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FINAL REPORT

DIRECTORY OF RURAL ENERGY PROGRAMMES IN SOUTHERN AFRICA

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FINAL PROJECT REPORT

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GLOSSARY

ACRONYMMS

ATS - Appropriate Technology Section, Lesotho

BTC - Botswana Technology Centre

Eskom - South Africa's electricity supply authority

FAO - Food and Agricultural Organisation, United Nations

FPP - Fuelwood and Poles Project, Lesotho

GDP - Gross domestic product

GTZ - Gesellschaft fur Technische Zusammenarbeit (German Agency for Technical Cooperation)

IDA - International Development Agency, World Bank

ITDG - International Technology Development Group

IVS - International Voluntary Services

LWP - Lesotho Woodlots Project

NORAD - Norwegian Aid Agency

NUL - Natioal University of Lesotho

NIR - National Institute for Research and Documentation, Botswana

NGO - Non-governmental organisation

ODA - Overseas Development Administration, UK

PV - Photovoltaic

RIIC - Rural Industries Innovation Centre, Botswana

RSA - Republic of South Africa

SADCC - Southern African Development Coordinating Conference

SEB - Swaziland Electricity Board

SENN - SADCC Energy NGO's Network

TAU - Technical and Administration Unit of SADCC

UNDP - United Nations Development Programme

UNESCO - United Nations Education, Scientific and Cultural Organisation

UNIDO - United Nations Industrial Development Organisation

USAID - United States Agency for International Development

WEP - Wood Energy Project, Malawi

WFP - World Food Programme, United Nations
WID - Women in Development, United Nations

DEFINITIONS AND UNITS

GWh - Gigawatt Hour (10^6 kWh)
MW - Megawatt (10^6 Watt)
kW - Kilowatt (10^3 Watt)
kWh - Kilowatt-hour, Basic unit of electricity consumption
PJ - Petajoule (10^{15} Joules)
Nett Energy - Energy as physically used by the consumer and includes inherent wastage from inefficient use.
Primary Energy - An energy form in which there has been chemical or thermodynammic transformation before use. Where secondary energy fuels (such as electricity) are imported, they may be refered to as primary energy sources with respect to that country.

MONITARY EXCHANGE RATES

Exchange Rate equivalent to 1-00 SA Rand (July,1990)

Botswana - 0.689 P (Pula)
France - 2.04 FF (French Franc)
Lesotho - 1.00 M (Maloti)
Malawi - 1.035 MK (Malawi Kwatcha)
Norway - 2.36 NOK (Norwegian Kroner)
Swaziland - 1.00 E (Elangeni)
USA - 0.38 US$ (US Dollar)
Zambia - 14.85 ZK (Zambia Kwatcha)
Zimbabwe - 0.925 Z$ (Zimbabwe Dollar)

ACKNOWLEDGEMENT

The Energy Research Institute at the University of Cape Town acknowledges the financial assistance of the National Energy Council. The authors would also like to thank those people and organisations who so freely shared information and experiences on appropriate energy programmes in the region.

PREFACE

This Directory of projects and programmes which focus on the energy problems of rural areas in southern Africa updates an earlier directory compiled by the Energy Research Institute in 1984 and covering Lesotho, Botswana, Swaziland and Zimbabwe. The latest directory has been expanded to include Malawi and Zambia and also to include overviews of the national energy situation and the energy policies of each of these countries.

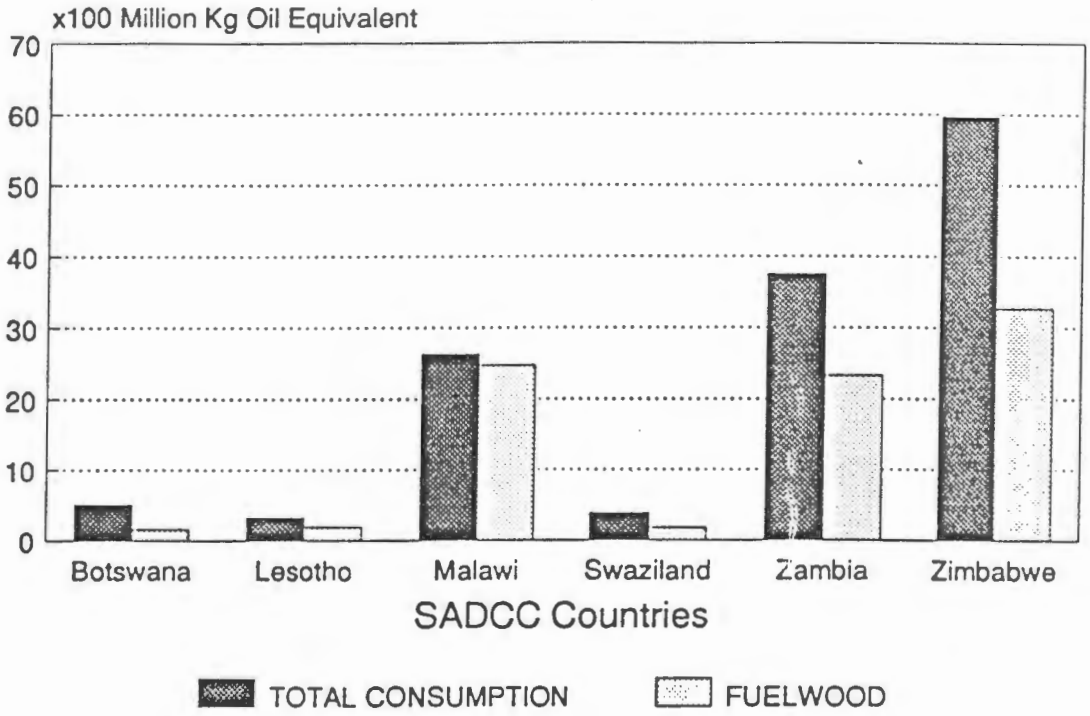
There have been a large number of rural energy programmes in these countries, most of them initiated and funded by foreign aid organisations. In many respects, South Africa lags behind in the range and extent of its involvement in, and commitment to, rural energy programmes. While its research and technical capability and resources are large in comparison with its neighbours, there is much room to learn from the experience of the many projects reviewed in this directory.

The directory entries are arranged alphabetically by country. For each of the countries covered, there is a short introduction covering the national energy situation and energy policies of that country, followed by a selected review of energy programmes which focus on rural areas. Project publications are listed where appropriate. At the end of each country entry is a short list of further projects and supply companies active in the area, but for whom sufficient information could not be obtained to construct a full directory entry. References in the text are listed at the end of the directory along with a bibliography of further relevant publications.

INTRODUCTION

Detailed breakdown of energy consumption data is presented under each country entry. It is interesting however to compare the total energy consumption of and the relative importance of fuelwood.

Figure 1. Nett Annual Energy Consumption in Six SADCC Countries for 1986



Source: SADCC (1987)

In all countries, bar Botswana and Swaziland, fuelwood accounts for more than half of the total energy consumed while in Malawi it is more than 90% of the total. In terms of total energy consumed, Zimbabwe, Zambia and Malawi have the highest figures. This is a reflection of both the degree of development (as in Zimbabwe) and the magnitude of the country's population. The importance of fuelwood in the total consumption is an indication of the lack of development as well as an indication of the rural/urban population split.

A comparison of populations and per capita energy consumption for each country is shown in the charts below.

