substitution

2.25 In terms of the overall costs to the country, charcoal is the most economic fuel, but for those who can afford it, electricity may be preferred because of convenience. Where families already have electricity, the use of inexpensive hot plates will cost the nation about

---

1/ The removal fee which at present is ZK 0.50 per bag is a tax on charcoal and should be paid before charcoal is removed from the woodlands. This tax is in addition to the charge for the wood raw material (stumpage fee).

the same as cooking with charcoal. However, the economic costs of cooking with electricity are higher than the consumer now pays. Thus people should not be prevented from substituting a more convenient fuel such as electricity for a less convenient fuel such as charcoal, but they should pay the full economic cost for the fuel. Therefore, the substitution of electricity (and kerosene) for charcoal should not be artificially encouraged but cheaper electrical hot plates and kerosene stoves should be an aim of the stove unit. The price of kerosene has now been raised to cover its economic cost and the same should happen to electricity.

Institutional Strengthening

2.26 The Energy Department has built up expertise and experience in survey work, energy accounting, monitoring of energy prices and energy flows. However, it needs continued support to enable it to carry on with this work and supply support to other government departments, Zambia Electricity Supply Corporation (ZESCO), the coal mines, and the refinery on matters concerning energy policy and planning. Therefore, the Department should be strengthened by recruiting more professional staff. It should undertake surveys to monitor the supply, demand and prices of fuels, chair an Energy Planning Committee, provide training courses to staff and other interested parties and liaise with the Southern Africa Development Coordination Conference (SADCC) Energy and Forestry Units. Not only should the Energy Department be strengthened, but other institutions such as the Forestry Department, the Central Statistical Office (CSO) and ZESCO must be strengthened as well. ZESCO needs to improve the reliability and stability of supply and its metering, billing and collection. The Forestry Department has to improve its woodland management and collection of resource fees and the CSO should improve its data collection and analysis capabilities.

Project Proposals

2.27 In order to undertake the above strategy and recommendations, the Government of Zambia will need help. A list of project proposals has been drawn up which are described in Annex 9. To the extent possible, this is a package of pilot projects which should be pursued concurrently, as the various proposals are interrelated. Preliminary estimates of costs have been prepared for all but one of the proposals and are as follows:

III. BACKGROUND

General Description

The Country

3.1 Zambia is a landlocked country in southern central Africa and shares common borders with Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zaire and Zimbabwe. The total area is about 753,000 km^2 most of which is high plateau ranging in altitude from 1,000 to 1,500 meters above sea level.

3.2 The country lies between 8^o-18^o south latitude and 22^o-34^o east longitude. The climate is subtropical: warm and wet from November to April, cool and dry from May to September and hot and dry from September to November. The average annual rainfall decreases from 1500 mm in the north-west to about 700 mm in the south-central region from around the capital city of Lusaka.

Population

3.3 The national population in 1980 (the last year of census) was 5.66 million with an annual rate of increase estimated at 3.4%. This rate of increase was expected to continue till 1985 when it would reach 3.6% per annum (amongst the highest in the world). Consequently, the projected population in 1985 and 1988 was 6.69 million and 7.44 million respectively.

3.4 Zambia is a highly urbanized country relative to other sub-Saharan African countries. In 1980, an estimated 40% of the population lived in urban areas. This percentage is expected to remain unchanged for the decade and the 1988 urban population is estimated at 2.97 million.

3.5 This high urbanization percentage was primarily caused by the development of the mining industry. The mining industry catalyzed the establishment of other supportive industries and together these offered large employment opportunities. Consequently, this prompted a high rural-urban migration principally along the famous "line of rail" i.e the towns and cities on the Livingstone-Lusaka-Copperbelt railway route and particularly round Lusaka and the Copperbelt.

3.6 This pattern of population distribution has had a marked influence on the energy consumption especially with regard to traditional energy sources; this is described later.

Economy

3.7 The Zambian GDP grew at a moderate rate of 1.8% per annum during the period 1984-1988, much less than the annual population increase thus average per capita income declined. In 1988, manufacturing accounted for 22.0% of GDP, Agriculture 18.0%, Services 16.3%, Mining 8.7%, Transport and Communications 5.2%, Construction 3.4%, and other sectors the remaining 26.4% (Table 3.1).

3.8 It is notable that, while the contribution to GDP of Manufacturing and Agriculture has generally been increasing, that of the mining sector has been decreasing.

TABLE 3.1: SECTORAL CONTRIBUTION TO GROSS DOMESTIC PRODUCT
1977 CONSTANT PRICES

Economic Activity	1984	1985	1986	1987	1988
Aggregate GDP (10^6ZK)	2011.5	2044.5	2059.3	2105.6	2161.8 a/
			In percent		
Agriculture (inc. wood)	16.5	16.8	18.2	17.4	18.0
Mining	9.9	9.1	8.6	8.7	8.7
Manufacturing	19.4	20.6	20.7	21.4	22.0
Construction	4.4	3.8	3.9	3.7	3.4
Transport & Communic.	5.8	5.3	5.4	5.4	5.2
Services	17.0	17.2	16.2	16.9	16.3
Others	27.0	27.2	27.0	26.5	26.4
Total	100	100	100	100	100

a/ In 1988, the value of woodfuel at the kerosene substitute price taking into account end use efficiency, is about ZK 400 million at constant 1977 prices. This is more than the total contribution of agriculture to GDP indicating that woodfuel has been significantly undervalued.

Source: Fourth National Development Plan, January 1989.

3.9 In spite of the above trend, the Zambian economy is still dominated by Copper Mining which is Zambia's leading export commodity. Although the share of mining in GDP has fallen gradually since 1964, copper still accounts for about 90% of total export earnings.

3.10 The unstable and low copper prices on the world market have brought about diverse fluctuations in exports in the last decade and export earnings have been declining. This has resulted in a serious and severe lack of foreign exchange for imported energy, for spares and equipment for the mining industry and other industries in general and has put the Zambian economy under pressure.

3.11 During the period 1980 - 86, copper production declined by 4.2% per annum (from 610,000 to 460,100 tpa), but this was somewhat arrested in 1987 when, due to an upswing in copper prices, production increased to 483,00 tons.

3.12 For a decade, the Zambian economy has been passing through a period of deepening crisis. The country's terms of trade have been worsening, domestic inflation has reached high levels (60% in 1988), capacity utilisation has been declining, reaching a low of 12% in some key industries and the country's external indebtedness grew from US $ 3.2 billion in 1980 to approximately US$5.6 billion in 1987, making the country a net exporter of financial resources. Generally investment is only at 10% of GDP.

3.13 In grappling with the worsening economic situation, Zambia has instituted various measures aimed at resuscitating the economy. In the mid-1980's the Government launched an ambitious program of economic liberalisation in which respectively, price controls were removed and subsidies were reduced. A weekly foreign exchange auctioning system was introduced and interest rates were also liberalised.

3.14 The Kwacha was consequently devalued seven-fold in a space of one year from October 1985 to October 1986 and this was coupled with a sharp acceleration in inflation. As the economy did not respond quickly and there was political opposition to the structural adjustment measures, the foreign exchange auctioning was abandoned in May 1987 and the rate of exchange fixed at ZK8/US $1. At the same juncture, a new economic recovery program was launched.

3.15 Under the new program, interest rate ceilings were reimposed, debt payments limited to 10% of export earnings, price controls were reintroduced and a program of gradual removal of subsidies on essential commodities embarked on. These measures were incorporated in the Interim National Development Plan of June 1987 - December 1988 which has since been replaced by the Forth National Development Plan (1989 - 1993).

3.16 More recently, the Government has embarked on a program of reforms aimed at restoring external and fiscal balance as well as restructuring the economy. The measures outlined in the Policy Framework Paper of September 1989 have been considerably strengthened by the adoption of the Fund-monitored annual program for 1990, whose main center piece is the introduction of a dual exchange rate system and the operation of an open General License scheme. Besides the price decontrol of all commodities (except maize meal) the Government has committed itself to an ambitious program of stabilization and liberalization of economic activities in order to bring about more efficient use of scarce domestic and foreign exchange resources. This new program of reform was endorsed by donors and the international community in the recently concluded Consultative Group Meeting on Zambia, held in Paris in April 1990.

Development Priorities

3.17 Zambia's development priorities and aspirations can be summarized as being:

(a) to diversify the economic structure in order to reduce the country's dependence on copper and undertake a crash economic program for promoting agriculture and industry.

(b) to give high priority to rural development in order to create a strong rural economy.

(c) to reduce the disparities in the level of income between rural and urban sectors.

(d) to promote a regional pattern of development, having regard to the characteristics and dimensions of each region's socio-economic potential and needs.

3.18 There has been emphasis on the need for a sustained program of agricultural reconstruction and development by encouraging people to return to the land and increase agricultural production.

3.19 The overall strategy for rural development envisages co-ordinated programs for improvement of agriculture, agro-industries, transportation, communication, social services, water supplies and other activities that have a bearing on the standard of living in rural areas.

3.20 In the Fourth National Development Plan, agriculture continues to be accorded the highest priority. This is in recognition of the fact that economic recovery can only be achieved if the vast land resource is utilised effectively. The overall strategy includes a combination of price and non-price incentives (eg. foreign exchange retention, tax incentives, provision of adequate credit, etc).

3.21 Emphasis is now placed on "growth from own resources", but the battle against economic degeneration will be a hard one.

Energy Situation

Supply

3.22 In the face of the above outlined economic difficulties, Zambia is fortunate to be well endowed with energy resources. Woodlands and forests are estimated to cover 58 million hectares (ha.) or 77% of the total land area. The growing stock on this area is in the region of 4.3 billion tons of wood (a.d.) with an annual production of about 130 million tons (a.d.). The hydropower potential is estimated at 4000 megawatts (MW) with an installed capacity of 1700 MW. Proven coal reserves exceed 30 million tons. These indigenous energy resources satisfy about 88% of total energy demand, the remainder being met by petroleum products, all of which are imported.

3.23 Woodfuel (fuelwood and charcoal) contributes the largest share of supply, accounting for 64% of total primary energy (Table 3.2). Electricity accounts for 12% while coal and petroleum respectively contribute 7% and 11%. Crop residues, another biomass fuel, completes the picture with 6% of supply.

3.24 Similarly, the energy consumption pattern shows the importance of woodfuel in meeting national energy needs, accounting for 58% of total final energy consumption. Electricity and petroleum account for 13% each coal 8% and crop residues the remaining 8%.

TABLE 3.2: ZAMBIA: ENERGY SUPPLY AND CONSUMPTION BY ENERGY SOURCE IN 1988
('000 toe)

	Primary Supply			Final Consumption		
Energy Source	Quantity	(PJ) c/	Percent	Quantity	(PJ) c/	Percent
Woodfuel a/	3303.0	(141.2)	64	2466.0	(105.4)	58
Crop residues	321.0	(13.7)	6	321.0	(13.7)	8
Electricity b/	595.5	(25.5)	12	537.6	(23.0)	13
Coal	341.9	(14.6)	7	341.9	(14.6)	8
Petroleum	567.3	(24.2)	11	567.3	(24.2)	13
Total	5128.7	(219.2)	100	4233.8	(180.9)	100

a/ 000 Toe's; Fuelwood 1964; charcoalwood 1339. The charcoalwood produced 502,000 toe's of charcoal.
b/ Excludes exports. Distribution losses 57,900 toe.
c/ 1 TOE = 42.74 GJ (10^9J); 1 PJ = 10^{15}J.

Source: ESMAP/DOE Energy Sector Strategy Study, 1988, amended and updated by the project.

Energy Demand

3.25 The energy demand picture in Zambia is dominated by households. According to estimates of energy consumption in 1988, households accounted for 58% of final energy consumption, primarily in the form of fuelwood and charcoal (Table 3.3).

TABLE 3.3: ZAMBIA: FINAL ENERGY CONSUMPTION BY SECTOR AND FUEL IN 1988 (PJ)

Sector/Fuel	WF	CR	Coal	Petroleum	Elec.	Total	%
Household (Rural)	(64.3)	(11.7)		(0.4)	(0.2)	(76.6)	(43)
Household (Urban)	(23.1)	(0.9)	-	(1.4)	(1.9)	(27.3)	(15)
Household	87.4	12.6	-	1.8	2.1	103.9	58
Agriculture & Forestry	8.6			0.7	0.4	9.7	5
Mining	0.5		7.9	6.6	16.8	31.8	18
Industry & Commerce	8.5	1.1	6.0	3.1	3.0	21.7	12
Government/service	0.4		0.7	0.3	0.7	2.1	1
Transport				11.7		11.7	6
Total	105.4	13.7	14.6	24.2	23.0	180.9	
Percent	58	8	8	13	13	100	

Source: ESMAP/DOE Energy Sector Strategy Study, 1988, amended and updated by the project.

3.26 Woodfuel met about 84% of household energy needs, crop residues 12% while electricity accounted for just over 2% and the remainder came from kerosene.

3.27 Although mining industry production has been declining over the last 10 years, the mines continue to dominate consumption of the so-called commercial energy, namely electricity, coal and petroleum. Respectively, the mining industry accounts for 72%, 54% and 28% of total consumption of these fuels and has been the single most important factor in the use of these energy forms. The energy consumption of the mines is likely to remain stagnant or fall due to continued reduction in copper production, high production costs and the energy conservation measures currently being implemented.

3.28 A notable feature of the energy consumption pattern in Zambia is the low energy utilisation in agriculture which accounts for only about 5% of final consumption. With the economic strategy of diversification into agriculture, there is wide scope for more energy utilisation in this sector to boost production. Electricity consumption is expected to take an upswing with the increased emphasis on irrigation.

3.29 Industry, Commerce and Transport are the other major users of energy in the form of coal and electricity for the former two and diesel and gasoline for the latter.

Woodfuel and Household Energy Issues

3.30 A serious concern about woodfuel issues has only recently surfaced despite the fact that woodfuel occupies such a prominent position in the national energy balance. Similarly, for households, the major users of energy, there has been insufficient attention accorded to the energy issues affecting this sector. Consequently, there is a limited knowledge on the supply and demand balance, and the problems associated with woodfuel use. Generally, it has been accepted that the use of woodfuel, particularly charcoal, is a major contributor to deforestation. However, there has been a real lack of knowledge on the extent to which tree cutting for charcoal production is a contributor to deforestation in relation to other contributors, such as agricultural expansion.

3.31 Woodfuel is largely a household fuel. Rural households use fuelwood, mainly from collected dead wood. Urban household purchase charcoal. The urban population consists of a large pool of low income households; these households either have little access to or cannot afford modern fuel such as electricity, and must, therefore, depend on charcoal for cooking. This has resulted in a number of problems: the price of charcoal has been increasing, worsening the financial position of most urban households in an already deteriorating economic situation; the supply of charcoal is erratic during the rainy season and this imposes severe hardships to charcoal-user households; the traditional charcoal stove is inefficient and much energy is wasted.

3.32 Charcoal is produced using the traditional earth clamp method. Generally, this method of charcoal production has been considered inefficient and wasteful, although no detailed study has been conducted on it, let alone on the organisation of charcoal production.

3.33 With the rising awareness of the importance of woodfuel has come the need to understand the issues associated with its use so that well founded intervention measures can be instituted where necessary. This study in particular looked at:

(a) the biomass resource; its management, use, productivity and regeneration;

(b) the various pressures on the woodlands and their relative contribution and deforestation;

(c) charcoal production; how it is organised, efficiency of the traditional methods and production cost of charcoal;

(d) charcoal marketing; the distribution network from the production site to the consumer, identification of the major actors, price mark-ups at each stage of distribution and the operational efficiency of the system; and

(e) energy demand patterns of urban households to determine the types, costs and quantities of energy by various end-uses and potentials for interfuel substitution.

3.34 Emphasis was placed on the possibility of substituting electricity for charcoal in urban households since Zambia has an overcapacity of installed hydropower. It was necessary to assess the economic and technical viability of this option given that the cost of electricity distribution and connection are high and end-use electrical equipment is extremely expensive. In order to implement this option, electricity connection needs to be made less expensive and cheap electric cookers made available.

3.35 It is against this background that the Zambia Urban Household Energy Strategy project was launched. The study has a comprehensive approach to household energy, covering woodfuel issues from the wood resource to the final consumer and assessing the household energy demand pattern, electricity and other fuels substitution options and the non-household energy use (food processing and preparation which is considered to have some influence on household energy consumption).

3.36 The focus has been on urban households - it is considered that the energy problems of these households require the most urgent attention. According to the 1980 census the residential sector was composed of approximately 400,000 urban households (35.5% of total), living in 57 towns. The households ranged from 700 in Senanga to 100,000 in Lusaka with 5.6 people per household. By 1988, the urban households had grown to an estimated 528,000 - nearly 3.0 million people.

Project Implementation

3.37 The Zambia Household Energy Strategy Project had six major components, namely:

(a) The Urban Household Energy Demand Survey;

(b) Non-Household Energy Use Survey;

(c) Biomass Survey;

(d) Charcoal Production Study; and

(e) Woodfuel Transportation and Distribution Survey;

(f) Electricity Substitution Study;

3.38 The Urban Household Energy Demand Survey was aimed at collecting data on energy consumption patterns plus other information such as income and appliance ownership, responses to energy scarcity and price changes, attitudes to conservation and fuel substitution. Information on the consumption of woodfuel was supplemented with the findings of the Woodfuel Transportation and Substitution Studies while that on electricity consumption was enriched by the Electricity Distribution Study. The latter also utilised information from the demand survey on electrification levels and patterns of electricity demand in the analysis of the economic and technical viability of widespread electrification in urban households. Investigations of Non-household

Energy provided information on the importance of this sub-sector and its effects on household energy demand.

3.39 The results concerning woodfuel were fed into the findings of the Biomass Survey which was aimed at assessing the biomass resources, deforestation, woody biomass regeneration and the various pressures on wood resources.

3.40 The findings of the Charcoal Production Study (which focused on traditional methods of charcoal making) and the Biomass Survey, showed the complimentary effects of improvements in either system e.g. through better management of biomass resources and improved efficiency/ organisation of charcoal production.

3.41 The Woodfuel Transportation and Distribution Study was aimed at tracing woodfuel marketing from production to final users, assess improvements that can be made on the supply system and the effects of such measures on woodfuel production and demand.

3.42 The results of the various surveys are now described.

IV. SUPPLY OF ENERGY

1. Traditional Fuels

A. Biomass Resources

Introduction

4.1 The total area of Zambia is about 753,000 km^2 (75.3 million ha.) most of which is high plateau ranging in altitude from 1,000 to 1,500 meters above sea level. There are approximately 11,000 km^2 of water and 600 km^2 of urban areas and roads, thus leaving 741,400 km^2 under trees, grass and agricultural crops. The area of arable land has been estimated at 51,900 km^2 but only about 10,000 km^2 is farmed in any one year, so the bulk of agricultural land alternates between trees and crops in a shifting cultivation system. New areas are being constantly opened up for agriculture and currently the Government of Zambia intends to clear 2000 km^2 of woodland along the Tazara rail line for agricultural development. However, open woodlands dominate the vegetation type of Zambia as Table 4.1 shows.

Table 4.1: EXTENT OF EIGHT MAJOR VEGETATION TYPES IN ZAMBIA

Vegetation type	Extent (Mha)	Percent of Total area
Forest	2.4	3.2
Miombo woodland	35.3	46.9
Munga woodland	3.8	5.0
Chipya woodland	2.4	3.2
Mopane woodland	4.4	5.8
Mkusi woodland	1.0	1.3
Kalahari sand woodland	10.0	13.3
Grassland	15.0	19.9
Lakes	1.0	1.4
Total	75.3	100.0

Note: The agricultural areas of 5.2 million hectares are scattered throughout the various woodland and grassland types. There are also about 0.1 million ha. of water ways and semi-permanent lakes, plus 60,000 ha of urban areas and roads in the above vegetation types.

Source: Chidumayo (1986).

4.2 Miombo woodland is the dominant vegetation type not only in Zambia but throughout Southern and Eastern Africa. Its productivity is strongly correlated to rainfall and in Zambia four classes of Miombo have been described with rainfall ranging from about 600 mm per annum to 1400 mm/a. (Chidumayo 1987). In undisturbed Miombo woodlands, previous estimates of above ground woody biomass ranged from about 97 m^3/ha (54 t/ha bone dry) in the driest class to 180 m^3/ha (99t/ha bone dry) in the wettest class. However, several areas have been cut over or disturbed in one way or another thus the actual growing stock in any particular class will be less than above figures.

4.3 An extensive woody biomass area survey was recently undertaken by the ETC Foundation on behalf of the Southern Africa Development Co-ordination Conference (SADCC) Energy Co-ordination Unit (SADCC Energy Co-ordination Unit 1987) which used satellite imagery to delineate nine vegetation types - eight woodlands and one swampland. The above ground woody biomass growing stock was assessed using published data from various sources but no ground truthing was undertaken. This study estimated that the growing stock was in the region of 2950 million air dry tons, (47,200 PJ) with an annual increment of approximately 83.5 million t. of wood - 100 million m^3, (1300 PJ). Because no ground truthing was undertaken, the above figures must be taken as orders of magnitude rather than precise numbers.

4.4 Indeed, the ground measurements that were carried out by this project indicate that the standing biomass and annual yield are higher than previous estimates. The above ground woody biomass may be about 4.3 billion tons (a.d.) - 69 Exajoules - with an annual increment of 130 million t. (a.d.) - 2080 PJ. Bearing this in mind, the annual increment is over fourteen times the estimate of 1988 woodfuel consumption - 141 PJ (Table 3.2) and woodfuel consumption accounts for 80% to 90% of total wood consumption including poles, sawnwood, panel products and paper etc. So the overall picture is that at present Zambia has sufficient woody biomass resources to meet demand on a sustained basis.

Woodland Assessment in Areas Serving Urban Centers 2/

Measurement of Growing Stock and Annual Yield

4.5 The woodland areas serving large population concentrations are considered to be the areas most under threat. This was verified from the demand survey which showed that small towns are using firewood from nearby scattered trees and woodlands whereas large towns use charcoal from relatively distant areas.

2/ This is a condensed version of the Biomass Assessment Study which is a project working paper. A fuller version is included as annex 1 to this report.

4.6 An examination was therefore made of the two large urban biomass catchment areas serving the Copperbelt and Lusaka to determine; woodland type and its condition; ownership and control of the resource; accessibility; growing stock; yield; loss of woodland areas; and causes of woodland depletion.

4.7 A second set of investigations was made to examine; the fee and taxes levied on wood and wood products; the quality of fee assessment; and the effectiveness of collection. Finally the past management practices were examined in relation to usefulness today.

4.8 Aerial photographs taken between 1982 and 1987 were examined of the biomass catchment areas for the Copperbelt and Lusaka. They covered an area of 6.8 million hectares and serve a 1988 urban population estimated to be 1,362,000 for the Copperbelt and 1,024,000 for Lusaka. 3/ These two urban complexes account for over 80% of urban population and 33% of total population (see map at back of the report: Forest Estate, Urban Population Distribution in Line of Rail District).

4.9 Three distinct natural land types were noted and are in order of importance, miombo woodlands, flood plain grasslands and munga/mopane woodlands. Ground surveys revealed that charcoal production is confined to the miombo woodlands. An analysis of the catchment areas gave the following land classification (Table 4.2).

4.10 Sixty-four percent of the land area is classified as woodland and most of this, 78%, is in a relatively unused state, therefore there is still a large reserve of woodland even in the most densely populated area of the country.

4.11 Three broad types of land ownership occur in natural woodlands namely trustlands, reserves and statelands. Statelands are administered by individuals or institutional leaseholders such as the forest service. Trustlands and reserves are owned by communities and administered by chiefs/headmen, although it is possible to have government forest reserves in these areas. This tenurial land system has not caused any access problems to the biomass resource, although there is no guarantee that any of the woodland areas will remain in tact unless steps are taken to reserve them and/or make it profitable to retain them as woodlands. At present one third of the forest area in the Copperbelt is reserved (gazetted forest) and managed by the forest service, but less than 7% of the forest area in the Lusaka catchment area is gazetted, so the security of wood products supply in the Lusaka catchment area could be a problem.

3/ The towns considered for the Lusaka catchment area are along the line of rail from Mazabuka in the South to Kapiri Mposhi in the North. The city of Lusaka accounts for 80% of the total population.

Table 4.2: LAND CLASSIFICATION FOR THE BIOMASS CATCHMENT AREAS a/
Units in km^2

Catchment Area	Total Area	Urban	Culti-vated	Grass land	Forest Planta-ation	Woodland c/ Cleared for wdfuel	Woodland c/ De- b/ graded	Woodland c/ Un-used
Copperbelt	27785	309	2763	3802	635	1633	2486	16157
%	100	1	10	14	2	6	9	58
Lusaka	40584	185	5945	10639	7	729	4761	18318
%	100	0	15	26	0	2	12	45
Total	68369	494	8708	14441	642	2362	7247	34475
%	100	1	13	21	1	3	11	50

a/ As analysed from the aerial photographs.
b/ Degraded woodlands have a severely reduced woodland cover which on aerial photographs resembles parkland. This degradation has been brought about by selective felling for shifting cultivation and/or charcoal production. Although woody biomass is available in degraded woodlands it is too scattered to be exploited commercially and is principally available for rural demand.
c/ Six percent of the woodland area is munga/mopane type, the rest is miombo. These woodland types are named after the dominant tree species in them.

4.12 Another factor which has to be considered is the environmental consequences of cutting trees. Most of the woodlands in the Copperbelt are on plateaux or gentle slopes and can be clear felled with little or no environmental damage. However, 10% of the land in the Lusaka catchment area is on escarpments or hills. If trees on such areas are clear felled, moderate to severe environmental damage may occur. This factor should be taken into consideration when determining management practices or land use changes.

4.13 It has been stated frequently that the largest cause of forest destruction is woodfuel clearing, this was recently reiterated in an article entitled 'Woodfuel Situation and Deforestation in Zambia' by K.E. Shamilupa Kalapula, 1989, AMBIO Vol. 18 No. 5. Other publications have urged increased electrification to save the forests.

4.14 The aerial photographs of the two biomass catchment areas were analysed in detail and contrary to what is commonly believed the major cause of natural vegetation destruction is conversion to cropland either permanently or on a rotational system and not cutting trees for fuel. This can be seen from Table 4.3.

Table 4.3: NATURAL VEGETATION CLEARANCE IN THE BIOMASS CATCHMENT AREAS a/
(Units in km^2)

Catchment Area	Cleared and Degraded Woodlands b/	Cause of Woodland Clearing: Urbaniza-tion c/	Cultivat. from Grasslnd	Cultivat. from Wdlnd	Shifting Cultiv. d/	Plantat. Forestry	Woodfuel Clearing e/
Copperbelt	7752	309	(74)	2689	2486	635	1633
%	100	4	-	35	32	8	21
Lusaka	11496	185	(131)	5814	4761	7	729
%	100	2	-	51	41	0	6
TOTAL	19248	494	(205)	8503	7247	642	2362
%	100	3	-	44	38	3	12

a/ As analysed from aerial photographs.
b/ Excluding cultivated land acquired from grassland indicated in Col. 4.
c/ Includes land cleared for mining and industrial development.
d/ This also includes some land that will revert to permanent woodlands.
e/ Some of this land may be converted to arable agricultural land.

4.15 Only 12% of woodland clearing can be directly attributed to woodfuel production. What is more, most of this land will regenerate and once again become productive woodland. Nearly half of the cleared land (44%) was cleared for permanent agriculture and another 38% for shifting cultivation. Together these land use changes account for over 80% of woodland clearance. This is not to condemn the clearing of land for agriculture. Clearly economic opportunities have brought about land use changes and Zambia has sufficient woodlands for this shift to continue.

4.16 However, what is important is that the use of land be more rationally planned; some land under trees cannot sustain agriculture and should not be converted. Other woodlands, especially in water catchment areas and on steep slopes, should be retained under trees for environmental reasons. When changes do take place say from woodland to agriculture the wood resource should be used, if it makes economic sense, by charging the farmer for the wood raw material, rather than being burnt on site as it has been in the past. It will then be the farmer's interest to make the best use of the wood resource.

4.17 To meet future demand for wood resource, sufficient areas of woodlands should be reserved and managed either by the forest department or by private individuals. The value of the wood raw material on these lands could and should be at a level to more than pay for the management initiatives.

4.18 In order to quantify the amount of woodland resources growing on urban biomass catchment areas, studies were undertaken in unused woodlands to determine standing mass and in coppice regrowth areas of known age to estimate annual increment. Sample plots were delineated, and various measurements taken such as the number of trees by species and the diameter of each stem. Between 36% and 54% of the trees were felled, divided into cord wood (suitable for fuel), twigs and leaves. The various parts of the tree were weighed and measured for moisture content.

4.19 From the sample plots, the biomass assessment found that in the dry miombo areas round Lusaka there was a standing weight of 72 tons of bone dry cord wood per hectare and in wet miombo areas on the Copperbelt, 130 tons of cord wood (b.d.) per hectare. From studies in the coppice regrowth areas the mean annual increment of cordwood was found to be 2.2t./ha. (b.d.) and 3.8t./ha. (b.d.) in dry and wet miombo woodlands respectively.

4.20 These figures are considerably higher than the estimates that have been used in the past (Chidumayo 1987) and further work should be done to verify these findings, but there might have been small sample bias.

4.21 The above figures were applied to the unused woodland areas only, assuming that just wood from these areas will be available to meet the demands of the large urban centers of Lusaka, and the Copperbelt. Table 4.4 gives an estimate of the growing stock and annual increment (yield) for the various catchment areas serving the above towns.

Table 4.4: AREA, STANDING STOCK AND ANNUAL INCREMENT OF UNUSED WOODLAND IN THE BIOMASS CATCHMENT AREAS OF THE COPPERBELT AND LUSAKA

(units million m.t. cord wood bone dry)

Catchment Areas	Total Area			Accessible Area a/			Gazetted Area b/		
	Area km^2	Growing Stock	Annual Incremt.	Area km^2	Growing Stock	Annual Incremt.	Area km^2	Growing Stock	Annual Incremt.
Copperbelt	16157	210.0	6.1	16157	210.0	6.1	7079	92.0	2.7
Lusaka	18318	132.0	4.1	14114	101.7	3.2	1548	11.1	0.4
Total	34475	342.0	10.2	30271	311.7	9.3	8627	103.1	3.1

a/ Assessible areas are areas where it is safe to clearfell trees without causing significant environmental damage.

b/ A gazetted area is an area reserved by government and managed by the forest service.

4.22 Total urban consumption of woodfuel may grow from 2.5 million tons in 1988 to 3.3 million tons in 2000. There is enough wood biomass to supply the woodfuel (and pole) demand for urban areas provided sufficient areas of woodlands are reserved and/or managed properly. However, there is insufficient area of gazetted (forest service) woodlands in the Lusaka catchment area to meet its present and future demands, therefore more woodland area should be reserved if the supply base is to be secured.

Resource Payments and Taxes

4.23 Unless resources are subsidized, the cost of providing particular resources must be recoverable in the selling price in order that production continues. Even if a raw material has very little production cost, such as oil or naturally grown trees, a price can be charged for the material if there is a demand for it. In this case the price may be derived from the cost of substitute materials.

4.24 Many trees have grown without human interference, and this is especially so in Zambia. However, there is a steady and constant demand for the wood raw material, for example about 16 million, 40 kg bags of charcoal were produced in 1988 of which 13 million bags went to the urban household sector. Therefore the owners of the resource could and should charge for it to reflect its value and to maintain the area under trees. If they do not then the traders or transporters of the product will capture the value of the raw material in their selling price and there will be little incentive to manage the cut over area.

4.25 In fact the Government of Zambia does levy stumpage fees on wood raw material for public land trees but they usually do not reflect the value of the resource. According to the Forestry Act, no one can harvest/collect forest products for sale without licence issued by the Chief Conservator of Forest or his representative. These stumpage fees vary according to the end use but not according to distance from the market. Wood for fuel is charge the lowest price and wood for sawing from fine hardwood the highest price.

4.26 For a particular end use the fee charged per unit volume can differ considerably depending on how the raw material is bought. For example the price per cubic meter of roundwood for fuel is as follows:

(a)	by the headload	ZK13.9
(b)	stacked m^3	ZK 5.5
(c)	metric cord	ZK 4.8
(d)	via bags of charcoal	ZK 1.7

4.27 People buying fuelwood by the head load are paying three times as much as those buying by the cord. A charcoaler paying the fee via the bag is paying one third the price of a producer who pays by the cord. These anomalies could easily be rectified by adjusting the fees to make them consistent.

4.28 The above fees were drawn up about eight years ago but only came into operation in 1988, because they had to be approved by cabinet which kept postponing the decision. Thus while eight years ago the fees may have reflected the then value of wood raw material, today the fee for charcoal wood has been eroded by inflation and is at most 4% of the selling price of charcoal. The growers or the managers of the raw material should be able to adjust their price according to market conditions and not be tied down by government.

4.29 The trade in wood products, particularly charcoal is sufficient to finance the forest service if economic stumpage fees are charged and if the fees are fully collected. The present set up is poorly organised for fee collection. There are too few people in the field to measure the wood raw material and collect the fees. This is because the forest service does not receive sufficient funds to employ more staff. Yet if the current fees could be collected, revenue would be about ten times the amount presently retired to government. 4/ In 1987 the collected fees from all forest products came to ZK2.8 million, yet stumpage fees on traded fuelwood and charcoal in urban areas should have raised about ZK20 million.

4.30 One principal problem is that the forest service receives money each year from a "Government vote", the amount depending on the country's economic performance. It retires its collected income to general treasury funds. If the service was made more accountable for its income and expenditure it should be able to more than pay its way. One solution could be to turn the forestry department into a self financing forestry commission. Another option is to have a revolving fund and keep a percentage of the collected fees. The various options should be discussed by the interested parties, - government, villagers, producers, traders etc. - and a solution proposed.

4.31 One reason for poor performance in the field is lack of equipment, transport, training, and low pay. A check on stackwood measurements revealed that where trees were assessed for stumpage fees, the assessment was about one third of actual stackwood volume. If field staff in particular and the forest service in general were rewarded for fee collection and raw material measurement by receiving a percentage of the fees then the revenue should increase significantly.

4.32 Besides stumpage fees, various taxes are levied on forest products. There is a "removal" tax on charcoal which at present is ZK0.50 per bag. This tax should be paid by the purchaser of the product, - the transporter or trader. The system of checking valid tax payments is poor and the same removal licence may be used repeatedly. In 1988 the removal fee on urban charcoal should have been about ZK6 million. If the organisation of producers and traders is improved then licences valid for one day only could be issued from charcoal depots. Also a removal tax on traded fuelwood could be levied. This would amount to ZK1.0 per stacked m^3 (ZK1.7 per solid m^3) to be on par with the charcoal fee.

4/ Some fees may be collected and pocketed and not retired to government.

Management of Woodfuel Areas

4.33 In the past, felling for woodfuel in the forest estate has been based on the technique of alternating clear-felled areas (coupes) and uncut strips (shelterbelt). Apparently shelterbelts were intended to act as sources of seed which would rain over the cleared areas. This reason is not valid because most of the regeneration in felled miombo woodland originates from stump coppice or root suckers and from a bank of stunted seedlings which are already present in the pre-felling woodland. However, in hilly or escarpment areas where shelterbelts are across the slope, these are very useful in controlling run off and erosion. Unfortunately, this harvesting technique appears to have been abandoned, especially in the Copperbelt area where extensive areas are clear-felled without any shelterbelts.

4.34 Post-felling management of deforested biomass areas in the forest estate is largely restricted to early burning during the early dry season (April-July). Early burning results in a patchy burn, it lowers regeneration loss and prevents the occurrence of extensive and destructive burns during the late dry season. This silvicultural practice tends to promote woody biomass regeneration. However, due to inadequate resources, the Forestry Department is no longer able to effectively mount annual early burning campaigns, even in the forest estate. But as mentioned previously, it is failing to collect at least 90% of fees due to government. With more manpower it could improve both fee collection from and management of woodlands. There should also be a surplus of money coming from such activities.

4.35 Outside the forest estate the Forestry Department has little control over the woody biomass. Land owners/users, and chiefs and village headmen in the case of vacant land, have responsibility over the land and the biomass growing on it. Where the woody biomass is cleared for woodfuel without subsequent conversion to agriculture, natural regeneration usually occurs unaided. However proper management through species selection, exclusion of animals in the first years and early burning can substantially increase desirable species and shorten the rotation period. The forest service could and should help with advice and training. In areas with a high human population density, small poles in coppice regrowth are selectively felled for a variety of construction works. Sometimes such felling may be so intense that it impairs woody biomass accumulation. Thus there is an urgent need not only to monitor and manage woodland areas, but to estimate the area required to meet future needs and to reserve it.