Figure 2. Population in Six SADCC Countries in 1986

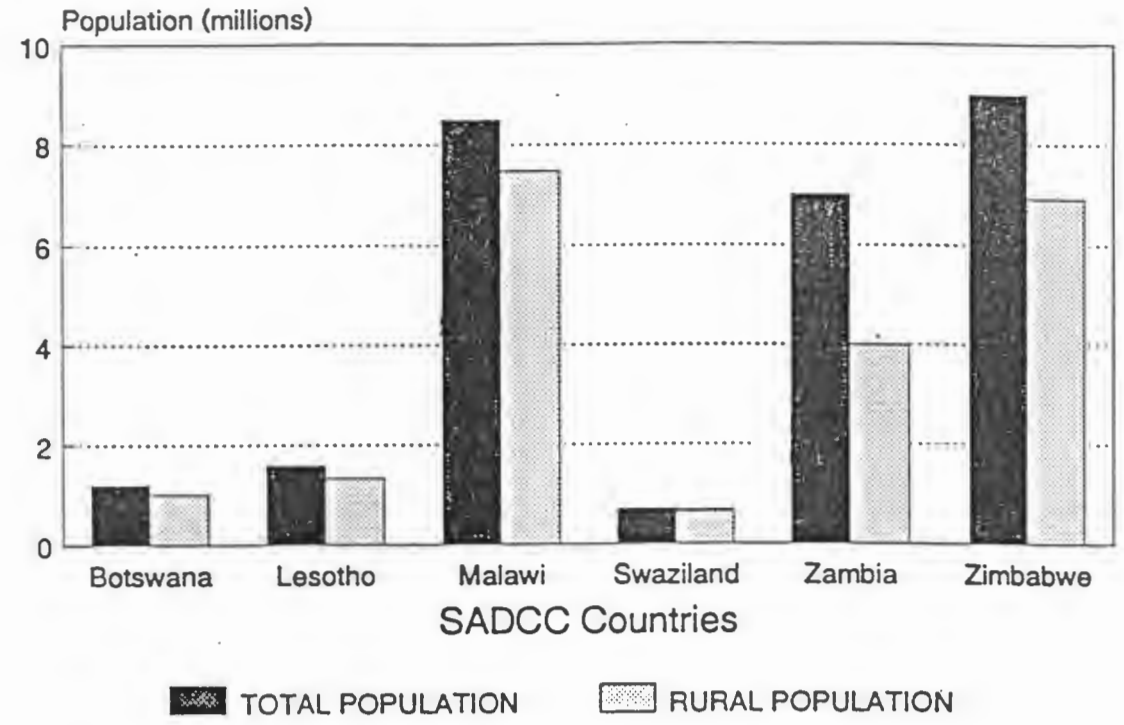
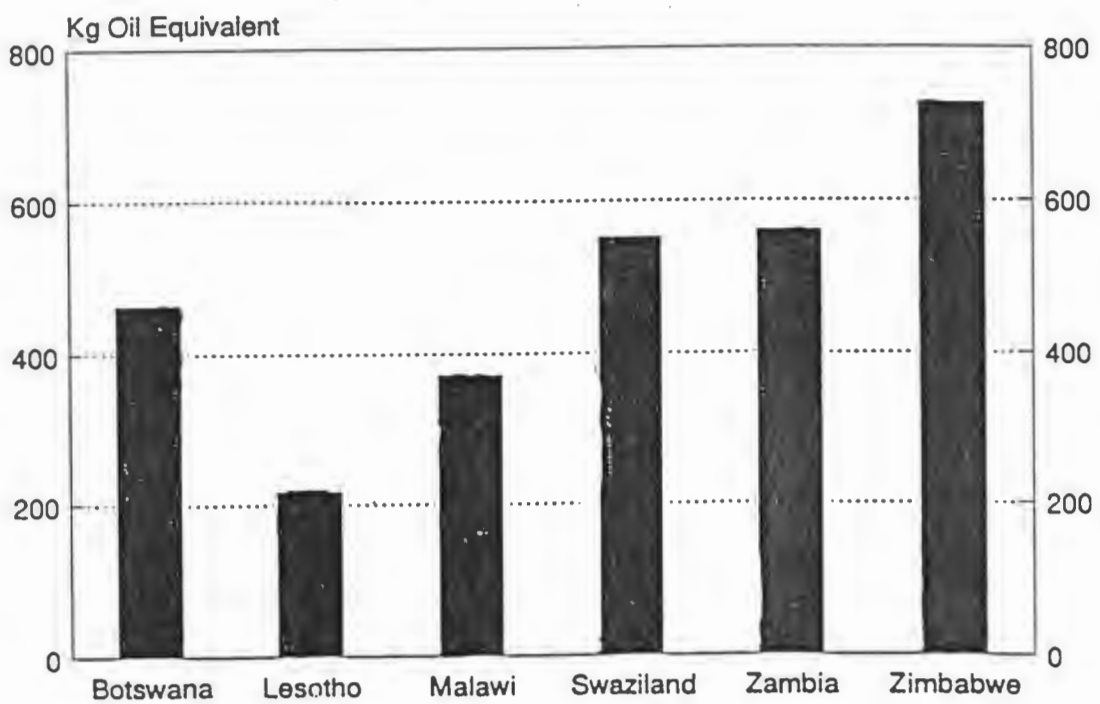


Figure 3. Per Capita Nett Energy Consumption in Six SADCC Countries in 1986



Source: SADCC (1987)

Lesotho and Malawi, which are both highly dependent on fuelwood, have the lowest per capita consumption figures. The other countries have a stronger industrial base consuming commercial fuels and thus reflect a higher per capita consumption.

Three main problems have characterised the energy situation in Botswana, Lesotho, Malawi, Swaziland, Zambia and Zimbabwe during the last decade, namely their dependence on the import of oil and oil-based products; the lack of significant intra-regional energy exchanges; and the depletion of fuelwood resources. Most of the current activity in the field of energy supply is thus being directed at these three problems.

In the first case, the problematic dependence on oil and oil-based products is being addressed through conservation measures in industry, substitution with other fuels, oil and natural gas exploration projects, and the constructing or upgrading of refineries and fuel stores. The extent of these projects differs from country to country.

The lack of a well developed intra-regional energy exchange is also a cause for concern. With the exception of electricity, most energy imports and exports are directed at either South Africa or the world markets. Improved intra-regional trade would reduce the cost of energy for many countries, on the other hand it would possibly not favour exporting countries' needs for foreign currency. There are a number of southern African countries with cross-border electricity supply arrangements and some current projects aim at increasing these links.

In all of the countries reviewed here, the consumption of coal, oil and electricity is largely confined to the modern industrial and commercial sector; and households in urban areas. The first two problems mentioned impact mainly on these sectors, and not surprisingly account for the largest portion of energy project funding. However, it is the third major energy problem, that of vanishing wood resources, that forms the focus for most of the programmes and projects reviewed here. Wood is the most widely used

energy source in rural areas and all of the countries suffer in some way from wood shortages, either on a regional or national scale. The majority of rural energy programmes thus deal with the problem of fuelwood shortage. This can be tackled in programmes concentrating on either:

- increasing the stock of available trees, such as in woodlots, plantations and tree-planting programmes;
- increasing the efficiency with which fuelwood is used, through the introduction of improved stoves and improved charcoal burners; or
- promoting and encouraging the use of alternatives to wood such as biogas, solar energy and rural electrification.

There are also other energy requirements in rural areas that do not traditionally use wood and chief among these is energy for water lifting. In underdeveloped rural areas, water for human consumption or crop irrigation is usually collected by hand from open streams or springs or is lifted manually from wells. Water lifting technologies which ease this arduous and time-consuming task include animal-powered pumps, biogas-powered diesel pumps, windmills and photovoltaic pumps. A number of the projects reviewed are active in this field.

The listing of organisations involved in rural energy and the review of their activities does not necessarily mean that they are all equally effective in their aims. Some of the constraints on the dissemination of appropriate energy technologies identified in this review are discussed below.

Almost all the programmes reviewed suffered from a lack of suitably trained managerial, technical and field staff. In some countries, the shortage of skills is a widespread problem, while in others it is due to the "unglamorous" nature of rural work or the low salaries paid. In Lesotho one project engineer claimed that although there were many Basotho engineers and technicians, they preferred to seek work in South Africa because of higher salaries and better conditions. The same person said that a serious (although temporary) staff shortage had been created by the workforce demands of the Lesotho Highlands Water Scheme.

The lack of developed communication and transport infrastructures in rural areas means that information gathering, communication and dissemination must be done by a large complement of workers in the field. Some projects, particularly in afforestation where large numbers of staff are required, have had to include staff training as an integral part of their work. In other projects, staff shortage means that field work has to be done through existing infrastructures, by people such as teachers and rural health workers. In many cases these people are not adequately trained or receive no extra pay for the additional work of disseminating the new technologies.

The shortage of local trained staff is often made up by the importation of "specialist" volunteer workers. Their employment is essentially free since their salaries are paid for by the aid organisations they represent. The disadvantage is that they are often unfamiliar with local language, culture and conditions. Those at a lower "hands-on" level are also seldom assigned to projects for very long and the resultant lack of continuity is detrimental to the project.

Lack of continuity in development projects is not only a result of staff turnover. When financial and technical aid is received for rural energy projects, it is usually a specific amount allocated to a specific project to be completed over an agreed time span. This arrangement, together with the fact that the local development programme management structures in many countries are poorly established often means the collapse of a particular programme when funding runs out. The process of rural development is by its nature a long-term affair, and a parallel long-term continuity in development programmes is critical to their success. The number of important projects which have not offered this continuity is evident by comparing this review with a similar one conducted in 1984 by Eberhard (1984).

A common denominator of almost all rural development projects and programmes in the region (including those around energy), whether managed by central governments or non-governmental organisations (NGO's), is their dependence on foreign aid. This can be in the form of grants, low-interest loans, or supply of equipment or specialist personnel. The proportion of budgets made up by foreign aid varies for different projects but is often substantial compared to locally raised funds. Although it is difficult

to isolate aid specifically directed to rural energy programmes, some of the individual programmes reviewed give an indication of funding amounts.

Receiving foreign aid can cause an unhealthy dependency. It is reasonable that before granting aid, foreign funders require to know how, and on what their aid will be spent. However, in some cases aid may be refused, or projects modified, because the funding organisation does not agree with the local development strategy, or wishes to push a particular technology. Aid is seldom granted without attached conditions, and unfavorable compromises may have to be made on the part of the local organisations. Where local development institutions are not well established, it is left to overseas organisations themselves to identify and promote rural development strategies. Unfamiliarity with local language, culture and conditions may affect such projects. Going some way towards localising the base of experience and expertise, and thus reducing the technological dependence on foreign organisations, is the establishment of regional networks of local experts and organisations involved in energy issues (such as SADCC's Energy Sector TAU, and the NGO network, SENN), who while relying on foreign funds, are arguably in a better position to develop and implement rural energy strategies in their own countries.

Despite problems with foreign aid, many of the projects reviewed here, which have indeed contributed much to rural development, would not exist without it. There are other factors pointing to the success or failure of a project and chief among these is the approach to technology dissemination and the choice of technology.

Organisations involved in rural energy projects obviously regard rural energy supplies as an important prerequisite to rural development. However local rural communities may have a different priority of needs and may rank energy supply below a number of other unfulfilled needs. There is a growing realisation among development organisations of the importance of multi-faceted programmes which focus on community development rather than on a specific issue such as wood shortage. Within such a programme, the accurate definition of the "energy problems" facing rural communities is critical. A fuelwood shortage, for example, may be problematic to the local community because it means longer hours spent collecting or more money spent buying wood. Development organisations however, may view it as primarily a

deforestation problem leading to soil erosion and other negative ecological consequences. The two different classifications of the problem invariable lead to a mismatch in the technology proposed to solve it and highlight the requirement for an accurate pre-project needs assessment in rural communities, covering the full range of basic needs, not only those around energy. The choice of a particular technical solution to the energy problem as perceived by the communities themselves is far more likely to prove successful.

The involvement of rural communities from the beginning is critical. Projects which have been imposed from the top down, such as many of the woodlot and stove projects reviewed here, have not resulted in widespread adaptation of new technologies. More success has been achieved where aid agencies and NGO's have worked closely with local communities, adopting the role of facilitators and assisting in widening the choice of possible appropriate technologies and strategies. Rural communities often operate within traditional systems of consensus decision-making. New initiatives have to be preceded by lengthy discussion. The adoption of new technologies also involves risks for poor households struggling to survive within marginal agricultural systems and with little availability of surplus energy or capital. New technology also provides opportunities, not only for social and economic advance, but also for empowerment. These processes are greatly facilitated by interventionist agencies encouraging communities to organise, assume responsibility and control new projects before and during their implementation.

The success of technology dissemination depends as much on the type of technology as on the approach to dissemination. That successful dissemination should by definition be a self-sustaining process is not recognised sufficiently by many development organisations. Large state-run projects such as rural electrification can afford to recover costs over a long time period, but for most smaller organisations, new technologies introduced must become economically viable over a much shorter period. In this respect it is important that, once initially disseminated, the manufacture and distribution of the new technologies be broadened and to include as far as possible, organisations and individuals located in the rural communities, be they artisans, self-help groups, small-farmers or traders.

South Africa has to a large extent been isolated from the mainstream development activity initiated by international aid agencies and, by comparison to her neighbours, the funding (local or foreign) directed towards rural development programmes is small. Among those that have received funding are institutions tied to "homeland" governments whose efforts at rural development have been seen by many as furthering apartheid policy. Many autonomous NGO's operating in South Africa are also at a disadvantage in that, although they may be in a position to raise foreign funds they are denied access to the regional and international NGO networks promoting joint action and information dissemination.

In comparison to its neighbours, South Africa has enormous resources and a substantial technical base. Hopefully, these will begin to be divided in part towards the problems of underdevelopment in rural areas in the region. Hopefully too, cognizance will be taken of the experience of projects and the problems of technology dissemination which are highlighted in this directory of rural energy programmes in southern Africa.

REGIONAL

SADCC ENERGY SECTOR
TECHNICAL AND ADMINISTRATIVE UNIT

ADDRESS: Rua Gil Vincente No.2
Box 2876
Luanda
Angola
Tel: 345 288/147
Telex: 4090 TAUANG (AN)

CONTACT PERSON: Mr. Feao, Regional Coordinator

SUMMARY:
The Technical and Administrative Unit (TAU) of the SADCC Energy Sector acts on behalf of SADCC member countries as a co-ordinating body for energy activities and regional energy programmes. The aims are broadly to secure reliable and cost effective energy supplies for all member states by promoting intra-regional trade and co-operation in energy matters. This is done through organising workshops and seminars, collecting and publishing energy data, and developing regional energy strategies.

The TAU has a library and computerised energy data base and regularly publishes energy statistics and related information about SADCC member countries.

Recent work in the field of rural energy supplies has included:

- The commissioning and publication of comprehensive national surveys of the biomass/fuelwood situation and activities in each member country and the development of common fuelwood models and methodologies for the implementation of effective measures against deforestation;
- The commissioning and publication of comprehensive national surveys of new and renewable energy activities in each member country. There are plans to establish a SADCC Research Centre which will serve to pool experience and research efforts in new and renewable energy technologies for the benefit of member countries; and

- The development of a comprehensive rural electrification programme (including the identification of geographic areas where concrete projects can be implemented over the next 20 years) for each member country and the publication of a Rural Electrification Manual.

SADCC REGION ENERGY NGO'S NETWORK

ADDRESS: 11 Samora Machel Ave.
Harare
Zimbabwe
Tel: 732 858
Telex: 22718 CUSZIM ZW

FUNDING: Inter-Pares
NORAD

SUMMARY:
The SADCC Region Energy NGO's Network (SENN) was established in 1987 with the broad objectives being:

- to co-ordinate the efforts of NGO's in initiation, implementation, dissemination and promotion of energy related activities in the SADCC region;
- to concentrate on the co-ordination, exchange and documentation of activities of Member Organisations in new and renewable sources of energy;
- to keep SADCC countries informed on the role played by NGO's in energy related activities; and
- to promote sharing of scarce resources within the region so that knowledge, skills, and materials required in the energy field are optimally used.

SENN's involvement in specific energy programmes is un-prescriptive, since its aim is to increase the capacity of NGO's to manage and implement their own projects. The network serves primarily as a channel through which information, expertise and technical support can be directed to NGO's who require it. It also encourages the sharing of resources and experience between NGO's and provides a critical link between SADCC structures and donors. The activities of SENN in each of it's member countries are co-ordinated through appointed representatives. The Zimbabwian organisation ZERO currently acts as SENN's secretariat. A regular newsletter is published through the Botswana Technology Centre.

BOTSWANA

INTRODUCTION

The Country

Botswana has a land area of about 582 000 square km. The country is remarkably flat with an altitude between 900 m and 1200 m. The annual rainfall ranges from 250 mm in the south-west to 650 mm in the north-east. In general, rainfall is sporadic and the whole country is prone to severe droughts from time to time. Temperature ranges are severe from 40°C in the summer daytime to well below freezing on winter nights.

Botswana has a population of about 1.2 million with an estimated population growth rate of 3.6% per annum. Roughly 84% of the population are rural. The vast majority of people live in a belt along the eastern border of the country where the climate and soil fertility allow some cultivation. This belt contains all of the major urban settlements as well as 80% of the rural population.

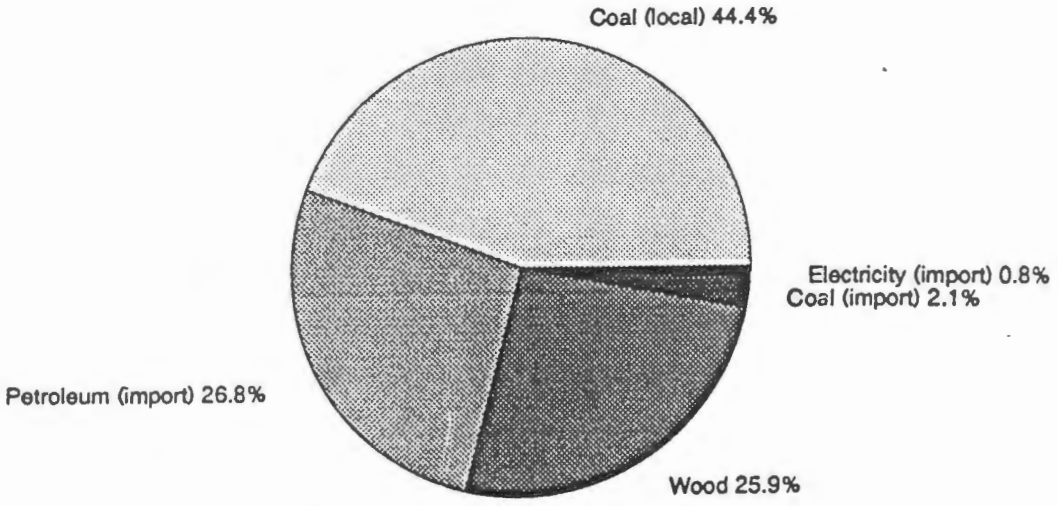
From being one of the poorest SADCC countries at the time of its independence a few decades ago, the exploitation of mineral deposits of copper-nickel, diamonds and coal in recent years has seen Botswana grow to be the richest. The mineral boom has totally transformed the economy, boosting the GNP at rates between 12 and 13 percent annually. The estimated GDP per capita is currently around US$ 900. However, this growth has been concentrated largely in the urban areas, with much of its benefits bypassing rural people. While traditional agriculture provides a livelihood for some 80% of the population, agriculture's contribution to the GNP is as low as 11%. The skewness of wealth distribution is reflected in the comparative energy consumption patterns in rural and urban areas. A 1982 survey showed that the per capita consumption of non-commercial energy in the rural areas was about twice that of urban areas, while the consumption of commercial energy in urban areas was 42 times higher than in rural areas.