Non-Woody Biomass

4.36 Besides burning fuelwood and charcoal, a few urban households burn crop residues for cooking, particularly bagasse (sugar cane waste) in areas close to the sugar factories. The estimated urban consumption in 1988 was 67,000 tons (air dry), 0.92 PJ. None of the sample households use dung for cooking, therefore, it is assumed that it is not an urban fuel. In fact there are a few reports of dung being used as a rural household fuel in the western province and crop residues are burnt in most rural areas particularly after harvest. To present a complete picture of biomass availability Table 4.7 gives an estimate of the annual production of crop residues and dung by the principal crops and animal types.

4.37 The annual production of crop residues is of the order of 1.6 million tons (a.d.) and that of dung 1.1 million tons (a.d.). Of course there are other uses for these residues such as animal feed and fertilizers. Also many of these resources are scattered or seasonal and will not be used as urban fuels unless they are readily available and are cheap.

Table 4.5: ZAMBIA - 1987 ESTIMATION OF CROP RESIDUES AND DUNG PRODUCTION a/

Crop Type	Area km^2	Crop Production 1000t	Biomass 1000t (bone dry)
Maize	6090	954	1161
Other Cereals	1090	84	97
Root crops	67	256	44
Miscellaneous	1610	120	114
Sugar cane	100	1250	141
Total Crop	8957		1557
Animal Type	Number Mill.		Dung 1000t (bone dry)
Cattle	2.85	-	1031
Pigs	0.22	-	19
Sheep/goats	0.50	-	40
Total animal			1090

a/ Based on FAO's 1987 Yearbook of Agricultural Production. The various factors to assess crop residues at 15% m.c. as multiples of crop outputs are: maize 1.4; rice 1.4; wheat 0.7; barley 0.82; sorghum 0.9; millet 2.0; cassava 0.2; pulses 0.13; groundnuts 2.3; sunflower 0.7; sugar cane 0.13; cotton 1.20. These results were then converted into bone dry weights by dividing by 1.15. For animals the following yearly production of bone dry dung per animal was assumed. Cattle 363 kgs; pigs 86 kgs; sheep/goats 79kgs.

B. CHARCOAL PRODUCTION 5/

Charcoal Production Techniques

4.38 Charcoal is the dominant urban household fuel accounting for about 60% of household energy consumption. Practically all charcoal is made from miombo woodland trees in traditional earth clamps (kilns), which on average produce 2600 kgs of lump charcoal.

4.39 Charcoal production is a full time informal family business, but workers may be hired to do specific tasks such as felling, crosscutting and clamp building. Hand tools dominate but many are of poor design especially axes; cross cut saws are rare. Thus there is scope for the introduction of new and improved tools and to give training on their proper use.

4.40 The conversion efficiency on a weight basis varied from 17% to 33%, but no tests were done on the degree of charcoal carbonisation. This can vary and thus affect the energy content of "charcoal". Therefore more detailed work has to be done on production techniques.

4.41 In 1988, the average production of charcoal from study sites was 56 kgs per day per person and production costs were estimated to be ZK 15.4 per 40 kg bag. 65 percent of the costs were for labor, 3% for tools, 12% for stumpage fee and removal tax and the remaining 20% the profit margin. The actual average selling price was ZK15 per bag.

4.42 Daily production is low because of a combination of factors, namely uncertainty of raw material supply, poor tools and organisation, the lack of services such as shops, education and health, shortages of food and poor accessibility to some sites.

4.43 The charcoal producer has been blamed for the destruction of the woodlands and for cutting trees without permission. However, agricultural clearing is the principal cause of permanent woodland clearing, not cutting trees for charcoal. This latter activity usually causes temporary deforestation if the areas are left to regenerate. Many trees are cut without the government receiving stumpage payments, but some of this is caused by poor administration and lack of people in the field to issue permits and collect fees. Charcoal production is not illegal, indeed, without it the country would have a much larger import bill for energy.

5/ A detailed description of charcoal production, transportation and marketing are given in project working papers and summarized in Annex 2.

4.44 In 1988, charcoal production provided full time employment for about 41,000 rurally based people. A further 3,500 were employed in transportation and another 1,000 in marketing and distribution. Therefore, it is a major employment activity.

4.45 Charcoal is used by over 80% of urban households, it is the principal fuel for 55% of the urban population (1.6 million people) in particular, the urban poor.

C. TRANSPORTATION AND DISTRIBUTION OF WOODFUELS

4.46 Fuelwood is the principal fuel for households in small towns and charcoal in cities. Many people in small towns still collect fuelwood but motorized vehicles are used to deliver charcoal and fuelwood to large urban areas.

4.47 Like charcoal production, transportation and distribution are in the hands of the informal sector. Woodfuel traders may own their vehicles but some hire them. They usually have agreements with producers but sometimes they go and look for charcoal in the bush. They may also deliver foodstuffs and other supplies to the producers.

4.48 There is a wide variety of transport modes but in terms of loads carried, 3-7 ton lories are the most important followed by 1-1.5 ton pick-ups. Practically all these vehicles are very old and some have been assembled from scrap vehicles consequently many are unreliable. Occasionally large lorries with trailers are used but only on surfaced roads, thus, some charcoal (and fuelwood) is sold at roadside, but most is collected from the bush.

4.49 The cost of transport has been increasing rapidly due to devaluation and inflation; there was a 60% inflation in 1988, and even more in 1989. The cost also varies between mode of transport; in late 1988, the average transport cost per bag of charcoal was ZK7.04 by lorry and ZK 14.50 by pickup, with a weighted price of about ZK8.90 per bag.

4.50 The price varies between towns, principally because of differences in average haulage distance but also because of variations in types of vehicles. In November 1988, the delivery cost per bag to Lusaka, with an average round trip distance of 184 kms, was ZK10.60, whereas that to Kitwe on the Copperbelt was ZK5.40 (round trip 81 kms). The weighted transport distance is about 120 kms and the weighted cost about ZK8.10 per bag.

4.51 Compared to long distance road haulage costs and rail costs the figures are high. The average cost by road for 120 kms in late 1988 was about ZK4.8 per bag and that by rail ZK1.2 per bag. Today the difference between long distance road and charcoal lorries/pick-up is two to three times.

4.52 During the rains in March and April 1989 which were exceptionally heavy, the number of vehicles transporting woodfuel decreased by 30%, and the average load per vehicle decreased by about 40%. These factors resulted in a 50% to 60% decrease in deliveries which in turn caused an increase in price.

4.53 In late 1988, a bag of charcoal cost ZK30 in Lusaka - production ZK15, transport ZK11, marketing ZK4. At the height of the rains, a bag sold for ZK150 but the average price was ZK120. After the rains the price decreased to ZK80 per bag, ZK50 higher than the price before the rains. By late 1989 due to an increase in the price of kerosene and the non-availability of electricity in the evenings the price of charcoal had increased to ZK100 per bag.

4.54 In March 1989 the economic cost of charcoal was about ZK50 per bag (Annex 6). By October 1989, allowing for inflation, the economic cost of a bag of charcoal was about ZK90 - ZK95 therefore the selling price is above the economic cost, unlike electricity where the current price is about half its economic cost.

4.55 In 1988, an estimated 513,000 tons of charcoal were transported to urban areas. This trade, at ZK30 per bag, was worth ZK385 million (US$49 million). The forest service should have collected about ZK18 million in stumpage fees from charcoal wood, and a further ZK2 million from traded fuelwood. In addition the removal tax on charcoal should have been ZK6 million. In fact the service collected only about 10% of these sums.

4.56 In 1989, the value of urban charcoal had increased to about ZK1300 million (US$65 million) but of course the stumpage fee and removal tax have not increased so in terms of selling price the combined fees have been reduced from about 6% to 2%. These fees are too low to cover the costs of the forest service and to entice private individuals to invest in woodland management or tree planting (see paras. 5.36 - 5.38).

4.57 It can be deduced that the charcoal producers and transport/ traders are capturing some of the raw material value in the selling price of charcoal.

4.58 If trees are to be managed properly, and continue as a major energy source then the stumpage fees will have to increase to cover the capital and recurrent costs of the forest service and to encourage private investment. Fees and taxes equal to about 10% of the selling price of the product should be sufficient to cover costs and provide some revenue for government. In return, training could be given to charcoal producers, bush roads could be improved and the fluctuations in supply between the wet and dry seasons reduced. Such steps should ensure a much more efficient industry, an even supply of charcoal or fuelwood year round and hopefully lower prices.

4.59 If wood raw material prices are increased, trees will be regarded as a valuable asset, to be planted and managed by private individuals as well as by the state. Trees could and should play a part in agricultural development by preventing erosion, providing shelter for crops, fodder for animals, conditioner for the soil through leaf and twig decomposition, and for several species of trees, a source of nitrogen and other fertilizers for the crops. The environmental benefits from trees can be just a great as the economic benefits of their products, but unless sufficient value is put on the raw material, trees may be regarded as a wasting asset.

2. Conventional Fuels

Electricity 6/

Production

4.60 Apart from biomass, Zambia has other indigenous energy resources namely hydropower and coal. With the exception of petroleum, the country is virtually self-sufficient in energy and is usually a net exporter of hydropower.

4.61 In 1986, electricity supplied 12% of Zambia's energy, but most of that was used for industrial purposes, household consumption accounting for only 1% of total demand; - 7% of electricity supply - although about 40% of urban household are connected to the grid according to 1988 listing.

4.62 The generating capacity is some 1759 MW and the estimate of energy production is 9625 GWh to 10,125 GWh per annum (34.6 PJ to 36.4 PJ). This is shown in Table 4.8.

6/ A much more detailed account of the electricity sector may be found in two sister ESMAP reports namely a) Zambia: Energy Sector Strategy: Activity Completion Report No. 094/88 and b) Zambia: Power Subsector Efficiency Study (Draft) Activity Completion Report 093/88.

Table 4.6: ZAMBIA 1988: INSTALLED POWER CAPACITY AND ESTIMATED FIRM ENERGY CAPABILITY

Power Station	Installed Capacity	Firm Energy
	MW	GWh/a
Interconnected System		
Kariba North	600	3,750-4,250
Kafue Gorge	900	5,000
Victoria Falls	108	770
SUBTOTAL	1,608	9,520-10,020
Northeastern System		
Lusiwasi	12	50
Chishimba Falls	6	20
Musonda Falls	5	30
Lunzua	1	5
Diesels	2	-
SUBTOTAL	26	105
Isolated Diesels	5	-
ZCCM		
Gas Turbine a/	80	-
Waste-Heat Thermal b/	40	-
GRAND TOTAL	1,759	9,625-10,125 c/

a/ Standby.
b/ Output is typically in the range of 3 MW.
c/ 34.65PJ - 36.45PJ.

Source: ZESCO and ESMAP estimates.

Consumption

4.63 The current domestic demand for electricity including distribution losses is about 7,070 GWh per year (25.5 PJ) so there is usually ample surplus for export. However, in April 1989 there was a fire at Kafue Gorge which knocked out this supply source; thus the firm energy capability dropped to 4625 - 5125 GWh/a (16.6PJ - 18.4PJ), some 28% to 35% less than domestic demand. The country had to import electricity from Zaire (and Zimbabwe) to the value of about US$1 million per month (about 100 GWh). Also households suffered from systematic outages each day and this meant that many people that used to cook with electricity had to cook with alternative fuels. It was estimated that it will take at least six months to repair the damage at Kafue Gorge and cost in the region of US$25 million to repair. The World Bank Energy Sector Strategy Study (Activity Completion Report 094/88 - Dec. 88) pointed out that Kafue Gorge power station was in urgent need of minor repairs to amongst other things, the 300 kv cables where the fire occurred. The total cost of rehabilitation was estimated to be about US$5 million, now the cost, including the cost of repair, importing electricity and the loss of foreign exchange through export losses will be ten times that amount. It cannot be over emphasized that timely care and maintenance is essential to ensure that such large capital investments are kept in good working order.

4.64 One fallacy that should be cleared up is that electrification will save deforestation. Zambia has adequate woodlands and .orests to give a sustainable supply of biomass energy to meet the count.y's future demands, if these areas are properly managed and if substantial portions are not cut down for agricultural expansion. It should be reiterated that household electricity accounts for about seven percent of electricity demand which in turn accounts for one percent of total energy demand. Even large investments in electricity connections will not alter the picture substantially and they may cause strains on foreign exchange requirements, for about 40% of investment costs are imported items.

4.65 Electricity is principally an enhancing fuel and a source of illumination rather than a substitution fuel for wood. Most people, especially the low income groups that have electricity do not cook with it but use it for lighting, ironing, radios, etc. The immediate strategy with regards to household electricity should be to ensure a reliable and consistent supply to existing consumers by (i) improving the interconnection system, and (ii) controlling voltage fluctuations. Reducing the cost of appliances and cables could be done by encouraging the local manufacture of (cheap) stoves and cables and/or reducing the import and sales tax on these goods. If people want electricity they should not be artificially deterred. However, they should pay the full cost of this energy through the tariff and connection charges.

Petroleum Products 7/

4.66 All petroleum products are imported into Zambia via a pipe line from Dar-es-Salaam in Tanzania to a refinery at Ndola in Zambia. A mix of refined products is imported, thus the output from the refinery more or less matches the demand, for petroleum products. Kerosene (paraffin) is the only fuel used in households, LPG, being confined to industrial use. In 1988, the consumption of petroleum products was estimated to be 567,300 t. of oil equivalent (24.2PJ) or 11% of total energy demand, but kerosene consumption was only 41,500 toe (1.8 PJ). There was a minor fire at the refinery in May 1989 which temporarily stopped production and curtailed supply of kerosene, a substitute cooking and lighting fuel.

7/ A detailed description of the petroleum sector may be found in the ESMAP Zambia Energy Sector Strategy: Activity Completion Report 094/88. There is also a separate working paper on energy pricing.

4.67 The urban household survey estimated the 1988 kerosene consumption to be 33,230 t. or - 41.2 million liters - (1.4 PJ) which is approximately 80% of total kerosene production in that year. Kerosene is a cheaper cooking fuel than electricity, taking into consideration wiring and stove costs. However, because the foreign exchange component is about 80% of the cost, encouraging the increased use of kerosene is costly in terms of foreign currency. As in the case of electricity, the use of kerosene should not be discouraged but the users should pay the full economic cost. In fact in October 1989, the government raised the price of kerosene from ZK 1.79/l. to ZK 4.85/l. including ZK 0.55 tax, which is approximately the economic cost.

Coal 8/

4.68 Coal is mined at Maamba colliery in the south of the country near Lake Kariba. It has proven open pit reserves of about 30 million tons of washed coal containing not more than 16% ash with an energy content of about 25.6 GJ/ton. Coal resources are known to exist in the Zambezi Valley and in the Luangwa, Luano and Lukusashi areas.

4.69 The current annual capacity from Maamba colliery is about 700,000 t. and the 1988 demand was estimated at 571,000 t. (14.6 PJ) - 7% of energy demand. A negligible amount of coal is used in the household sector, the copper industry being the main end user. Technically, there is a potential for using reject fines to make coal briquettes as a substitute for urban charcoal and a pilot briquetting plant is being built. A prototype ceramic heating stove has been designed and this could be modified to accommodate pans. However, the economics of production and delivery have to be worked out.

4.70 If coal cannot be delivered by rail to the main urban centers it is doubtful if it can be sold at a competitive price to charcoal; people's reactions to using coal have to be assessed, so at this stage coal is a potential rather than an actual household fuel. The current surplus of capacity over consumption is some 129,000 t. equivalent to about 107,000 t. of charcoal; 20% of the 1988 urban household demand for charcoal.

8/ A more detailed description of coal production can be found in the ESMAP Energy Sector Strategy Activity Completion Report No. 094/88.

3. Potential Supply of Energy

4.71 Table 4.9 gives the potential annual supply of energy with an estimate of the 1988 consumption for Zambia. The striking feature of the table is that there is a large annual surplus of wood but of course much of this surplus is remote from demand centers. Nevertheless there are sufficient areas of wood close to demand centers to supply the needs of Zambia if properly managed.

Table 4.7: ZAMBIA: 1988 POTENTIAL ANNUAL SUPPLY OF ENERGY FROM EXISTING SYSTEMS WITH AN ESTIMATE OF DEMAND

Energy type	Units	Quantity	PJ's	1988 Demand PJ'S	Ratio: Annual Supply to Demand (= 1)
Crop residues - Dung a/	Mill. t. (air dry)	3.10	42.98	13.72	3.1
Wood b/	Mill. t. (air dry)	130.00	2080.00	162.35 c/	12.8
Coal d/	Mill. t.	0.70	17.92	14.61	1.2
Petroleum products e/	Mill. t.	1.10	47.01	24.25	1.9
Electricity f/	GWh	9875.00	35.55	25.45	1.4

a/ Crop residues: 15% mcdb 10% ash, 1.79 mill t. Energy value 13.4 GJ/t.
Dung: 15% mcdb 20% ash 1.31 mill t. Energy value 14.5 GJ/t.

b/ This is a rough estimate of annual production based on the survey findings. It is a higher estimate than the ETC foundation estimate. The actual growing stock is about 4,330 million air dry tons (69 Exajoules (10^{18}J) or more than 400 times current demand.

c/ The estimated consumption includes non energy uses such as poles and sawnwood. The division is: energy 141.17 PJ's, non energy 21.18 PJ's.

d/ The estimated reserves at Maamba colliery are 30 million tons, about 50 years supply at current demand.

e/ This is the capacity of the refinery at Ndola.

f/ This is the firm output at present.

V. DEMAND

Household and Related Non-Household Demand

Surveys 9/

5.1 Energy demand surveys were carried out in several urban areas, there was one principal survey and two followup surveys. The surveys were stratified by town size and class of area. A non-household survey of food processors and foodstuff manufacturers was carried out to determine the effect, if any, these sectors had on household energy consumption. The surveys consisted of questions and measurements on energy consumption plus information on socio-economic factors.

Economic and Socio-Demographic Aspects

5.2 According to the 1980 census, about 2,236,000 people lived in 400,000 households in 57 towns. In 1980, the distribution of the households by size of town was roughly 50%, 31% and 19% respectively for large, medium and small towns. 10/ According to the listing carried out during this survey, the urban population increased from 400,000 households in 1980 to 528,000 households in 1988 (2,966,000 people) making an average urban household growth rate of 3.5% per year. In 1988, the distribution of the households by size of town was 57%, 26% and 17% respectively for large, medium and small towns.

5.3 The 1988 distribution of households by standard of area gave the following results: 16% of the households lived in high cost areas, 34% in medium cost areas and 50% in low cost areas. It appears from this distribution and by comparison to the 1980 distribution that the number of households in low cost areas has increased much faster (by 8.2% per annum) than in high and medium cost areas (less than 1% per annum).

5.4 The average income of urban households in Zambia is ZK1,094 per month (US$139) with 1.6 earners. The average income masks a very skewed income distribution because about 45% of the households have an income of less or equal to ZK600 per month (US$76). Fifty per cent of the households receive only 20% of the total income whereas the richest 20% of the households, account for almost 60% of the total income earned by the whole sector.

9/ A full description of the survey is found in the project working paper on Demand. A summary is given in Annex 3.

10/ Large towns house over 200,000 people, medium towns house between 50,000 and 200,000 people and small towns house less than 50,000.

5.5 In 1988 urban households spent on average ZK116.4 per month (US$ 15) to purchase their fuels, this represents 11% of their monthly income and 22% of their expenditure. Charcoal expenditure takes the major share with 55% of the total fuel expenditure followed by firewood with 25%, whereas the expenses on electricity and kerosene represent only 11% and 9% respectively.

Energy Balance for Urban Households

5.6 Table 5.1 gives the 1988 estimated urban household energy balance for Zambia by end use for a population of 2.97 million people.

5.7 In 1988 urban households consumed 640,000 Tons of Oil Equivalent (TOE) of energy, 27.35 Peta joules (PJ) dominated by:

(a) two sources of energy, namely charcoal and firewood representing respectively 58% and 26% of the total consumption; and

(b) three end-uses, cooking, water heating and space heating representing respectively 49%, 16% and 22% of the total consumption of this sector.

5.8 Electricity, representing only 7% of the total energy consumed by urban households, is principally used for cooking and lighting, accounting respectively for 57% and 20% electricity consumed. However, practically all households that have electricity use it for lighting but less than 60% use it for cooking purposes.

5.9 Kerosene accounts for 5% of urban household energy consumption and is mainly used for lighting and fire ignition; this represents respectively 54% and 27% of the total kerosene consumption.

5.10 Crop residues, mainly sugar cane waste (bagasse), are used in a town close to sugar factories and are used by low income households.

5.11 As it is to be expected cooking is the dominant end use for household fuel, with space heating also being important. Together with water heating these three end uses account for 88% of consumption. Any household energy demand strategy must make cooking efficiency the number one priority.

5.12 In comparison to the 1986 assessment of total household energy consumption in the World Bank Energy Sector Strategy (World Bank 1988) it appears that this earlier document over-estimated consumption of biomass fuels, for total household consumption in 1986 is more than four times greater than the estimate of 1988 urban consumption yet total population is only two and a half times more. If downward adjustments are made to total biomass consumption and account is taken of residues, this reduces somewhat the dominant position of woodfuel but it still accounts for about 60% of total household and non-household consumption. Thus from a strategy viewpoint most emphasis has to be placed on ensuring a continual supply of fuelwood and charcoal.

TABLE 5.1: ZAMBIA 1988: ENERGY BALANCE FOR URBAN HOUSEHOLDS a/
Units TOE (PJ)

	Cooking	Water Heating	Space Heating	Cooling	Ironing	TV	Fridge	Lighting	Fire ignition	Other	Total	%
Charcoal	186,600	62,580	96,710	-	25,030	-	-	-	-	1,140	372,060	58
	(7.98)	(2.67)	(4.13)	-	(1.07)	-	-	-	-	(0.05)	(15.90)	
Firewood b/	86,880	28,210	40,060	-	12,130	-	-	-	-	570	167,850	26
	(3.71)	(1.21)	(1.71)		(0.52)					(0.02)	(7.17)	
Crop Residues	14,330	7,160	-	-	-	-	-	-	-	-	21,490	4
	(0.61)	(0.31)									(0.92)	
Electricity	25,650	2,290 c/	2,070	130	2,290	630	2,830	9,030	-	-	44,920	7
	(1.10)	(0.10)	(0.09)	(0.00)	(0.10)	(0.03)	(0.12)	(0.38)			(1.92)	
Kerosene	3,110	260	-	-	-	-	-	18,060	9,000	3,300	33,730	5
	(0.13)	(0.01)						(0.78)	(0.38)	(0.14)	(1.44)	
TOTAL d/	316,570	100,500	138,840	130	39,450	630	2,830	27,090	9,000	5,010	640,050	100
	(13.53)	(4.30)	(5.93)	(0.00)	(1.69)	(0.03)	(0.12)	(1.16)	(0.38)	(0.21)	(27.35)	
Percentage	50	16	22	0	6	0	0	4	1	1	100	

a/ 528,000 households; 2,966,000 people - 40% of Zambia's population.

b/ Excluding firewood used in funerals estimated at 16,000 TOE (43,000 tons) which when added brings the total household energy consumption to about 656,000 TOE.

c/ Geysers for water heating only.

d/ This table does not take into consideration end use efficiency.

Major Determinants of Energy Pattern

5.13 In order to identify the major determinants of household energy consumption, a statistical analysis known as the Principal Component Analysis was used. The main conclusions that emerge from this analysis can be summarized as follows:

(a) The urban household energy picture is dominated by 4 sources of energy (not in terms of quantities but in terms of behavior); namely electricity and kerosene reflected by one factor and charcoal and firewood reflected by another factor. This is described in Annex 3. The first factor can be considered as representing the use of conventional fuels and second one as representing the use of traditional fuels. 11/

- There is a high positive correlations between:

(b) the use of firewood and the size of town.
The smaller the town the higher the proportion of households using firewood. The proportion of households who use firewood is 22% in large towns, 48% in medium towns and 72% in small towns.

(c) the use of charcoal and the class of area.
98% of households living in low cost areas use charcoal compared to 85% in medium cost and 66% in high cost areas.

- There is a high negative correlations between:

(a) the use of electricity and the use of kerosene.
The use of electricity excludes or reduces considerably the use of kerosene especially for lighting (the main use of kerosene). About 55% of the electrified house-holds that still use kerosene use it mainly for other purposes such as fire ignition and cooking.

(b) the use of charcoal and the use of firewood.
Firewood and charcoal are substitutable, and the use of charcoal excludes or reduces considerably the use of firewood or vice-versa. Only 33% of households who use charcoal also use firewood but of these 63% use it rarely or as stand-by fuel.

5.14 The above analysis shows clearly that the energy pattern in small towns is dominated by firewood and the energy pattern of medium and large towns is dominated by charcoal in low and medium cost areas and electricity in high cost areas.

11/ A factor is a linear combination of the basic variables.

5.15 However, charcoal is still used by a relatively large proportion of electrified households in medium and high cost areas:

(a) on a daily basis for those who have no electric stove/hot-plate;

(b) in case of power failure as a stand-by fuel by those already using electricity for cooking. This was the situation in May-Dec 1989 where many households were systematically cut off in the evenings because of the fire at Kafue Gorge power station;

5.16 Expenditure is positively correlated with the possession of electric appliances and the use of electricity. This fact seems to indicate that expenditures rather than income explains better the standard of living of the households. Households spend on the average only 48% of their income for non durable goods; this is reduced to 15% in the higher income classes.

These two facts combined seem to indicate that:

(a) in low income classes the situation is dominated by the affordability of certain items.

(b) in high income classes, it is rather the availability of certain goods which determines the situation.

5.17 These conclusions are very important as they show the critical determinants of the energy pattern that can be used for forecasting purposes.

5.18 Finally, from the correlation circle, it is easy to see how the interfuel substitution process can operate and how one fuel affects another (this is described in Annex 3).

(a) Any increase of the electrification rate will reduce considerably the consumption of kerosene as more than half of kerosene consumption is used for lighting purposes.

(b) At present, house electrification has no direct impact on charcoal or firewood consumption. The unavailability of electric stoves at an affordable price is the major barrier. Over 40% of electrified households are not using electricity for cooking and 67% of these households declared that it is because stoves/hot plates are too expensive to purchase. Cheap and available electric hot plates combined with reliability of supply 12/ could have an impact on:

12/ The availability of spare parts for repairs is also crucial. The survey results show that 11% of electrified households were not able to repair their stoves and shifted back to charcoal.

(i) Charcoal consumption which is principally used for cooking, water heating and space heating

(ii) Kerosene consumption which is mainly used for lighting and fire ignition.

5.19 However, there are two major determinants to this substitution process:

(a) The substitution between firewood and charcoal is mainly determined by the increase of the town size and can be linked to the increase of the urbanization rate;

(b) The substitution between electricity and charcoal for cooking is exclusively determined by income, the availability of cooking appliances at a reasonable cost and the reliability of supply.

5.20 During the 1988/89 rainy season, as mentioned above, the price of charcoal in Lusaka went up from ZK30 per large bag (containing 40 kg of charcoal) to ZK150, mainly due to shortages of supply because of the exceptionally heavy rains.

5.21 Assuming an average price of ZK120 per bag, it appears that 64% of the households (those who earn less than ZK800 per month) would have to spend on the average 72% of their total income to buy charcoal if they did not alter their eating habits. As a result of the price hike about one-third of the people who originally used charcoal shifted either to kerosene (23%) or to firewood (6%) and 3% to a combination of fuels but very few shifted to electricity (1%). This indicates that the substitution process can move in either direction when conditions change.

5.22 After the rainy season the charcoal price gradually came down to ZK60 per bag (US$6); by comparison it was US$3.8 before the rainy season and before the first devaluation of the Kwacha. 13/ But after the second devaluation of the Kwacha, the price of charcoal went up again and seems to have stabilized around ZK100 ($6.25) per bag of 40kg.

5.23 A third round survey 14/ was then conducted in Lusaka amongst the same households surveyed during the second round. The results showed

---

13/ After the household energy survey a first devaluation occurred in November 1988. The US$ went up from ZK7.86 to ZK10.0; a second one took place in July 1989 increasing the dollar to ZK16.0. Since then it has further increasing by small steps until by February 1990 it reached ZK24.0 to the US Dollar.

14/ This survey was done during late July and early August 1989 and 28 households out of 34 that substituted other fuels for charcoal shifted back to charcoal, the remaining 6 households moved house.

that all the households that originally use charcoal and who shifted to either kerosene or firewood during the last rains moved back to charcoal although the price of kerosene remained unchanged and very competitive. However the price of kerosene increased a few months later in October 1989 when it went up to ZK4.85 per liter (US$0.30) from ZK1.79.

5.24 It appears that although kerosene at ZK1.79 per liter was substantially cheaper than charcoal, other factors influenced the switch back to charcoal. These may be availability of charcoal nearby, cooking habits, fragility of the kerosene stove, tainting of food by kerosene and/or its smell, and the more useful attributes of the charcoal stove. A further survey of these respondents should be carried out to discover the reasons.

5.25 The reason why more people did not switch to other fuels could have been unavailability. The supply of kerosene cannot be increased rapidly because of technical and distributional problems. Secondly cheap electrical hot plates are unavailable; and thirdly, fuelwood is scarce within walking distances of large towns and impassible roads curtail/preclude road transport. What probably happened as well was that people used less fuel to cook per day.

Cooking Practices and Eating Habits

5.26 The demand survey questionnaire included a section on cooking practices. It appears from the answers that households already tend to have an energy-saving behavior. Any action concerning energy conservation in food preparation should concentrate on improving the efficiency of the cooking appliances and training households how to use these appliances properly.

5.27 The results of the non-household energy demand survey show that about 15% of the total urban population regularly have lunch outside their homes and cooking at home requires about 4 times more energy per meal per person than cooking in restaurants and in other eating places. Also the larger the town the larger the percentage of the population that dined out. This trend is likely to continue as towns become larger.

5.28 As processed food becomes more available, energy consumption should decrease. Already maize meal is the staple food in towns and most rural areas, where as not long ago cooked maize seed was universal. Maize takes two to three hours to cook unless the seeds are presoaked. On the other hand maize meal porridge only takes about twenty minutes to prepare, so there is a considerable saving of time and energy. The same argument applies to bread, precooked meats and tinned vegetables etc. but price and availability of these latter products are constraining factors.

Fuel Prices and Cooking Costs

Introduction

5.29 In general terms, the principal issues concerning urban household fuel prices and cooking costs in Zambia fall into three categories:

(a) Relative costs of cooking with different fuels. Although clearly not the only factor which consumers consider, the relative costs of using different fuels are a key determinant of the choices which households make concerning the fuels to use in their daily lives. During 1988-89, the relative cost structure of cooking with different fuels was highly unstable, and changed dramatically during different periods. Over the period as a whole, relative costs which consumers have faced have not fully reflected the long-term economic costs to the country of supplying different fuels. Distortions were greatest during the 1988/89 wet season.

(b) Cooking fuel affordability for low-income households. Even during periods of stable charcoal supply, the average share of income spent on charcoal, the dominant fuel used to meet basic cooking needs by low-income families in major urban areas, is high in Zambia, compared to most African countries. With the charcoal supply disruptions of the 1988/89 wet season, the costs of normal cooking became virtually intolerable for low-income groups.

(c) Financial viability of energy supply organizations. Subsidies of kerosene for household use have been supported through taxation of other petroleum products, enabling the petroleum product supply system to maintain overall financial viability. However, in general, and for the household sector specifically, electricity rates are well below the financial costs of supply, severely undercutting the ability of ZESCO to maintain financial viability.

5.29 The study team prepared estimates of the full costs to consumers and to the country as a whole of cooking with charcoal, kerosene and electricity, 15/ in order to assess the relative costs of

---

15/ Detailed analysis was not conducted for firewood, the other major urban cooking fuel. Prices and costs have tended to follow the same trends as for charcoal, but prices, costs and use vary substantially from area to area, depending largely upon the extent to which it is available from nearby areas. Unless firewood is transported over long distances or no measures are taken over the long term to sustainably manage firewood resources, it should remain a most inexpensive fuel in economic terms.

cooking, and to identify distortions between the costs faced by consumers and costs to the country (economic costs). These estimates included amortized costs of cooking equipment. For electricity, estimates were prepared both for homes with electricity connections and homes without connections. For the later, amortized costs of home wiring and and electricity connection were included, based on the prorated expected share of cooking in total power use.

5.30 To estimate economic costs, costs to consumers were adjusted to exclude any subsidies (both direct and indirect), taxes and duties. "Shadow" foreign exchange rates also were used in the calculations, to account for the severe scarcity of foreign exchange. Current scarcity of foreign exchange is one of the most pressing problems in the country. Efforts to minimize foreign exchange requirements are one of the most important thrusts of the Government's energy policy, and a practical strategy for urban household energy development must take foreign exchange scarcity into account. In the team's analysis for March 1989, a shadow exchange rate of ZK25/US$ was used, instead of the official rate of exhange at that time of ZK10/US$. Because of the difficulty of estimating the actual value of foreign exchange, however, calculations also were prepared at the official rate and at ZK40/US$.

5.31 The study team's analysis of fuel prices and cooking costs was greatly complicated by the rapid price changes and foreign exchange devaluations which occured during 1989 (see Table 5.2). The team's analysis focusses on March 1989, but it must be recognized that the fuel price regime of this month was greatly affected by the abnormalities of the 1988/89 wet season. (Historically, charcoal prices have tended to increase significantly during the wet season, but during 1988/89, the impact of the rains on charcoal suply was especially severe.) The team also has conducted rough analysis of fuel prices and costs for October 1988 and October 1989, in order to provide better overall perspective. However, cost estimates for October 1989, especially those prepared in economic terms, must be considered preliminary and indicative only, due to uncertainty regarding the validity of assumptions made regarding domestic prices and the extent to which shadow foreign exchange rates may have moved upwards since March. 16/

16/ In the indicative estimates for October 1989, all domestice prices were assumed to have increased by 65% above March levels, based on the estimated general rate of inflation. Shadow exchange rates of ZK30-40/US$ were used.

TABLE 5.2: PRICE OF DIFFERENT FUELS AT THREE SPECIFIC TIME PERIODS a/

FUEL		November 88 ZK (US cent)	March 89 ZK (US cent)	October 89 ZK (US cent)
Wood b/	(Kg)	0.40 (5)	n/a	0.80 (4)
Charcoal	(Kg)	0.75 (10)	2.50 (25)	2.35 (13)
Kerosene	(L)	1.60 (20)	1.79 (18)	4.85 (26)
Electricity c/	(KWh)	0.15 (1.9)	0.15 (1.5)	0.25 (1.4)
Exchange rate ZK to US$		7.86	10.0	18.5

a/ These prices include taxes which are as follows: Wood, zero; charcoal, removal fee ZK0.50 per bag; kerosene 15% of wholesale price namely ZK0.19, ZK0.21, ZK0.55 per liter for the three time periods; electricity 15% sales tax namely ZK0.02, ZK0.02, ZK0.04 per KWh for the three time periods.

b/ The price paid for wood varies considerably. There is over 100% difference per kg between the lowest and highest price. Up to half of the fuelwood is collected and not purchased.

c/ Estimated average total charges, including demand, energy and sales tax charges.

Prices and Cooking Costs for Different Fuels

Charcoal

5.32 Retail prices. The vast majority of urban households purchase charcoal by the 40-kg bag. During September and October of 1988, charcoal cost about ZK30/bag in the Lusaka market. This price consisted of: (a) about ZK15/bag charged by producers at kiln sites in the bush, (b) about ZK9/bag for transport to the market, and (c) about ZK6/bag for marketing. However, during the following wet season (December-February), prices rose to as much as ZK150/bag, as a result of supply disruptions and scarcity. Prices then fell in March to about ZK100/bag, and gradually decreased further over the next few months to ZK70-80/bag. With successive devaluations of the Kwacha and domestic inflation, the price then gradually increased, and seemed to have stabilized at about ZK100/bag in November 1989.

5.33 During the 1988/89 wet season, the Government's attempts to maintain a controlled fixed price for charcoal of ZK25/bag were ineffective. Indeed, the attempt to control prices may have actually been one factor driving up prices, as it introduced risk into charcoal marketing. Certainly the attempt to control prices increased hardship for many consumers who were unable to purchase charcoal in the main urban markets and were required to purchase from informal sales points well outside of the city center. The attempt to fix prices has now been abandoned by the Government.