The economy of Botswana is closely tied to that of the Republic of South Africa largely because most import and export trade is either based in the RSA or has to pass through its borders. In addition, almost all the investment capital in the modern sector is supplied by South African-based companies.

Energy Consumption and Resources

The relative importance of the different primary energy sources in Botswana is indicated in the chart below:

Figure 1. Primary Energy Consumption in Botswana by Source

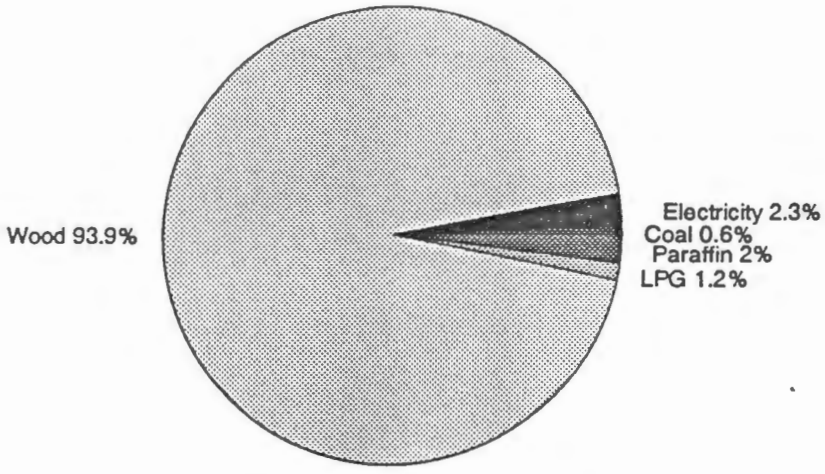


Source: SADCC (1989a)

The proportional consumption of wood reported above is considerably below the average for African countries, and may represent an underestimation. Two different sources gives this figure as 50% (Earthscan,1984:9) and 41% (calculated from Kgathi,1987:35).

The total national energy consumption is just over 31 PJ of which about 27% is consumed by households. Fuel use in households is given in Fig.2.

Figure 2. Household Energy Consumption in Botswana by Fuel Type



Source:SADCC (1989a)

Fuelwood satisfies the major portion of household energy needs and is particularly important in the rural areas. Fuelwood consumption estimates range from 0.57 m^3 (404 kg) to 1.25 m^3 (887 kg) per capita/year, while it is estimated that the natural regeneration of woodland is around 1.25 m^3/ha/year. There is evidence in many areas that the natural woodland resource is being depleted and considerable efforts will be required in the future to counter this. The deforestation problem is exacerbated because of the concentration of the rural population in a narrow strip along the eastern border of the country. There is no data on the extent of natural forestation in the country but there is no doubt that it is insufficient to support the growing rural population. Afforestation programmes were started some years back and by 1981, some 345 ha of woodlots had been established. According to one estimate, by the year 2000 an additional 700 000 ha will need to be planted (Kgathi,1987:30).

Coal is present in large reserves, estimated at around 40 million tonnes. Annual production is currently about 580 000 tonnes of which 73% is used in generating electricity. Only one coal field is currently being worked although two others with potential are being explored. Botswana's coal is of a relatively low grade and has a high

ash content. A small quantity of higher grade coal has to be imported. There is no attractive export market for the low grade coal and because of its relative abundance, local use in households and small industry is being encouraged.

Botswana is virtually self sufficient in electricity. In 1987, 722 GWh were generated locally and 67 GWh imported from Eskom. Generation capacity is currently at 186 MW coal-fired with 12 MW diesel stand-by. The majority of electricity generated is consumed by the mining industry with only about 8% consumed by households.

The country has no indigenous source of petroleum fuels and all are imported, primarily through RSA. Although some large sedimentary basins have been identified below the Kgalagadi, no detailed geophyisical investigations have been done to determine the presence of petroleum resources.

With regard to new and renewable energy sources, there is an excellent solar regime and solar energy technologies such as solar water heaters and solar stills are already being used on a small scale. Most of Botswana has a low wind regime and wind-generated electricity has little potential. However, windmills for water pumping have been used successfully for many years by cattle ranchers. With a national herd size of more than twice the population, there is great potential for biogas production although it would only be feasible in specific instances because the cattle are free-ranging and most cattle posts are remote.

Energy Planning and Policy

Evidence of deforestation and the continued high degree of dependence on wood as a fuel is a genuine cause for concern in Botswana. Wood is used not only for fuel but also as a source for building materials, fencing poles and furniture. Although at a national level there might be areas with a wood surplus, wood depletion is occuring at an alarming rate particularly around major settlements, where the demand for wood from urban households is impinging upon the sources of supply for rural villages (RES Report,1985). Intensively cultivated land, or areas where there is a high concentration of livestock, are also showing signs of deforestation.

In the rural areas of pre-independence Botswana, it was the tribal chiefs who carried the responsibility of woodland control in their particular regions. Control on tree cutting and wood collecting was also reinforced through traditions and customs which the tribal chiefs upheld. Since independence, these powers have been largely abrogated and delegated to land boards and other local authorities and there is now little control over the communal resource. The woodlands have been opened to commercial cutting and even in strongly tribal areas, the chiefs have little control over traders from other tribes or areas. There is also no written law that can be used against uncooperative woodfuel traders.

Although rural development is considered important, the government is at the same time in favour of limited intervention in the economy and aims to create favourable conditions for private initiative. Three key state-run rural development programmes are the Tribal Grazing Land Policy, the Arable Lands Development Program, and the Rural Industries Program, which all aim to direct resources to the creation of rural opportunities. Official policy is reflected in the technology dissemination methods followed by the major rural energy organisations, where emphasis is placed on allowing the private manufacture and distribution of new technologies in a free market. The government also offers incentives for private sector involvement which promotes economic opportunities for the rural population.

There are a number of government and non-government organisations involved in afforestation activities to different degrees and in different ways. Afforestation methods include agroforestry (where food crops are planted together with fruit and woodfuel trees), community-run woodlots, plantations dedicated to providing building and fencing poles, and soil stabilisation projects. In the last two instances, fuelwood is produced only as a by-product. A major constraint to the widespread success of afforestation programmes is the shortage of trained foresters and extension staff. A number of promising projects have been of limited success because of insufficient support.

Efforts to reduce the consumption of wood include the development of a fuel-efficient wood stove and the promotion of coal use in the home together with the development of

a low-cost coal stove. The development of new and renewable energy technologies is being undertaken by a number of state-aided bodies.

BOTSWANA TECHNOLOGY CENTRE

ADDRESS:	Private Bag 0082 Gaborone Tel: 314161 Telex: 2928 TECEN BD Fax: 374677
LOCATION:	Plot 10062 Machel Drive, Gaborone
CONTACT PERSONS:	Mr J. Diphaha, Managing Director Deborah Garraway-Stayers, TIS Manager Victor Meeussen, Systems Engineer
FUNDING:	P 1.25 mill p.a.(approx) Govt. of Botswana
DURATION:	1979 -

OBJECTIVE:

To identify, monitor and promote the development and implementation of technologies appropriate to the current development of Botswana and its economy.

SUMMARY:

The Botswana Technology Centre (BTC) is a non-profit government funded organisation reporting to the Ministry of Finance and Development Planning. BTC consists of the Technical Information Service (TIS), responsible for collection and dissemination of information, the Technology Development Division, providing technical and engineering advice, and the Personnel and Administration Unit. BTC also manages the Food Technology Research Service at Kanye.

BTC is supported by 46 professional and administrative staff. Approximately 8-10 are professional, 6-8 semi-professional and the remainder administrative.

The Botswana Technology Centre (BTC) is the national focal point for science and technology in Botswana and pursues the Government's policy of economic development and employment creation by assisting in technology choice. Its functions are:

- To actively disseminate selected technical information to policy makers, organisations and individuals.
- To serve and co-ordinate all technology endeavours within Botswana by promoting collaboration on the exchange of information.
- To assess technologies and policy issues for actual or potential impact on the Government's objectives and to recommend accordingly.
- To facilitate the development of prototype technology.

In order to fulfill these functions, the work of BTC includes:

- The establishment and maintenance of communication links with information and technology institutions both inside and outside Botswana.
- The monitoring and evaluating of alternative technologies.
- The design and comparative testing of technologies, as well as case studies and technology assessment studies on behalf of both the Government and the private sector.
- Discussion and advice on the application of technologies with individuals and institutions at seminars, through technical papers and through other media.
- Provision of assistance to ministries, parastatals and the private sector in identifying opportunities for the application of technical solutions.
- The establishment, where necessary of pilot projects which may include the setting up of production facilities and the training of local staff.

The Technical Information Service (TIS), as a section within BTC, actively collects and disseminates technical information to institutions and individuals. The TIS has a well-stocked library which is open to the public and has the facility for liaison with world-wide information networks such as TOOL, GATE and UNIDO. TIS distributes newsletters, technical bulletins, and technical papers country- and world-wide and contributes to a regular radio programme. TIS also has a "resource person" data bank which lists interests and fields of expertise of people and institutions within Botswana.

The Technology Development Division (TDD) includes personnel from a range of disciplines and is engaged in a wide range of projects. Some of these relating to rural energy are listed below.

PROJECTS:

Most of the projects carried out by the TDD are in response to enquiries and requests for help from individuals or institutions from the public and private sector. Some of the current projects related to appropriate energy are listed below:

- Design and development of electronic photovoltaic (PV) controllers for local production.
- Economic assessment of water lifting devices.
- Development and dissemination of hand-operated rural workshop equipment to ITDG and ATP designs.
- Comparative testing of 12V fluorescent lamps for households without access to mains electricity.
- Testing of solar water heaters.
- Investigating passive solar principles applicable to buildings from simple houses to office blocks.

In addition, BTC staff work closely with various Government Ministries, organisations and private concerns on the projects listed below:

- The establishment of quality standards for installation of PV lighting systems through the Photovoltaic Lighting Working Group.
- Science and Technology policy for Botswana with the IDRC, UNDP and NIR.
- Publication of the SENN newsletter "Energy", and involvement with SADCCs Technical Advisory Unit (TAU).
- Recommendations for the introduction of hand-operated pumps to the relevant government ministries (Agriculture, Water Affairs)
- Participation in the Photovoltaic Working Group and providing a venue for producers and users of PV pumping equipment.

The BTC is particularly closely involved with projects coordinated by the Energy Unit of the Ministry of Mineral Resources and Water Affairs. A major current project concerns the promotion of the domestic use of coal instead of wood which has included the development of a fuel efficient coal burning stove.

PUBLICATIONS:

AARSSE, A.T. (1985) Power From the Sun - Light at Night, TP2 (3rd Edition)

ANDRINGA & IDZENGA (1985) Solar Energy Data for Botswana

AUSTIN, M. (1986) The Pneumatic Water Depth Sensor, TB6.

GRAUW, C. (1987) Getting the Most From Your Diesel Engine, TP9.

JACOBS, G. (1985) Battery Operation and Maintenance, TP6.

JACOBS, G. (1985) Technical Evaluation of RIIC Biogas Installation at Diphawana

JACOBS, G. (1986) Better Care for Your Car Battery, TB1.

JACOBS, G. (1987) Solar Lighting for Community Use, TB11.

WHITBY, G. & HITCHINGS, R. (1985) Rural Workshop Equipment, TP4, (2nd Edition).

FORESTRY ASSOCIATION OF BOTSWANA

ADDRESS: PO Box 2088
Gaborone
Tel: 351660 / 373827

CONTACT PERSONS: Mrs P.K. Walker, Acting Director

DURATION: 1983 -

OBJECTIVES:

- to promote the theory and practice of silviculture, arboriculturè and related sciences in Botswana
- to act as a focal point for all NGO forestry activity
- to co-operate with all government departments on forestry matters
- to lobby and advise Government on forestry issues
- to assist all organisations involved in forestry work
- to promote forestry education at all levels in Botswana
- to develop a nation-wide forestry extension service
- to promote local scientific research in forestry and related sciences

SUMMARY:

The Forestry Association of Botswana (FAB) is a non-profit, non-governmental organisation started in 1983 by a group of individuals concerned about the firewood and building pole shortage in certain parts of the country and the consequent environmental damage by overcutting. It is directed by a Board of Trustees and in 1986/87 had a compliment of 11 full-time personnel, consisting of 2 IVS volunteers, 7 Batswana, 1 OBS volunteer and 1 expatriate. There have been some changes since then resulting in a present level of understaffing.

The FAB is represented on several Government Reference Groups concerned with forestry and conservation policy and has been active in the formulation of the National Conservation Strategy. They also act as consultants to other NGO's on request.

The primary aim of the FAB's extension programme is to increase public awareness of the need to care for natural woodland. This service includes organising talks and seminars, consulting with aid agencies on the placement and supervision of volunteer workers, and supporting specific afforestation projects in the form of advice on design, costs, implementation and management.

The research branch aims to test a range of indigenous and exotic tree species in nursery and field conditions for suitability as fuelwood or building poles. Recent activities include the mapping of woodland areas, monitoring of flowering and seeding times, seed germination tests, and a National Tree Seed Collection programme with a seed storage facility at the Gaberone headquarters.

The FAB is developing an information and resource centre concerned with all aspects of forestry for its members and the public. At present it produces quarterly newsletters and an annual journal. The FAB also offers two forestry degree scholarships.

PUBLICATIONS:

Journal of the Forestry Association of Botswana (annual publication)
FAB Newsletter (published quarterly)

MINISTRY OF AGRICULTURE:

FORESTRY UNIT

ADDRESS: Private Bag 003
Gaborone
Tel: 350500

CONTACT PERSON: Mr E. Maloiso

SUMMARY:
The Forestry Unit (FU) was established in 1936, and is now part of the Division of Land Utilisation in the Department of Field Services of the Ministry. It has the responsibility for the development of forestry resources and woodlots. Government activities in woodlot establishment in Botswana go back as far as 1941, although most of the activity occurred between 1970 and 1982. The FU is at present badly understaffed. Its nine regional foresters are each responsible for a huge land area of some 65 000 square km.

Activities of the Unit can be divided into three categories:

- Establishing and running tree nurseries. There are currently ten in number stocking mainly exotic species of which the Eucalyptus camaldulensis, E.grandis, and E. teriticornis are the most popular.
- Establishing and maintaining forestry plantations to provide a supply of fuelwood and poles. The total area planted by the FU is currently about 650 ha. Planting programmes are constrained by lack of funds and a shortage of staff.
- Organising and monitoring the harvesting of wood in the timber concession areas.

In 1985, the National Tree Planting Day was introduced to increase public awareness. It has gained considerable popularity and is widely publicised through radio, television and poster campaigns. Direct afforestation activity by the FU has been constrained by staff and funding shortages, and much of the leading work has been done by the Forestry Association of Botswana.

Another key component of the Ministry of Agriculture is the Agricultural Resources Board which is responsible for the promotion and conservation of veld resources. The

Livestock Section of the Ministry may play a greater role in the future if the use of biogas technology and dung for fuel increases.

MINISTRY OF MINERAL AND WATER AFFAIRS:

ENERGY UNIT

ADDRESS: Private Bag 007
Gaborone
Tel: 352454

CONTACT PERSON: Mr Boyce Sebetela
Senior Energy Officer
Mr B. Mogotsi
Renewable Energy Coordinator

DURATION: 1984 -

OBJECTIVES:

- To serve as the Government's focal point for policy and operational matters pertaining to energy.
- To coordinate and manage the development of Botswana's energy sector.
- To develop local energy resources thus minimising dependence on energy imports.
- To provide short, medium and long-term energy planning.

SUMMARY:

There are a number of government ministries, parastatals and NGO's whose work in some way involves energy issues in Botswana. The Energy Unit has been set up to co-ordinate these activities under a national strategy so as to avoid duplication and inefficiency. Their work involves drawing up national energy plans, commissioning of studies on energy resources, needs and consumption patterns, liaison with various ministries involved in energy and with parastatals and NGO's. With regard to renewables and appropriate energy technologies, much of this liaison is carried out with BTC, RIIC and the Forestry Association of Botswana.

PROJECTS:

The Botswana Energy Master Plan

This project, jointly funded by the Government of Botswana's Ministry of Mineral Resources and Water Affairs and the German Agency for Technical Development (GTZ) has reached final draft stage. The report assesses the present energy situation for each fuel type and projects possible future scenarios. It also analyses existing institutions and makes recommendations.

Solar Technology Standards

Together with BTC and other groups the Energy Unit is involved in establishing technical standards for the local manufacture and installation of solar water heaters and photovoltaic equipment.

The Coal Utilisation Project

Botswana has relatively extensive deposits of coal. The Coal Utilisation Project aims to encourage its use in the private manufacturing sector so as to minimise the use of imported petroleum, and in the domestic sector to reduce deforestation. This work is being done with support from BTC technical staff.

Urban Household Energy Project

A "Use and Attitude" survey on the energy consumption patterns in urban areas by the now defunct Botswana Renewable Energy Technology Project (BRET) was found to contain some inaccuracies and a new survey was commissioned in September 1988 and the results were expected to be published by the end of 1989. The information will be used to provide a strategy for the substitution of imported fuels. The survey will possibly be extended into the rural areas as well.

Rural Electrification Development Plan

The Energy Unit is studying the feasibility of a possible 10 year rural electrification scheme starting in 1990. The Energy Unit will provide guidelines and criteria for the electricity authorities.

PUBLICATIONS:

BURRIL, G. (1985) Training Needs Assessment for Renewable Energy Technologies, Min. of Mineral Resources and Water Affairs, Gaborone

CHERNICHOVSKY, D. et.al. (1985) The Household Economy of Rural Botswana, World Bank Staff Working Paper No.715, World Bank, Washington DC

ETC FOUNDATION (1987) SADCC Energy Development: Fuelwood Study, Report on Botswana, ETC Found., Leusden, The Netherlands.

FOSTER, J. & YANO, Y. (1983) Energy Planning in the Republic of Botswana, Report of Mission 11-21 July 1982, Department of Technical Co-operation for Development, United Nations, New York.