5.34 Based on interviews with transporters coming into Lusaka in February and a few charcoal traders, the typical price charged by producers in the major supply areas for Lusaka at that time was ZK50/bag. The balance of the charcoal price (ZK100/bag in February and ZK50/bag in March) usually accrued to trader-transporters who succeeded in travelling through to the bush and back, and typically marketed the charcoal themselves. These prices imply major increases in returns to labor/profit on a unit basis for producers, and traders-transporters (although trader-transporters had to deal with both marketing risk and extremely difficult transport logistics). Income levels for these groups, however, may nevertheless have declined, as the volume of production and sales fell sharply.

5.35 Based on data from the urban household energy survey during the latter part of 1988, the shares of family income and expenditures spent on charcoal for cooking by low-income households was already high. In urban households reporting incomes of ZK800 per month or less (64% of total urban households) 17/ 19% of income was spent on charcoal, and charcoal accounted for 24% of total expenditures. In most African countries, by contrast, expenditures for fuel by low-income groups usually account for closer to 10% of total expenditures. With the rapid, three-to-five-fold increase in prices during the wet season, the burden of high fuel costs relative to income clearly increased dramatically. About one-third of urban households shifted from charcoal to other fuels but most families had little choice but to limit their consumption as much as possible.

5.36 Economic costs. The economic cost of charcoal delivered to the market in March 1989 is estimated at about ZK45-55/bag (Annex 6). This is about one-half of the cost which consumers were actually paying during that month. The primary reason for this distortion is the residual effect of the rapid price rise caused by scarcity during the 1988/89 wet season.

5.37 The economic cost of charcoal in March 1989 is estimated based on (a) an estimate of the long-term cost of the wood raw material to the country, (b) the production, transport and marketing costs reported during surveys during the later half of 1988, adjusted for inflation. Duties and taxes are excluded, and foreign exchange is shadow-priced at ZK25/US$. The economic cost of the wood raw material is estimated at about ZK15 per cord (US$1.50) (equivalent to about ZK2.7/bag of charcoal). This equates to ZK9.1 (US$0.91) per solid cubic meter, excluding the removal fee which is a tax. This economic cost of wood is based on the estimated costs associated with wood production on a sustainable basis. The estimate is not based on the costs of producing wood from new plantations. Rather, it is based on the estimated marginal cost and wood production which would stem from an improved natural

17/ The average income reported by urban households was ZK1094/month.

woodland management program. (Improved woodland management is the most cost-effective means to sustainably provide sufficient supplies of wood for charcoal production over the long-term).

5.38 In the months following March 1989 the gap betwee the economic costs and actual costs to consumers of charcoal narrowed. Whereas financial prices fell, and then increased only slightly during the latter months of the year, economic costs rose with inflation and devaluation. In October 1989, the economic cost of charcoal is roughly estimated at ZK90-95/bag, whereas the cost to consumers was about ZK100/bag. Due to inflation, the economic cost of the wood raw material is roughly ZK17 (US$0.92) per solid cubic meter, or ZK5/bag of charcoal, excluding the removal fee.

Electricity

5.39 Cost of electric cooking to consumers. For homes which already have electricity connections, the costs of cooking with electricity include the high costs for cooking equipment as well as energy costs. For homes without connections, electric cooking costs also include a portion of the high costs of connection and home wiring. 18/

5.40 Zambia's household electricity rates are among the lowest in Africa. Rates vary somewhat, depending upon the tariff category and the ratio between fixed monthly demand charges and unit energy charges. In March 1989, the average total charge per energy unit, including sales tax of ZK0.02 was only about ZK0.15/kWh (US cents 1.5/kWh at the OER). Rates have since been increased in local currency terms, resulting in total charges of about ZK0.18/kWh in May and ZK0.25/kWh in October 1989. In foreign exchange terms, however, average charges in October (US cents 1.35/kWh at the OER) were less than in March.

5.41 Prevailing household electricity rates clearly are well below the financial cost of household electricity supply. Rough estimates suggest that the cost of providing electricity to households over the long term was at least ZK0.32/kWh including sales tax of 0.04 19/ in March 1989 (Annex 4). By international standards, this cost of supply of US cents 3.2/kWh is still very low, due to Zambia's surplus of hydroelectric generating capacity. However, it is over twice as high as charges accruing to the Zambia Electricity Supply Corporation (ZESCO). By October 1989, tariffs had been increased twice, but with continuing

---

18/ In the following analysis, the present value of fixed costs for cooking equipment, connections and wiring are calculated per kilowatt-hour, assuming a real discount rate of 12%. The portion of connection and wiring costs included is based on estimates of the share of cooking in total household electricity use.

19/ Sales taxes of 15% do not accrue to ZESCO.

inflation and devaluation, the gap between costs and prices remained at least as large as in March.

5.42 The fact that consumers (both households and others) are charged below-cost rates seriously undermines the financial viability of ZESCO's operations. The gap between revenues and costs, however, is yet further exacerbated by ZESCO's inadequate billing and collection practices, which result in additional major losses or revenue and major delays in payments. 20/

5.43 In contrast to energy costs, the costs of electric stoves currently marketed in Zambia are very high. In March 1989, two-ring, imported electric hot plates for sale in Lusaka shops cost between ZK3700 and ZK5200 each (US$370-520 at the OER). One reason for the high cost is sales tax (25%) and import duty (20%). However, marketing markups also are very high, presumably in part due to the scarcity of foreign exchange. With the purchase of a ZK4000 hot plate, stove costs are estimated to account for about three-quarters of the total cost of electric cooking in homes with connections (see Table 5.3).

TABLE 5.3: COSTS TO USERS OF ELECTRIC COOKING
(March 1989)

	(ZK/KWh)	
	Currently imported hot plates	Alternative hot plates
Energy	0.15	0.15
Stove	0.44	0.18
Total for connected households	0.59	0.33
Connection	0.05	0.05 - 0.07
Home wiring	0.25	0.28 - 0.37
Total for non-connected households	0.89	0.66 - 0.77

Source: Annex 4.

5.44 For homes with connections, the development and marketing of very simple hot plates on a non-profit basis could sustantially reduce the upfront costs of electric cooking. Two alternatives are under consideration: (a) The production and sale by ZESCO of a single-ring hot plate, using imported parts but assembled in Zambia, and (b) the development of a ceramic hot plate by the Department of Energy and the

20/ see ESMAP, Zambia: Power Subsector Efficiency Study (December 1988).

National Council for Scientific Research, using only some imported metal parts and switches. If sold on a non-profit basis, it may be possible to retail these stove at ZK1000 and ZK375, respectively (in March 1989 prices). Because the ZESCO hot plate should last longer and have a higher power rating, the cost per unit energy consumed should be roughly equal for the two stoves. Use of these stoves could bring done the cost of electric cooking by about 45% for homes with electricity connections.

5.45 For the roughly 60% of urban homes which do not have electricity connections, high upfront costs for home wiring and connection are a major impedement to adoption of electric cooking. In March 1989, the wiring of a two-room home cost about ZK5000 (US$500 at the OER), or almost five times the average monthly income level. In March, ZESCO also was charging consumers a flat fee of ZK1000 for connections where additional poles were not required (e.g. 30-50 meters from existing lines). This fee, however, had not been changed since 1988, and actual costs in March 1989 to ZESCO were reportedly ZK3500 per connection. 21/ If wiring and connection costs are included on a prorated basis, the cost paid by consumers for electric cooking can be over twice as high as the cost paid by consumers with existing connections.

5.46 Economic costs of electric cooking. The ratios between the costs which consumers pay for electric cooking and the costs to society (economic costs), vary depending upon the types of stove used and whether or not households already have connections. While the ratios discussed here reflect March 1989 prices, the same basic trends existed in October 1989 as well.

5.47 Assuming a shadow foreign exchange rate of ZK25/US$, consumers paid only about 40% of the economic cost of providing electricity in March 1989 (the economic cost of supply at that time is roughly estimated at ZK0.36/kWh, while average actual charges were ZK0.15/kWh). This wide difference reflects both the fact that consumers do not pay the full financial costs of supply and the fact that foreign exchange accounts for about 34% of supply costs.

5.48 Because electric cooking equipment currently on the market is priced well above economic cost, however, the distortion seen in electricity prices is currently offset by counter distortions in cooking equipment prices. March 1989 retail prices for two-ring imported hot plates are estimated to be about 70% above economic cost, even after shadow-pricing foreign exchange. For a household which paid ZK4000 in

---

21/ On average for each connection, two households are joined to the grid. In addition to these wiring and connection fees, some households are also charged by ZESCO for a portion of additional distribution expansion costs, if a whole housing block is being newly electrified.

March 1989 for such a hot plate, therefore, the average total cost which it pays for electric cooking is about equal to the economic cost (see Table 5.4).

TABLE 5.4: THE RATIO BETWEEN COSTS PAID BY CONSUMERS AND ECONOMIC COSTS FOR ELECTRIC COOKING a/
March 1989 Prices
(Costs paid by consumers/economic costs)

	Currently imported hot plates	Alternative hot plates
Electricity Costs	0.4	0.4
Stove Costs	1.7	0.7 - 0.8
Total costs for connected homes	1.0	0.5 - 0.6
Connection/wiring costs	0.8	0.7 - 0.8
Total costs for non-connected homes	0.9	0.6 - 0.7

a/ Assumes a shadow foreign exchange rate of ZK25/US$.

Source: Annex 4.

5.49 It is important to note, however, that if measures are taken to correct the distortion in cooking equipment prices, households then would pay substantially less than the economic cost of electric cooking because of the energy price distortion. With the development and use of alternative hot plates, households with electricity connections would then pay only 50-60% of the economic costs of electrtic cooking. Measures to correct equipment price distortions, therefore, are best matched by efforts to correct electricity price distortions.

5.50 In March 1989, households paid only about 70-80% of the economic cost of wiring and connection. This reflects the fact that the ZK1000 connection fee which prevailed at that time did not fully reflect actual financial costs, and the fact that over 40% of the costs are in foreign exchange.

5.51 For households requiring wiring and connection, the cost which they pay for electric cooking are 60-90% of the economic costs (see Table 5.4).

Kerosene

5.52 Costs of kerosene cooking to consumers. In procuring and refining the nation's petroleum products, ZIMOIL recovers the full financial costs of supply as a whole through the wholesale prices charged for the various fuels. 22/ However, the situation for various fuels varies substantially. In March 1989, the price of kerosene for household use was heavily cross-subsidized through the prices of other fuels. (Kerosene for household use is dyed, to distinguish it from kerosene for industrial use, which is priced higher.) The wholesale and retail prices of kerosene in March were about 60% and 68% of the financial costs of supply, respectively. By October, however, the retail price of household kerosene was increased from ZK1.79/liter in Lusaka to ZK4.85/liter. In October, the retail price of kerosene appeared to be just slightly higher than the financial cost of supply.

5.53 In March 1989, wick-type kerosene stoves retailed for about ZK400 each (US$40 at the OER). On average, stove costs accounted for a little over 40% of the total cost of kerosene cooking (see Annex 5). With the rise in energy price, however, stove costs accounted for only some 30% of estimated kerosene cooking costs in October.

5.54 Economic costs of kerosene cooking. Assuming a shadow foreign exchange rate of ZK25/US$, consumers paid only about 45% of the economic cost of kerosene cooking (see Annex 5). This is due both to the fact that kerosene was heavily cross-subsidized at that time, and to the fact that foreign exchange accounted for about 80% of the total pre-tax cost of kerosene cooking. In October, however, consumers were paying about 85% of the economic cost, assuming a shadow foreign exchange rate of ZK30/US$ at that time.

Relative Costs of Cooking with Different Fuels

Costs to Consumers

5.55 As Table 5.5 shows, the relative costs of cooking with different fuels have been unstable during October 1988 to October 1989. During the 1988/89 wet season, charcoal cooking moved from being the least expensive means of cooking to the most expensive. Consumers responded by trying to shift from charcoal to kerosene, collected wood and electricity. After March, the price of charcoal fell slightly, while the costs associated with cooking with other fuels except collected wood rose in large part due to devaluation and inflation. Relative prices, therefore, moved somewhat back towards what they were before.

22/ For a detailed description of Zambia's petroleum product procurement situation, see ESMAP/DOE, Zambia: Energy Sector Strategy (December 1988).

TABLE 5.5: CONSUMER COOKING COST PER GIGAJOULE WITH DIFFERENT FUELS AT THREE SPECIFIC TIME PERIODS a/
Units ZK (US$) per gigajoule of useful energy

FUEL	November 88	Ratio to Charcoal	March 89	Ratio to Charcoal	October 89	Ratio to Charcoal
Wood (Purchased)	170 (22)	1.0	n/a	-	670 (36)	1.3
Charcoal	170 (22)	1.0	560 (56)	1.0	520 (28)	1.0
Kerosene	215 (27)	1.3	260 (26)	0.5	580 (31)	1.1
Electricity b/	220 (28)	1.3	270 (27)	0.5	340 (18)	0.7
Electricity c/	320 (41)	1.9	410 (41)	0.7	560 (30)	1.1
Exchange rate ZK to US$	7.86		10.0		18.5	

a/ Includes fuel and amortized stove prices and wiring plus connection fees where relevant. Only currently available electric hot plates are considered.
b/ Homes with connection
c/ Homes needing connection

5.56 In terms of what consumers actually pay, cooking with electric hot plates is the least-expensive way to cook in homes which already have electricity and a hot plate. Unless families use large electric ranges (which only the relatively wealthy can afford), simple electric cooking equipment tends to be used only for some cooking tasks, and usually does not substitute for the bulk of cooking energy; also even before the fire at Kafue gorge hydro station, there were frequent outages, especially at meal times. For homes requiring connections, the high costs of connection and wiring not only increase the overall costs of electric cooking, but also represent an almost insurmountable burden for lower income households, as connection and wiring costs must be paid upfront.

5.57 During and immediately after the 1988/89 wet season, kerosene cooking cost consumers less than one half as much as charcoal cooking, even if the high costs of kerosene stoves are included. With the recent increase in kerosene prices, however, kerosene cooking once again became slightly more expensive than charcoal cooking by October 1989.

Relative Economic Costs

5.58 In terms of the overall costs to the country, cooking with charcoal is clearly the least-cost means of cooking for most households and for the bulk of cooking tasks (see Table 5.6). This is true even if the full costs of putting charcoal supply on a more sustainable basis are included. For households that already have electricity connections, cooking with electric hot plates costs about the same as cooking with charcoal, in economic terms, if foreign exchange is shadow-priced at

ZK25/US$ in March 1989 prices. As already discussed, however, cooking with electric hot plates is usually conducted for only a portion of cooking tasks. Furthermore, the majority of urban household would require new electricity connections to use electricity, and the prorated costs of connection and wiring push up the economic costs of electric cooking to levels well above those for charcoal. Cooking with kerosene is clearly the highest cost means of cooking, in economic terms.

5.59 If overall stove efficiency can be increased by 15%, then clearly this will have the greatest impact on devices that are at present the least efficient. This is illustrated in Table 5.6 where the cost of cooking with a 30% efficient charcoal stove is the cheapest option at all assumed foreign exchange values. Therefore improving the stove efficiency can be a substantial benefit to the household and the country. This is further discussed in sections 6.14 - 6.17.

TABLE 5.6: ESTIMATED ECONOMIC COSTS OF COOKING WITH DIFFERENT FUELS
MARCH 1989 PRICES
Kwacha per Gigajoule of Useful Energy

Fuels	Estimated Average Cooking Efficiency	Assumed Value of Foreign Exchange		
		ZK10/US$	ZK25/US$	ZK40/US$
Charcoal	15%-30%	240-120	290-145	345-175
Kerosene a/	35%-	255-285	580-640	905-990
	50%	160-200	405-450	635-695
Electricity				
Home with connection b/	60%-75%	170-135	285-230	395-315
Home requiring connection c	60%-75%	285-230	460-370	635-510

a/ Ranges show values for different assumptions concerning lifetime and daily consumption rates.

b/ Estimates are for currently available hot plates only. However, these costs would not change significantly if cheaper hot plates come onto the market, for the lifetime of these hot plates would be less and the economic cost would be similar - see Annex 4.

c/ Includes cost of wiring for a 2-room home and connection 30m from the grid, with two households per connection prorated by the share of cooking consumption in total anticipated power use. Estimates are for currently available hot plates only.

Source: Annex 4, 5, 6.

5.60 Relative foreign exchange costs. Because of Zambia's acute scarcity of foreign exchange, the relative foreign exchange cost of cooking with different household fuels is a key aspect of the relative cost to the country of using these fuels. As Table 5.7 shows, the share of foreign exchange in the total costs of cooking are far lower for charcoal than for any other fuel. Comprised primarily of the foreign exchange cost of transportation, the share of foreign exchange is charcoal cooking was just 15-16% in 1989.

TABLE 5.7: THE SHARE OF FOREIGN EXCHANGE OF THE COST OF COOKING WITH VARIOUS FUELS

	Percentage of Total Financial Cost (Excluding Duties & Taxes)	
	March 89	October 89
Charcoal	15 - 16	15 - 16
Kerosene	80	76
Electricity a/		
Energy	34	37
Hot plate	52	56
Subtotal	40	43
(for homes with electricity)		
Wiring & connection	37	40
Total	38	41

a/ Figures are the average for the three different hot plates considered.

Source: Annex 6.

5.61 Although electricity is often thought of as an indigenous fuel in Zambia, the share of foreign exchange in electric cooking is on the order of 40%. Although the incremental foreign exchange costs of generation are very low, due to current surplus capacity and the reliance on domestic hydropower, substantial foreign exchange costs are involved in system operation, distribution system expansion and rehabilitation, electric cooking equipment, home wiring, and home connections (see Table 5.7). Development of locally assembled hot plates also will not radically reduce the overall foreign exchange share in electric cooking costs.

5.62 The share of foreign exchange costs in the cost of kerosene cooking are high--about 80% in March and 76% in October 1989.

5.63 Distortions in relative costs faced by consumers. In March 1989, the relative costs of using different cooking fuels by urban households was radically out-of-line with economic costs. Kerosene cooking, for example, cost consumers about one-half of charcoal cooking, while it cost the country about double the cost of charcoal cooking (see Table 5.8). Electric cooking also cost consumers substantially less than charcoal cooking, but cost the country the same or 80% more than charcoal cooking, depending upon whether or not homes have connections. These distortions resulted from the pricing of kerosene and electricity well below economic cost, but the increase in charcoal prices to about twice its long-term economic cost.

TABLE 5.8: RELATIVE ECONOMIC COSTS AND COSTS PAID BY CONSUMERS FOR COOKING WITH DIFFERENT FUELS
Ratio of the cost of cooking with alternative fuels to the cost of Cooking with Charcoal
(Cost of alternative fuel divided by Charcoal Cost)

	Costs Paid by Consumers		
	March 1989 Prices	October 1989 Prices	Economic Cost a/
Kerosene	0.5	1.1	2.0 - 2.2
Electricity b/			
Homes with connection	0.5	0.7	1.0
Homes needing connection	0.7	1.1	1.6

a/ Based on March 1989 Prices and a shadow foreign exchange rate of ZK25/US$.
b/ Same assumption as Table 5.6

Source: Tables 5.5 and 5.6.

5.64 With the fall in charcoal prices in real terms and increase in kerosene prices in real terms, distortions in the cost structure faced by consumers in October had softened somewhat (see Table 5.8). However, the the underlying factors which caused severe price distortions to arise--the instability of the charcoal supply system and a tendency for kerosene and electricity prices to erode with respect to inflation--have not been adequately addressed. Hence, severe distortions may well arise again.

Conclusions

Charcoal

5.65 Charcoal is both the dominant fuel for urban households, especially low-income households, and the least-cost cooking fuel in economic terms for most cooking and households. Price increases above supply costs during the wet season, however, are a critical problem associated with this key fuel, as witnessed during 1988/89. Caused by a breakdown in the supply system and resulting shortages, above-cost prices both intensify the burden of already high energy costs for low-income families, and they cause shifts to other fuels, such as kerosene, which have much higher economic and foreign exchange costs (Table 5.6).

5.66 Attempts to administratively control charcoal prices are clearly not the answer to the problem, as recent experience has demonstrated. A better strategy is to focus on the root cause of the problem, rather than its symptoms: measures to improve the stability, organization and efficiency of the charcoal industry should be given top priority. In addition, the burden of fuel costs to households could be substantially reduced through the commercialization of improved charcoal (and firewood) stoves. (Table 5.6)

5.67 The stumpage fee charged for wood used in charcoal production should be increased to provide producers and consumers correct signals regarding the cost of the wood raw material to the country and to provide sufficient revenue for implementation of improved woodland management schemes. Ideally the fee should be on a sliding scale depending on the distance from the market in order to prevent the transporter/trader capturing the saving in transport costs from sites near to the market and to encourage the growing of trees near to the market to save transport costs and thus foreign exchange. Rough estimates suggest that a minimum fee at sites remote from the market of about ZK17 per solid cubic meter (US$0.92) in October 1989 prices, would be required to cover the costs of a long-term program to improve the sustainability of woodland use for charcoal production. The bulk if not all this fee should be credited to the forest service. The impact of such an increase on overall charcoal price levels would be minimal -- the suggested fee equate to about K5.0/bag in October 1989 prices (5% of retail prices). Perhaps even more important, more concerted efforts need to be made to collect stumpage and wood removal fees in the first place.

5.68 The removal fee, which at present is ZK0.5 per bag of charcoal is a product tax. It should go to the government's general revenue and part could be used to improve rural roads, especially bush roads in charcoal producing areas. The value of this tax has been eroded by inflation, and should be about ZK3.0 per bag (US$0.19) in October 1989 prices. There is no removal fee on traded fuelwood but, if it were imposed it would amount to some ZK 9.0 per solid m^3 (US$0.49) in October 1989 prices (ZK14.5 per air dry ton).

Electricity

5.69 In terms of the relative costs to the country, there is no compelling rationale for promotion of the substitution of electricity for charcoal. For those who can afford the upfront costs, however, the use of electricity for cooking is likely to be preferred to using charcoal, due to convenience. Where households already have electricity connections, the economic cost of using simple electric hot plates for cooking is about the same as using charcoal. To provide consumers with greater fuel choices, it is worthwhile to develop and disseminate less-expensive hot plates than those currently on the market. It must be recognized, however, that consumers are continuing to pay substantially less than the financial or economic cost of electricity supply.

5.70 The reported current costs of home wiring and connection of non-electrified homes are very high. If these costs are included on a prorated basis, the economic cost of cooking with electricity is about twice as high as the economic cost of cooking with charcoal. Household electrification cannot be justified solely for the substitution of electricity for charcoal. However, urban household electrification involves a series of wider issues and benefits. Particularly important are the benefits associated with electric lighting. However, the high upfront costs of wiring and connection are an insurmountable burden for most households. A review of means to improve cost-effectiveness is well warranted. It also is worthwhile to investigate the means by which these high upfront costs might be paid by consumers on an amortized basis over an extended period. It is recommended that these reviews be conducted as part of a wider distribution system study, as proposed and designed in the previous ESMAP study, "Zambia: Power Subsector Efficiency Study."

5.71 Especially important, it must be recognized that under current conditions the financial footing of ZESCO will continue to erode, with continued ramifications for the quality of electricity service, unless revenues are increased. An urgently needed program to improve billing and collection procedures has been recommended in the above previous study. Additional tariff reform, and increases that better track domestic inflation and exchange rate changes will be necessary for ZESCO to improve its financial situation.

Kerosene

5.72 Cooking with kerosene is the most expensive common means of cooking in both economic and foreign exchange terms. Consumers should continue to be given the choice of cooking with kerosene, but they should pay the full cost. To ensure this, the most important measure is to ensure that kerosene retail prices are corrected in a timely fasion to reflect changes in the exchange rate and domestic inflation.

Coal

5.73 The economic and financial costs of supplying coal briquettes on a commercial basis, and consumer acceptance, will only become clearer when the DOE/NCSR pilot project progresses further. However, there appear to be good prospects for the development of briquettes which could be competitive with charcoal, especially if utilization efficiencies are high. Two factors to keep in mind in order to minimize costs are the importance of utilizing rail transport and the cost advantage of using washery plant slurry as opposed to washed fines.

5.74 It would also be worthwhile to test consumer acceptance of using lump coal directly in the clay stoves being developed for briquette use.

VI. FUTURE DEMAND AND SUPPLY

Energy Demand Forecasting for Urban Households

Method and Assumptions

6.1 Forecasts were made to the year 2000 on the basis of past trends with regards to town size and standard of living. However, for electricity the forecasts were tempered by the practicality of achieving certain targets. A detailed description of the techniques is given in a separate working paper on forecasting.

6.2 The assumptions that were made are as follows:

(a) Town growth

(i) Large towns would grow at 5.2% per annum
(ii) Medium towns would grow at 1.7% per annum
(iii) Small towns would grow at 1.9% per annum

(b) Growth within large and medium towns:

		Period 1988-1995	1996 - 2000
(i)	Low income areas	7.2% p.a.	6.5% p.a.
(ii)	Medium income areas	minus 0.8% p.a.	minus 1.6% p.a.
(iii)	High income areas	3.3% p.a.	2.7% p.a.

(c) Electrification

After consultation with ZESCO, and analysing a one page questionnaire sent to companies the following assumptions were made:

(i) The electrification rate observed between 1980 and 1988 (i.e 4.4% per year) would be maintained for the period of 1989-2000. This gives the following number of electrified households in 1995, - 284,000 - and 2000; - 352,000 -(Table 6.1). It should be noted that ZESCO only made about half the connections in the period 1980-88, private companies and government parastatals completed the other 50%.

(ii) In the year 2000 all households living in high cost areas will have access to electricity and medium cost areas will have the same electrification percentage as that of the high cost areas in 1988 (i.e 88%). The small towns will have the same electrification rate of 4.4% .The remainder in terms of number of households has been assigned to low cost areas and the electrification percentage worked out afterwards (19%).

TABLE 6.1: Forecast of Electrified Household in 1995 and 2000

Year	Number of Households Total	Electrified	%	Units 000 Households Increase in Electrified Household Total	Per Year	% P.Y.
1980	400	149	37			
1988	528	210	40	61	7.6	4.4
1995	683	284	42	74	10.6	4.4
2000	825	352	43	68	13.6	4.4

6.3 The above program may be too ambitious. In 1988 ZESCO connected 3,183 households and expect to connect an average of 7,400 households for the coming 5 years (if households are given support to overcome the high cost of wiring which amounts to over US$505) and if ZESCO is given all the materials and transport requirements and financial support to overcome the high connection cost (estimated at about US$175 per household (US$350 per house). 23/ The ESMAP/DOE Energy Sector Strategy No 094/88 used 3 scenarios to estimate the number of new connections. The low case assumed 2,000 connections every year and the base and high cases assume respectively 4,000 and 7,000 connections; it should be pointed out that for each connection, 2 households get access to electricity. But if ZESCO connects only 3,183 new households every year for the period 1988-2000, and if employers stop connecting households, the urban electrification percentage will drop to 30% by the year 2000.

6.4 Using the data base, simulations can be made around the central forecast. By adjusting some or all of the parameters that were fixed in the preceding steps, new energy policies or programs, such as the introduction of improved stoves, can be reflected in the energy demand forecasts and their impacts rapidly assessed.

Results

6.5 Table 6.2 gives the estimated urban household consumption of energy in 1988 and Tables 6.3 and 6.4 give the forecasted consumption in 1995 and 2000 in original units. Table 6.5 gives the consumption in standard units for the above periods and the cumulative total for 1988 - 2000.

23/ In 1988 the consumer only paid ZK1000 (US$127) so they were being subsidized. By July 1989 the dollar value of connection charges had fallen to US$62 and in February 1990, it was US$42.

6.6 In the year 2,000 urban households may consume about one million TOE of energy (42.86 PJ). The energy balance will still be dominated by charcoal and firewood accounting respectively for about 60% and 24% of total consumption.

6.7 The woodfuel consumption would be 4.8 million tons of wood equivalent compared to 3 million of tons in 1988 24/ representing an increase of 60% for the whole period which is slightly higher than the increase of the total number of urban households (56%). However firewood consumption would increase at a much lower rate (only 43%) than charcoal consumption. This is due to the greater increase in the size of large and medium towns compared to small towns.

6.8 Although demand for electricity and kerosene will increase faster than other fuels their share will still remain very low (respectively 6% and 7% of total consumption). This scenario shows clearly that even with a high number of newly electrified households (11,800 per year), charcoal and firewood will play a major role in urban household energy consumption and therefore deserve most attention from Government. Organizing and up-grading the business of woodfuel should be considered a top priority. Electricity cannot be considered as a substitute for woodfuel and electrification will not stop woodfuel consumption. For instance if all urban households were electrified by the year 2,000 woodfuel consumption would be about 3.6 million tons of wood equivalent compared to 4.8 million tons. This means that total electrification, at a minimum cost of US$420 million 25/, will only reduce the woodfuel consumption by 25% and therefore should be considered in this context as an enhancing fuel which has other advantages such as lighting. As an alternative, to achieve a 25% reduction of woodfuel consumption by the year 2,000 the introduction of improved stoves which reduces wood consumption by a cumulative 2% per annum would be sufficient and far less expensive, about US$5 million. It should also be noted that the foreign exchange cost to put a simple electric hot plate in each urban house would cost in the region of US$70 million (Annex 7).

24/ These are air dry tons, the equivalent bone dry weight in 1988 and 2000 is respectively 2.4 and 3.9 million t.

25/ 615,000 households will require electrification: minimum connection cost 307,500 x US$350 (one connection server two households); wiring cost for two room, 615,000 x US$505.

TABLE 6.2: ZAMBIA 198[illegible] ESTIMATED URBAN HOUSEHOLD ENERGY CONSUMPTION

POPULATION: 2,966,000
HOUSEHOLDS: 528,000

END-USE FUEL	Lighting	Cooking + Water Heating with stove	Space Heating	Fire Ignition	Other	Total
Electricity (GWh)	108	302	24	0	99	533
Kerosene '000 m3	24	5	0	10	3	42
Charcoal '000 tons	0	342	132	0	39	513
Firewood '000 tons	0	307	107	0	34	448
Crop Residues '000 tons	0	67	0	0	0	67

CENTRAL FORECASTS

TABLE 6.3: ZAMBIA: FORECAST OF 1995 URBAN HOUSEHOLD ENERGY CONSUMPTION

POPULATION: 3,836,000
HOUSEHOLDS: 683,000

END-USE FUEL	Lighting	Cooking + Water Heating with stove	Space Heating	Fire Ignition	Other	Total
Electricity (GWh)	143	396	31	0	130	700
Kerosene '000 m3	31	7	0	14	4	56
Charcoal '000 tons	0	451	178	0	51	680
Firewood '000 tons	0	376	133	0	44	553
Crop Residues '000 tons	0	87	0	0	0	87

TABLE 6.4: ZAMBIA: FORECAST OF 2000 URBAN HOUSEHOLD ENERGY CONSUMPTION

POPULATION: 4,634,000
HOUSEHOLDS: 825,000

END-USE FUEL	Lighting	Cooking + Water Heating with stove	Space Heating	Fire Ignition	Other	Total
Electricity (GWh)	179	497	38	0	160	874
Kerosene '000 m3	38	8	0	17	6	69
Charcoal '000 tons	0	548	219	0	61	828
Firewood '000 tons	0	436	155	0	50	641
Crop Residues '000 tons	0	102	0	0	0	102

Table 6.5: ZAMBIA: URBAN HOUSEHOLDS TOTAL ENERGY CONSUMPTION 1988-2000 IN STANDARD ENERGY UNITS

	1988		1995		2000		1988-2000	
	PJ	%	PJ	%	PJ	%	PJ	%
Electricity	1.92	7	2.52	7	3.15	7	32.29	7
Kerosene	1.45	5	1.93	6	2.38	6	24.49	6
Charcoal	15.90	58	21.08	59	25.67	60	265.89	59
Firewood	7.17	26	8.85	25	10.26	24	112.26	25
Crop Residues	0.92	4	1.19	3	1.40	3	14.80	3
	27.36	100	35.57	100	42.86	100	449.73	100

Supply Constraints

Foreign Exchange

6.9 In 1988 the urban household consumption of energy was estimated to be 27.36 Petajoules of energy, equal to 640,000 ton of oil equivalent. By 1995 the consumption is estimated to grow to 35.57 PJ (832,000 toe) reaching 42.86 PJ (1,003,000 toe) in the year 2000. This 57% increase in Energy consumption between 1988 and 2000 is going to put considerable pressure on the balance of payments. In 1988 the foreign exchange cost of using the various household fuels amounted to some US$26 million, this could increase the US$41 million per year by the year 2000. The cumulative foreign exchange requirement for the 13 year period from 1988 to 2000 could be in the region of US$425 million. The estimated foreign exchange costs for 1988, 2000 and the period 1988-2000 are shown in Table 6.6a. This table has been compiled from the foreign exchange components of each fuel and is fully described in Annex 7. In addition the foreign exchange cost to purchase electric hot plates and kerosene stoves could be US$33 million of which the hot plates account for over 90% of the total (Annex 7).

6.10 Table 6.6b forecasts consumption assuming that there have been successful initiatives in energy conservation by the introduction of improved (charcoal and fuelwood) stoves and by improvements to the transportation and distribution of woodfuels. Successful initiatives could save US$8 million per year of foreign exchange by the year 2000, with a cumulative foreign exchange saving of US$33 million. There should also be further foreign exchange savings with the introduction of cheaper electrical stoves and other initiatives to reduce connection and wiring costs. The cost of such initiatives is estimated to be considerably less than the forecasted saving, so that they should more than pay their way. The outline of an improved stove program to achieve a 25% saving in forecasted woodfuel consumption is described in Annex 8.

Table 6.6a: THE ESTIMATED CONSUMPTION OF ENERGY IN 1988, 2000; 1988-2000 AND THE FOREIGN EXCHANGE COST OF PROVIDING THIS ENERGY a/ b/

(a) With no stove and woodfuel transportation initiatives

Energy Type	1988 Consumption PJ c/	%	FE Cost Mill US$ d/	%	2000 Consumption PJ	%	FE Cost Mill US$	%	1988 - 2000 Consumption PJ	%	FE Cost Mill US$	%
Electricity e/	1.92	7	6	23	3.15	7	10	24	32.29	7	100	23
Kerosene	1.45	5	9	35	2.38	6	15	37	24.49	6	157	37
Charcoal	15.90	58	9	34	25.67	60	14	34	265.89	59	144	34
Fuelwood	7.17	26	2	8	10.26	24	2	5	112.26	25	24	6
Crop residue	0.92	4	0	0	1.40	3	0	0	14.80	3	0	0
TOTAL	27.36	100	26	100	42.86	100	41	100	449.73	100	425	100

a/ Detailed calculations in Annex 7

b/ The provision of energy includes:

(i)for electricity the generation and transmission to a town plus for new connections only a 30 meter connection and the wiring of a two-roomed house;

(ii)for kerosene the ex-refinery price and transport to the filling station;

(iii)for charcoal and fuelwood, the production and transport to market;

(iv)for crop residues no production or transport costs, they are waste products collected by foot.

(v)Excluded are the appliance costs.

c/ A Petajoule is 10^{15} Joules = 23400 TOE.

d/ The value of the dollar is in constant 1988 terms.

e/ Electricity is delivered to the house, other fuels have to be collected from the market. This may involve a small foreign exchange cost.

Table 6.6b: THE ESTIMATED CONSUMPTION OF ENERGY IN 1988, 2000; 1988-2000 AND THE FOREIGN EXCHANGE COST OF PROVIDING THIS ENERGY a/ b/
(b) With stove and woodfuel transportation initiatives

Energy Type	1988 Consumption PJ c/	%	FE Cost Mill US$ d/	%	2000 Consumption PJ	%	FE Cost Mill US$	%	1988 - 2000 Consumption PJ	%	FE Cost Mill US$	%
Electricity e/	1.92	7	6	23	3.15	9	10	30	32.29	8	100	26
Kerosene	1.45	5	9	35	2.38	6	15	46	24.49	6	157	40
Charcoal f/	15.90	58	9	34	21.30	58	7	21	247.16	58	115	29
Fuelwood f/	7.17	26	2	8	8.51	23	1	3	104.59	25	20	5
Crop resid.	0.92	4	0	0	1.40	4	0	0	14.80	3	0	0
TOTAL	27.36	100	26	100	36.74	100	33	100	423.33	100	392	100

a/ Detailed calculations in Annex 7
b/ The provision of energy includes:
(i) for electricity the generation and transmission to a town plus for new connections only a 30 meter connection and the wiring of a two-roomed house;
(ii) for kerosene the ex-refinery price and transport to the filling station;
(iii) for charcoal and fuelwood, the production and transport to market;
(iv) for crop residues no production or transport costs, they are waste products collected by foot.
(v) Excluded are the appliance costs.
c/ A Petajoule is 10^{15} Joules = 23400 TOE.
d/ The value of the dollar is in constant 1988 terms.
e/ Electricity is delivered to the house, other fuels have to be collected from the market. This may involve a small foreign exchange cost.
f/ Assumed improved stove used by 50% of households in 2000 with an efficiency twice the present stoves. (See Annex 8). Also by 2000 the transport costs for woodfuel is gradually reduced especially the foreign exchange component. The foreign exchange cost of charcoal transportation is gradually reduced from $16.8/t to $10.0/t by 2000. Similarly that for fuelwood is reduced from $3.5/t to $2.1/t by 2000.