LARSSON, F. Wind Resources in Botswana, Min. of Mineral Resources and Water Affairs, Gaborone.

LE BEL, P. (1985) Financial and Economic Analysis of Selected Renewable Energy Technologies (Botswana), Min. of Mineral Resources and Water Affairs, Gaborone.

McGOWAN, R. & HODGKIN, J. (1985) Draft Report of Photovoltaic Electrification of Health Clinics and Village Schools in Botswana, Min. of Mineral Resources and Water Affairs, Gaborone.

MINISTRY OF MINERAL RESOURCES AND WATER AFFAIRS (1987) Botswana Energy Master Plan, Final Draft Report, German Agency for Technical Development (GTZ), Lahmeyer Int. Consultants.

OKI, J. (1985) Development and Dissemination of Village Solar Water Heaters, Min. of Mineral Resources and Water Affairs, Gaborone.

UNDP/WORLD BANK (1984) Botswana : Issues and Options in the Energy Sector, UNDP/World Bank.

NATIONAL INSTITUTE OF DEVELOPMENT RESEARCH AND DOCUMENTATION

ADDRESS:
N.I.R.
University of Botswana
Private Bag 0022
Gaborone
Tel: 356364

LOCATION:
Jawara Rd
Gaborone Village

CONTACT PERSON:
Dr Datta, Director
Mr N.T. Morapedi

DURATION:
1975 -

OBJECTIVES:

- To promote, co-ordinate and conduct research on issues of socio-economic, environmental and cultural development affecting Botswana.
- To develop the national research capacity within Botswana.
- To document, publish and disseminate the results of such research.

SUMMARY:

The National Institute of Development Research and Documentation (NIR) was established as a Documentation Centre at the University of Botswana in 1975 and developed into a full research institute three years later. In accordance with the above objectives, the NIR has been engaged in launching various research projects, organising seminars and conferences, and mounting short training programmes and workshops. The NIR has co-ordinated a number of research projects related to appropriate energy and energy resources in Botswana. Some of these are listed below with resulting publications which are available from the Institute or their agents, Botswana Book Centre, PO Box 91, Gaborone

PROJECTS:

Some energy related work which the NIR is at present involved in is listed below, along with the aims of the research:

A critical review of surveys on socio-economic aspects of fuelwood in Botswana.

- Examine the methodologies adopted in previous fuelwood surveys in Botswana.
- Compare the results and check for accuracy.
- Assess gaps in the information so far gathered.
- Examine the extent to which these surveys have influenced energy policy and planning in the country.

Research into the germination and growth of indigenous savanna tree species in Botswana.

- Provide germination and growth information that will facilitate the planting of indigenous tree species in local nurseries.
- Select indigenous species that will enhance the quality of woodlot management.
- Provide information on techniques to combat bush encroachment of woodlots.

A survey of wood production and consumption in Dukwe.

- Study the wood utilisation patterns in the area.
- Study the production potential of the existing woodland in the area.
- Study the attitudes towards woodlots and wood gathering of local residents and foresters.
- Provide a feasibility study of controlled forestry projects in the area.

PUBLICATIONS:

ANDRINGA, J. (1986) Solar Radiation in Botswana, University Of Botswana, Gaborone.

ARNTZEN, J. (1983) Firewood Collection in Mosomane, Kgatleng District, Botswana

ARNTZEN, J.W. & Kgadi, D.L. (1984) "Some of the Determinants of the Consumption of Firewood Energy", Pula: Botswana Journal of African Studies, Vol.4, No.1, pp24, University of Botswana, Gaborone.

JELLENIC, N.E. & van Vegten, J.A. (1981) A Pain in the Neck: The Firewood Situation in South-Western Kgatleng, Botswana

KGATHI, D.L. (1984) Aspects of Firewood Trade Between Rural Kweneng and Urban Gaborone; A Socio- Economic Perspective

KGATHI, D.L. (1985) Strategies for Solving the Rural Energy Crisis in Developing Countries with Special Reference to Botswana: A Critical Review, University of Botswana, Gaborone.

KGATHI, D.L. (1987) Conventional Solutions Adopted to Alleviate the Rural Energy Problem: The Case of Botswana

MAZONDE, I.N. (1978) Science and Technology in Botswana: A Critical Appraisal with Emphasis on Appropriate Technology for Rural Development

MAZONDE, I.N. (1985) A Bibliography on Rural Development in the Communal Areas of Botswana

TIETEMA, T. (ed.) (1985) Current and Planned Research in Relàtion to Reafforestation, Woodlots and Firewood

RURAL INDUSTRIES INNOVATION CENTRE

ADDRESS:	Private Bag 11 Kanye Tel: 340392/3 & 340448/9 Fax: 340642 Telex: 2974 BD
CONTACT PERSON:	Mr Kit Morei, General Manager Mr Molebatse Mosemyana, Tech. Director
FUNDING:	US$ 0.6 Mill pa. (approx) - Government US$ 0.4 Mill pa. (approx) - Various
DURATION:	1977 -

OBJECTIVE:

To identify, adapt, develop and disseminate low-cost technologies geared to local needs and local resources, particularly technologies using renewable energy sources and those that create employment opportunities and improve productivity and living standards amongst the rural population.

SUMMARY:

The Rural Industries Innovation Centre (RIIC) is wholly owned by Rural Industries Promotions (Botswana) which is a non-profit non-government association located at:

RIP(B) Headquarters
PO Box 2088
Gaborone (Tel: 314431/2)

RIP(B) also owns and operates the Pioneer Rural Industries Centre at Palapye (P O Box 18, Palapye, Tel: 420380), BOIRIC Pty Ltd. a sorghum milling unit, Makwati Furniture Pty Ltd. and Solar Systems Afrique Pty Ltd. manufacturers of solar water heaters and photovoltaic lighting and pumping units.

Although it operates as an NGO, RIP(B) works closely with Government (Min. of Commerce and Industry) in the implementation of rural development policies, and receives financial support from the Government. RIP(B) acts as the general co-ordinating body, operates an information centre and library and provides managerial and technical assistance to a number of other development organisations.

Decisions on major areas of research and development are taken by RIIC with little formal intervention by the Government although RIIC maintains a high degree of informal liaison with the Botswana Technology Centre and with the Energy Unit of the Ministry of Mineral Resources and Water Affairs.

The RIIC Research and Development Section at Kanye is made up of 6 units:
- the design office providing technical support to all sections;
- the R&D Workshop with the major role of manufacturing prototypes as specified by the design office;
- the non-ferrous foundry which manufactures castings for special needs of RIIC technologies;
- the installation team who install and maintain RIIC technologies at the Centre and in the field;
- the institutional support section responsible for repair and maintenance of RIIC facilities; and
- the transport section responsible for the allocation and maintenance of RIIC vehicles.

The R&D Section is involved in a number of programmes of practical research and development, manufacture of appropriate technologies and training. Some of those related to appropriate energy will be discussed below.

PROJECTS:

Wind Powered Water Pumping

Most of Botswana is located in a region of low average wind speeds (2.0 - 3.5 m/s). The country also has a deep water table and thus wind is not an obvious source for water pumping. RIIC has however developed a windmill more suitable to these conditions than the conventional type and which is also suitable to local manufacture.

The RIIC "Motswedi" windmill has six blades mounted on a six metre diameter rotor. The horizontal axis is connected to a right-angle gearbox which drives a vertical shaft running down the centre of the 12 m tower. The tower is placed a metre or so from the actual borehole (allowing a secondary power source when there is no wind, typically diesel) and power from the central shaft is transmitted via a variable step-up V-belt drive to the borehole pump shaft which in turn drives a rotary helical screw pump. The "Motswedi" can pump 8 m^3/day from a depth of 75 m with an average wind speed of 3.8 m/s and as much as 30 m^3/day at higher wind speeds.

The "Motswedi" windmill was based on the ITDG "Kijito" windmill but modified to drive a rotary helical screw rather than a reciprocating pump to provide good efficiencies at low wind regimes and to be as maintenance free as possible. The variable step-up and variable speed mechanisms allow for starting at low wind speeds and for more efficient energy extraction at higher wind speeds. In May 1988 there were about 20 RIIC windmills throughout Botswana pumping water for community needs, livestock, vegetable growing and waterholes at game reserves. Windmill performance at the Centre and in the field is being monitored with the help of computer expertise from IT Power (UK).

A major disadvantage of the "Motswedi" is its high cost. When tested against a South African make, the Climax 18, the RIIC design was found to have a marginal cost advantage at windspeeds of around 2 m/s which was quickly reduced in favour of the Climax 18 at higher speeds. This situation may have worsened in the last few years with the strengthening of the Botswana Pula against the SA Rand (P1=R1-43 in 1989), making imports from South Africa even cheaper. The "Motswedi" sells for around P 10 800. RIIC also markets the more conventional reciprocating NIMRIC windmill which can pump 8 -10 m^3/day from a depth of 50 m and sells for around P 6 750.

So far, all RIIC windmills have been manufactured at the Centre. The Botswana Energy Master Plan estimates that, given the average demand for water, the poor wind speeds and the potential of alternatives, the saturation market for windmills is likely to be around 500, about double the number already installed.