6.11 Kerosene requires the largest amount of foreign exchange followed by charcoal with crop residues the least, because it is assumed that the crop product has borne all the foreign exchange costs. The above table also gives the share of the particular energy type, electricity and kerosene account for the smallest share, but of course end use efficiency is not taken into consideration. Table 6.7 gives the foreign exchange cost of the different energy type for the year 2000 by cost per PJ and cost per PJ of useful energy assuming the energy is used for cooking.

TABLE 6.7: FOREIGN EXCHANGE COST PER UNIT OF ENERGY FOR DIFFERENT ENERGY TYPES IN THE YEAR 2000

		Delivered Costs			Final Consumption Costs			
Energy Type	Consumption PJ	F E Cost mill $	F E Cost Per PJ mill $	Ranking (Charcoal = 1)	End-use Efficiency %	FE Cost per useful PJ mill $	Ranking (Ch=1) A	B
Electricity a/	3.15	9.79	3.11	5.8	60	5.18	1.4	3.6
Kerosene	2.38	15.18	6.38	11.8	35	18.23	5.1	12.8
Charcoal	25.67	13.91	0.54	1	15	3.60	1	-
Charcoal b/	21.30	6.87	0.32	0.6	22.5	1.42	-	1
Fuelwood	10.26	2.24	0.22	0.4	15	1.47	0.4	-
Fuelwood c/	8.51	1.12	0.13	0.2	22.5	0.58	-	0.4
Crop Residues	1.40	0.00	0.00	0	15	0.00	0	0

a/ Electricity with connection costs assuming 14,900 houses connected in that year.

b/ Improved charcoal stoves used by 50% of consumers, efficiency 30%, FE of transport costs reduced to $10 per t.

c/ Improved fuelwood stoves used by 50% of consumers efficiency 30%, FE of transport costs reduced to $2.1 per t.

6.12 If delivered costs are compared, kerosene is the most expensive fuel - 14 times more in terms of foreign exchange than charcoal, whereas electricity is second at 6 times more. If end use efficiency is considered, with cooking being taken as the common standard, (Ranking A) then electricity is only 1.4 times more expensive than charcoal and kerosene five times more. Thus by encouraging the switch to kerosene or electricity the government is going to encounter a much higher cost in foreign exchange terms. If the saving of foreign exchange is of primary concern then improvement of the growing, production, distribution and consumption of biomass should be given top priority. This can be seen by examining Ranking B which assumes initiatives in improved stove promotion and woodfuel transport cost reduction have been successful. The saving in foreign exchange is nearly US$4 million annually for the period 1992 - 2000, and kerosene becomes nearly thirteen times more expensive than charcoal in foreign exchange terms with electricity 3.6 times as expensive. That is not to say fuel switching to more convenient fuels should be discouraged, but the potential customers should pay the full economic cost.

6.13 The above tables do not include the foreign exchange cost of the stoves, which for electricity could be about $30.6 million by 2000 and for kerosene US$2.3 by 2000 (annex 7); this is relatively high whereas for biomass it is very low. But also the efficiency of biomass stoves are low. In countries like Rwanda, Kenya and Tanzania, simple fuelwood and charcoal stoves have been developed made out of metal or fired clay with or without a metal surround. These stoves have an efficiency of between 25% and 35% and cost 1.5 to 3 times more than the traditional stoves (in the region of $4 to $10). The mass production and promotion of improved biomass stoves could both save money for householders and foreign exchange for the government. Also the production of cheap electrical rings and/or the removal/reduction of import duty 26/ on electrical rings or hotplates and spare parts should make these stoves more affordable to households with electricity. Again the promotion of more robust wick and pressure kerosene stoves could save energy. Thus there is need for a concerted and sustained effort in the promotion of all types of stoves.

6.14 However, because charcoal and fuelwood are the principal cooking fuels and because their stove efficiencies are the lowest, the greatest returns will come from successful biomass stoves. A model has been constructed which assumes that an improved charcoal stove with an efficiency of between 25% and 30% will be marketed commercially by about 1992 and by the year 2000 50% to 75% of the charcoal users will be using such an improved stove. This means that by the turn of the century 136,000 to 204,000 improved charcoal stoves will be made annually. By way of comparison, commercial production of improved charcoal stoves commenced in Kenya in late 1983 early 1984: by 1988 the annual production was estimated to be between 125,000 and 140,000. (Jones H Mike 1989, Energy Efficient Stoves in East Africa: Bureau of Science and Technology USAID).

6.15 Applying the above assumption to the forecasted use of charcoal for cooking and water heating the following savings in charcoal are estimated - Table 6.8. The assumptions behind Table 6.8 are described in Annex 8.

6.16 Each householder using an improved charcoal stove will save between 8 and 10 bags of charcoal a year. At the October 1989 price of ZK100 per bag ($5.4) this is worth between ZK800 and ZK1000 per year. Over a three year period the household will have to spend about ZK60 extra to purchase the stove and replacement grates so the savings to the household is considerable, somewhere in the region of an average monthly household income.

6.17 The country will save foreign exchange by not having to transport the saved charcoal. At constant 1988 costs assuming a reduction in transport costs of US$6.8 in FE by 2000, the foreign exchange saving per ton of charcoal not transported, over an average round trip distance of 120 kms, is US$10.0 by the year 2000. Therefore the estimated foreign exchange saving in the year 2000 will range from US$1.1 million (25% stove efficiency 136,000 production) to US$2.1

26/ The import duty on electrical cables and appliances ranges from 20% to 70%. In addition there is a sales tax of 25% to 30%.

million (30% stove efficiency 204,000 production). The respective cumulative F.E. saving between 1992 and 2000 is estimated to be between US$5.9 million and US$11.0 million depending on the success of the program and the efficiency of the stoves. If there were no transport cost reductions, the savings would be greater ranging from US$8.1 million to US$15.3 million (Annex 8).

Table 6.8: CUMULATIVE CHARCOAL SAVING AND SAVING BY THE YEAR 2000 FOR VARIOUS EFFICIENCIES AND PRODUCTION OF IMPROVED CHARCOAL STOVES

Annual Production 2000 1000's	People Using Stoves 2000 a/ 1000's	Stove Efficiency b/ %	AV. Charcoal Savings per day Kgs	Saving in 2000 '000t	1992-2000 Cumulative Savings '000t
136	350	25	0.88	112	482
		30	1.10	140	603
204	525	25	0.88	168	724
		30	1.10	210	905

a/ Three years lifetime: sum of 1998 to 2000 production.
b/ Unimproved stove efficiency 15%.

Source: Annex 8.

6.18 There should be similar initiatives for fuelwood, kerosene and electricity, therefore the total saving of foreign exchange if it is in proportion to the amount of fuels used for cooking (excluding crop residues) will be between US$7 million and US$18 million. The cost of an improved stove program has been estimated at $2.6 million, therefore such a program should be given top priority.

Transport Constraints

6.19 The transport of fuelwood and charcoal is usually in old and dilapidated 3-7 ton lorries and 1-1.5 ton pickups. Most travel on very poor bush roads that are usually impassible during the heavy rain, thus causing supply shortages. Compared to the long haul costs mainly on surfaced roads, the costs are nearly double and the foreign exchange cost over three times more. Improvements in bush roads and bush transport, the establishment of charcoal and fuelwood depots on good bush roads and/or on surfaced roads should reduce transport costs especially foreign exchange costs. Also better organization of road transport should lead to improved back haul and thus further reduce the costs. If the cost of road transport of charcoal and fuelwood could be gradually reduced to that charged by CH transporters (a parastatal transport firm) 27/, then the saving between 1988 and 2000 would be about ZK460 million or US$59 million in constant 1988 terms of which about US$50 are foreign exchange costs 28/. Clearly such a saving warrants a serious effort in the improvement of charcoal and fuelwood road transport.

6.20 Similar arguments could be made for the use or improvement of rail transport. New areas of woodlands are being cleared for agriculture along the Tazara rail corridor. Rail transport is considerably cheaper per ton kilometer than road transport but there is a shortage of rolling stock amongst other things. The potential charcoal production from the land clearing in the Tazara corridor is in the region of 3.5 million tons. Such quantities may have export potential especially to the Middle East. The FOB price of charcoal from Africa is between US$100 and US$120 per ton, a study should be undertaken to see if it is feasible and profitable to export Zambian charcoal.

6.21 Again coal for household use will only be competitive if it is transported to most urban centers by rail and if suitable stoves can be developed and accepted by households. The lack of rolling stock prevents this at present. Indeed frequently the mines cannot get sufficient quantities delivered to existing customers on time so until the rail transport problems are sorted out all charcoal (and some coal) will have to be delivered by road or potential supply sources discarded.

Organizational Constraints

6.22 Besides foreign exchange and transport constraints, there are organizational problems that with better management and training could be overcome. Previous World Bank reports have pointed out the poor record in the electrical sector for meter reading, bill delivery, and bill payment, especially in the household sector. A priority must be to improve this record. Similarly this report has pointed out the poor record in collecting stumpage fees and taxes, again this must be improved by better incentives and enhanced management. Also the stumpage fees and electrical charges should be increased to cover their economic costs, but this will not solve budgetary problems until collection is improved.

27/ In 1988 CH transports charged ZK1.0 per ton per km (US cents 13) for journeys less than 100 kms and ZK0.8 per t/km (US cents 10) for journeys more than 100 kms round trip. The foreign exchange component was estimated to be 34%. Average transport costs for profitable private transport firms in Kenya with slightly higher diesel costs are US cents 12.5 per t/km.

28/ The saving would be less by about US$10 million (FE US$2.8 mill) if the above proposed stove program was successful.

6.23 One way to improve collection is by improving monitoring and then comparing the two to determine the rate of compliance. The monitors could also check for valid licences. The Energy Department through the recent surveys of woodfuel traders and household consumption, monitored the consumption of energy and trade in woodfuel. They alerted the Government and Forestry Department that the current fee payment rate is less than 10%. The Energy Department needs strengthening so that it can carry on this monitoring. Such collected information can then be used to see how successful fee collection for woodfulels and electricity payment has been and to make suggestions for improvements.

6.24 Besides improving the organization of collection, there could be a considerable improvement in energy production, particularly woodfuel, through better management of the resources, improved training and better marketing. In the past woodland management plans were compiled by the forest service and these plans were carried out by field staff under the supervision of trained officers. Thirty to forty years ago, there was a shift in emphasis from woodlands to plantations, and the woodland section became neglected. The forest service should revive the interest in woodland management for potentially the woodlands are large revenue earners, they will remain the dominant suppliers of woodfuel and poles as well as other forest products and afford considerable employment opportunities. However, all the various sectors need support from government and donor organizations if the cost of energy production is going to be reduced.

VII. STRATEGY AND RECOMMENDATIONS

Introduction

7.1 As clearly stated in the Department Of Energy/ESMAP Energy Sector Strategy Study 29/ the basic objective of Zambia's national energy strategy is to satisfy demand for energy at the least economic cost, but in a way that is consistent with national development priorities, with the availability of resources, and with the long-term viability of the energy supply organizations. This broad strategic objective is greatly influenced by the household sector which has the dominant share of energy demand especially urban demand. This objective was broken down into several components which remain valid for the urban household strategy namely:

(a) provide sufficient affordable energy to households to satisfy their basic needs;

(b) provide adequate, reliable least-cost energy supply, minimizing net imports of energy, in order to conserve foreign exchange;

(c) meet energy needs in an environmentally-sound manner; and

(d) ensure adequate maintenance of energy supply systems and the financial viability of the producers/suppliers responsible for them.

Urban Household Energy Strategy

7.2 This overall strategy should bear in mind the principal constraint of limited investment resources, both domestic and external. Therefore, the urban household energy strategy seeks to minimize investment requirements by emphasizing improvement in resource management and existing capacity utilization and efficiency, by namely:

(a) Ensuring a sustainable supply of woodfuel by reserving sufficient areas of woodlands within economic transport distances of the demand centers and managing these resources properly.

(b) Encouraging private individuals to manage existing tree resources and to plant trees for commercial purposes. The main means of encouragement will be through the price mechanism for

---

29/ ESMAP 1988; Zambia, Energy Sector Strategy, Report No. 094/88.

the wood raw material - that is, increasing the price of wood sufficiently to induce private individuals to grow and manage trees. The price of wood should also be such as to make the forest service self sufficient if efficiently organized. A second way to encourage people to plant and tend trees is with training and extension efforts.

(c) Improving the collection of fees from the sale of tree products from public land; this could be done by providing adequate transport and through an incentive scheme with the collectors of the fees receiving a percentage of the income.

(d) Uplifting the status of the charcoal producers by recognizing their importance as a major energy producer, providing them with training, market intelligence, access to improved tools, and social services, encouraging them to organize themselves into groups to improve production and marketing of the product and giving them access to loans etc.

(e) Coupled with the above, woodfuel transport and distribution could be enhanced by improving key bush roads, better utilizing the existing transport fleet, and the establishment of stores in towns and on surfaced roads or at rail depots.

(f) Developing and commercialization of cheap locally produced or assembled stoves, particularly charcoal and electric. In the case of charcoal stoves, the goal should be to increase the efficiency to at least 25% and for electric rings to lower the cost and make spare parts easily obtainable.

(g) Increasing the price of fuels to at least their economic cost and ensuring that this price is adjusted when necessary to account for inflation and the cost of foreign exchange.

(h) As with woodfuel, the monitoring of electricity consumption is poor, particularly at the household level. This could be improved by providing incentives to meter readers, reducing illegal connections and improving bill payments. At the same time the reliability of supply and voltage stability should be improved considerably.

(i) Monitoring the supply, demand and price of energy so that energy accounting, planning and development can be based on a sound footing. To do this the Department of Energy and other related bodies should be strengthened.

Recommendations

7.3 To achieve this strategy recommendations are made both on the supply and demand side and on the organization and strengthening of institutions. Because this study has shown that woodfuel is and will remain the most important household fuel and a fuel with the least foreign exchange cost, most emphasis is placed on the growing, production, distribution and marketing of this renewable resource. Also because this resource is generally used in a very inefficient way, improvement of end-use efficiency will be given equal priority.

7.4 Inter-fuel substitution cannot be meaningful without a sound and proper pricing policy reflecting the costs to the nation especially scarce foreign exchange. To undertake such policy initiatives will require trained manpower at all levels and a full commitment on behalf of government and industry.

Biomass Management

7.5 The following recommendations are proposed on the basis of the findings of the biomass survey and are intended to improve woody biomass management and increase revenue collection which in turn should lead to increased investment in biomass energy activities. Although the recommendations are addressed to the government, the Forest Department as a forestry institution holds the key to their proper implementation.

7.6 The miombo woodlands represent by far the largest area of wood reserves in the country and they are the principal source of fuelwood, charcoal, poles and fine hardwood sawntimber. Very little attention is paid to these woodlands and they are treated as a wasting asset rather than a perpetual source of wood products. They provide a considerable source of rural employment and income. These areas also supply over 60% of total energy and 70% of urban household energy. Therefore, the government should establish a Miombo Woodland Monitoring and Management Unit within the Forestry Department, MLNR, that would have responsibility for undertaking inventories in woodland areas, establishing sample plots both permanent and temporary and carry out experiments in management of these woodlands, undertake a survey of species and the uses of species both for wood and nonwood products. The rural people should be involved in the management and exploitation of these resources. Eventually, the cost of such a unit should be more than covered by the fees collected from the sale of forest products. Indeed not only should the government benefit but the involved rural people should directly benefit from produce sale and generated employment.

7.7 The tasks of a Miombo Woodland Monitoring and Management Unit would be to:

(a) Check and map all areas of woodlands noting their present condition and possible future status;

(b) List in order of priority areas that should be reserved for water catchment, wood and other resources production, species protection, agricultural production, etc.;

(c) Establish permanent and temporary management plots to measure and monitor tree growth and woodland production;

(d) Draw up management plans for the areas that will remain under woodlands;

(e) Meet with local people and decide who will manage the woodlands;

(f) Organise training courses and train extension workers from forestry and agriculture to teach woodland management;

(g) Recruit and train people to undertake the various tasks;

(h) Draw up plans for the woodland resources that are going to be cleared owing to a change of land use;

(i) Establish stumpage fees that are to be charged by the forest service. Ideally these fees should decrease with increasing distance from the market and vary according to end use. Such fees should set a standard for charges to be levied by private individuals on trees they manage;

(j) Establish sets of rules concerning resource payments, rewards and penalties;

(k) Start pilot projects to test management practices and fee collection systems;

(l) Ensure that there are sufficient resources available to undertake the tasks;

(m) Modify management and fee collection schemes as a result of pilot study experiences; and

(n) Put into operation the modified schemes on areas designated for management.

7.8 The Miombo Woodland Monitoring and Management Unit should immediately undertake surveys to determine the quantity of wood coming from :

(a) the Forestry Department's (gazetted) forestry estate; and

(b) forest lands outside the forestry estate particularly land being cleared for agriculture.

7.9 The results of such a survey should enable the government to backup or reject the conclusions of this study which indicate that:

(a) land clearing for agriculture is the principal cause of deforestation;

(b) non gazetted woodland if only cleared for woodfuel production, will revert to trees and thus the deforestation in this case is temporary.

7.10 The government should include long term land use planning in the remit of the land use planning division of Ministry of Agriculture and Co-operatives. The plans of the various ministries especially the Ministry of Agriculture should be ascertained so that a timely use of the trees on land to be permanently cleared can be planned for; once the plans are known the Forest Department/Miombo Woodland Monitoring Management Unit should go into the areas before the land is cleared to assess the standing crop so that a stumpage fee can be levied on these areas. Similarly an assessment of woodland areas in the forestry estate should be made so as to calculate the amount of sawlogs, polewood and cord wood. Once this is done the stumpage fees should be based on the area to be cleared (coupe) and its estimated standing stock as follows:

(a) Volume of sawlogs;

(b) Number and volume of poles; and

(c) Stacked volume of cord wood.

7.11 A revolving fund should be established from the fees collected by the Forest Department. This revolving fund should be sufficient to finance the monitoring service itself. In addition part of the collected fees should revert to government. It is proposed that in gazetted forests the stumpage fee be kept by the Forest Department and the removal fee (tax) be remitted to government. In non gazetted woodlands the local authorities, villagers and charcoal producers etc. who are involved in the management of woodlands should keep a percentage of the stumpage fee, say 67% and the forest service retain 33% if they provide a management/ monitoring service. Where areas are being cleared for agricultural production the involved parties will all benefit from the stumpage fee. On all areas the government will collect and keep the removal fees. These proposals should be discussed by a committee of interested parties who then could make recommendations to the government.

7.12 At present about 16 million bags of charcoal (2.6 million bone dry tons wood 30/) and 440,000 cords of wood (0.4 million bone dry tons wood) are produced for sale to all sectors (urban households consumed

---

30/ 1 metric cord contains about 900 kgs of bone dry wood.

about 13 million bags of charcoal and 220,000 cords of bought wood). It is estimated that about 25% of this wood comes from gazetted forest land and the remainder from land clearing and non-gazetted woodlands. If this is correct and assuming the Forest Department keeps 33% of the stumpage fees from non-gazetted trees then with existing stumpage fees of ZK8 per cord, the forest service could collect ZK13.0 million and other parties ZK13.0 million. The government through the charcoal removal fees would also collect ZK8 million and if a pro-rata fee is levied on fuelwood an additional ZK1 million would be forthcoming.

7.13 This fee of ZK13.0 million is insufficient to cover the present Forest Department costs which in 1989, after inflation has been taken into consideration, may amount to some ZK30 million. Also additional money, up to ZK10 million will be required for improved management, monitoring, charcoal management, extension efforts and fee collection. Thus a review of stumpage fees should be carried out as a matter of urgency. The Forest Department should be free to peg the stumpage fees to the average inflation rate so that the value of the wood raw material is not eroded. If indeed the Forest Department requires ZK40 million in 1989 value terms to undertake a competent job of managing the forestry estate and to monitor trees outside the gazetted forest, then an approximate stumpage fee to cover its costs will be about ZK24 per cord (ZK15 per solid cubic meter). While this may seem a large increase on the present rate it should be pointed out that in terms of the selling price it represents ZK4.3 per bag of charcoal, a fraction of the selling price . It should be noted that if the fee collection rate is 80% efficient then the stumpage fee would have to be increased to ZK30 per cord (ZK18 per cubic meter) the equivalent of ZK5.3 per bag.

7.14 A stumpage fee of ZK24 per cord should be attractive enough to induce rural people to manage existing trees and woodlands outside gazetted areas and also to plant trees for sale. Such a fee will be a minimum charge for wood raw material: it should increase for more valuable end products such as poles and sawnwood and increase the closer the grower is to market. Eventually once the trade in wood products is normalized, wood users should bid for parcels of wood according to distance from the market and value of the finished product.

7.15 The government should regulate the harvesting of forest produce in hilly/escarpment areas, whether these are within or outside the forest estate, to minimize environmental degradation. In such areas the shelterbelt/coupe method of felling should be enforced and woodfuel harvesting should be subject to both stumpage fees and levies.

7.16 More reliable data are required on annual yield in both mature and young woodlands and how annual yield is affected by soil type, rainfall, species composition, source of regeneration, age and management. This can best be done by establishing permanent sample plots in different parts of the country to monitor annual yield.

7.17 Woodfuel harvesters should be encouraged by government and non-government agencies to carry out early burning in areas in which they operate. It is also hoped that as they see the benefits from managing woodlands in the form of remittances from stumpage fees they will be encouraged not only to improve management but actively encourage others to manage and plant trees.

7.18 The government should initiate discussions among the Forest Department, Natural Resources Department, Energy Department, District Councils and Ward Political Committees in order to work out mechanisms for co-operating in the implementation of biomass energy recommendations.

Charcoal Production

7.19 Charcoal is the second largest source of energy supply in Zambia to-day, firewood being the primary source. Firewood mainly meets the energy requirements of the rural population and is self-collected whereas charcoal is the principal urban household fuel. It is a fuel based on an indigenous raw material which if properly managed can last indefinitely. Zambia is in the fortunate position of having a considerable reserve of wood raw material but in areas near population centers this reserve is being depleted mainly due to agricultural pressures. If charcoal keeps its competitive position vis a vis other fuels there is no reason why demand for charcoal should decrease. Indeed it is in the governments interest to encourage the use of charcoal for in economic terms it is the cheapest fuel. It is also a fuel that requires practically no foreign exchange to produce although it does require foreign exchange to transport to market. Again it is a fuel that provides a considerable amount of rural employment both in the production of the charcoal, the loading of the product on to vehicles, and in some cases the transport of the charcoal to roadside. There is also some employment created in the managing of the wood raw material. This study estimates that about 41,000 people are employed in charcoal production, 3,500 in transport and about 1,000 in marketing. If kerosene were fully substituted for charcoal an additional 210,000 ton would have to be imported which would cost in the region of US$ 30 million in terms of foreign exchange.

7.20 Unlike farmers who have extension services, co-operatives to buy inputs, subsidized fertilizers and a fairly well organised transport system to get the product from the field to the store or market the charcoal producers are provided with nothing. They even do not get coupons to buy maize meal at a discount for they are considered to be farmers who can grow their own food. They are also sometimes described as the destroyers of trees, whereas in fact in many cases they are salvaging a resource that would be wasted when woodlands are converted to farms.

7.21 First and foremost the status of the charcoal producers should be improved. The government should recognize that charcoalers are providing an important (indigenous) energy to the urban areas and are saving the country a considerable amount of foreign exchange. As with farmers, basic services should be provided for them, and they should receive courses and on the job training to improve their skills both on the production side and in the management of the resource.

7.22 Also, because shortages occur every year during the rainy season, strategic supplies could be built up both by producers and traders to counter these shortages; again access roads could and should be improved to mitigate these shortages and to reduce transport costs.

Therefore, it is recommended that:

(a) The Government should encourage the charcoal producers to form active producer organisations so that it can channel help through these organisations. At present a skeletal charcoal producers organisation exists in some parts of the country but generally this organisation is weak and most producers are ignorant about its existence. Currently the majority of charcoal producers operate in remote areas where there are no education, health and commercial (especially shopping) facilities. Often they travel long distances for medical care and basic requirements, such as maize meal, sugar, salt, etc. This adversely affects their productivity. If such facilities were located at or closer to large charcoal producers settlements, it will reduce the amount of travelling and improve productivity.

(b) The proposed Miombo Woodland Monitoring and Management Unit within the forestry department should have a Charcoal Production Section. This section should be actively involved with the charcoal associations training them in:

(i) techniques of managing the woodlands so as to encourage regeneration of desired charcoal species;

(ii) the use and maintenance of correct tools especially hand tools such as axes and saws. Power saws have their place in the cutting process but are more difficult to maintain and also require considerable foreign exchange, this is why the emphasis should be put on hand tools. Such tools and maintenance equipment should be readily available at shops near the production sites or near charcoal depots;

(iii) while the current earth kiln charcoal method is reasonably efficient there are ways of improving earth kiln techniques. The current earth kiln charcoal production method has a very good conversion efficiency (about 25% bone dry wood to charcoal, 20% air dry wood to charcoal) but the factors that determine conversion efficiency are still poorly understood. The government should, therefore, carry out detailed field studies to investigate the role of (i) wood moisture content,

(ii) kiln management practices and (iii) size of kiln on conversion efficiency. Only when the determinants of conversion efficiency are properly understood can a strategy be formulated for increasing conversion efficiency.

(iv) The production techniques in say Sudan and Somalia should be studied. In Somalia metal sheets are used to cover the clamps before soil is placed on top, this gives an increased recovery percent and also a cleaner charcoal. In Sudan as the charcoal season proceeds, the wood is properly air dried and large kilns are built (100 m^3 plus) which again increases recovery. Earth kilns with chimneys - the cassamance kilns have been developed to improve production. Therefore, existing techniques should be studied to see if and how they can be improved.

(v) Brick and metal kilns are not recommended for miombo woodlands because the producer is constantly on the move. However, such kilns, especially brick kilns could be set up where there is a constant supply of raw materials such as at sawmills.

(vi) As charcoal production is one of the most important forest industries, the Forest Department should give this industry a high priority and devote sufficient funds to improving charcoal production. Increased revenue from stumpage fees should more than pay for the improved service.

(vii) Charcoal production can make a significant contribution to forest service and government revenues. However, this can only be done if the Forest Department is provided with adequate and properly trained manpower and other resources, such as equipment and transport, to enable it collect stumpage fees and charcoal levies. Its task would be made easier if viable charcoal producers associations existed. Then there should be co-operation between the resource owners and the charcoal producers and they could be of mutual assistance. For example removal permits could be issued from charcoal stores and be valid for a single journey instead of issuing a permit from a forest office valid for a longer period. The government should, therefore, strengthen and equip the Forest Department to achieve this objective.

(viii) Little is known about seasonality in charcoal production and to what extent this affects price instability. The proposed Charcoal Production Section should, therefore, support a study to investigate seasonality in charcoal production. The results of such a study can be used in the rational re-organisation of the woodfuel industry in the country.

(c) Experience has shown that by having a controlled price the storage of charcoal will be discouraged. The market price has always been above the controlled price thus the seller runs the risk of his product being confiscated. The government by lifting the control on charcoal price started taking necessary measures to stabilize its price, this is the first step to ensure an adequate all year round supply.

7.23 A technical course in charcoal production, including tree felling, simple book-keeping and charcoal marketing could be introduced at the forest training college or other suitable schools. The government should encourage the erection of charcoal depots both near production sites and in urban areas. They should also encourage people that can afford it to lay in a stock of charcoal to tide them over the rainy season. The charcoal producers association could run the stores near the woodlands and the traders in the towns. However, the simplest way to overcome shortages is to improve the access into the woodlands and to invest in improved transport means both vehicular transport and animal carts. As the charcoal transport study shows the cost per ton kilometer for charcoal is two to three times the cost of surfaced road transport by large vehicles.

7.24 The proposed Charcoal Production Section should liaise closely with the Land Use Unit and the charcoal association so as to ensure a timely and an efficient use of the wood resources on land to be cleared for agriculture.

Energy Conservation

7.25 Cooking is the principal end-use of energy, accounting for 50% of household energy use.

7.26 Water heating on the stove uses another 16% of household energy, therefore the stove accounts for 66% of household energy. Cooking by institution and restaurants etc. also accounts for a large proportion of non-household energy use.

7.27 The efficiency of charcoal and firewood stoves are low, on average about 15%, that of kerosene stove moderate -about 35%- and only electricity is reasonably high - about 60% .Therefore improvement in stove efficiency could lead to energy saving for householders especially for fuelwood and charcoal which account for 57% of total energy consumption.

7.28 Improved stoves in other countries eg. Kenya have given efficiencies in the range of 25-30% for fuelwood and charcoal. If such efficiencies can be achieved here there would be a considerable monetary saving for households (between 8 and 10 bags of 40kg) and foreign exchange savings for the country as a result of charcoal transport savings.

7.29 Electric and kerosene stoves are imported and are extremely expensive. Cheaper stoves could be made or assembled in Zambia.

Therefore it is recommended:

(a) That a Stove Unit be set up in Zambia preferably attached to the National Council for Scientific Research (NCSR) but with inputs from artisans, industry, government and the university.

The task of the stove unit will be to:

(i) undertake market research to find out the kind of stoves (and utensils) people and institutions etc. desire. Existing stove and stove programs should be examined to determine their advantages and disadvantages;

(ii) design in co-operation with industry and artisans stoves that can be manufactured from local materials, keeping the foreign exchange cost as low as possible;

(iii) Laboratory test the stoves and if satisfactory, field test them;

(iv) Modify the stoves as a result of both laboratory and field tests;

(v) Undertake field tests and keep modifying until a satisfactory product is made;

(vi) Assist if necessary the producers in establishing stove manufacturing units and follow up with advice, quality control and modifications;

(vii) Give the stoves seals of approval and constantly check that quality is being maintained;

(viii) Run demonstration and advertisement campaigns to popularize the stoves - both households and non-households stoves;

(ix) Look at ways of further improving the stoves and utensils; and

(x) Undertake detailed costing analyses at all stages.

(b) An evaluation of the on-going program of disseminating an Improved Charcoal Stove should be undertaken to determine whether and what savings are being achieved by households using this stove.;

(c) In order to undertake these recommendations there should be courses and on the job training for artisans; and

(d) Presently the import duty on stoves and components is between 20% and 70% and it could be reduced. This would reduce the cost of stoves both imported and locally manufactured.

Woodfuel Transportation

7.30 The transport of woodfuel and in particular charcoal is relatively disorganised and expensive.

7.31 Various methods of transport are used such as manual, animal and motorized vehicles, the former two being used to transport charcoal over short distances to either a bush road or to a surfaced road.

7.32 The bush roads are generally in a very poor condition.

7.33 The cost of transporting charcoal and firewood is two to three times the cost of transporting other goods on surfaced roads.

7.34 The vehicles used to transport charcoal and firewood are usually old or very old.

7.35 No stores for charcoal are available at roadside or railway sidings, thus advantage cannot be taken of low rail rates or low surfaced road rates.

Therefore it is recommended that:

(a) The Government improve key bush roads and encourage the transport of charcoal to accessible stores at surfaced roads;

(b) Help charcoal associations and woodfuel traders to establish stores at strategic points near production areas and in towns;

(c) Look into the transport of charcoal and suggest means of reducing costs. This may be by:

(i) improving bush transport by animal, tractor-trailer and small lorries;

(ii) co-ordinating with the railways and road transporters to transport charcoal in empty return wagons/lorries;

(iii) facilitating the acquisition of loans by the charcoal associations and private transporters to buy lorries; and

(iv) encourage competition between all transport sectors.

(d) The collection of the charcoal removal fee should be enforced and a similar one levied on fuelwood; and

(e) Removal fee permits should be valid for one journey only. These fees amount to about ZK8 millions at existing charges and could assist in the development of bush roads etc. The removal fee of ZK0.5 per bag of charcoal has not been increased to account for inflation. By February 1990 the fee should be approximately ZK 1.5 per bag. If a similar charge was placed on fuelwood, the tax would be about ZK8.5 per cord.

Substitution

7.36 In terms of the overall costs to the country, charcoal is clearly the most economic urban fuel. One key reason is that foreign exchange costs account for only about 16% of the total cost of using charcoal for cooking.

7.37 The use of firewood for cooking is strongly correlated to the extent to which it is available from nearby areas. Unless firewood is transported over long distances, it remains a most inexpensive fuel in economic terms.

7.38 For those who can afford it, the use of electricity for cooking is likely to be preferred over charcoal, due to convenience. Where families already have electricity, use of inexpensive hot plates for electric cooking costs the nation about the same as charcoal. It should be recognized, however, that the economic costs of using electricity for cooking are higher than the prices which consumers now pay.

7.39 The actual cost to the nation of kerosene use for cooking, in terms of both the cost of kerosene procurement and the cost of scarce foreign exchange, is almost as expensive as cooking with electricity for households needing connection and wiring.

7.40 The economic and financial costs of supplying coal briquettes on a commercial basis, and consumer acceptance, will only become clearer when the DOE/NCSR pilot project progresses further.

Therefore is is recommended that:

(a) The substitution of electricity and kerosene for charcoal should be approached with caution because of these three fuels, charcoal is the cheapest in economic terms . It was also the cheapest fuel in financial terms in October 1988.

(b) In October 1989 the government removed subsidies from kerosene; it should do the same for electricity. This measure has at least two advantages (a) it will give the correct signal to the consumers for a more optimum use of resources and (b) it will improve the financial situation of the Utility- most of the electricity consumption is in high income areas and people can afford such an increase.

(c) As previously mentioned charcoal could be made cheaper by improving the transport and supply systems and improving end-use efficiency for both households and non-households.

(d) Wood is the cheapest fuel but to encourage its use it has to be grown near the consumer and marketed properly. More efficient stoves for households and institutions have to be introduced and promoted.

(e) Coal is also a relatively cheap fuel but it has to gain consumer acceptance, stoves have to be introduced commercially and delivery costs kept low, therefore, trials should be made to test coal on the market.

Strengthening of Institutions

The Energy Department

7.41 The Energy Department has built up expertise and experience in survey work, energy accounting, monitoring of energy prices and energy flows.

7.42 The Energy Department is housed in cramped offices that are constantly being broken into and valuable equipment stolen.

7.43 The Energy Department has received valuable equipment from the present project but it has insufficient personnel to use this equipment fully.

7.44 The Energy Department is in an excellent position to liaise with other government departments, ZESCO, the coal mines and the refinery on matters concerning energy policy and planning.

Therefore, it is recommended that:

(a) The Energy Department be strengthened by recruiting more professional people;

(b) Frequent surveys be undertaken to monitor:

(i) consumption and availability of fuels in different seasons and in different areas;

(ii) consumption of fuels in households and non-households with improved and unimproved cooking devices;

(iii) a sub-sample of households in order to follow up on fuel switching habits and to identify the reasons for switching;

(iv) the traffic in charcoal and fuelwood coming into towns;

(v) the effect charcoal prices have on the health and nutrition of poor households;

(vi) the price of fuels at various outlets.

(c) In this way the Energy Department should have up to date information for planning purposes;

(d) The Energy Department should chair an Energy Planning Committee of all relevant institutions, both government and non-government to plan for efficient production and use of energy. This committee should also have representatives from the Land Use Unit from the Ministry of Agriculture and Cooperatives, and the proposed Miombo Woodland Management and Monitoring Unit plus the Charcoal Production Section;

(e) Give advanced training courses to staff as may be necessary;

(f) Publish technical reports and articles on energy matters;

(g) In conjunction with ZESCO, Central Statistical Office, Maamba Collieries, Forest Department and the oil companies, strengthen the collection and analysis of fuel production statistics;

(h) Obtain better office accommodation for the Energy Department;

(i) Liaise with the SADCC energy Technical Administrative Unit (TAU) in Angola and the Forest Unit in Malawi.

Central Statistical Office

7.45 The sample frame for the Demand Survey was based on the results of the 1980 census. However, the various reports and publications consulted did not show coherency and it was difficult to gauge the reliability of one source of information from another, this led to undertaking a household listing.

It is recommended that:

A more critical check of collected data should be undertaken systematically bearing in mind the importance of reliable data in any decision making

Zambia Electricity Supply Corporation

7.46 The study on electricity substitution was done in conjunction with ZESCO. During the study it was found that much information necessary for planning was not readily available at ZESCO headquarters. This necessitated consulting the ZESCO district offices to obtain the required information.

7.47 Furthermore, ZESCO has a critical shortage of manpower which means that some jobs are left aside and especially it is very weak on market research.

7.48 The foreign exchange component on the electricity supply is quite substantial (more than a third of total costs). There is scope for local manufacture of some of the components but at present there is no R and D being conducted by ZESCO.

7.49 The Demand Survey showed that 65% of households who use electricity for cooking still use charcoal on a stand-by basis in case of power failure. It has also been observed that there are large fluctuations in the voltage and this has a consequence of reducing the life of electric appliances, most of which are imported. This situation has worsened since the fire at Kafue Gorge hydro station which could have been prevented if timely maintenance had been undertaken.

Therefore, it is recommended that:

(a) ZESCO establishes a centralised information system by which all information will be gathered and updated for proper planning.

(b) ZESCO improves the reliability of electricity supply and controls the voltage regulation to optimal levels.

(c) ZESCO strengthens its planning unit to undertake detailed economic analyses of electrification.

(d) Better conditions of service be established in order for ZESCO to attract and retain qualified personnel.

(e) Strengthen the capacity of meter reading and billing.

The Forestry Department

7.50 Less than 10% of the stumpage and removal fees are collected at present due to lack of manpower, transport and adequate compensation.

Therefore, it is recommended that:

(a) More people be hired and trained to be stationed at entry points of towns to monitor and control the trade in forest products particularly charcoal.

(b) More people be hired and trained to assess the standing biomass for sale.

(c) All personnel should be given adequate transport and appropriate compensation.

(d) There should be a monitoring unit to check whether the collected fees are being accounted for and if the measurements of forest products are accurate.

7.51 The forest service is the lead agency for undertaking woodland management on the area it manages and for assisting management in other areas. Through its extension services it could train and help people to grow and manage trees, train charcoal producers and improve bush roads etc. The establishment of the proposed Miombo Woodland Management and Monitoring Unit and the Charcoal Production Section are key elements of the energy strategy for Zambia.

VIII. PROJECT PROPOSALS

Background

Supply of Traditional Fuels

Biomass Resources

8.1 The gross density of cord wood biomass in catchment areas (BCA's) supplying major towns in Central, Copperbelt and Lusaka provinces is at least 5000 tons (bone-dry) per square kilometer. 31/ Assuming similar density throughout the country (753,000 sq.km.) there are about 3,765 million tons of cord wood reserves and 112 million t. of annual production. 32/ Only nine percent of this cord wood reserve is located in catchment areas that supply woodfuel to major towns in Central, Copperbelt and Lusaka Provinces. This underlines the great inequality in the spatial distribution of wood resources in relation to demand.

8.2 Even so if sufficient area of these woodlands are reserved and/or managed there should be enough wood raw material to meet future demand in the Lusaka region and Copperbelts. If sufficient areas are not managed close by, accessibility will in future be a major constraint in the harvesting and transportation of woodfuel to urban areas.

8.3 Currently woodfuel (firewood and charcoal) supplied to urban areas comes from within and outside the gazetted forest reserves. The forest reserves in 1988 covered 7,4 million ha or 10% of the country. In the Lusaka biomass catchment area only 4% (0.15 million ha) is reserved. This may have to be increased to ensure a sustained supply of wood products. Woodfuel harvesting causes temporary deforestation and accounts for a small proportion of total deforestation. The major cause of deforestation is conversion of forest land to cultivation. A small proportion of the waste wood in cultivation lands is converted to charcoal, especially where these lands are close to urban charcoal markets. Regeneration in woodfuel areas occurs naturally if the land is left to recuperate. However, with management, regeneration should be better both qualitatively and quantitatively.

31/ This figure has been derived by dividing the estimated volume in unused woodlands in the BCA's - 342 million t. (b.d.) by the total area in the BCA's - 68,369 km^2 = 5002 t/km^2 with an annual increment of 149 t/km^2 (1.55/ha).

32/ This is equivalent to 4330 million tons air dry cordwood (15% mcdb) and 130 million t. airdry annual production (15% mcdb).

8.4 A stumpage fee of ZK8.00 is charged on a cord of wood ($3m^3$ stacked) cut for fuel. However, due to lack of resources and inadequately trained manpower less than 10% of the stumpage fees are collected by the Forest Department. In 1988 an estimated 3.3 million cords of woodfuel were harvested for sale with a potential revenue in stumpage fees of ZK26.2 million and ZK8.0 million removal fee. If fully collected this would greatly boost Government revenue.

Charcoal Production

8.5 Firewood is the major fuel used in rural areas and small towns while charcoal is the dominant woodfuel in medium and large towns. Charcoal is produced by the traditional earth-kiln method which has a conversion efficiency of 25% (bone-dry wood to charcoal). This efficiency is relatively high for the earth-kiln technology of charcoal production but could be improved further.

8.6 In 1988 about 41,000 people were involved in commercial charcoal production throughout the country with a total output of 16 million bags (or 640,000 tons). The charcoal production activity is labour intensive with a low annual productivity of about 16 tons per full-time charcoal producer. Investment in tools (axes, shovels, hoes and rakes/forks) is extremely low and production costs (including a 25% profit margin) in 1988 was estimated at ZK375.00 per ton of charcoal or ZK15.00 per bag (US$1.9).

8.7 The majority of charcoal producers operate in remote areas where there are inadequate or no education, health and commercial facilities. Thus producers have to travel long distances to seek these services. This negatively affects their productivity. The majority of charcoal producers are not organized to facilitate the flow of assistance from either government or non-governmental organisations. Generally the charcoal production industry is accorded very low status while charcoal producers are regarded as destroyers of trees, even though they produce a valuable energy product. These negative attitudes towards charcoal producers and their industry have undermined efforts to improve the industry.

Transportation and Distribution

8.8 Although some of the woodfuel used in urban areas is self-collected and transported manually, the largest proportion of woodfuel used in urban areas is transported by motor vehicles. Occasionally manual and animal transportation is used to move woodfuel from production sites to accessible points on bush or surfaced roads.

8.9 Woodfuel transportation is informal and relatively disorganized. Because of this and the fact that part of the journey is along bush roads that are badly maintained and in poor condition, transportation costs are arbitrarily determined and are 2-3 times the cost of transporting other goods on surfaced roads. During the rainy season bush roads are often impassable and woodfuel supplies become erratic and scarce. This results in shortages and price increases. For example, the flow of woodfuel into Lusaka in February 1989 was about 40% less than that observed in the dry season month of October 1988. Furthermore, because controlled charcoal prices were far below market prices, distribution of charcoal during the rainy season was chaotic with most sales taking place outside designated market places to avoid confiscation of charcoal.

8.10 Before charcoal can be removed from the production site a fee (tax) of ZK0.50 is levied on each bag of charcoal. But due to inadequate manpower in the Forest Department only a small proportion of this revenue is collected. In 1988 a total of 13 million bags of charcoal 33/ were used for household purposes in urban areas which could have generated from removal fees alone a total of ZK 6.5 million as Government revenue. The total revenue from stumpage fees and taxes collected by the forest services in 1987 was ZK 2.8 million.

Supply Constraints

Biomass Energy

8.11 The household energy demand forecast for the year 2000 shows that woodfuel consumption will increase by 61% during 1988-2000. To only meet this increase in demand the equivalent of an additional 30,500 ha of woodlands will be cleared. Therefore, there is a pressing need to fully manage the woodland resources to ensure they remain renewable.

8.12 One of the most important supply constraints is access to biomass resources. Currently only 13% of the woodlands are in catchment areas supplying the major towns in Central, Copperbelt and Lusaka Provinces. Thus distances to biomass resource areas may increase unless these areas are properly managed and this will affect retail woodfuel prices. Longer distances to woodfuel areas also implies longer transportation on bush roads which become impassable during the rainy season. Thus upgrading of these roads, the reorganisation of woodfuel transportation, to make it more efficient, and the establishment of storage facilities, especially for charcoal, along all-weather routes and/or in urban areas will be necessary for improving future woodfuel security and for stabilizing woodfuel prices.

8.13 The indigenous woodlands which are the main sources of woodfuel are potentially renewable and unless woodfuel areas are converted to agriculture, natural regeneration is spontaneous. It is, therefore,

---

33/ Total consumption of charcoal by all sectors estimated to 640,000t (16 million bags).

possible to utilise indigenous woodlands for woodfuel and other products on a sustainable basis. In order to achieve sustainable utilization, indigenous woodlands and especially areas cleared for woodfuel production will have to be scientifically managed. Current mean annual cord wood production in regrowth areas is estimated at 2-4 tons (bone-dry weight) per ha. with a rotation period of 33-34 years. With scientific management this productivity could be increased by 20-30% and with significant reductions in the rotation period. This is important for two main reasons. First, the environmental impacts of deforestation will be minimized and shortened and second, the woodlands can be sustainably utilized over shorter periods while slowing down the rate of deforestation.

8.14 Currently conversion of forest land to agriculture is the major cause of deforestation which is often permanent. Unless the expansion of agriculture is controlled, it might result in competition with woodfuel for the same forest land and therefore, exacerbated the problem of access to woodfuel biomass resources. This potential competition can be averted by ensuring that waste wood on farmland is used for woodfuel. This can properly be done if there is a strong coordination between the Agricultural Land Use Unit and the Forest Department.

8.15 Although the current earth-kiln method of charcoal production is relatively efficient (25% conversion rate) further studies should be done to determine possibilities for improving this efficiency. Such a program should be an integral part of a strategy to increase woodfuel supply for meeting future demand.

8.16 Charcoal production by the earth-kiln method is labor intensive with a low productivity. Whereas a high labor input is good for ensuring rural employment opportunities, the low productivity could be improved by organizing producers into strong societies through which education, health and other social services can be provided by government and non-government organisations. Currently charcoal producers are considered destroyers of trees and semi-illegal operators. These attitudes undermine the status of the charcoal industry and therefore act as social constraints on improving future biomass supply. Improved status and provision of assistance to charcoal producers could improve the organisation of the industry and productivity of charcoal producers while raising their individual and collective responsibility towards better management of indigenous forest resources.

End Use Efficiency

8.17 The use of the fireplace or stove for cooking and water heating accounts for 66% of household energy use. The cooking devices are either inefficient especially the woodfuel stoves or expensive in the case of electric stoves. Household expenditure could be reduced through cheaper and more efficient stoves and at the same time the government could save foreign exchange. Initiatives in this area of conservation should give considerable returns.

Organizational Constraints

8.18 To achieve a more efficient use of energy especially indigenous energy resources, several government agencies and parastatals have to be strengthened, and private individuals or organisations encouraged to manage and produce energy more effectively. This will not be done by exhortation but through providing proper monetary incentives and adequate transport and equipment to undertake the task. The trade in fuels, especially woodfuels is large and income from the sale of the wood raw material, electricity or oil products should be more than sufficient to give adequate rewards to the producers while at the same time supplying reliable and relatively cheap fuels to the consumers.

Project Proposals

8.19 This report has pinpointed the importance of biomass as a household energy, and the above background information has emphasized where effort is required in order to ensure that biomass will remain an important and renewable fuel. A list of project proposals is given in table 8.1. Such projects could help the people of Zambia produce and use energy, especially indigenous energy, in an efficient and profitable way. To the extent possible this package of proposals should be pursued concurrently as the various proposals are interrelated. Preliminary estimates of costs have been prepared for all but one proposal. A detailed description of each proposal is given in Annex 9.

TABLE 8.1: PROJECT PROPOSALS

PROJECT TITLE	ESTIMATED COST (US$)
1. Establishment of an Indigenous (Miombo) Woodland Monitoring and Management Unit (IWMMU).	1,660,000
2. Improvement of Collection of Woodfuel Fees and Levies and Re-Assessment of Stumpage Fees	580,000
3. Planting and Managing Trees by Private Farmers and/or Individuals	?
4. Feasibility Study of the of the Utilization of Wood Resources for Charcoal in the Tazara Corridor	60,000
5. Strengthening of Charcoal Producers' Organisations	60,000
6. Improvement of the Earth-Kiln Charcoal Production Technology	140,000
7. Improvement of Charcoal Supply and Distribution	600,000
8. Establishment of a Stove Unit	2,570,000
9. Evaluating the Popularity of the Improved Charcoal Stove	10,000
10. Strengthening of the Department of Energy	240,000
Total (excluding 3)	5,920,000

References

Chidumayo E.N., 1986: Bush fires and vegetation management in Zambia: Natural Resources Department, Lusaka.

Chidumayo E.N, 1987a: Species Structure in Zambian Miombo Woodland J of Ecology 3 109-118.

Chidumayo E.N, 1987b: A survey of wood stocks for charcoal production in the Miombo Woodland of Zambia. Forestry Ecology and Management 20.105.115.

ETC Foundation, 1987: Wood Energy Development: Biomass Assessment, a study of the SADCC Region, ETC Foundation, P.O. Box 64: 3830 AB Leusden, The Netherlands.

FAO, 1989: Yearbook of Agricultural Production, FAO, Rome.

Government of Zambia 1989. Fourth National Development Plan: Govt. Printers, P.O. Box 30136, Lusaka.

Government of Zambia 1988. The Forests Act: Supplement to the Republic of Zambia, Gov. Gazette dated the 25th March 1988. Govt. Printers, P.O. Box 30136, Lusaka.

Jones H. Mike 1989. Energy Efficient Stoves in East Africa. Report No. 89.01. Bureau for Science and Technology USAID, Washington D.C.

Lees H.M.N. 1962: Working Plan for the Forests Supplying the Copperbelt, Western Province, Govt. Printers, P.O. Box 30136, Lusaka.

Shamilupa Kalapula E. 1989. Woodfuel Situation and Deforestation in Zambia. Ambio Vol. 18 No. 15.

ESMAP 1986: Zambia Energy Sector Institutional Review. Activity Completion Report No. 060/86, World Bank, Washington D.C.

ESMAP 1988: Zambia Energy Sector Strategy: Activity Completion Report No. 094/88. World Bank, Washington D.C.

ESMAP 1988: Zambia Power Subsector Efficiency Study (Draft) Activity Completion Report No. 093/88, World Bank, Washington D.C.

ESMAP 1990: Project Working Papers:

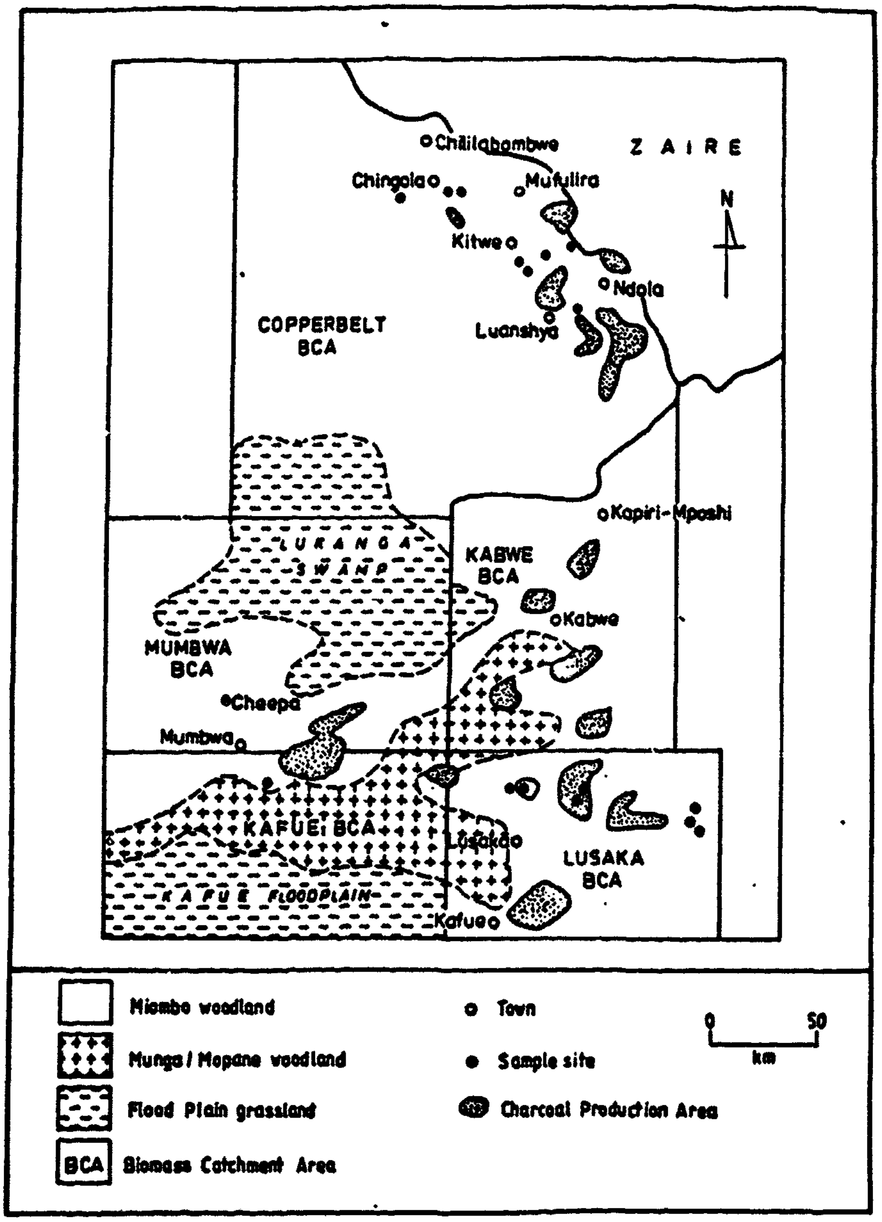
(a) Biomass
(b) Charcoal Production Report
(c) Demand and Annex
(d) Fuel Price and Costs
(e) Woodfuel Transportation and Distribution

WOODLAND ASSESSMENT IN AREAS SERVING URBAN CENTERS

Biomass Weight Determination

1. Population and woodland resources are not spread evenly throughout the country, nearly half the population live in urban areas specifically in the Copperbelt and the Lusaka regions. It is the demands on the woodland resources in these areas that is most under threat and therefore, an inventory was undertaken to measure the area of these woodlands, their condition, growing stock and annual increment. (Fig 1).

Fig. 1: Location of biomass catchment areas, main charcoal production areas in 1984, sample plots and vegetation types in central Zambia.



2. This was done to determine which areas, if any, are being depleted and the steps needed to halt or reverse this situation. Sixteen sample plots measuring 0.02 ha. in mature and coppice regrowth Miombo woodlands were chosen so that there was a representation of site, aspect (escarpment, plateau) and Miombo sub-type. All trees over 1m tall were identified, counted and measured. A sample ranging from 36 - 54% in the coppice stands to 46-90% in the mature stands was felled, divided into cord wood, twigs and leaves, weighed, measured for moisture content and stacked into metric cords (3m x 1m). The data were then analysed to determine the quantity of wood growing on the various plots, by leaves, twigs and cord wood. The cordwood was further divided by diameter class and species. Because the ages of the coppice regrowth stands were known the mean annual increment could be determined for these plots.

3. The above data were combined with measurements made by the Department of Natural Resources between 1982 and 1986. Thirty-one mature miombo plots on plateaux and the escarpments ranging in area from 0.14 ha. to 0.60 ha. were measured for girth at stump height and breast height. These girth measurements were translated into volume/weight measurements using data from the current survey. The pooled data gave a mean cordwood bone dry weight of 72 t. per ha. for the Lusaka (dry) miombo catchment areas and 130 t. per ha. for the Copperbelt (wet) miombo catchment areas. These figures are somewhat higher than previous figures and it seems as though there has been an underestimation of biomass weight/volume in mature miombo woodlands.

Vegetation Cover Assessment

4. The latest aerial photographs were obtained for the Lusaka and Copperbelt biomass catchment areas (BCA's) and these were analysed by land use or tree vegetation cover and by tenurial ownership. Table A1.1 gives a breakdown of tenurial ownership, by catchment areas and the reserved forest area in each sub-sector.

5. There are three main categories of land ownership - statelands, trustland and reserves. Statelands are administered by individuals or institutional leaseholders such as the forest service. Trustlands and reserves are communal lands administered by chiefs and their village headmen, although there are government forest reserves in these areas as well but these reserves are controlled by the forest service. This tenurial land system has not presented any major constraints on access to biomass resources. However, because forest reserves are controlled by an arm of government these reserves are usually the first to be cleared for agricultural development. This can be seen in Table A1.2 where the area of forest reserve in the Copperbelt stateland is more than the actual forest area. This concentration of deforestation in the forest estate whether located in stateland or not has become a major threat to the future of the gazetted forest estate.

Table A1.1: LAND OWNERSHIP AND FOREST RESERVE BY CATCHMENT AREAS
Units in km^2

Catchment Area a/	Landownership	Year of Aerial Photos	Land Area: Total	Forest Reserve	%	Actual b/ Forest area	%
Copperbelt	Stateland (SL)	1984	5674	4335		3875	
	Trust Land (TL)		7811	2624		6468	
	Reserves (R)		14300	1215		10568	
	Total		27785	8174	29	20911	75
Kabwe	Stateland	1982	3182	204		1715	
	Trust Land		6184	662		4150	
	Reserves		5693	0		3473	
	Total		15059	866	6	9338	62
Mumbwa	Stateland	1987	0	0		0	
	Trust Land		1956	98		1408	
	Reserves		11633	140		4409	
	Total		13589	238	2	5817	42
Lusaka	Stateland	1982	4145	166		2818	
	Trust Land		3926	192		3458	
	Reserves		3865	93		2384	
	Total		11936	451	4	8660	72

a/ The aerial photographs were not available for Kafue catchment area (Fig. 1). This has a total area of about 14700 km^2 of which 5900 km^2 is flood plain (grasslands) 5900 km^2 Munga/Mopane woodland and 2900 km^2 Miombo woodland. Only the latter is currently used for charcoal production and two areas are being exploited to supply Lusaka (Fig 1).

b/ Includes unused woodland, degraded woodlands, plantations and temporarily deforested areas and forest reserve.

6. Lusaka is supplied with woodfuel from Kabwe, Mumbwa and Lusaka catchment areas as well as a little from Kafue. The Copperbelt is also supplied from Kabwe catchment area as well as the Copperbelt itself. In the above catchment areas the area of woodlands/forests range from 42% in Mumbwa where there is a large treeless swamp to 75% in the Copperbelt. However, the area of forest actually controlled by the forest service is very small except in the Copperbelt where it is 29% of the total area, but as pointed out some of this latter reserve has to be cleared for agriculture and is due to be degazetted. Clearly if the supply of wood products, especially woodfuel is to be guaranteed by the forest service the area of forest reserve will have to increase not decrease.

Table A1.2: LAND CLASSIFICATION FOR THE BIOMASS CATCHMENT AREAS a/
Units in km^2

Catchment Area	Total Area	Urban	Culti-vated	Grass land	Forest planta-tion	Woodland: Cleared for Wdfuel	Woodland: De- b/ graded	Woodland: Un-used
Copperbelt	27785	309	2763	3802	635	1633	2486	16157
%	100	1	10	14	2	6	9	58
Kabwe	15059	127	2510	3084	3	117	1256	7962
%	100	1	17	20	0	1	8	53
Mumbwa	13589	0	1280	6492	0	39	834	4944
%	100	0	10	48	0	0	6	36
Lusaka	11936	58	2155	1063	4	573	2671	5412
%		1	18	9	0	5	22	45
Total	68369	494	8708	14441	642	2362	7247	34475
%	100	1	13	21	1	3	11	50

a/ As analysed from the aerial photographs.

b/ Degraded woodlands have a severely reduced woodland cover which on aerial photographs resembles parkland. This degradation has been brought about by selective felling for shifting cultivation and/or charcoal production. Although woody biomass is available in degraded woodlands it is too scattered to be exploited commercially and is principally available for rural demand.

7. Table A1.1 classified forests by ownership category. Because land ownership is not an impediment to woodland access this classification will not be dealt with further. What is important is the actual area of intact woodlands and this is shown in Table A1.2.

8. Half the land area in the Lusaka/Copperbelt urban catchment area is classified as unused woodland, although only about one quarter of this land - 12% of the total land area - is actual forest reserve and this mainly serves the Copperbelt. It is this unused woodland that will supply the bulk of the woodfuel to urban areas, although in time if the cleared woodland and degraded woodlands are allowed to remain as forest areas and protected from overcutting, they will regenerate naturally and could supply some urban woodfuel.

9. However, if past trends continue, the woodlands will be looked on as a source of agricultural land both permanent and temporary. Most of the cultivated area shown in Table A1.2 was claimed from the woodlands as opposed to the grasslands as the following table shows - Table A1.3. Table A1.3 gives a breakdown of the natural vegetation clearance in the biomass catchment areas.

Table A1.3: NATURAL VEGETATION CLEARANCE IN THE BIOMASS CATCHMENT AREAS a/
(Units in km^2)

Catchment Area	Cleared and Degraded Woodlands b/	Cause of Woodland Clearing: Urbanization c/	Cultivat. from Grasslnd	Cultivat. from Wdlnd	Shifting Cultiv. d/	Plantat. Forestry	Woodfuel Clearing e/
Copperbelt	7752	309	(74)	2689	2486	635	1633
	%	4	-	35	32	8	21
Kabwe	3921	127	(92)	2418	1256	3	117
	%	3	-	62	32	0	3
Mumbwa	2114	0	(39)	1241	834	0	39
	%	0	-	59	39	0	2
Lusaka	5461	58	(0)	2155	2671	4	573
	%	1	-	39	49	0	11
TOTAL	19248	494	(205)	8503	7247	642	2362
	%	3	-	44	38	3	12

a/ As analysed from aerial photographs.
b/ Excluding cultivated land acquired from grassland indicated in Col. 4.
c/ Includes land cleared for mining and industrial development.
d/ This also includes some land that will revert to permanent woodlands.
e/ Some of this land may be converted to arable agricultural land.

10. Only twelve percent of woodland clearing can be directly attributed to woodfuel production. What is more, most of this land will regenerate and once again become productive woodland. Nearly half of the land (44%) was cleared for permanent agriculture and another 38% for shifting cultivation so that the major cause of natural vegetation destruction in the urban biomass catchment areas is conversion to cropland either permanently or on a rotation system. Together these land use changes account for over eighty percent of woodland clearance.

11. In the past land clearing for agricultural development has not always been co-ordinated with charcoal production; felled trees have been burnt in situ. Now there is another scheme to clear some 2000 km^2 of woodlands along the Tazara railway corridor which may contain about 14 million tons of wood or potentially some 3.5 million tons of charcoal worth at least some US$ 175 million ex site at US$2 per 40 kg/bag. 1/ This is enough to supply the urban areas for a decade or more if the agricultural development is properly planned and co-ordinated. As this clearance scheme is already underway with access roads being built there is urgent need to plan the development so that the best use can be made of the woodland resources.

12. Before an assessment can be made of biomass availability in the

1/ At January 1990 prices, the market value is about US$365 million.

urban biomass catchment areas, the land topography has to be considered. Thus the land was divided into three types namely grassland/swamps; plateaux/interfluves; and escarpment/hills. Obviously there are no trees in the first category and clearfelling trees on escarpment or hills can be detrimental to the soil stability. Therefore from the point of charcoal production clearfelling on plateaux or interfluves is preferable. Table A1.4 gives the relative importance of the topographical types in the different catchment areas.

Table A1.4: RELATIVE IMPORTANCE OF LAND FORMS IN THE BIOMASS CATCHMENT AREAS

Catchment Area	Total Area	Percentage of area by land form: Grassland Swamp a/	Plateau/ Interfluve	Escarpment/ Hill
Copperbelt	27785	15	85	0
Kabwe	15059	21	77	2
Mumbwa	13589	47	53	0
Lusaka	11936	6	62	32
Total	68369	21	73	6

a/ These are semi permanent or permanent water logged areas.

13. Excluding the grasslands, Lusaka has over one third of the area classified as escarpment or hills, this means that there are physical and ecological constraints to cutting wood in at least one third and up to two thirds of the unused woodlands. The other three catchment areas have relatively little escarpments or hills and so it would be safe to clearfell the woodlands in these areas.

14. From the sample plots, the biomass assessment found that in the dry miombo areas there was a standing weight of 72 tons of bone dry cord wood per hectare and in wet miombo areas 130 tons of cord wood per hectare. From studies in the coppice regrowth areas the mean annual increment of cordwood was found to be 2.2t./ha. and 3.8t./ha. in dry and wet miombo woodlands respectively. The above figures can be applied to the unused woodland areas assuming that only wood from these areas will be available to meet the demands of the large urban centers of Lusaka, Kitwe and Ndola. Table A1.5 gives an estimate of the growing stock and annual increment (yield) for the various catchment areas serving the above towns.

Table A1.5: AREA, STANDING STOCK AND ANNUAL INCREMENT OF UNUSED WOODLAND; TOTAL AREA, ACCESSIBLE AREA AND GAZETTED AREA (million tons bone dry)

Catchment Areas	Total Area: Area (km^2)	Total Area: Growing Stock	Total Area: Annual Incremt.	Accessible Area: Area (km^2)	Accessible Area: Growing Stock	Accessible Area: Annual Incremt.	Gazetted Area: Area (km^2)	Gazetted Area: Growing Stock	Gazetted Area: Annual Incremt.
Copperbelt a/	16157	210.0	6.1	16157	210	6.1	7079	92.0	2.70
Kabwe	7962	57.4	1.8	7616	54.9	1.7	863	6.2	0.20
Mumbwa	4944	35.6	1.1	4906	35.3	1.1	238	1.7	0.05
Lusaka b/	5412	39.0	1.2	L 1592	11.5	0.4	447	3.2	0.10
				H 3502	25.2	0.8			
Total	34475	342.0	10.2	L 30271	311.7	9.3	8627	103.1	3.05
				H 32181	325.4	9.7			
Charcoal equiv. million/t			2.5			2.3-2.4			0.08

L = low estimate for Lusaka;
H = high estimate

a/ Copperbelt: standing stock of cordwood, 130 t/ha; annual increment (MAI) 3.8 t/ha. All other areas: standing stock of cordwood, 72t/ha; MAI 2.2t/ha.

b/ There are 5412 km^2 of unused woodlands in the Lusaka region (Table A1.2). It is assumed that the escarpments are covered with unused woodlands (3820 km^2). The low estimate assumes that for ecological reasons all these areas are inaccessible, even for selective felling. (Therefore accessible area = 5412 - 3820 km^2). The high estimate assumes that up to half of the escarpments are available for woodfuel production on a clear felling basis and/or all the areas are available for selective felling. (Accessible area = 5412 - 1910 km^2).

15. It appears from the above table that there is sufficient growing stock in the Copperbelt region to give a sustained supply of woodfuel and other wood products for many years to come even from the gazetted forest area, provided that these areas are maintained and managed. Of course the areas nearest the demand centers tend to be exploited first for charcoal production and it is also these areas that are the source of firewood for the poorer sections of the urban communities. It is socially and economically desirable to maintain these firewood sources because burning wood directly is more energy efficient and they are accessible to foot or bicycle transport.

16. The current household demand for charcoal in Lusaka is approximately 233,000 t/a. and that for fuelwood 87,000 t/a. equivalent to annual household demand of over 1 million tons of cordwood. The gazetted forests that presently supply Lusaka from Kabwe, Mumbwa, Lusaka and Kafue biomass catchment areas give a sustained supply of approximately 350,000 t. of cordwood. Clearly this is insufficient to meet demand. However there is sufficient wood from the accessible woodlands

in these catchment areas, - about 3.2 million t. of cordwood - to meet present and future demand provided that most of these areas are kept under tree cover and managed properly. Undoubtedly there will be a change of land use on some of the woodland areas, including gazetted areas. It is important that these areas are chosen with care, since some areas in the past were unable to support arable agriculture on a sustained basis. Also it is important to ensure that the wood on these areas is used productively rather than burnt in situ. It cannot be overemphasised that these woodland resources are a substantial asset for the country; they supply the bulk of household energy, they create employment, particularly rural employment, they save considerable foreign exchange and if properly managed the resource is renewable.

Control Over Forest Products

17. According to the Forest Act, no one can harvest/collect forest produce for sale without a licence issued by the Chief Conservator of Forests or his representative. With respect to woody biomass, forest produce includes trees, timber, wood, poles, bamboos, slabs, chips, sawdust, fibres, leaves, fruits, seeds, roots, bark and charcoal.

18. Woodfuel licence fees are based on the volume of stacked cord wood or branches/twigs in the case of headload firewood. The current (1989) fee is ZK8.00 per cord or ZK3.00 per stacked m^3 or ZK0.50 per headload. 2/ 3/ The stumpage fee may even be charged on the finished product rather than the raw material thus a fee of ZK0.50 per bag of charcoal may be charged in place of the stumpage fee. In addition there is a removal fee which is discussed latter. The above fees are not consistent; paying the fee via the end product is the cheapest way and buying by the headload is the most expensive.

19. Assuming that:

(a) 1 stacked m^3 is equivalent to 0.55 solid m^3;

(b) 1 headload is equivalent to 24 kgs of air dry wood (36 litres or 20 kgs bone dry wood); and

(c) 1 bag of charcoal weighs 40 kg whose conversion efficiency is 25% on a bone dry weight basis;

2/ The exchange rate in May 1989 was ZK10 = 1US. There was a devaluation on 1st July 1989 to ZK16 = 1US$. In February 1990 the rate is ZK 24 = US$1.

3/ Zambia Gazette March 25th 1988.

then the fee per solid m^3 may be determined for each measure. The following are the equivalent prices per solid m^3 for each method of levying the stumpage fee:

(i) Headload ZK 13.9; per solid m^3;

(ii) Stacked m^3 ZK 5.5, per solid m^3;

(iii) Metric cord ZK 4.8, per solid m^3 (one cord = 3 stacked m^3)

(iv) Charcoal bag ZK 1.7, per solid m^3.

It will be seen that people buying by the head load-usually the poorest sector of the community - pay nearly 3 times the price than those buying by the cord. Likewise if the fee is paid via the bag of charcoal the cost is about one third the cost of paying by the cord. These anomalies should be rectified.

20. Licence fees for poles vary with species, but the average fee is ZK0.50 per pole. In a woodfuel area, pole harvesting by licensed people usually has precedence over woodfuel harvesting. Indeed selective felling for poles has in the past always preceded clear-felling for woodfuel in the Copperbelt area (Lees, 1962).

21. Once the cord wood has been converted to charcoal and packed for sale an additional removal fee (product tax) of ZK0.50 per bag (or ZK0.13-ZK0.20 per 10 kg) 4/ should be paid by the charcoal trader to the government via the FD before delivery to the market. But because of inadequate manpower and other resources, collection of stumpage fees (based on cord wood) by the FD is largely confined to the forest estate. And although the charcoal removal fee has a wider enforcement than the stumpage fee, a large proportion of the charcoal still reaches the market unlevied.

22. The importance of the different types of forest produce in miombo woodland can be assessed from the revenue earned in Chisamba National Forest in the Lusaka BCA during 1988. Poles which were bought for fencing on commercial farms contributed only 3% to total revenue. The largest contribution to revenue was made by stumpage fees for cord wood for charcoal and the charcoal levy which together made up 78% of the total revenue. Thus woodfuel is not only the major forest product in miombo woodlands, but it provides the highest contribution to revenue from miombo woodland

4/ A bag can vary in weight between 25 kgs and 40 kgs. A standard bag is taken as 40 kgs of charcoal.

23. Another interesting observation is that the actual biomass usually exceeds the estimated cord wood biomass for charcoal production. This arises because the estimation of cord wood is based on a visual assessment by (usually) inexperienced forest guards/rangers. Data from the charcoal production study in Chisamba National Forest based on seven producers showed that the underestimation may be as much as 66% of actual charcoal biomass. Thus only one-third of the potential revenue is actually collected from cord wood.