Animal Powered Water Pumping

The ADP consists of a central vertical shaft or axle to which two long horizontal spokes are attached, on opposite sides of the axle. The animals are harnessed to the spokes and are driven around a circular walkway rotating the central axle. The axle is connected to a simple chain-driven gearbox with a 1:800 ratio allowing the pump shaft to be rotated at speeds of around 1500 rpm. The ADP allows harnessing of up to 8 oxen, horses, donkeys or mules. Experience to date has shown that under optimal conditions, with a centrifugal pump at low heads (approx 10 m), the pumping rate is about 40 m^3/hr. With a mono pump at high heads (approx 75 m) this is reduced to about 4 m^3/hr. Apart from the head and type of pump set used, pumping rates are dependent on the number, type and condition of the animals used.

The first prototype of the RIIC Animal Drawn Pump (ADP) was produced in 1982 and installed for trials at the Kolobeng Horticultural Co-operative at Manyana. The requirement here was 200 m^3/day at a 10 m head. The unit currently marketed is the Mark II with a self-lubricating triplex chain drive. There are currently 9 ADPs installed in southern Africa. One was until recently in use at a village in Swaziland, but is now inoperative because of constant problems with the drive chain breaking. Another is being tested at the Institute of Agricultural Engineering in Harare, Zimbabwe. Two are under test at RIIC and the remainder are used for irrigation and livestock watering.

The ADPs have generally performed well in the field although tests are still being carried out. In cases where they have been problematic, it has often been due to poor organisation amongst co-operative or syndicate members in providing draught animals at the right times and in the numbers required. The purchase price of the ADP is about twice that of a Lister Diesel of equivalent rating.

Human Powered Water Pumping

A human powered pump, the "Thebe", designed specifically for deep boreholes has been developed by RIIC to cover applications that cannot be met by the conventional hand pumps. The "Thebe" consists of a vertical axle to which is attached a single long horizontal spoke. The operator walks around a circular walkway pushing against the spoke thus rotating the central axle. The bottom of this vertical shaft is connected to a

crank which converts the vertical rotary motion to a horizontal reciprocal motion. A tie-rod transmits this reciprocal motion to a pump head rocker assembly where it is converted to a reciprocal vertical motion in the pump shaft, driving a standard reciprocating pump.

The main advantage of this pump is that is utilises the operator's more powerful leg muscles, allowing lifting from a greater depth. A donkey can be harnessed to the pump instead. A standard pumping rate for one person is 1 m^3/h from 20 m depth. The "Thebe" is suitable for boreholes between 5 and 100 m deep and is available from RIIC at a price of around P 1 400.

Biogas

Initial experiments were carried out on three different digester designs, namely the floating-dome or Indian type, the Chinese type and the horizontal plug-flow type. This early work identified the floating-dome type as being the most appropriate to conditions in Botswana. An initial economic assessment also showed that biogas production is most favourable for borehole syndicates, commercial farms and cattle posts (in that order).

By July 1988 there were 13 biogas plants in operation. Plants at Diphawana ($75m^3$) and Mogwalale ($120m^3$), both at borehole syndicates, use dung collected at the borehole to feed the digesters which then produce enough gas to run diesel engine water pumps to water the cattle. Other digesters used for water pumping are at Serowe ($25m^3$) and Khawa ($40m^3$). Biogas is also being used at the Kang Brigades ($50m^3$) to heat an oven for bread baking and at the Kang clinic for cooking and refrigeration.

RIIC has produced a full set of plans and building instructions for floating-dome digesters of up to $45m^3$ as well as a "Maintenance and Operators Manual". There is a $10m^3$ demonstration digester at RIIC which is also used to provide gas in order to test various appliances for suitability and modification. The test section includes a diesel engine with a modified air inlet which runs on a 80/20 biogas/diesel mix, various stove burners, gas lights and a gas refrigerator. These appliances are being tested and modified with the aim of producing models that can be locally manufactured.

Solar Desalination

Botswana has one of the best solar radiation potentials in the world coupled with a number of regions where the salinity of borehole water makes it unpotable. Extensive R&D into low-cost solar desalination was carried out between 1983 and 1987, the results being two batch-type solar still models known as the "Brick" and the "Mexican" stills. The brick still is constructed on site by trained builders. It consists of two parallel walls of cement block approximately a metre apart and anything up to 5 m in length. The rear wall is somewhat higher than the front wall and glass panes are mounted at a slope between the walls. The end walls are also of cement block. The inside floor is cast cement and painted with black waterproofing. Saline water is fed into the floor and evaporation causes pure water to condense on the inside of the sloping glass roof to be led away in a specially constructed gutter. Production rates of potable water depend on feed water salinity, sunshine and a number of other factors, but under typical conditions, potable water production from a 1m x 5m still is 20 litres per day. The Mexican still operates on a similar principle but consists of pre-fabricated fibreglass modules, each with an area of 1.6 m^2. Modules are connected in any combination. Unlike the brick still, the Mexican is easily transportable and quick and easy to install. Production rates of potable water average 3 l/day in winter and up to 8 l/day in summer. Both still types operate batch-wise in that the concentrated brine is periodically removed from the still and replaced with more feed. A small amount of salt is added to the condensate before drinking.

Where stills have been installed, they have been well managed and fully utilised, however their economic viability is only clear in very remote, sparsely populated areas where fresh water has to be trucked in over long distances. In many instances (village population > 800) it is still cheaper to truck water. However, the economics could easily change particularly if more fresh-water boreholes become saline, as has happened in some cases. A further factor is the production of salt as a by-product of the distillation process. This is being produced in large quantities at one site and a proposal has been put forward to the Veterinary Department to buy the salt and make it available for sale as cattle-licks through Livestock Advisory Centres. There are at present 10 brick units at Khawa and three large Mexican still installations at Zutshwa (64 modules), Khawa (37 modules) and Ukwi (176 modules). Management of the stills has been handed over to the Kgalahadi District Council but RIIC still provides technical support.

Solar Water Heating

There are two similar designs of batch-fed flow-through solar water heaters offered by RIIC, the "brick" and the "blacksmith". Both consist of a header tank (kept filled by hand) connected to a second collecting tank painted black and mounted inside an insulated, glass-covered case. The collector tank has an outlet tap. While exposed to the sun the water inside the collector tank warms up and when required warm water is drawn out of the tank and replaced from the header tank by gravity pressure. While operation of the two types is essentially the same, construction is slightly different. The "brick" model is a permanent structure with the collector tank (a converted oil drum) housed inside cement block walls and a glass roof. A packing of glass-wool or straw is placed around the unexposed areas of the tank and the exposed area painted black. It is available in 100 and 200 litre capacity. In the case of the "blacksmith" model, the collector/storage tank assembly is fabricated from sheet metal, insulated with glass-wool and covered with a glass top. The unit has a capacity of 65 litres and is easily portable. The brick model is intended to be made on site and does not require too much skill to build while the blacksmith model has been developed to encourage the commercial manufacture of these units at small rural workshops, and sells for around P 375.

Other Water Related Activities

There are a number of other projects related to water lifting which are being carried out at RIIC. There is a review programme of different makes of hand pumps including field assessment of hand pumps, some of which have been in service for over 30 years. The more promising models include the Blair, Indian Mk II and the Bushpump, a new design from Zimbabwe. Also being investigated is the feasibility of manual shallow-borehole drilling.

Retained Heat Cooker

The RIIC has designed and tested a durable low-cost retained heat cooker known locally as the "Maikapei". The unit consists of a galvanised sheet metal bin lined with 2-inch poly-urethane foam. It is manufactured by local tinsmiths and sells for around P 12. A number of standard sizes are available corresponding to various sizes of three-legged pots.

Other R&D and Production Activities

RIIC has been involved in the design and production of energy and time-saving equipment suitable for rural industry including:

- A grain dehuller/grinder suitable for sorghum, millet, cow peas and maize. The unit is operated off a 5.5 kW electric motor or a 10 HP petrol motor and is capable of processing 600 kg/hr of grain. The "Tshilo/Dehuller Mk II" won the First International Award for Technology and Development in Genoa, Italy in 1986 and has been exported to a number of African countries. The dehuller sells for around P 4 750.
- A low cost sorghum thresher operating off a small petrol motor with a possible throughput of about 2 tonnes/day. The unit retails for around P 2 000.
- A hand operated chaff cutter which produces a suitable cattle feed from crop residue and sells for around P 750.
- Three designs of wood or coal-fired ovens suitable for small bakeries, the "Rim" oven, the "Square" oven and the "Kgotetso" oven.
- A hand operated cement block press, based on a South American design with local modifications known as the "CINVA Ram Block Press". The bricks are 10% cement, 90% soil and using the press, 2-3 people can produce 150-200 bricks per day.

Other technologies in which RIIC has had design or manufacture input include a diamond-mesh wire fence machine, various trailers and carts, harnesses and wheel-barrows, a peanut sheller, a root cutter, and ploughs and seed-planters.