24. The 1988 urban households consumption of fuelwood and charcoal is estimated at 2.5 million tons of roundwood equivalent - 2.05 t. charcoal wood and 0.45 t. fuelwood. Allowing for 0.2 million tons of fuelwood which was self collected, the 2.3 million tons, equivalent to 3.6 million m^3 should have generated about ZK18 million for the government from stumpage fees and ZK 6 million from charcoal removal fees (tax). In fact fees from all forest products supplying all sectors - service, industry, rural and urban households, came to ZK2.8 million in 1987 so the rate of collection is probably less than 10%. This is not because the stumpage price is high in relation to the selling price. Indeed the reverse is true, for fuelwood the stumpage price represents about 2% of selling price, for charcoal about 4% (in addition to the removal fee of 2%) and poles less than 1%. These stumpage prices do not cover growing cost and there is a clear case for increasing the price charged for wood raw material. However, the first and most urgent task of the forest service should be to improve the collection rate on existing charges. It is most important that a body like the Energy Department constantly monitors the woodfuel products coming into towns so that it can provide information to the government in general and the forest service in particular on the quantities and prices of woodfuel products.

CHARCOAL PRODUCTION, TRANSPORTATION AND DISTRIBUTION

A. CHARCOAL PRODUCTION

Introduction

25. Charcoal is the dominant urban household fuel accounting for about 60% of energy used in households. Practically all charcoal is made from miombo woodland trees in traditional earth kilns, although a little is made from sawmill off-cuts, but again in traditional kilns. In order to look into the physical, social and economic aspects of charcoal production, studies were carried out in the production areas which supply Lusaka and the Copperbelt. A detailed description of these studies is recorded in a separate working paper, but the salient points are discussed here.

Charcoal Production Techniques

26. Charcoal is produced from both forestry department forests (gazetted areas) and non-gazetted forests with the ratio of production in the region of one third and two thirds respectively. Seeing that studies were undertaken in gazetted areas the following description specifically refers to these areas, but charcoaling techniques are common throughout Zambia.

27. In gazetted forest areas, land is allocated for charcoal production and the trees are first measured for cord wood volume. As mentioned previously (Annex 1, para. 23) this study found that the actual quantity of cord wood was about three times the measured quantity, thus the forest service is losing up to two-thirds of the stumpage revenue. Certain trees may be reserved for sawnwood production and there may be pole quantity wood within the area; these will be extracted first. Of the remaining trees, ninety five percent will be cut and only five percent left standing because of size or species unsuitability.

28. Charcoal production can be divided into six stages, namely

(a) felling and cross-cutting of stems;

(b) gathering of the logs and piling these into a clamp at the kiln site;

(c) digging soil lumps and covering the clamp with them;

(d) igniting and carbonization of the logs;

(e) recovering the charcoal from the kiln; and

(f) bagging the charcoal for sale.

29. Hand tools dominate the production process, but many of these tools, especially the axes seem to be of a poor design for the designated tasks. With improved hand tools, productivity could be increased and physical effort reduced.

30. Charcoal production is a family business and various family members perform different tasks. Young men fell and cross-cut whereas women and children undertake log carting and bagging charcoal. Experienced charcoalers will build and tend the charcoal kilns and while tending the kiln or kilns other tasks may be performed simultaneously.

31. Average clamp (kiln) sizes ranged from 40 m^3 to 50 m^3 on a rectangular base, generally with logs being placed across the clamp on lengthwise stringers. After piling, the clamp may be left uncovered to allow the wood to dry. However the study noted that there was a considerable difference in clamp moisture content prior to covering ranging from 24 to 66% (dry basis). Charcoal burners do not seem to notice any impact of moisture on productivity.

32. The clamps are first covered with a grass or leaves and then sealed with soil except for the ignition point, which is usually positioned in relation to the wind direction; the wall is generally very thick between 30 and 45 cm. Following ignition, and after the fire is established the hole is sealed to allow controlled carbonisation.

33. With earth kilns, carbonisation is an art and a skilled operator can obtain a much higher charcoal production than an unskilled one. The initial moisture content of the wood should also be a significant factor in charcoal production, the drier the wood the higher the recovery. However, conflicting results were obtained from the observed kilns. Obviously many factors play a part in determining charcoal yield such as moisture content, log size, duration of burn and skill of the operator. What is also important is to determine the energy content of the charcoal. Lightly charred wood will have a high recovery percent, but a low energy value (about 22 MJ/kg) but fully carbonized wood will at best have about 35% recovery 1/ (bone drywood weight), but a high energy content (31 MJ/kg). The present study was unable to separate the various variables and more controlled experiments are needed before improved charcoal production techniques based on the traditional kilns can be recommended. The average recovery percentage based on bone dry

---

1/ Wood contains on average 50% carbon so the theoretical maximum recovery percentage for charcoal production is 50 on a weight for weight basis. Charcoal has about twice the energy content of wood, therefore, on an energy for energy basis the recovery percentage would be about double the above.

wood to charcoal production was 24 2/ and each stacked cubic meter of wood contained on average 301 kgs of bone dry wood; therefore each stacked cubic meter produces 72 kgs of lump charcoal and a solid cubic meter 131 kgs of charcoal.

Social Aspects of Charcoal Production

34. Typically charcoal production is a full time business, organized by a middle aged family man with about six years of experience in charcoal making. Family members assist in the production process but hired help is frequently used. Also charcoal producers help each other at various stages of the process such as kiln building and covering.

35. The tools owned by the charcoaler are simple hand tools and in some case inappropriate, particularly the axe which is generally small in size and a poor design. Crow bars, hoes, shovels, rakes, forks and wheel barrows are the other typical kinds of hand tools. A power saw is the only mechanical tool and this is infrequent used in the Lusaka area, but a little more common in the Copperbelt. No cross cut saws are employed, yet in other countries these are common. Therefore there is considerable room for improvement in the type and design of tools that charcoal producers use.

36. The survey showed that although for most of the charcoal makers their occupation was classified as full time very few worked the whole day. This was for a number of reasons both to do with the equipment and the lack of facilities. As explained above the design and kind of tools could be improved making the various tasks, particularly felling and crosscutting, less strenuous. No training was provided to the producers except on the job training, thus productivity varies enormously as was noted in the kiln conversion efficiency which ranged from 17% to 33%. Schools, health centers, shops etc. are few and far between and in many instances producers have to rely on charcoal traders to bring them provisions. Charcoal production is generally looked down upon and the industry is frequently accused of destroying the forests, where as clearing for agricultural production is the chief culprit. Unlike farmer who get extension service assistance and subsidized inputs, charcoalers have to fend for themselves. Yet charcoal is the most important urban household fuel, but of course (unprocessed) firewood is the premier fuel used principally in rural households. In terms of processed energy for all sectors, charcoal is more or less on par with electricity and oil products and unlike these energy forms it creates considerable rural employment. In 1988 it was estimated that 41,000 people were employed in charcoal production, not to mention the people involved in distribution (approximately 3,500) and selling (about 1000). It cannot be over emphasized that charcoal is a vital energy form, it is based on an indigenous renewable resource and is creating employment particularly rural employment thus government should do more

---

2/ If the average wood moisture content on a dry basis is 20% then the recovery percentage will be 20 not 24.

to uplift the status of the charcoal producers and to facilitate its production and distribution.

Economic Aspects of Charcoal Production

37. To determine the costs of charcoal production requires a knowledge of the different operation stages, the people who perform these operation, their wage rates, and whether more than one operation can be performed at the same time - such as attending more than one kiln or cross cutting and kiln building while maintaining a burning kiln. It was found that where as the average daily production per kiln was 43 kgs the production per person day was 56 kgs indicating that each person is looking after 1.3 kilns. Taking this into consideration the estimated production cost of a 40 kg bag of charcoal is indicated in the table below:

Table A2.1: TOTAL LABOUR INPUTS FOR AN AVERAGE CHARCOAL CLAMP OF 65 BAGS (2600 KGS) IN CHISAMBA (LUSAKA AREA) - 1988

Cost Component	Workdays	ZK/workday	ZK/bag
Felling	4	30	1.85
Cross-cutting	4	40	2.46
Haulage to clamp	4	12	0.74
Building clamp	3	40	1.85
Kiln-maintenance	17	12	3.14
Total labor			10.04
Equipment/tools			0.40
Wood raw material (including removal fee of ZK0.5 per bag)			1.92
Sub-total			12.36
Profit (25% mark-up)			3.09
Total			15.45

Note: Workdays refer to full days of actual work: 25 work days per month.

38. The above table includes the cost of wood raw material as well as labor, tools and a profit margin. Because stumpage fees are poorly assessed or not collected and the ZK0.5 removal fee per bag of charcoal is not always collected, the average fee may be as low as ZK0.2 per bag, thus lowering production costs to ZK13.6 per bag (including the same profit). The survey found in fact that in October 1988 the ex-kiln price in the Lusaka supply area was fairly uniformed at ZK15.00 per bag which is close to the estimated production costs. The uniform price also indicates that there must have been good communication between producers and/or traders.

39. In November 1988, there was a 10% devaluation of the kwacha and some producers immediately took advantage of this and increased their price to ZK20.00 per bag. Soon all producers followed. Very heavy rains fell in February 1989 which disrupted the supply of charcoal from the woodlands. Those producers that could get their supply to the roadside or market then increased the bag price considerably to as much as ZK50 per bag. This may be because they heard the market price had gone up to as much as ZK150 per bag or it could have been because they wanted to maintain their income on a much restricted supply. It was anticipated that the producer price would fall from the high of ZK50 per bag as supply increases but perhaps not as low as ZK20 per bag that was charged just before the rains; also much depends on the reliability and availability of alternate fuels. If we assume that the producer price would increase by the average inflation rate then a price of ZK22 - ZK23 was anticipated. However, on July 1, 1989 the kwacha was devalued by 60%, electricity supplies have been seriously curtailed especially at the evening cooking time due to a fire at Kafue Gorge power station, and supplies of kerosene cannot be increased substantially. Therefore in a fairly free market led situation the current price of charcoal ex forest is in the region of ZK30 - ZK35 per bag. Nevertheless there are considerable savings of foreign exchange by using charcoal as opposed to kerosene or electricity. If kerosene were substituted for charcoal, taking into consideration efficiency differences, an additional 210,000 tons (9.0 PJ) of oil equivalent would have to be imported at an annual cost in the region of US$30 million in terms of foreign exchange.

40. Because charcoal is such an important fuel the government should make a commitment to improve the status of the producers by providing them with training, facilities and easier access to goods and services. The government should encourage the charcoalers to form active producer organizations so that it can channel help through these organizations. The government should take measures to stabilize the price of charcoal not by controlled prices but by ensuring that there are adequate supplies all the year round and that there is an easy entry to the trade for prospective producers. This could be done by having technical courses in charcoal production including woodland management and tree felling. Together with recommendations that will be made later on concerning the transportation of charcoal, the government by giving a little help could ensure that this industry gets the support it deserves.

B. TRANSPORTATION AND DISTRIBUTION OF WOODFUEL

Introduction

41. The transportation and distribution of woodfuel to towns is one of the least understood aspects of the woodfuel business. Therefore surveys were mounted in the forest, at the roadside both near the production site and on the outskirts of towns and at the selling sites. A detailed description of all these aspects of the woodfuel trade is

described in a separate working paper, however, this section brings out the salient points.

Means of Transport

42. There is a wide variety of transport modes from human, bicycles, wheel barrows through animal to motorized means. In terms of number the former are the most important, but in terms of load carried the latter dominate. If the biomass resource is near the town then fuelwood is the principal household energy, whereas charcoal takes over when the resource is relatively distant. This is also related to town size; the smaller towns use fuelwood and the larger towns use charcoal. However, irrespective of town size there are always people who will go out and collect fuelwood either for self consumption or for sale. In this case the means of transport is usually the head, bicycle or wheelbarrow. If charcoal is produced near towns it may be transported by the above means but the common form of transport for charcoal is by motorized vehicles. Large sized fuelwood is also brought into town by motorized vehicle but this is usually for non-household use or particular household tasks such as during funeral mourning periods where fires are kept going for a number of days to warm and feed the mourners.

43. Two kinds of vehicles are used for dedicated woodfuel transport, the lorry and the pick-up. The nominal capacity of the lorry is three to seven tons where as that of the pick-up is between one and one and a half tons. Occasionally large lorries with trailers are used but only where charcoal (or fuelwood) can be loaded at the roadside. Practically all the vehicles used for woodfuel transport are old, most being bought second hand or built up from scrap vehicles. Only one transporter in the survey was using a new vehicle specifically bought for woodfuel transport. One reason for this could be that most woodfuel is collected from the production site requiring considerable travel on bush roads, which are often rutted and sometimes impassible in the rains. There is also poor communication between the charcoal producer and the transporter so a transporter may either have to make a separate journey to the production site to ensure that a full load is available or travel round the bush until a full load is obtained. The bulk of the producers sell their product at site, but some will hire local labor and the occasional ox-cart to transport the woodfuel to a surfaced road. However, in the Copperbelt many producers also hire lorries to take their products, principally charcoal, to town where it is sold to market traders. No charcoal is transported by rail, although it could be the cheapest means, and there are large haulers who have well over half their fleet travelling empty in one direction so these vehicles are potential carriers of woodfuel. But until the producers and the transport sectors are better organized woodfuel transportation will remain haphazard.

Transportation Costs

44. As is to be expected the distance travelled is one of the principal factors determining transport costs. However, other variables

are involved and these include capacity (type) of vehicle - lorry or pickup-; road surface; load on vehicle; whether the vehicle was hired out at a fixed fee, irrespective of load or distance travelled, or charged according to distance and load and finally whether the vehicle was full in both directions or empty in one. Table A2.2 gives the average fees charged by transporters, per bag of charcoal, for the towns of Lusaka, Kitwe and Mansa for 1987, and 1988 as found from the survey.

Table A2.2: CHARCOAL TRANSPORTATION CHARGES PER BAG PER TOWN (Units Kwacha)

Town	November '88	June '88	January '88	1987	Round trip average distance travelled
Lusaka	10.60	8.30	6.60	4.70	184
Kitwe	5.40	5.20	4.80	4.30	81
Mansa	7.70	7.00	7.00	5.70	94

Average transport distance: 120 miles (round trip) weighted cost November 1988 ZK8.10 per bag.

45. Charcoal transportation appears to be an expensive business; maintenance and vehicle running costs are high. In terms of fuel and oil a Lusaka transporter spends about ZK1.43 per kilometer, while a Kitwe transporter spends ZK1.94 per kilometer and a Mansa transporter ZK 3.10 per kilometer. 3/

46. An attempt was made using the costs supplied by lorry and pick-up owners to determine their actual costs based on monthly outgoings and number of charcoal bags transported, Table A2.3. These figures indicate that it costs ZK7.04 per 40kg bag to haul by lorry and ZK14.50 per 40 kg bag to haul by pick up. Whereas the lorry cost are less than charges, the pickup costs are more. Clearly more detailed work is required to determine how accurate these costs are.

47. Compared to long distance road haulage costs and rail transport the above figures are high. The standard road transport costs by Contract Haulage, a government owned firm and by Zambia railways are given in Table A2.4.

48. Using the above figures for road transport and the average round trip distance given in Table A2.2 the cost per bag of charcoal, including profit and depreciation ranges from ZK3.89 to ZK7.36 (average ZK4.80). Of course the above costs would be half for a one way journey

3/ The 1988 Lusaka fuel prices per liter for diesel and petrol were respectively ZK2.18 and ZK3.34.

but there would be additional costs to get the charcoal to the roadside from the bush. Rail costs are cheaper still, but for most charcoal haulage it would be impractical. However, new farming areas are being opened up along the Tazara rail line so rail transport in this area is possible, but it would have to be coupled with (bush) road transport to the rail line.

Table A2.3: AVERAGE TRANSPORTATION COSTS PER BAG FOR LORRIES AND PICK-UPS (Units Kwacha) a/

Cost Item	Lorries	Pick-ups
Fuel and oil	2.07	5.14
Maintenance	1.79	4.06
Insurance and licensing	0.02	0.03
Labor	0.63	1.81
Depreciation	1.12	0.56
Profit (25%)	1.41	2.90
Total	7.04	14.50

a/ The weighted average for motorized transport is about ZK8.90 per bag.

Table A2.4: ROAD AND RAIL TRANSPORTATION (MAY 1989)

Road Transportation		Rail Transportation	
Distance	Kwacha per ton/km	Commodity	Kwacha per ton/km
1-50 km	1.45	Petroleum	0.24
51-100 km	1.20	Fertilizer	0.21
101-200 km	1.00	Coal	0.25
201 km and above	0.80	Maize	0.24
		Other	0.15

49. Each year the supply of charcoal and fuelwood is curtailed during the rainy season and in 1989 the rains were prolonged and heavy so the supply was severely interrupted. This was noticeable in the market place when the price of charcoal peaked at about ZK150 per 40 kg bag having risen from ZK30 per bag. After the rains the price of a bag of charcoal dropped to about ZK60 per bag, but because of the non availability of electricity during peak cooking times and a restricted supply of kerosene it again rose to about ZK90 per bag and by end of 1989 was ZK100-120 per bag. Because the price of charcoal is well above formerly controlled price of ZK25 per bag, the charcoal traders did not keep large supplies and sometimes sold it outside the city limits thus incurring extra costs for the purchaser who has to pay for the charcoal to be hauled from outside town to the house. In order to encourage

traders to store charcoal the controlled price had to be removed. In fact this has now happened.

50. Surveys were undertaken for motorized vehicles before and during the rains and it was found that:

(a) more pick-ups were used during the rains because they could negotiate the bush roads more easily;

(b) the loading capacity on the vehicles decreased during the rains because of adverse road conditions;

(c) the hourly flow of vehicles decreased on average by 30%, again because of adverse road conditions.

These facts are illustrated in Table A2.5 for Lusaka.

Table A2.5: TRANSPORT OF FUELWOOD AND CHARCOAL ON THE MAIN LUSAKA ROAD ARTERIES a/ BEFORE (ROUND 1) AND DURING RAINS (ROUND 2) b/

I/: PERCENTAGE OF PICKUPS AND LORRIES DURING ROUND 1 AND ROUND 2.

		Vehicle				
		Pick-up		Lorry		
Woodfuel	Round	1	2	1	2	Total
Charcoal		44		56		100
"			60		40	100
Firewood		42		58		100
"			47		53	100

II/: PERCENTAGE TYPE OF LOAD CARRIED DURING ROUND 1 AND ROUND 2.

		Pick-up		Lorry	
Loading	Round	1	2	1	2
Accessory		1	27	7	47
Undercarriage		18	9	11	5
Level carriage		13	24	12	18
Over carriage		68	40	70	30
Total		100	100	100	100

Accessory loads include one or two bags or logs on top of a load of maize or copper etc.
Undercarriage are loads which are below the level of the vehicle sides.
Level carriage are loads at the level of the vehicle side.
Overcarriage are loads above the level of the vehicle sides.

III/ AVERAGE NUMBER OF VEHICLES PASSING PER HOUR

Woodfuel	All vehicles Round 1	2	% decrease in round 2
Charcoal	13.3	10.2	23
Fuelwood	3.7	1.7	54
Total	17.0	11.9	30

a/ Great North road Numbwa road Great East/International airport road.
b/ Round 1 Nov/Dec 1988: round 2 March/April 1989.

51. Whilst the amount of woodfuel transported decreased considerably the production of charcoal did not decrease significantly therefore there were considerable supplies of fuelwood and charcoal waiting to be picked up at the production site. If bush roads could be improved, and stocks of charcoal kept at the roadside and at the market site, then this supply hiatus could be overcome.

Marketing of Woodfuel

52. There are three common methods of selling woodfuel to the consumer namely at roadside near to the production site, from organized markets in towns or from homestead traders, although as was noted earlier in exceptional circumstances woodfuel may be sold on the outskirts of towns. Most of the woodfuel sold along the roadside is bought by transporters/traders who then resell it. Only a small fraction is sold directly to the consumer as passing trade. By far the largest amount of woodfuel is sold at organized markets and practically all of this is charcoal. Charcoal is principally sold by the bag, although some is sold by the tin or heap.

53. The survey found that 1.5% of listed houses sold woodfuel and 92% of these sold charcoal. However, over half the fuelwood burnt by households was self collected. Homestead traders sold charcoal and firewood mainly in small quantities and several of these traders sold woodfuel intermittently, especially at the end of the month to supplement their income; they bought charcoal from markets and resold it. Very occasionally a homestead trader would hire a lorry and purchase charcoal from the producer.

54. The market traders are therefore the key retail sellers, they are also the principal purchasers of woodfuel from the producers either via hiring a vehicle or through owning a vehicle themselves (transporter/trader). These traders when they buy charcoal (but not fuelwood) are supposed to pay a removal fee of ZK0.50 per bag. In 1988 an estimated 513,000 tons of charcoal were consumed by urban households and this should have fetched ZK 6.4 million in removal fees, as well as ZK 18.0

million in stumpage fees plus a further ZK 1.8 million from firewood stumpage giving a total figure of ZK 26.2 million. The actual income from all stumpage and removal fees is less than ten percent of the above figure, therefore, there is considerable scope for improving the collection, especially from traders. Also a case can be made out for increasing the stumpage fees and widening the scope of removal fees to include firewood and other forest products and using some of this money to manage the resource and to assist the charcoal industry. There is a pressing need to organize the charcoal producers so that help can be given to them. Bush roads need to be improved; also to overcome the temporary woodfuel shortages, stores need to be established on surfaced or good bush roads and in towns.

55. Transporters and traders could then be sure of getting loads without searching for them, this may act as an incentive to invest in new vehicles or fill empty one way lorries. The removal of the controlled price for charcoal should encourage storage facilities in towns and the use of large vehicles. The building of roads and giving assistance to the charcoal producers will cost money but with better communications and organisation the cost of transport could be reduced considerably to somewhere near that of the long distance road haulage companies. Such steps should ensure a much more efficient industry all year round, an even supply of charcoal and hopefully lower prices.

HOUSEHOLD ENERGY DEMAND

Survey Methodology

56. The method used to conduct the energy demand survey in urban areas of Zambia employed random survey techniques and stratified sampling procedures, taking into consideration the objectives of the study within the budget and the time schedule limits.

57. For Zambia, it was assumed that (i) the size of town (ii) the availability of electricity and (iii) the income level may influence the energy consumption pattern in the urban areas and therefore these factors were used to stratify the sample.

58. After consultation with the Central Statistic Office eight towns, representing small, medium and large urban areas, were chosen for sampling. After choosing the eight towns, the major problem was the non-existence of up-dated information on population distribution by town etc. The latest data-base remains the 1980 National Census. Using this material could considerably limit the results of the survey and possibly prevent applying its findings to the urban population as a whole. To surmount this difficulty and despite the high cost in money and time, a complete listing of households in all the selected Standard Enumeration Areas (SEA's) 1/ was undertaken. This listing constituted the master sample from which the final sample was drawn, making this survey the first one of its kind in Zambia.

59. In total 20,291 households were listed and of these 1,213 enumerated. However, for all the listed households, questions were asked about electricity connection and woodfuel trading. 40% of the listed households were electrified and 240 of the households sold woodfuel from their houses of which 121 were questioned to supplement the charcoal marketing and distribution study. It was found that the majority of these traders were located in low cost areas and they were dealing in very small quantities. Enumerated households were asked about the quantity and use of energy by season as well as socio-economic information through a very comprehensive questionnaire.

60. Food processors and restaurants were also visited and enumerated during the household energy demand survey in the 8 selected towns in order to determine the importance of this sector and its eventual influence oin household energy demand.

61. A second round of interviews was carried out during early March 1989 of dedicated charcoal-using households. This complementary survey covered households in Lusaka and concentrated mainly on those who used

---

1/ The Standard Enumeration Area is a sub-division of a town with a very clear and well defined geographic boundary.

charcoal on a daily basis. The aim was to find out how the households had reacted to the scarcity and high prices of charcoal during the 1989 rainy season characterized by an exceptionally heavy rains. Finally these households were again questioned after the price of charcoal came down to discover if they had moved back to charcoal. In fact every household did. A full detailed description of the methodologies and questionnaires is described in a separate working paper.

Major Determinants of Energy Patterns

62. Intuitive reasoning supplemented with a few results from descriptive statistics suggests that numerous more or less strong correlations exist between energy variables on the one hand and social-economic variables on the other.

63. However, analysis of the data and the associated correlation tables tend to be a complex and painstaking task, and results are difficult to interpret especially when no similar work which may give some indications, has been performed before.

64. A better approach, one that is almost always possible, is to simplify the analysis (without losing essential information) by identifying a subset of social-economic variables that largely explains the energy consumption structure in the residential sector, discarding the less important variables.

65. The second step consisted of eliminating all variables that have a coefficient of determination less than 0.3 when related to other variables one by one. Therefore, there remained 20 variables which could be used to describe the residential sector by identifying the underlying dimensions, or factors, of communities.

66. For this simplification it is suggested that multivariate analysis techniques be used which, in comparison with conventional statistical methods afford a better overall view of large quantities of data, revealing the relations, similarities and differences of interest.

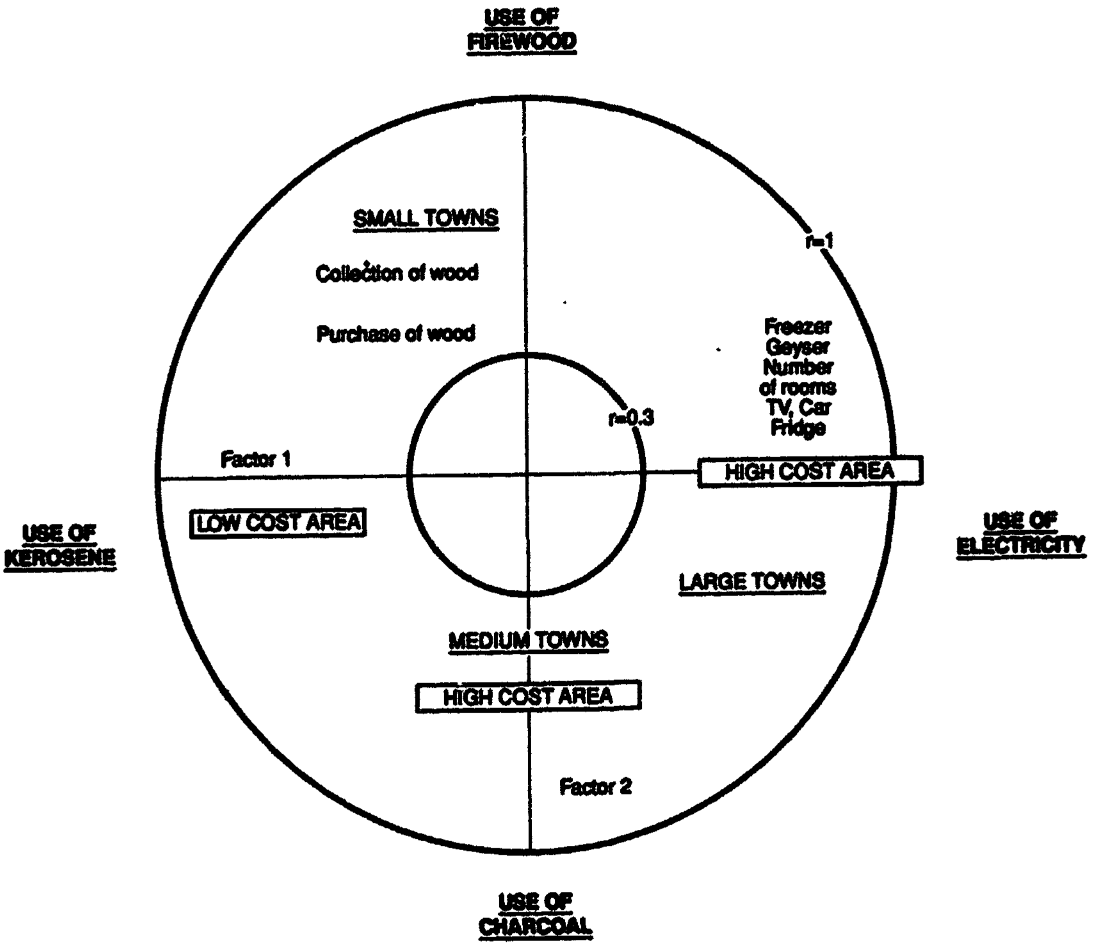
67. One of these techniques, is the Principal Component Analysis which identifies new, synthetic determinants as linear combinations of the basic variables.

68. This technique has the advantage of simplifying the correlation table and supplying valid approximation by considering that the survey results describe the co-ordinates of a cluster of data points (1213 households in this case) in a space with a number of dimensions equal to the number of studied variables (the first selected subset has 65 variables).

69. As a result of this exercise, 4 factors were retained, as almost 60% of the variance is attributable to these first four factors. The first factor alone explains more than 34% of the variance. (Fig. A3.1) 2/

70. The 20 selected variables were then projected in the main plan called the correlation circle involving the first and second factor which explains 45.5% of the variance.

Figure A3.1: Circle of Correlation - Main Plan
Correlation between a) Conventional Fuels (Factor 1)
b) Traditional Fuels (Factor 2)



2/ The KMO measure sampling adequacy is excellent, i.e. 0.89. This is an index for comparing the magnitudes of the observed correlation coefficients with the magnitudes of the partial correlation coefficients.

71. The main conclusions that emerge from this analysis can be summarized as follows:

(a) The urban household energy picture is dominated by 4 sources of energy (not in terms of quantities but in terms of behavior); namely charcoal and firewood reflected by one factor and electricity and kerosene reflected by another factor. The first factor can be considered as representing the use of conventional fuels and second one as representing the use of traditional fuels.

- There is a high positive correlations between:

(b) the use of firewood and the size of town.
The smaller the town the higher the proportion of households using firewood. The proportion of households who use firewood is 22% in large towns, 48% in medium towns and 72% in small towns.

(c) the use of charcoal and the class of area.
98% of households living in low cost areas use charcoal compared to 85% in medium cost and 66% in high cost areas.

- There is a high negative correlations between:

((d) the use of electricity and the use of kerosene.
The use of electricity excludes or reduces considerably the use of kerosene especially for lighting (the main use of kerosene). About 55% of the electrified households that still use kerosene use it mainly for other purposes such as fire ignition and cooking.

(e) the use of charcoal and the use of firewood.
Firewood and charcoal are substitutable and the use of charcoal excludes or reduces considerably the use of firewood or vice-versa. Only 33% of households who use charcoal also use firewood but of these 63% use it rarely or as stand-by fuel.

72. The above analysis shows clearly that the energy pattern in small towns is dominated by firewood and the energy pattern of medium and large towns is dominated by charcoal in low and medium cost areas and electricity in high cost areas. However, charcoal is still used by a relatively large proportion of electrified households in medium and high cost areas:

(a) on a daily basis for those who have no electric stove/hot-plate;

(b) in case of power failure as a stand-by fuel by those already using electricity for cooking.

73. Although the income seems not to play a major role in the energy pattern and was eliminated from the analysis after the first selection, the expenditure is positively correlated with the possession of electric appliances and the use of electricity. This fact seems to indicate that expenditures rather than income explains better the standard of living of the households. Households spend on the average only 48% of their income for non durable goods; this is reduced to 15% in the higher income classes.

These two facts combined seem to indicate that:

(a) in low income classes the situation is dominated by the affordability of certain items.

(b) in high income classes, it is rather the availability of certain goods which determines the situation.

74. These conclusions are very important as they show the critical determinants of the energy pattern that can be used for forecasting purposes.

75. Finally, from the correlation circle, it is easy to see how the interfuel substitution process can operate and how one fuel affects another.

(a) Any increase of the electrification rate will reduce considerably the consumption of kerosene as more than half of kerosene consumption is used for lighting purposes.

(b) The increase of electrification has no direct impact on charcoal or firewood consumption. The unavailability of electric stoves at an affordable price is the major barrier. Still over 40% of electrified households are not using electricity for cooking and 67% of these households declared that it is because stoves/hot plates are too expensive to purchase. Cheap and available electric hot plates combined with any new electrification 3/ could impact on:

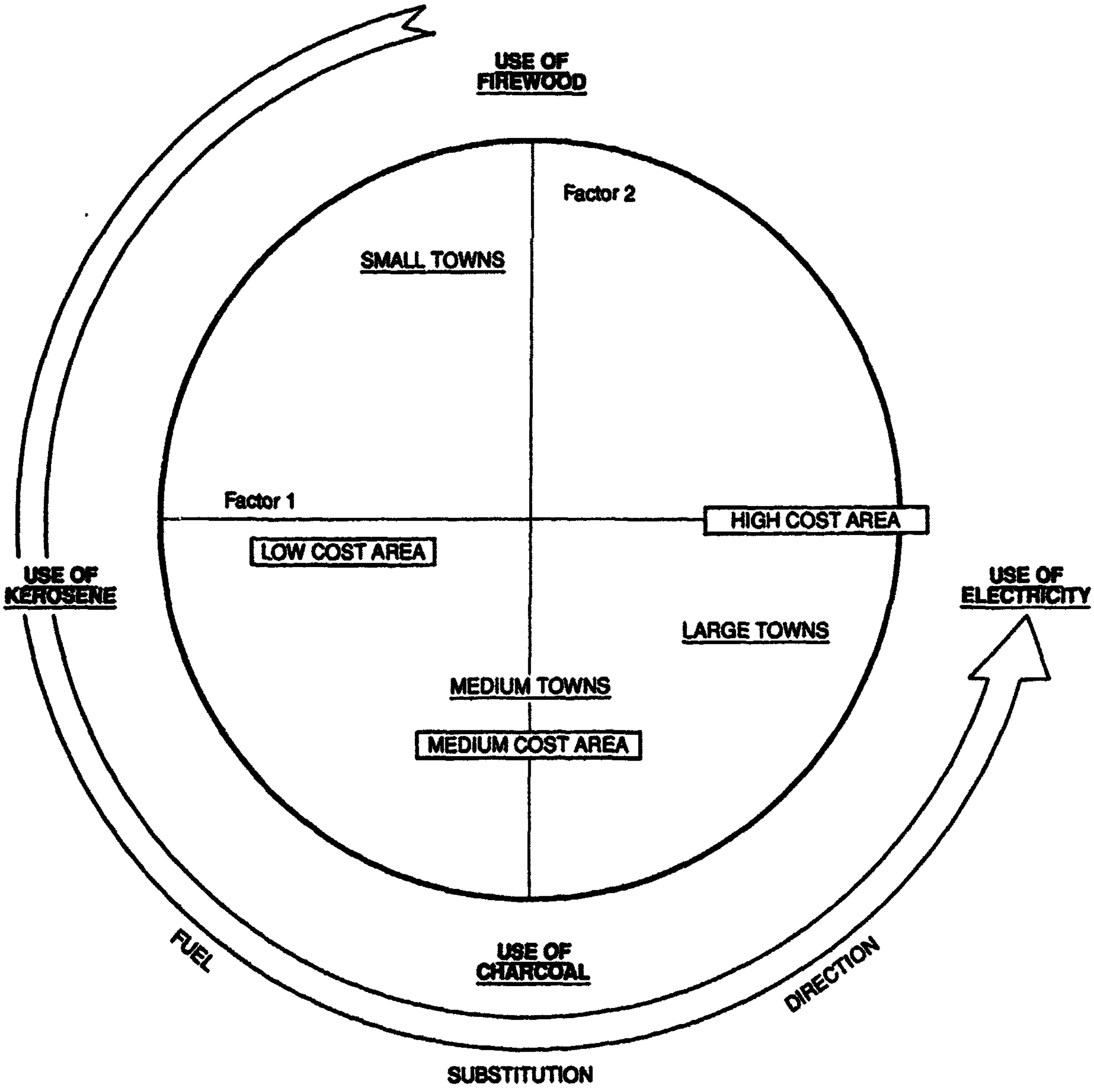
(i) Charcoal consumption which is principally used for cooking, water heating and space heating

(ii) Kerosene consumption which is mainly used for lighting and fire ignition.

3/ The availability of spare parts for repairs is also crucial. The survey results show that 11% of electrified households were not able to repair their stoves and shifted back to charcoal.

76. It is useful to represent schematically on the circle of correlation how interfuel substitution is being done and relate it to main determinants. The substitution between fuels is being done in a continuous spectrum anti-clockwise round the circle (fig. A3.2) starting from firewood and ending at electricity. However, there are two major determinants to this substitution process:

Figure A3.2: Circle of Correlation - Main Plan
Fuel Substitution Process



(a) The substitution between firewood and charcoal is mainly determined by the increase of the town size and can be linked to the increase of the urbanization rate;

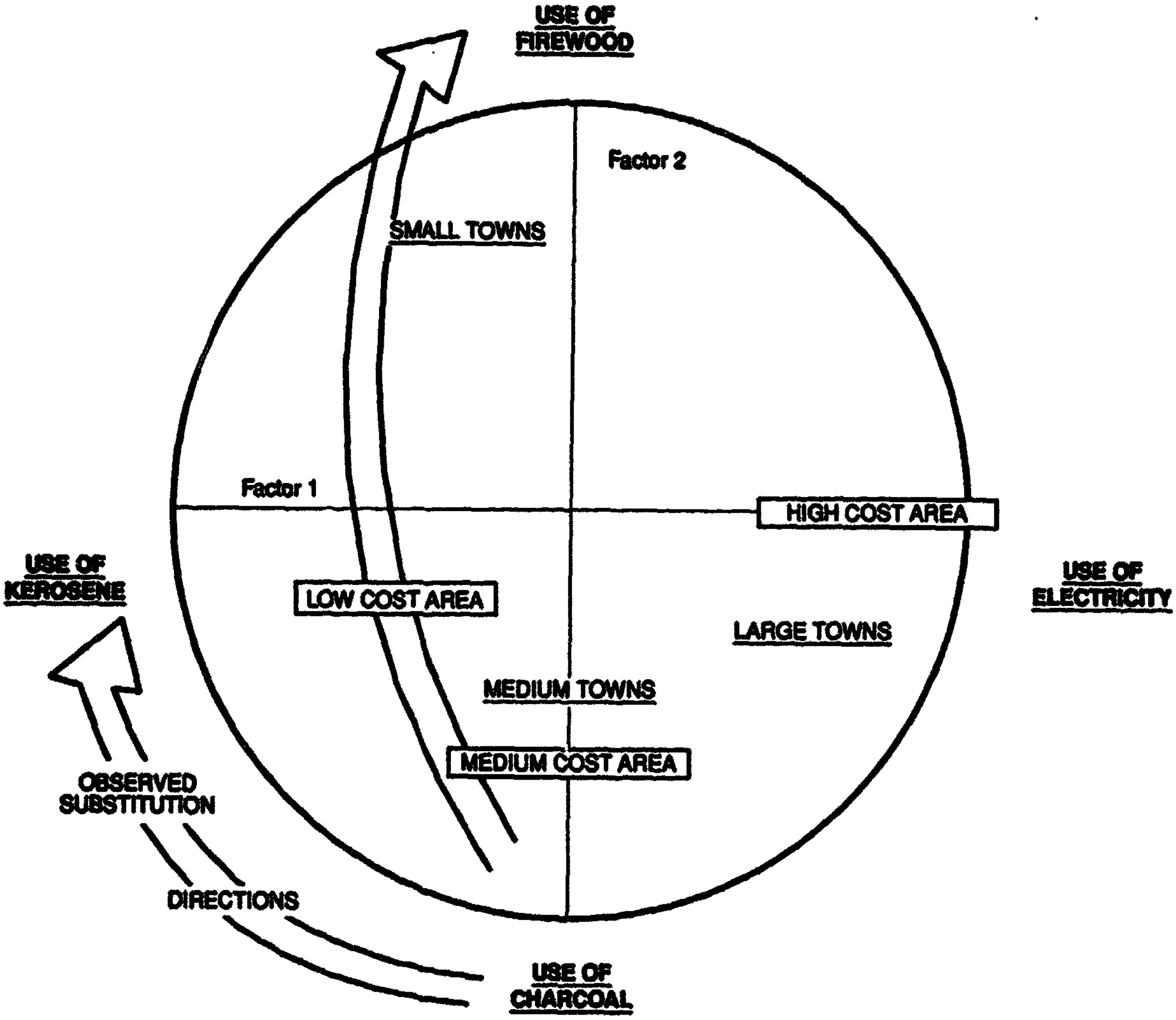
(b) The substitution between electricity and charcoal for cooking is exclusively determined by income and the availability of cooking appliances at a reasonable cost.

77. During the 1988/89 rainy season as mentioned above the price of charcoal in Lusaka went up from ZK30 per large bag (containing 40 kg of charcoal) to ZK150 mainly due to shortages of supply because of the exceptionally heavy rains.

78. Using the survey results which indicated that during rainy season the average consumption of charcoal-user household is 3.7 kg per day and assuming that the large bag was sold on the average for ZK120, it appears that 64% of the households (those who earn less than K800 per month) had to spend on the average 72% of their total income to buy charcoal.

79. The results of the second round of the demand survey conducted in Lusaka after the heavy rains, showed that about one-third of the households which used to use charcoal shifted either to kerosene (23%) or to firewood (6%) but very few shifted to electricity (1%). This result indicates that the substitution process can be reversed compared to the one described above. (Figure A3.3)

**Figure A3.3: Circle of Correlation - Main Plan
Effect of high charcoal prices**



THE COSTS OF ELECTRIC COOKING: COSTS PAID BY CONSUMERS AND THE FINANCIAL AND ECONOMIC COSTS OF SUPPLY

March 1989 Prices

Estimated Long-Run Marginal Costs of Electricity Supply to Connected Households:

1. Rough estimates are based on previous estimates in the ESMAP/DOE report, Zambia: Energy Sector Strategy (December 1988), using the base case investment program through 2006. Early 1988 prices are adjusted to March 1989 prices assuming 4% international inflation and 50% domestic inflation. The exchange rate is adjusted from ZK7.86/US$ to ZK10/US$. Sales tax and import duties are excluded in the economic analysis.

Thousand ZK

	Forex percent	Early '88 prices	Early '88 Forex	March 1989 Prices Forex	Local	Total	% Forex	Financial Cost (incl. import duty & Tax)
Salaries	0%	29152	0	0	43728	43728	0%	43728
Wages	0%	13224	0	0	19836	19836	0%	19836
Maintenance 1	75%	739	554	721	277	998	72%	998
Maintenance 2	75%	7445	5584	7259	2792	10051	72%	10051
Gen. Fuel	90%	6295	5666	7365	944	8309	89%	8309
Supplies	30%	2601	780	1014	2731	3745	27%	3745
Transport	60%	25181	15109	19641	15109	34750	57%	34750
Admin.	2%	6349	127	165	9333	9498	2%	9498
Distr. ext., pa	70%	43200	30240	39312	19440	58752	67%	94061
Transn., pa	70%	2866	2006	2608	1290	3898	67%	6240
Working capital	0%	24303	0	0	36455	36455	0%	36455
Total	37%	161355	60066	78085	151934	230019	34%	267671

ESMAP/DOE 1988 base forecast for household use, 2006 (GWH): 974

Financial cost per kWh: (of which FE 0.080)	0.275
Financial cost per KWh: (incl. sales tax of 15%)	0.316
Financial cost per KWh: (excl. import duty and all taxes)	0.236

	Value of foreign exchange assumed (ZK/US$) 10	25	40
Economic cost per kWh:	0.236	0.356	0.477

II. ELECTRIC STOVE COSTS

Stove Cost (ZK)	Retail Price	Forex Percent	Financial Cost excl. Tax & Duty	Forex Percent	Economic Cost, if ZK10=US$1	Forex Percent	Avg. KW	Lifetime (Years)	Hours Per day	Kwh Per day
Hot Plate 1	375	37%	275	50%	275	50%	0.8	2	4.0	3.2
Hot Plate 2	1000	56%	695	80%	695	80%	1.2	4	4.0	4.8
Hot Plate 3:										
Stove	4000	19%	3050	25%	1200	63%				
Ring Replacement and Repair	600	19%	457	25%	184	63%				
Total Replacement Over Lifetime	1328	19%	1012	25%	407	63%				
Total	5328	19%	4062	25%	1607	63%	1.4	10	4.0	5.6

Present Value of Stock Costs
(Discount Rate = 12%)

	Hot Plate 1	Hot Plate 2	Hot Plate 3
Stove Financial Cost per kWh (incl. taxes):	0.180	0.178	0.436
Stove Financial Cost per kWh (excl. taxes):	0.132	0.123	0.332
Stove Economic Cost per kWh, with following forex values:			
10 (ZK/US$)	0.132	0.123	0.132
25 (ZK/US$)	0.230	0.271	0.255
40 (ZK/US$)	0.329	0.420	0.378

Note: Hot Plate 1 is a simple, one-ring ceramic hot plate.
Hot Plate 2 is intended to model the one-ring hot plate proposed for development by ZESCO.
Hot Plate 3 is intended to model imported two-ring hot plates on the market in March 1989.

III. COST OF ELECTRIC COOKING FOR CONNECTED HOUSEHOLDS
(including stove cost)
ZK/kWh

	Hot Plate 1	Hot Plate 2	Hot Plate 3
Financial Cost, incl. sales tax	0.50	0.49	0.75
Financial Cost, excluding taxes	0.37	0.36	0.57
Economic Cost with following			
forex values: 10 (ZK/US$)	0.37	0.36	0.37
25 (ZK/US$)	0.59	0.63	0.61
40 (ZK/US$)	0.81	0.90	0.86
Cost to users at current prices, including tax:	0.33	0.33	0.59

IV. COST OF HOME WIRING AND CONNECTION
(1) WIRING COST (FOR TWO ROOMS)
(ZK)

	Imported	Local	Total
Materials	2003	1097	3100
Labor		1023	1023
Administration		310	310
Transport	93	62	155
Profit		459	459
Total Financial Cost	2096	2951	5047
Sales Tax	419	590	1009
Import Duty @ 20%	279	0	279
Total Taxes	698	590	1288
Financial Cost, excluding Taxes	1398	2361	3759
	Forex Values:		
	ZK10/US$	ZK25/US$	ZK40/US$
Economic Cost	3759	5856	7953

(2) CONNECTION COST

Cost estimates based on ZESCO'S proposal in early 1989
for a connection fee rate increase.
Note: For every connection, two households are joined to the grid

(ZK per House)

	Imported	Local	Total
Materials	1323	960	2283
Labor		93	93
Contingencies & Overhead		325	325
Transport	130	86	216
Administration		584	584
Total Financial Cost	1453	2048	3501
Sales Tax	291	410	701
Import Duty (@ 20%)	194	0	194
Total	485	410	895
Financial Cost, excl. Taxes	968	1638	2606
(per household)	(484)	(819)	(1303)
	Forex Values:		
	ZK10/US$	zk25/us$	ZK40/US$
Economic Cost	2606	4058	5510
(per household)	(1303)	(2030)	(2756)

(3) ASSUMPTIONS FOR PRORATING CONNECTION AND WIRING COSTS
(20 Year Assumed Lifetime)

	kWh Consumption per Household per Year					
	Cooking			Total		
	Hot Plate 1	Hot Plate 2	Hot Plate 3	Hot Plate 1	Hot Plate 2	Hot Plate 3
Total	23,360	35,040	40,880	37,829	49,509	55,349
PV of Total:						
(Discount Rate @ 12%)				13,646	18,262	20,571

(4) PRESENT VALUE COST OF CONNECTION & WIRING PER KWH
(Prorated Cooking Share)

	Hot Plate 1	Hot Plate 2	Hot Plate 3
Connection and wiring cost:			
Financial:	0.50	0.37	0.33
Financial, excl. tax:	0.37	0.28	0.25
Economic cost with following			
Forex values: 10 (ZK/US$)	0.37	0.28	0.25
25 (ZK/US$)	0.58	0.43	0.38
40 (ZK/US$)	0.78	0.59	0.52
Cost to users at current prices, including taxes:	0.44	0.33	0.29

V. TOTAL COST OF ELECTRIC COOKING
FOR HOUSEHOLDS REQUIRING CONNECTION & WIRING
(Including Stove, Connection & Wiring Costs)

(Two-room house, middle/low income, 30 meters from grid)

		ZK/kWh	
	Hot Plate 1	Hot Plate 2	Hot Plate 3
Financial Cost	1.00	0.86	1.08
Financial Cost, excl. Taxes	0.74	0.64	0.62
Economic Cost with following			
forex values: 10 (ZK/US$)	0.74	0.64	0.62
25 (ZK/US$)	1.17	1.06	0.99
40 (ZK/US$)	1.59	1.49	1.38
Cost to Users at Current Prices, incl. taxes	0.77	0.66	0.88

THE COSTS OF KEROSENE COOKING: COSTS PAID BY CONSUMERS AND THE FINANCIAL AND ECONOMIC COSTS OF SUPPLY

(March 1989 Prices)

I. Fuel Costs

	ZK/Liter	Est. % Forex	Forex	Local
		Consumer Cost		
Wholesale	1.19	97%	1.15	0.04
Duty	0.18	0%	0.00	0.18
Trans./Marketing	0.42	60%	0.25	0.17
Retail Price, Lusaka	1.79	79%	1.41	0.38
		Actual Financial Cost		
Wholesale	2.02	97%	1.96	0.06
Duty	0.18	0%	0.00	0.18
Trans./Marketing	0.42	60%	0.25	0.17
Retail Price, Lusaka	2.62	84%	2.21	0.41
		Economic Cost		
	ZK/Liter			
Forex Values (ZK/US$): 10	2.44			
25	5.76			
40	9.07			

II. STOVE COSTS

	Retail Price	(of which FE)	Forex Percent	Financial Cost excl. Tax & Duty	Forex Percent	Economic Cost, if ZK10=US$1	Forex Percent
	400	(152)	38%	290	52%	240	63%

		Cost of Stove	Scenario 1	Scenario 2	Scenario 3
Liters used per week:			2.46	2.46	3.79
Est. Lifetime (years):			2	3	2
Consumption on per Year:	1		128	128	197
	2		114	114	175
	3			102	
(mid-yr. discounting)					
Discount Rate:	12%				
PV of liters used per stove:			242	344	372
PV of the stove per liter fuel (e.g. 400 by 242)			1.65	1.16	1.08
PV of the economic of stove cost per liter at following Forex Values (ZK/US$):	10	240	0.99	0.70	0.65
	25	468	1.93	1.36	1.26
	40	696	2.88	2.02	1.87

III. TOTAL COST OF KEROSENE COOKING (ZK/Liter)

		Scenario 1	Scenario 2	Scenario 3
Cost to Consumers at Current Prices:		3.44	2.95	2.87
Actual Financial Cost:		4.27	3.78	3.70
Economic Cost at Following Forex Values (ZK/US$):	10	3.43	3.14	3.09
	25	7.69	7.12	7.02
	40	11.95	11.09	10.94

THE COSTS OF CHARCOAL COOKING: COSTS PAID BY CONSUMERS AND THE FINANCIAL AND ECONOMIC COSTS OF SUPPLY

1. These costs are based on the costs of production, transportation marketing as found during the various studies and the average selling price in 1988 of charcoal from the kiln site of ZK 15.0 per bag and from the urban market namely ZK30.0 per bag. Using these figures the economic and financial costs in March 1989 terms was estimated as follows:

I. CHARCOAL PRODUCTION COSTS

(March 1989 Prices)

Estimated Financial Costs in 1988:	Total Labor Costs per Average Clamp (65 bags) Workdays	ZK/Workday	ZK/BAG (40 kgs)
Felling	4	30	1.85
Cross-Cutting	4	40	2.40
Haulage to Clamp	4	10	0.74
Building Clamp	3	40	1.85
Maintaining/Harvesting	17	12	3.14
Total Labor			10.04
Equipment/Tools			0.40
Wood Raw Material: (Stumpage ZK8/cord removal tax ZK0.5/bag)			1.92
Subtotal			12.36
Profit 17.6%			2.64
Total			15.00

Note: Workdays refer to full days of actual work

Estimated Financial Costs in March 1989:	ZK/Bag
Assumed Rate of Inflation: 50%	
Labor and Tools: (10.44 x 1.5)	15.66
Wood Raw Material: (Stumpage ZK8/cord removal tax ZK0.5/bag)	1.92
Profit 18.2%	3.92
Totals	21.50

Estimated Economic Costs in March 1989:	ZK/Bag
Assumed Rate of Inflation 50%	
Labor and Tools:	15.66
Wood raw material: (Stumpage only ZK15/cord removal tax excluded)	2.66
Profit 18.6%	4.18
Total	22.50

II. CHARCOAL TRANSPORTATION AND MARKETING COSTS

2. The average charge by transporters (weighted mean of lorry and pick up transport) in 1988 was ZK 8.90 per bag and the average distance transported was 120 kms round trip. However, based on information collected from three urban centers the average cost for 120 kms was calculated to be ZK 8.10. Thus the 1988 cost of marketing including profit ranged from ZK6.1 to ZK6.9 as follows:

	ZK/bag	ZK/bag
Selling price ex kiln	15.0	15.0
Transport costs (120 kms)	8.9	8.1
Marketing costs	6.1	6.9
Selling price ex market	30.0	30.0

3. The above range of transport and marketing costs will be used to determine the March 1989 costs together with the following assumptions:

1. All costs are local except 60% of the transport costs;
2. Local costs increased by 50% because of inflation;
3. Foreign exchange costs increased by 32%, - 27% devaluation and 4% international inflation.

		ZK 1988 per bag			ZK March 89 per bag		
		Total	FE	Local	Total	FE	Local
A.	Transport cost	8.90	5.34	3.56	12.39	7.05	5.34
	Marketing costs	6.10	0.00	6.10	9.15	0.00	9.15
	Total	15.00	5.34	9.66	21.54	7.05	14.49
B.	Transport cost	8.10	4.86	3.24	11.28	6.42	4.86
	Marketing cost	6.90	0.00	6.90	10.35	0.00	10.35
	Total	15.00	4.86	10.14	21.63	6.42	15.21

III. ESTIMATE OF THE TOTAL COST OF CHARCOAL SUPPLY

A. Actual Financial cost ZK/bag

		1988				1989			
		Production	Transport	Marketing	Total	Production	Transport	Marketing	Total
Case A	Local	15.00	3.56	6.10	24.66	21.50	5.34	9.15	35.99
	FE	0.00	5.34	0.00	5.34	0.00	7.05	0.00	7.05
	Total	15.00	8.90	6.10	30.00	21.50	12.39	9.15	43.04
Case B	Local	15.00	3.24	6.90	25.14	21.50	4.86	10.35	36.71
	FE	0.00	4.86	0.00	4.86	0.00	6.42	0.00	6.42
	Total	15.00	8.10	6.90	30.00	21.50	11.28	10.35	43.13

B. Economic cost of supply March 1989

	CASE A				CASE B			
	Production	Transport	Marketing	Total	Production	Transport	Marketing	Total
Forex value ZK10/US$								
Local	22.50	5.34	9.15	36.99	22.50	4.86	10.35	37.71
FE	0.00	7.05	0.00	7.05	0.00	6.42	0.00	6.42
Total	22.50	12.39	9.15	44.04	22.50	11.28	10.35	44.13
Forex value ZK25/US$								
Local	22.50	5.34	9.15	36.99	22.50	4.86	10.35	37.71
FE	0.00	17.62	0.00	17.62	0.00	16.05	0.00	16.05
Total	22.50	22.96	9.15	54.61	22.50	20.91	10.35	53.76
Forex value of ZK40/US$								
Local	22.50	5.34	9.15	36.99	22.50	4.86	10.35	37.71
FE	0.00	28.20	0.00	28.20	0.00	25.68	0.00	25.68
Total	22.50	33.54	9.15	65.19	22.50	30.54	10.35	63.39

FOREIGN EXCHANGE COSTS

A. **Electricity** - Costs taken from Annex 4 Economic costs. Exchange rate assumed ZK10 = US$1.

i) Cost per household

	Total cost with taxes & duty ZK	(US$)	Economic cost excluding taxes & duty ZK	(US$)	Foreign Exchange cost ZK	(US$)	FE%
Connection a/	1750	(175)	1303	(130)	484	(48)	37
Wiring	5047	(505)	3759	(376)	1398	(140)	37
Fuel (mWh)	316	(32)	236	(24)	80	(8)	34

a/ It is assumed that for every connection two households are served therefore connection cost per household is half that shown in Annex 4.

ii) Estimated foreign exchange cost

Year	Energy Consumption Units GWh's	(PJ's)	FE Cost US$ mill.	Connection cost New consumers	FE cost US$mill.	Total cost FE cost US$mill.
1988	533	(1.92)	4.3	8,800	1.7	6.0
1995	700	(2.52)	5.6	12,000	2.3	7.9
2000	874	(3.15)	7.0	14,900	2.8	9.8
88-2000	8970	(32.29)	73.4	150,400	42.5	115.9

iii) Cost of electric hot plate

Plate	Life time years	Retail price ZK	(US$)	Economic cost ZK	(US$)	FE cost ZK	(US$)	Cost per MWH(ZK) Total	Econ.	FE
1 a/	2	375	(38)	275	(28)	138	(14)	180	132	66
2 a/	4	1000	(100)	695	(70)	556	(56)	178	123	98
3	10	4000	(400)	1200	(120)	762	(76)	436	132	83

a/ Not available at present.

iv) The foreign exchange cost of electric hot plate-type 3 in all electrified homes.

It is assumed that all electrified houses will have hot plate by the year 2000.

Total stoves purchased in the following years a/

	1988	1995	2000	1988-2000
Stoves in use	210,000	283,900	352,100	-
Stoves purchased	25,600	35,100	44,300	402,900
FE cost (US$ mill)	1.9	2.7	3.4	30.6

a/ To calculate number of stoves purchased assume for	Yr 2000
(i) First time purchase for houses connected in that year	14,900
(ii) For 10 yr. lifetime sum people connected in 90,80,70 etc.	26,700
(iii) Assume 10% of b) for repair to other stoves	2,700
Total	44,300

Note: If all urban households were electrified by the year 2000, that is 825,000, and each had a simple hot plate with a life time of 10 years, the foreign exchange cost of such a hot plate would be on the order of US$70 million.

B. Kerosene. Costs taken from Annex 5
Exchange rate ZK10 - US$1.

i) Cost per liter

	Consumer Cost		Actual Financial Cost		FE	Cost	FE %
	ZK	(US$)	ZK	(US$)	ZK	(US$)	
Fuel a/	1.79	(0.18)	2.62	(0.26)	2.21	(0.22)	84

a/ Price per liter retail outlet Lusaka.

ii) Estimated Foreign exchange cost

Year	Estimated Mill. Lt.	(PJ's)	FE Cost US$ Mill.
1988	42	(1.45)	9.3
1995	56	(1.93)	12.4
2000	69	(2.38)	15.2
1988-2000	710	(24.49)	156.9

iii) Cost of a kerosene stove ZK. Retail price 400, Financial cost 290, Economic cost 240, of which foreign exchange 152 ($15.2).

iv) Estimate of No. of stoves in used with 3 years lifetime.

	1988	1995	2000	1988-2000
Stoves in use	28,500	35,000	42,000	-
Stoves purchased	9,500	11,700	14,000	152,000
FE cost (US$mill)	0.1	0.2	0.2	2.3

C. Charcoal. Costs taken from Annex 6. Exchange rate ZK10 = US$1

i) Cost for 40 kg/bag. 350,000 improved stoves in use by 200,000: average stove efficiency 30%, twice the existing efficiency.

Financial cost ZK (US$)	Economic cost ZK (US$)	Foreign exchange ZK (US$)
43.04 - 43.13	44.04 - 44.13	6.42 - 7.05
(4.30 - 4.31)	(4.40 - 4.41)	0.64 - 0.70)

ii) Estimated foreign exchange cost with no stove initiative units.

			Transport costs (US$ mill.)	
Year	000t	(PJ)	no improvements	with improvements
1988	513	(15.90)	8.6	8.6
1995	680	(21.08)	11.4	10.2
2000	828	(25.67)	13.9	8.3
1988-2000	8577	(265.89)	144.1	122.1

iii) Estimated foreign exchange cost with stove initiative a/

			Transport costs (US$ mill.)	
Year	000t	(PJ)	no improvements	with improvements
1988	513	(15.90)	8.6	8.6
1995	633	(19.62)	10.6	9.5
2000	687	(21.30)	11.5	6.9
1988-2000	7973	(247.16)	133.9	114.7
1988-2000 (iii) - (ii)	604	(18.73)	10.2	7.4

a/ At present IT costs about US$16.8 in foreign exchange to transport 1 ton of charcoal for a round trip of 120 kms. CH haulers foreign exchange costs are about US$5.4 for the same journey. With transport initiatives it is assumed that the foreign exchange costs will be reduced to US$15 in 1995 and US$10 in 2000 for the average trip of 120 kms. The CH costs are as follows:

D. C.H. Transport costs:

	Late 1988 ex. rate K7.86 = US$1 Cost per ton/km		March 1989 ex. rate K10 = US$1 Estimates Cost per t/km	
	Cost	FE share	Cost	FE share
Item	ZK	ZK	ZK	ZK
Fuel and oil	0.15	0.09	0.21	0.12
Vehicle maintenance	0.20	0.10	0.28	0.13
Depreciation etc.	0.26	0.13	0.37	0.17
Driver salary	0.03	0.00	0.40	0.00
Administration	0.20	0.00	0.30	0.00
Workshop	0.16	0.02	0.21	0.30
Total	1.00	0.34 (34%)	1.44	0.45 (31%)
US$	0.13	0.043	0.14	0.045

E. Fuelwood

i) Assume negligible foreign exchange cost in production. Only foreign exchange costs in the transport of the fuelwood from site to market, but half of the fuelwood is self collected with no transport cost. Average two way transport distance 50 kms. Transport cost of fuelwood transporters assumed to be proportional to the charcoal costs that is in terms of foreign exchange $\$16.8 \times \frac{50}{120} = \$7.0$

per ton transported over 50 km round trip. However only half commercially transported, therefore, average cost in foreign exchange is $3.5 per/t.

ii) Estimated foreign exchange cost.

Year	Energy consumption 000t	(PJ's)	Transport costs (US$ mill.) no improvements	with improvements
1988	448	(7.17)	1.6	1.6
1995	553	(8.85)	1.9	1.7
2000	641	(10.26)	2.2	1.3
88-2000	7010	(112.16)	24.5	20.9

Note: Cost of stove not included in above but most stoves are three stones obtained at no cost.

F. Crop residues

i) Assume no production or transport costs as the main residue is bagasse a waste product from the sugar factories which is collected free of charge and transported by foot.

IMPROVED STOVE PROGRAM

A. Charcoal Stove Initiative

80. The stove program commences in 1990 and works on several types of improved stoves but especially on improved charcoal stoves. This annex describes the production possibilities for improved charcoal stoves.

81. After design and field testing, commercial production begins in 1992. Table 1 gives two production targets between 1992 and 2000. The lower target assumes that 136,000 units plus 350,000 replacement grates will be produced in 2000, and the upper target assumes that 204,000 units plus 525,000 grates will be produced by then.

82. In Kenya their improved charcoal stove program started in late 1981 and commercial production started late 1983 or early 1984. Four years later in 1988 annual production was estimated to be between 125,000 and 140,000 units. (Jones H. Mike 1989; Energy Efficient Stoves in East Africa: Bureau of Science and Technology USAID).

Table A8.1: Production Targets for Improved Charcoal Stoves
and Replacement Grates
(Units 000's)

	Year	92	93	94	95	96	97	98	99	2000
Lower	stoves	20	28	38	50	62	80	98	116	136
target	grates	20	48	86	116	152	194	242	294	350
Upper	stoves	30	42	57	75	93	120	147	174	204
target	grates	30	72	129	174	228	291	363	441	525

83. It is assumed that the average lifetime of the stove is three years and that of the grate is one year; it is also assumed that households only buy one improved stove at a time. Therefore by the year 2000, 350,000 to 525,000 (urban) households will be using improved charcoal stoves out of total population of urban charcoal users estimated to be 690,000. In percentage terms of users this represents between 50% and 75%.

84. The efficiency of the traditional stove is about 15%, whereas the efficiency of the improved stove should be at least 25% and on average be 30%.

85. In charcoal using households, an average of 2.20 kg of charcoal are consumed per day for cooking and water heating. Therefore with improved stoves having a 25% efficiency the saving of charcoal should be 0.88 kg per day and with 30% efficiency the saving should be 1.10 kg per day. The yearly saving per household should be as follows:

a. 25% efficiency: 321 kgs or 8 x 40 kg bags or ZK 800 (US$44)
b. 30% efficiency: 402 kgs or 10 x 40 kg bags or ZK1000 (US$55)

86. By the year 2000, 350,000 improved stove users will save between 112,000 t. and 141,000 t. of charcoal per year. 525,000 improved stove users will save between 169,000 t. and 211,000 t. of charcoal per year.

87. The traditional stove costs about ZK 70 (US$ 4). The improved stove should not cost more than ZK 180 (US$ 10), and the replacement grate is not more than ZK30 (US$1.6). The foreign exchange element in both stoves is negligible. The traditional stove lasts one year so the cost over three years is ZK 210. The improved stove lasts 3 years but requires three replacement grates, therefore the total cost over three years is ZK 270 or ZK 60 more than the traditional stove over the three year period. However, it will cost ZK110 more to purchase the improved stove, but the saving in charcoal over the three year period should be between ZK2400 and ZK3000.

88. The country will save foreign exchange by not having to transport the saved charcoal. The saving of foreign exchange should vary between US$16.8 per ton and US$10.0 per ton. The latter case assumes that the March 1989 F.E. transport cost of US$16.8 is reduced to about twice that of surfaced road haulage through improved efficiency - namely $10 per t. The former case assumes no transport cost reductions (Annex 7). By the year 2000, assuming there has been savings in transport costs, if 350,000 improved stoves are in use with efficiencies between 25% and 30%, the savings in foreign exchange will be between US$1.1 million and US$1.4 million. Similarly if 525,000 improved stoves are in use the F.E. savings will be between US$1.7 million and US$ 2.1 million. With no transportation cost reduction, the savings will be 68% more than the above, in that particular year.

89. The cumulative saving between 1992 and 2000 are given in Table A8.2.

90. The foreign exchange cost of the entire improved stove program (not just charcoal) is estimated to be US$ 2.6 million, for the first five years including a loan element of US$0.5 million. Therefore such a program if it is continued to the year 2000 should not cost more than US$4.7 million so there should be an overall saving of money and charcoal.

Table A8.2: Improved Stove Program - Cumulative Saving in Tons and Foreign Exchange: US$; 92-2000

Stove Efficiency	Lower target 000 t.	mill. US$ a/	mill. US$ b/	Upper target 000 t.	mill. US$ a/	mill. US$ b/
25%	482	8.1	5.9	724	12.0	8.7
30%	603	10.2	7.4	905	15.3	11.1

a/ No savings in transport costs.
b/ Savings in transport costs.

B. Other Stove Initiatives

91. There will be similar initiatives for firewood, coal, kerosene and electricity. The main purpose of the electricity stove effort would be to produce a cheap locally manufactured product of similar efficiency and/or to assemble a cheap imported stove. Reducing import taxes on stove components (and stoves) should also make stoves more affordable.

92. The aim of the kerosene stove component is to produce efficient low cost wick and pressure stoves at least comparable with the present stoves.

93. Coal stoves are not presently used for heating or cooking. Prototype stoves are being developed but they have to be market tested. Also supplies of coal or coal briquettes have to be readily available. Before commercialisation is contemplated it is important that the stoves be properly tested, people are willing to buy the stoves and the fuel is readily available.

94. For firewood the aim is to introduce simple and cheap locally made stoves to replace the very adaptable but relatively inefficient three stone fire or metal tripod. The efficiency gains should be similar to the improved charcoal stove. While the potential market for firewood stoves is large, it is difficult to penetrate especially where people do not presently buy stoves and/or wood. Therefore acceptability may take longer than for charcoal stoves.

PROJECT PROPOSALS

Project 1: Establishment of an Indigenous (Miombo) Woodland Monitoring and Management Unit (IWMMU)

Objective

95. The household energy strategy has shown that indigenous (Miombo) woodlands are valuable sources of poles, timber, firewood and charcoal. Firewood harvesting and charcoal production provide about 41,00G rural jobs and can contribute 30-40 million Kwacha to government revenue. The indigenous woodlands are potentially renewable and therefore, can provide these economic and ecological services indefinitely. However, currently the Forest Department is providing very little management in indigenous woodlands due to limited manpower and other resources. The strategy study has estimated that with good management the productivity of indigenous woodlands would be increased initially by 20-30%, approximately 1 m^3 per hectare per year, the rotation could be shortened, valuable species favoured, exploitation would be regulated and indigenous forestry industries greatly improved and their future sustained. Eventually at least half cf the gazetted forest areas, about 4 million ha, should have improved management giving an annual increased production of 4 million m^3 worth at least ZK20 million (US $0.8 million) at current (low) stumpage fees.

96. Thus the objective of this project is to strengthen the management of indigenous woodlands through the establishment of an indigenous (Miombo) Woodland Monitoring and Management Unit (IWMMU) in the Forest Department. This Unit should be adequately equipped with suitably trained manpower, accommodation and equipment to enable it carry out periodic assessment of standing stocks in indigenous woodlands throughout the country, plan and monitor their utilization and provide expert management and extension services to rural people.

97. The tasks of a Miombo Woodland Monitoring and Management Unit would be to:

(a) Check and map all areas of woodlands noting their present condition and possible future status;

(b) List in order of priority areas that should be reserved for water catchment, wood and other resources production, species protection, agricultural production, etc.;

(c) Establish permanent and temporary management plots to measure and monitor tree growth and woodland production;

(d) Draw up management plans for the areas that will remain under woodlands;

(e) Meet with local people and decide who will manage the woodlands;

(f) Organise training courses and train extension workers from forestry and agriculture to teach woodland management;

(g) Recruit and train people to undertake the various tasks;

(h) Draw up plans for the woodland resources that are going to be cleared owing to a change of land use;

(i) Establish stumpage fees that are to be charged by the forest service. Ideally these fees should decrease with increasing distance from the market and vary according to end use. Such fees should set a standard for charges to be levied by private individuals on trees they manage;

(j) Establish sets of rules concerning resource payments, rewards and penalties;

(k) Start pilot projects to test management practices and fee collection systems;

(l) Ensure that there are sufficient resources available to undertake the tasks;

(m) Modify management and fee collection schemes as a result of pilot study experiences; and

(n) Put into operation the modified schemes on areas designated for management.

98. Financial support is sought for the initial period of five years to set up and operationalize the Unit in the Forest Department.

Output

The establishment of the Unit will increase capability of the Forest Department to assess, plan and regulate the exploitation of indigenous woodland resources. Secondly, by courses and on the job training suitably trained manpower will be produced.

3. ESTIMATED BUDGET (US $)

1.	Acquisition of latest aerial photos, satellite imagery for the whole country for different periods	100,000
2.	Equipment (tapes, compasses, relascopes, weighing scales, moisture meters, cutting tools, computers, books, etc.	100,000
3.	Three 4-wheel drive vehicles	45,000
4.	Establishment and maintenance of management study plots	200,000
5.	Stationery and printing costs	25,000
6.	Vehicle and equipment running costs (5 years)	150,000
7.	Organising and run training & extension courses	255,000
8.	Consultancy fees (over 5 years)	100,000
9.	Full-time management expert initially for 3 years	360,000
10.	Housing for management expert	50,000
11.	Office accommodation for the Unit	50,000
12.	Allowances	75,000
13.	Contingencies (10%)	150,000
	Total	1,660,000

Project 2: Improvement of Collection of Woodfuel fees and Levies and Re-Assessment of Stumpage Fees

Objective

99. One of the major constraints in the proper management of indigenous woodlands is lack of financial resources. The household energy strategy has shown that for 1988 less than 10% of the potential revenue from fuelwood stumpage fees (K30 million) and charcoal removal fees (K8 million) is actually collected and remitted to the government treasury. While noting the efforts the Forest Department has made to establish a revolving fund, the strategy study supports these efforts and further recommends that such a fund be established and a proportion of the revenue that the Forest Department annually collects from forest fees and levies be retained by the Department. Such monies from the revolving fund should be used to improve the management of indigenous woodlands by the proposed IWMMU. Not only that, the revenues from the woodland, forest and plantation resources should be sufficient to finance the forest service and provide the government with revenue as well. Also if villagers, charcoal producers and other private individuals are involved in the management of the woodland resources they too should benefit from a share of the fees. Again stumpage fees are approved by government at intervals of a decade or more, they bear very little relationship to the growing cost, the market price or the distance from the market and of course they are not adjusted to account for inflation or other market forces.

100. Therefore, a "stumpage" committee should be set up of interested parties including the growers, users, the Energy Department and the Treasury to look into:

(a) the funds the forest service requires to undertake its duties.

(b) the remittances that the forest service should keep from the collected fees bearing in mind the goal of the service should be one of self-financing.

(c) the fees that the government should retain for general purposes.

(d) the remittances villagers, charcoal producers, and other private individuals should be given for managing the resource.

(e) The fixing of a fee structure both stumpage and removal that takes into consideration the growing cost of trees and/or the market cost of the products. These fees should have a built in inflation adjuster and be variable by product and if possible by distance from the market in order to account for transport costs.

(f) the way the forest service can impose the fees without first seeking government approval.

101. Because the present collection system gives very little incentive to collect or even to hand over the collected money to government, ways must be found to reward the collectors and the forest service in general to improve the collection and remittance. Therefore, the committee should also:

(a) Look at incentive systems and recommend how they can be applied;

(b) Recommend a system of penalties for non-compliance with fee remittance;

102. The Energy Department through its surveys has shown how production can be monitored. This department should act as a monitoring unit and funds should be provided for this service. The committee should be set up immediately and report within six months.

103. In order to strengthen the capacity of the Forest Department, funds are sought to strengthen its capacity to collect the revenue from woodfuel fees and levies and maintain a revolving fund. Assistance is required initially for two years during which time a strong revenue collecting unit will be established in Central, Copperbelt and Lusaka provinces and a revolving fund set up. The unit will mount permanent road check-points to ensure that charcoal and firewood removal fees have been or are being paid. Forest Officers will work in shifts (day and

night) at the check-points and will require vehicles to ensure smooth and timely deployment. After two years the system should be self-financing through the revolving fund.

Output

104. Increased government revenue through efficient collection of woodfuel fees and levies. Improved financial capacity of the Forest Department to manage indigenous woodland resources and regulation of woodland exploitation.

ESTIMATED BUDGET (US $)

1.	Eight vehicles (one per each large urban town in Central, Copperbelt and Lusaka Provinces)	80,000
2.	Vehicle running costs for two years	160,000
3.	Employment of additional manpower (64 officers, 8 per town)	128,000
4.	Secretariat assistance to the the stumpage fee committee (6 months)	10,000
5.	Assistance to the Department of Energy monitoring unit (2 years)	21,000
6.	Allowances	128,000
7.	Contingencies (10%)	53,000
	Total Cost	580,000

Project 3: Planting and/or Managing Trees by Charcoalers, Private Farmers and/or individuals

Objective

105. While the bulk of urban woodfuel will come from the natural woodlands, farmers should be encouraged to plant and/or manage trees on their own land to meet their own requirements of fuelwood, poles and roughly hewn timber and if possible produce a surplus for sale to other (urban) consumers. Many trees fix nitrogen and if grown in rows or strips at right angles to the prevailing wind can act as shelter belts as well as fertilizer. If the leaves of nitrogen fixing trees are mulched into the soil or fed to cattle and then returned to the soil via the dung the farmer can maintain if not improve soil fertility (and have a nitrogen rich animal feed) without a large purchase of artificial fertilizers. If judiciously placed the trees can be spaced throughout the field without taking much land from the agricultural crop. Indeed the beneficial effects of the trees on improving the micro-climate should more than compensate for the land taken for tree planting (not more than about 5%).

106. Besides planting trees in agro-forestry formations there are usually parcels of lands on most farms that are not suitable for arable crops. Here again tree planting should be encouraged. There are also areas of land that have been abandoned or that have been reserved for tree planting such as the proposed Lusaka fuelwood plantation. If these areas are near enough to urban centers it may be profitable to invest in plantations. For example the May 1989 price of pole wood in the Lusaka market is over ZK 2,000 per m3, that of fuelwood about ZK 600 per m3 and that of charcoal ZK 70 per bag which in wood equivalent terms is about ZK 240 per m3. Therefore, the government should encourage farmers and private individuals/organisations to invest in tree growing.

107. Already the Ministry of Agriculture has established an agro-forestry unit; this should further be enhanced and demonstration plots established or expanded to show farmers the benefits of agro-forestry. The Forestry Department should assist the Agricultural Department by growing agro-forestry trees in seed orchards or collecting suitable agro-forestry tree seeds. These agro-forestry seeds should be kept in seed stores and distributed in timely fashion. It should be stressed that farmers themselves must be encouraged to raise their own tree seedlings rather than wait for them to be given/sold by Government. It is usually far more effective and cheaper to distribute seeds rather than seedlings. Therefore, if necessary, farmers should be taught the simple techniques of raising seedlings. This could also be done through the school system; the growing of seedlings and trees plus their different uses should be part of the primary curriculum. A school nursery could be established in many schools and trees planted round the compound to provide shade and wood products.

108. With regards to the planting of trees in blocks, especially near urban centers, the various government and city authorities which have control of land reserved for tree planting should rent or lease the land to individuals or organisations so that they can plant trees commercially.

109. Government and its Land-use Authorities should lease/allocate land to private individuals/organizations/cooperatives for woodland management and harvesting, and the establishment of plantations to produce poles, fuelwood and charcoal. The 'professional' charcoal/fuelwood producers and their cooperatives should be primary target and be given priority.

110. The Forestry Department should provide technical advice and guidance on management techniques, harvestable units and suitable seeds for planting to meet desired end uses.

Output

111. The outputs from this proposal are ambitious and may take a decade or more to fully achieve. They can be stated as follows:

(a) The establishment of seed orchards and the identification of "plus" trees in the natural woodlands as seed sources.

(b) The establishment/expansion of seed centers to collect, treat and distribute tree seeds, especially agro-forestry seeds.

(c) The establishment/expansion of tree nurseries in schools and the introduction of silviculture into the primary school curriculum.

(d) The establishment/expansion of agro-forestry and shelterbelt demonstration plots to show farmers the benefits of trees on farm.

(e) The production of extension material about seed collection, seedling production, agro-forestry practices, tree growing and tending, uses of trees for fertilizer, fodder, food and wood products, markets for tree products etc.

(f) The introduction of agro-forestry courses at forest schools, agricultural colleges and even teacher training colleges.

(g) The expansion of extension services in agriculture and forestry and the co-ordination of their efforts.

(h) The making available of land to individuals or organisations interested in the planting of trees as a commercial crop.

ESTIMATED BUDGET

112. It is difficult at this time to draw up a budget for such a program. There should be a committee of relevant government and non-government organisations such as farmer's unions or co-operatives to draw up a plan of action. Such a committee could be assisted by international organisations such as the Food and Agricultural Organisation of the U.N. (FAO) and the International Council for Research into Agro-Forestry (ICRAF) based in Nairobi.

113. With regards to the renting or leasing of land for tree planting, this could be done by existing bodies at no additional cost, rather there should be an income from this activity.

PROJECT 4: Feasibility Study of the Utilization of Wood Resources for Charcoal in the Tazara Corridor

Objective

114. The government has started an agricultural development scheme along the Tanzania-Zambia railway (Tazara) corridor which will result in the clearing of 200,000 ha. This will cause the destruction of at least

14 million tons (bone-dry) of cord wood. This waste wood could profitably be converted to charcoal to supply urban areas in the Copperbelt and Lusaka, an estimated 3.5 million tons of charcoal worth ZK8750 million (US $ 365 million) at ZK100 per bag. This is enough to supply the urban areas for a decade or more if properly planned and co-ordinated. However, the major constraint to such utilization is accessibility because the Tazara corridor is located far from the major towns. But if the Tazara and Zambia railways were involved in the transportation of the charcoal to Lusaka and Copperbelt towns, the cost of transportation would be greatly reduced. Once in towns, the charcoal can be stored to improve woodfuel security and reduce scarcity during the rainy season.

115. Funds are sought to carry out a feasibility study to determine the best way of implementing such a scheme and the possibility of involving farmers and full-time charcoal producers in charcoal production.

116. The study should be done immediately and completed within a period of less than one year before much of the wood resources in the Tazara corridor are destroyed. The study should be coordinated by the Departments of Agriculture, Forest and Energy, and besides (i) looking at the supply of raw material (ii) assess the costs of getting it to the rail points, (iii) the number of feeder roads required, (iv) the additional rail and road wagons and storage facilities needed in the bush, at the rail points and in towns, (v) examine the possibility of exporting only TAZARA charcoal especially to the Middle East by railway to Dar-es-Salaam. The FOB price of charcoal from Africa is between $100 and $120 per ton.

Output

A report and recommendations about the utilization of wood resources in the Tazara corridor for charcoal production.

ESTIMATED BUDGET (US $)

1. One 4-wheel drive vehicle	15,000
2. Vehicle running costs	10,000
3. Stationery and printing costs	5,000
4. Consultancy expenses	20,000
5. Allowances	5,000
6. Contingencies (10%)	5,000
Total	60,000

Project 5: Strengthening of Charcoal Producers' Organizations

Objective

117. Charcoal producers operate in remote rural areas where there are inadequate or no education, health and commercial facilities. Often they have to travel long distances to obtain these social services. Currently charcoal producers have a very low status and are wrongly considered illegal self-employed workers. The household energy strategy study has shown that charcoal producers although producing a valuable energy product, are poorly or not at all organized. This makes it more difficult for government and non-government agencies to reach charcoal producers and provide them with basic social services and to improve the charcoal production industry. An estimated 41,000 workers are employed in the charcoal production industry. They supply over 50% of urban household energy worth some ZK1300 million (US $54.2 million) annually at ZK100 per bag.

118. Funds are, therefore, sought to undertake a study of charcoal producers and make recommendations on how best they can be organized (e.g as producers' societies) and assisted by both government and non-government agencies. The possibilities of moving charcoal producers to the TAZARA corridor should be actively investigated. Also a plan should be drawn up in order of priority, on economic and social grounds, to see where bush roads need building or improving. Once this is known then a bush road project can be formulated. Ultimately improved well-being of charcoal producers and their families will result in increased productivity, lower costs and better status accorded to the industry.

119. The study should be carried out and completed over a period of one year and should be carried out in representative charcoal production areas of Central, Copperbelt and Lusaka provinces. The study should be coordinated by the Forest and Energy Departments.

Output

120. Report and recommendations about how best charcoal producers can be organized and assisted by government and non-governmental organisations.

ESTIMATED BUDGET (US $)

1.	One 4-wheel drive vehicle	15,000
2.	Vehicle running costs for one year	10,000
3.	Stationery and report production	5,000
4.	Consultancy fees and related expenses	20,000
5.	Allowances	5,000
6.	Contingencies (10%)	5,000
	Total cost	60,000

Project 6: Improvement of the Earth-Kiln Charcoal Production Technology

Objective

121. Although the household energy strategy study found that the traditional earth-kiln method of charcoal production in Zambia is relatively efficient (25% conversion efficiency on bone-dry wood weight basis), the study did not identify the major determinants of conversion efficiency. This means that no specific proposals have been made to further improve the efficiency of the earth-kiln method. Factors such as wood moisture content, kiln size, kiln management and duration of the carbonization process appear to affect conversion efficiency. Also the cutting methods and tools should be studied to see if and how productivity could be increased and the management of the wood resource sustained. Annual charcoal production is worth ZK1600 million (US $66.7 million) at ZK100 per bag and every 1% increase in efficiency would save over 1,000 tons of wood annually.

122. Funds are, therefore, sought to investigate factors affecting conversion efficiency in the earth-kiln charcoal production process. The results of such a study will lead to the formulation of specific recommendations for improving the conversion efficiency of the earth-kiln technology. The study should include a review of the performance of other earth-kiln charcoal production technologies in relevant African regions such as Sudan, Somalia and West Africa. The study will last two years and should be carried out under the auspices of the Departments of Forest and Energy.

Output

123. A report and recommendations about how improvements can be made in the conversion efficiency of the traditional earth-kiln method of charcoal production in Zambia. These recommendations can then be passed on to charcoal producers through training courses and on the job training.

ESTIMATED BUDGET (US $)

1.	One 4-wheel drive vehicle	15,000
2.	Vehicle running costs for two years	20,000
3.	Equipment (tapes, meters, scales etc)	10,000
4.	Stationery and report production	5,000
5.	Travel and subsistence (abroad)	20,000
6.	Consultancy fees (spread over 2 years)	37,000
7.	Allowances	20,000
8.	Contingencies (10%)	13,000
	Total Cost	140,000

Project 7: Improvement of Charcoal Supply and Distribution

Objective

124. Erratic charcoal supplies during the rainy season is caused partly by limited access to production areas because bush roads become impassable and partly by the low productivity of charcoal producers because they travel long distances to buy essential commodities, such as maize meal. The household energy strategy study proposes that if stocks of charcoal were held at all-weather accessible road sites and in urban areas, seasonality in supply and price fluctuations would be minimized. Charcoal production would also increase if essential commodities were sold nearer to production areas.

125. Funds are, therefore, sought to implement a pilot scheme to establish charcoal depots at strategic rural road-side sites and in urban areas. Essential commodities would be delivered and sold at rural charcoal depots for sale to charcoal producers. The scheme will involve charcoal producers, farmers and the Forest Department in the transportation of charcoal from production sites to rural road-side depots from where urban traders and transporters will buy the charcoal which may also be stored in urban depots. The existence of urban depots (wholesale warehouses) will enable any transporter to buy charcoal from road-side depots, pay the removal fee, deliver and sell the charcoal at urban depots without necessarily being involved in the retail trade. The rural depots will be managed by the producers aided by the Forest Department while the urban depots can be run by private businessmen again, if necessary, aided by the Forestry Department. In order to ensure a steady supply of essential commodities, the Forest Department (and later the charcoal producers societies once formed) will buy essential commodities in bulk, deliver to rural charcoal depots where these will be sold to registered charcoal producers. In co-ordination with the charcoal producers study, a priority list will be drawn up for building or improving bush roads.

126. The pilot scheme is proposed to run for two years in one or two supply areas in Lusaka. If successful the scheme will be extended to other areas in Lusaka, Central and Copperbelt Provinces.

Output

127. At the end of two years the scheme should result in specific recommendations on how best the charcoal transportation and distribution can be re-organised as well as appropriate methods to supply essential commodities to charcoal producers. Other outputs will include (a) increased rural employment (b) improved woodfuel security and reduction in charcoal price fluctuations, (c) improved welfare and productivity of charcoal producers, (d) improved collection of charcoal levies at source and (e) priority plan for bush road improvement/construction. Bush road improvement finance is not included in the budget. This should be financed by government from some of the removal fees paid by the transporters.

ESTIMATED BUDGET (US $)

1.	Two lorries	120,000
2.	Vehicle running costs	100,000
3.	Extension work and equipment to promote the scheme	15,000
4.	Manpower (2 drivers, 4 forest officers and 4 watchmen)	30,000
5.	Allowances	20,000
6.	Construction of depots	250,000
7.	Initial funds to purchase essential commodities	10,000
8.	Contingency costs (10%)	55,000
	Total	600,000

Project 8: Establishment of a Stove Unit

Objective

128. Several kinds of stoves are used for cooking, water heating and space heating utilising various sources of energy. In 1988 86% of household energy was used for cooking, water heating and space heating as the following table shows (Table A8.1). Therefore, a project to improve the efficiency of stoves could have a considerable impact on energy consumption and reduce the money households spend on energy.

Table A8.1: 1988 URBAN HOUSEHOLD ENERGY CONSUMPTION: CONSUMPTION OF ENERGY USING STOVES COMPARED TO TOTAL CONSUMPTION
Units TJ (10^{12} Joules)

End-use	Cooking & Water heating		Space heating with stove		Sub-total Cooking & heat		Total consumption		Estimated stove efficiency
Energy type	TJ	%	TJ	%	TJ	%	TJ	%	
Electricity	1,080	6	-	-	1,080	5	1,937	7	60%
Kerosene	242	1	n/a	n/a	242	1	1,484	6	35%
Charcoal	10,500	60	3,900	70	14,400	62	15,510	58	15%
Firewood	4,768	27	1,696	30	6,464	28	7,088	26	15%
Crop-resid.	898	5	-	-	898	4	898	3	15%
		100		100		100		100	
	17,488	65	5,596	21	23,084	86	26,917	100	

129. It will be observed from the above table that charcoal is the dominant fuel in the urban household sector followed by fuelwood. The efficiency of these stoves is low and estimated at 15%, so that there is room for a considerable efficiency improvements. Simple but improved stoves in other countries have given efficiencies of around 30% both for fuelwood and charcoal.

130. Fuelwood is the dominant fuel in rural areas and improved stoves can be introduced into these areas if they are cheap, especially where fuelwood is becoming scarce or where people are buying the wood.

131. Although about 40% of the urban people have electricity and electricity is a relatively cheap fuel, very few people cook with it because existing stoves are expensive. If cheap stoves could be introduced many more urban people would cook with this fuel.

132. Besides domestic cooking, many institutions and commercial enterprises use stoves for cooking and water heating, again there is need to improve the efficiency of these stoves especially those that use wood and charcoal.

133. Zambia has considerable reserves of coal and this could be used both domestically and commercially for space heating and cooking if suitable and cheap stoves can be manufactured.

134. For all these reasons there is an urgent need for a long term commitment to improve the efficiency of stoves. Some development work on new stoves or improving the efficiencies of existing stoves has been on-going for sometime in Zambia in different institutions. The National Council for Scientific Research is working on biogas stoves, coal briquettes stoves and a ceramic electric hot plate. Maamba Collieries has developed a coal stove while the University of Zambia produced an improved charcoal stove which is currently being popularised. No major work has been done on wood stoves or on institutional stoves.

135. There is a need to co-ordinate and prioritize all these activities and to have a long term commitment to the commercial production of (cheap) improved stoves especially for fuelwood and charcoal for domestic and non-household use. Doubling the efficiency of biomass stoves, a thing that has been achieved in other developing countries such as Kenya and Sudan, could save households about 1 bag of charcoal a month, which at present costs about ZK 100 per bag. If improved stoves were popularized so that they became standard household items the country could save a considerable amount of energy.

136. The objective of the project is to establish a Stove Unit capable of designing, adapting, evaluating, improving stoves and getting them commercially made in collaboration with artisans, stove manufacturers and other relevant institutions. It is proposed that the Unit be attached to the National Council for Scientific Research.

137. The Unit will require donor support for an initial period of 5 years after which Government should take over.

Output

138. Design, testing, marketing and commercial production of improved household, commercial and institutional stoves using all types of energy particularly charcoal and firewood. The design and commercial production of cheap electrical rings/hotplates.

139. The task of the stove unit will be to:

(a) undertake market research to find out the kind of stoves (and utensils) people and institutions etc. desire. Existing stove and stove programs should be examined to determine their advantages and disadvantages;

(b) design in co-operation with industry and artisans stoves that can be manufactured from local materials, keeping the foreign exchange cost as low as possible;

(c) Laboratory test the stoves and if satisfactory, field test them;

(d) Modify the stoves as a result of both laboratory and field tests;

(e) Undertake field tests and keep modifying until a satisfactory product is made;

(f) Assist if necessary the producers in establishing stove manufacturing units and follow up with advice, quality control and modifications;

(g) Give the stoves seals of approval and constantly check that quality is being maintained;

(h) Run demonstration and advertisement campaigns to popularize the stoves - both households and non-households stoves;

(i) Look at ways of further improving the stoves and utensils; and

(j) Undertake detailed costing analyses at all stages.

140. In order to undertake these recommendations there should be courses and on the job training for artisans and continual research and development to improve stoves and utensils.

Estimated Budget (US $)

141. The estimated budget for the establishment of this Unit is as follows: It is in two parts, the first part is to run the project for

five years and the second part is a loan fund to enable potential stove manufacturers to purchase equipment such as clay mixing, molding, kilns, sheds etc. and to help artisans with tools etc. This will be a revolving fund to be administrated by an appropriate organisation such as the Small Industry Development Organization (SIDO).

	US $
1. Equipment (Clay working equipment, kilns etc)	200,000
2. Materials (Clay, metal, tools for development and teaching	100,000
3. Vehicles (1 lorry, 4 four wheel drive vehicle - of which 2 for demonstration/survey unit).	120,000
4. Vehicle Running costs (5 years)	325,000
5. Manpower (5 years) a/	150,000
6. Long Term expert (3 years)	360,000
7. Consultancies (spread over 5 years)	100,000
8. Field trips allowances & visits abroad	125,000
9. On Job Training for artisans	100,000
10. Office accommodation	50,000
11. House for expert	50,000
12. Demonstration/Survey Unit	150,000
13. Office equipment	52,000
14. Contingencies (10%)	188,000
Sub total	2,070,000
15. Loans to artisans/industry	500,000
Total	2,570,000

a/ Manpower: 2 Engineers/scientists
3 Technicians
1 Economist
1 Sociologist
5 Drivers
1 Secretary
1 Messenger

Project 9: Evaluation of the Popularisation of the Improved Charcoal Stove

Objective

142. The Department of Energy in conjunction with the Non-Governmental Organisation Co-ordinating Committee, has been promoting an improved charcoal stove that was developed by the University of Zambia. The popularisation program was started in July 1988 and has a) involved the training of artisans, operating both from their homes and markets, on the making of stoves and b) conducting demonstrations in various places on the efficient use of stoves. The program started in Lusaka but has

now moved to the Copperbelt. Indications are that there is a wide acceptance of the improved stove.

143. Over one year has passed since the launching of the program, and now there is need for a critical evaluation of this stove to measure the impact on the household budget and fuel saving, and to assess other attributes. It is also necessary to evaluate the method of popularisation being followed in order to evaluate its effectiveness.

144. It is, therefore, recommended that an evaluation exercise be undertaken as soon as possible to determine, quantitatively, to what extent the objectives are being fulfilled and to recommend if necessary, more effective way of popularising the stove should any short-comings be identified.

145. This project should also assist the Department of Energy to build some experience in evaluating such programs. This kind of experience is necessary especially in view of the proposed Stove Unit with which the Department will have a close collaboration.

146. The evaluation exercise should be done over a period of 6 months and start as soon as possible.

Output

147. The survey will give information to the improved stove program as to the penetration and use of the stove with an estimation of the charcoal saving and other attributes. It will also give pointers as to the drawbacks of the stove, if any, which could lead to design improvements.

The estimated cost for this exercise is as follows:

ESTIMATED BUDGET (in US$)

1. Manpower	7,000
2. Materials	1,000
3. Fuel cost	1,000
4. Contingency	1,000
Total	10,000

Project 10: Strengthening of the Department of Energy

Objective

148. This Household Energy Strategy Project has demonstrated to the Government of Zambia the importance of collecting reliable basic

information so that energy planning and the development of a meaningful energy strategy can be formulated with confidence. The collection of information is an on going exercise and should not be confined to the urban household sector but be expanded to include industry, the service sector and the rural areas.

149. In order to expand the work of data collection and analysis, further staff need to be recruited so that such thing as monitoring the trade in fuelwood and charcoal can continue and backing is given to the proposed stove unit to undertake market analyses and consumer acceptability surveys. More work is required to monitor energy prices and their seasonal fluctuations. Also the DOE should be in a position to issue policy guidelines to Government etc. On a regional basis the department should liaise with the SADCC energy Technical Administrative Unit (TAU) in Angola and the forestry unit in Malawi.

150. Thus the Department of Energy is seeking support for three years to build up its strength so as to recruit and train more staff in established positions.

Output

151. Continued household energy assessments both in urban and rural areas. Undertake energy assessments for industry and the service sectors. Market analyses and consumer acceptability surveys for all types of stoves. Monitoring trade in fuelwood and charcoal. Advising Tazara Corridor Committee on charcoal production from land clearing. Assisting the charcoal producer's survey. Advising Government on energy policy and co-ordinating regional initiatives through SADCC.

Budget (US $)

152. The budget is for three years, by that time the staff should be on the Government's payroll and local funds should be available to run the equipment and vehicles:

1. Manpower- salaries and allowances a/	65,000
2. Vehicle replacement (year 3) - three 4 wheel drive vehicles	45,000
3. Vehicles running costs	90,000
4. Equipment running costs	10,000
5. Publication and office equipment	8,000
6. Contingencies (10%)	22,000
Total	240,000

a/ 1 Co-ordinator, 2 Professionals, Enumerators, 3 Drivers, 2 Watchmen

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

Country	Project	Date	Number
ENERGY EFFICIENCY AND STRATEGY			
Africa			
Regional	The Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development	3/90	112/90
	Participants' Reports - Regional Power Seminar on Reducing Electric System Losses in Africa	8/88	087/88
Bangladesh	Power System Efficiency Study	2/85	031/85
Bolivia	La Paz Private Power Technical Assistance	2/90	111/90
Botswana	Pump Electrification Prefeasibility Study	1/86	047/86
	Review of Electricity Service Connection Policy	7/87	071/87
	Tuli Block Farms Electrification Prefeasibility Study	7/87	072/87
Burkina	Technical Assistance Program	3/86	052/86
Burundi	Presentation of Energy Projects for the Fourth Five-Year Plan (1983-1987)	5/85	036/85
	Review of Petroleum Import and Distribution Arrangements	1/84	012/84
Burundi/Rwanda/Zaire (EGL Report)			
	Evaluation de l'Energie des Pays des Grands Lacs	2/89	098/89
Congo	Power Development Study	5/90	106/90
Costa Rica	Recommended Technical Assistance Projects	11/84	027/84
Ethiopia	Power System Efficiency Study	10/85	045/85
The Gambia	Petroleum Supply Management Assistance	4/85	035/85
Ghana	Energy Rationalization in the Industrial Sector of Ghana	6/88	084/88
Guinea-Bissau	Recommended Technical Assistance Projects in the Electric Power Sector	4/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors	2/90	100/90
Indonesia	Energy Efficiency Improvement in the Brick, Tile and Lime Industries on Java	4/87	067/87
	Power Generation Efficiency Study	2/86	050/86
	Diesel Generation Efficiency Improvement Study	12/88	095/88
Jamaica	Petroleum Procurement, Refining, and Distribution	11/86	061/86
Kenya	Power System Efficiency Report	3/84	014/84
Liberia	Power System Efficiency Study	12/87	081/87
	Recommended Technical Assistance Projects	6/85	038/85
Madagascar	Power System Efficiency Study	12/87	075/87
Malaysia	Sabah Power System Efficiency Study	3/87	068/87
Mauritius	Power System Efficiency Study	5/87	070/87
Mozambique	Household Electricity Utilization Study	5/90	113/90
Panama	Power System Loss Reduction Study	6/83	004/83
Papua New Guinea	Energy Sector Institutional Review: Proposals for Strengthening the Department of Minerals and Energy	10/84	023/84
	Power Tariff Study	10/84	024/84

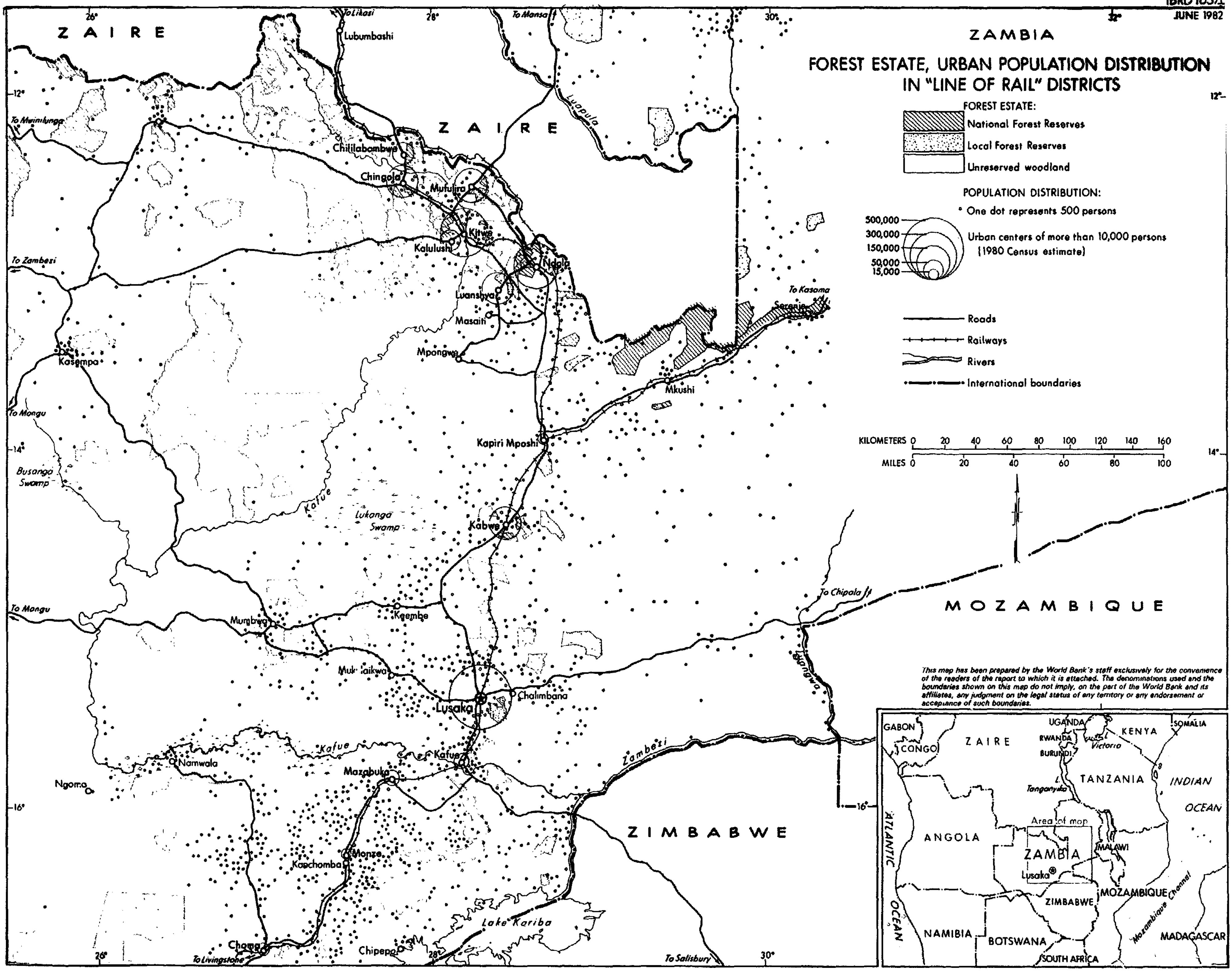
ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

Activities Completed

Country	Project	Date	Number
ENERGY EFFICIENCY AND STRATEGY (Continued)			
Senegal	Assistance Given for Preparation of Documents for Energy Sector Donors' Meeting	4/86	056/86
Seychelles	Electric Power System Efficiency Study	8/84	021/84
Sri Lanka	Power System Loss Reduction Study	7/83	007/83
Syria	Electric Power Efficiency Study	9/88	089/88
	Energy Efficiency in the Cement Industry	7/89	099/89
Syria	Energy Efficiency Improvement in the Fertilizer Sector	6/90	115/90
Sudan	Power System Efficiency Study	6/84	018/84
	Management Assistance to the Ministry of Energy and Mining	5/83	003/83
Togo	Power System Efficiency Study	12/87	078/87
Tunisia	Interfuel Substitution Study	5/90	114/90
Uganda	Energy Efficiency in Tobacco Curing Industry	2/86	049/86
	Institutional Strengthening in the Energy Sector	1/85	029/85
	Power System Efficiency Study	12/88	092/88
Zambia	Energy Sector Institutional Review	11/86	060/86
	Energy Sector Strategy	12/88	094/88
	Power System Efficiency Study	12/88	093/88
Zimbabwe	Petroleum Supply Management	2/90	109/90
	Power Sector Management Assistance Project: Background, Objectives, and Work Plan	4/85	034/85
	Power System Loss Reduction Study	6/83	005/83
HOUSEHOLD, RURAL, AND RENEWABLE ENERGY			
Burundi	Peat Utilization Project	11/85	046/85
	Improved Charcoal Cookstove Strategy	9/85	042/85
Cape Verde	Household Energy Strategy Study	2/90	110/90
China	Country-Level Rural Energy Assessments: A Joint Study of ESMAP and Chinese Experts	5/89	101/89
	Fuelwood Development Conservation Project	12/89	105/89
Costa Rica	Forest Residues Utilization Study, Volumes I & II	2/90	108/90
Côte d'Ivoire	Improved Biomass Utilization--Pilot Projects Using Agro-Industrial Residues	4/87	069/87
Ethiopia	Agricultural Residue Briquetting: Pilot Project	12/86	062/86
	Bagasse Study	12/86	063/86
The Gambia	Solar Water Heating Retrofit Project	2/85	030/85
	Solar Photovoltaic Applications	3/85	032/85
Ghana	Sawmill Residues Utilization Study, Vol. I & II	10/88	074/87
Global	Proceedings of the ESMAP Eastern and Southern Africa Household Energy Planning Seminar	6/88	085/88
India	Opportunities for Commercialization of Non-Conventional Energy Systems	11/88	091/88
Indonesia	Urban Household Energy Strategy Study	2/90	107/90
Jamaica	FIDCO Sawmill Residues Utilization Study	9/88	088/88
	Charcoal Production Project	9/88	090/88

Activities Completed

Country	Project	Date	Number
HOUSEHOLD, RURAL, AND RENEWABLE ENERGY (Continued)			
Kenya	Solar Water Heating Study	2/87	066/87
	Urban Woodfuel Development	10/87	076/87
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry	11/83	009/83
Mauritania	Elements of a Household Energy Strategy	7/90	123/90
Mauritius	Bagasse Power Potential	10/87	077/87
Niger	Household Energy Conservation and Substitution	12/87	082/87
	Improved Stoves Project	12/87	080/87
Pakistan	Assessment of Photovoltaic Programs, Applications and Markets	10/89	103/89
Peru	Proposal for a Stove Dissemination Program in the Sierra	2/87	064/87
Rwanda	Improved Charcoal Cookstove Strategy	8/86	059/86
	Improved Charcoal Production Techniques	2/87	065/87
Senegal	Industrial Energy Conservation Project	6/85	037/85
	Urban Household Energy Strategy	2/89	096/89
Sri Lanka	Industrial Energy Conservation: Feasibility Studies for Selected Industries	3/86	054/86
Sudan	Wood Energy/Forestry Project	4/88	073/88
Tanzania	Woodfuel/Forestry Project	8/88	086/88
	Small-Holder Tobacco Curing Efficiency Project	5/89	102/89
Thailand	Accelerated Dissemination of Improved Stoves and Charcoal Kilns	9/87	079/87
	Rural Energy Issues and Options	9/85	044/85
	Northeast Region Village Forestry and Woodfuel Pre-Investment Study	2/88	083/88
Togo	Wood Recovery in the Nangbeto Lake	4/86	055/86
Uganda	Fuelwood/Forestry Feasibility Study	3/86	053/86
	Energy Efficiency Improvement in the Brick and Tile Industry	2/89	097/89
Zimbabwe	Charcoal Utilization Prefeasibility Study	6/90	119/90


IBRD 16370
JUNE 1982
ZAMBIA
FOREST ESTATE, URBAN POPULATION DISTRIBUTION IN "LINE OF RAIL" DISTRICTS
FOREST ESTATE:
National Forest Reserves
Local Forest Reserves
Unreserved woodland
POPULATION DISTRIBUTION:
One dot represents 500 persons
500,000
300,000
150,000
50,000
15,000
Urban centers of more than 10,000 persons (1980 Census estimate)
Roads
Railways
Rivers
International boundaries
KILOMETERS 0 20 40 60 80 100 120 140 160
MILES 0 20 40 60 80 100
ZAIRE
ZAIRE
MOZAMBIQUE
ZIMBABWE
To Likasi
Lubumbashi
To Mansa
Luapula
To Mwinilunga
Chililabombwe
Chingola
Mufulira
Kitwe
Kalulushi
Ndola
Luanshya
Masaiti
Mpongwe
To Kasama
Serenje
Mkushi
To Zambezi
Kasempa
To Mongu
Kapiri Mposhi
Busango Swamp
Kafue
Lukanga Swamp
Kabwe
To Chipata
To Mongu
Mumbwa
Keembe
Mukonchaikwa
Lusaka
Chalimbana
Luangwa
Kafue
Kafue
Namwala
Mazabuka
Ngoma
Zambezi
Monze
Kaochomba
Lake Kariba
Choma
Chipepo
To Livingstone
To Salisbury
26°
28°
30°
32°
12°
14°
16°
This map has been prepared by the World Bank's staff exclusively for the convenience of the readers of the report to which it is attached. The denominations used and the boundaries shown on this map do not imply, on the part of the World Bank and its affiliates, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.
GABON
CONGO
ZAIRE
UGANDA
KENYA
SOMALIA
RWANDA
BURUNDI
Victoria
TANZANIA
Tanganyika
INDIAN OCEAN
ATLANTIC OCEAN
ANGOLA
Area of map
ZAMBIA
Lusaka
MALAWI
ZIMBABWE
MOZAMBIQUE
Mozambique Channel
NAMIBIA
BOTSWANA
SOUTH AFRICA
MADAGASCAR