DISSEMINATION:

Activities carried out by the RIIC Research and Development Section are supported by an active programme of extension and information dissemination. The Extension Department is responsible for identifying community needs and determining the impact and acceptability of RIIC products after their development and installation. It also disseminates information on RIIC technologies through seminars and workshops in rural areas, demonstrations at agricultural shows, school visits and radio broadcasts. Extension workers liaise closely with Government extension networks. There is also a well stocked library and information office at the Kanye centre providing pamphlets and manuals.

Dissemination is also achieved through RIIC's Village Artisan Training Programme which runs courses specialising in skills needed to set up small-scale businesses, including tanning, baking, blacksmithing and carpentry.

Apart from the objectives listed above, one of the principles guiding the development of technology and its dissemination at RIIC is that the commercial manufacture of these technologies should not be the responsibility of RIIC, but should eventually be taken over by small businesses in the private sector. Towards this end RIIC assists some small workshops by providing artisan training, detailed plans and manuals, jigs and fixtures and a marketing infrastructure.

PUBLICATIONS:

RIIC produces a range of pamphlets advertising and explaining the devices developed by or distributed through them. In addition a regular newsletter, "Dikgang Tsa Maranyane" is published jointly with BTC. Other publications include:

RIIC Windpower Pumping - Botswana, Final Technical Report, RIIC, Kanye.

WOTO, T. Rural Needs in Perspective: A Study of Five Villages in Botswana

WOTO, T. (1987) Small-Scale Desalination Seminar: Conference Proceedings

WOTO, T. (1988) Biogas Technology in Botswana: A Sociological Evaluation

YATES, R. et.al. (1985) Solar Desalination Field Research, 2nd Six-monthly report, RIIC, Kanye.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
Botswana Housing Corp.	Solar water heaters
Kalahari Conservation Society	Tree-planting
	Conservation education
	Aerial surveys
	Env. impact assessments
Kgatleng Development Board	Woodfuel plantations
	Nurseries
	Forestry extension
Kweneng Rural Development Ass.	Fuelwood plantation
	Village nurseries
	Tree planting
Madiba Electrical Brigade	PV system design and installation
Min. of Agriculture	Windmills
Min. of Local Government and Lands	Woodlots Conservation
Min. of Mineral Resources	Rural water supply
Pioneer Rural Ind. Cntr, Palapye	Rural industry
Price Ossca	Woodlots
Serowe Forestry Brigade	Forestry training
	Nuresries
YWCA	Woodlots

COMMERCIAL EQUIPMENT SUPPLIERS

Name of Organisation	Field of Interest
Solar Power	Solar water heaters
Taurus Batteries (Pty) Ltd	ARCO Solar PV Systems
	Deep-discharge batteries
Solar Systems Afrique (Pty) Ltd	PV Systems
	Solar water heaters

LESOTHO

INTRODUCTION

The Country

Lesotho has a land area of little more than 30 000 square km and is completely landlocked by the Republic of South Africa. The country is very mountainous with about 65% of the land area lying above 2000 m. Mean annual rainfall ranges from 500 mm to 1200 mm and occurs mostly in summer. The whole of the country is subject to severe frost in the winter and snow falls regularly in the highlands. Only about 9% of the land is arable. Most of the remaining land is rangeland or is marginally arable.

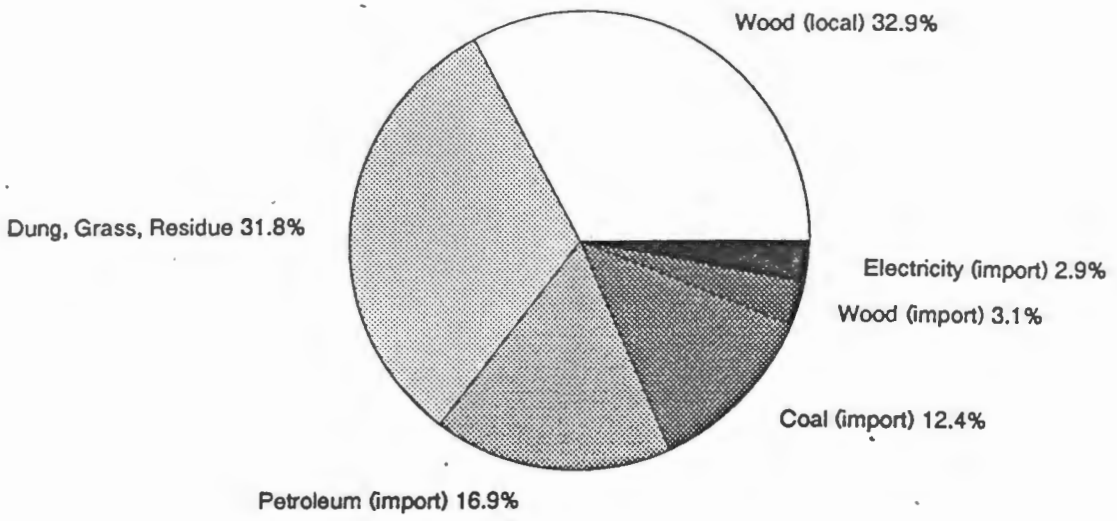
The 1986 census determined the de jure population as 1.58 million but the substantial absentee labour force employed inside the RSA reduces this to a de facto population of 1.44 million. Population is increasing at about 2.63% per annum. About 84% of the population are rural although there is a migratory tendency towards the lowlands and urban agglomerations.

The economy of Lesotho is dominated by that of the RSA. More than half of the GNP is generated through wages paid to migrant workers and much of this is spent on imports, which exceed exports by a factor of ten. Internal employment opportunities are few, with the government providing almost half of the formal employment. The economy grew at a high pace in the 1970s but has slowed down considerably since then with a steady decline in per capita income. The agricultural basis is largely subsistence and suffers from an unfavourable climate, advancing erosion, overgrazing and increasing population pressure. The manufacturing industry is relatively small although it has been growing at a rate faster than the overall economy. The GDP in 1983 was approximately US$ 401 million, or US$ 254 per capita.

Energy Consumption and Resources

The total energy consumption in Lesotho is estimated at 26 PJ (Kingdom of Lesotho,1988). The relative importance of the different primary energy sources in Lesotho is indicated in the chart below:

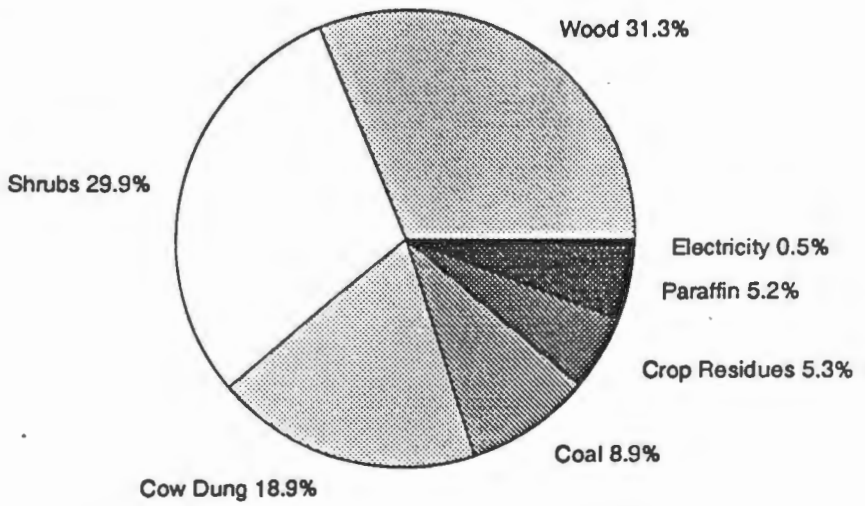
Figure 1. Primary Energy Consumption in Lesotho by Source



Source: SADCC (1989a)

Nearly 90% of the total energy consumed is due to households. Transport accounts for around 6.5% with commerce, industry and government making up the rest. Fuel use in households is indicated in the chart below:

Figure 2. Household Energy Consumption in Lesotho by Fuel Type



Source: Kingdom of Lesotho (1988)

The Dept of Energy has estimated that a total of 1.2 million tonnes annually of biomass is burned for energy, corresponding to a consumption of approximately 12 kg per household per day, or 4.38 tonnes per household per annum. This is extremely high when compared to other data. Gay & Khoboko (1982) give an estimate of 1.25 tonnes in the east of Lesotho; Steele & Ncholu (1983) give 1.8 to 2.6 tonnes in the north; and Wicksteed (1984) gives 1.0 to 1.5 in the south of the country. It is possible that the Dept of Energy figure is slightly overestimated, nonetheless, the high dependence on wood and in particular, the widespread use of shrubs, dung and crop residue gives cause for concern.

Lesotho has a limited supply of wood. Almost all indigenous forests have been eradicated and the severity of the climate and landscape does not encourage easy or rapid vegetation growth. The state-run woodlot programme has about 7 000 ha under plantation and a further 3 000 ha reserved for future planting. It is estimated that about one-third of all villages have access to a woodlot or forest reserve. The shortage of wood is illustrated by the high consumption of dung and crop residue and by the volume of wood that is imported into the country from South Africa.

The relatively small amount of commercial energy consumed is mainly imported from RSA. Petroleum based products, coal, electricity and even some firewood are imported and sold locally, while in rural areas, collected wood, shrubs, dung and agricultural residues form the major fuel sources. These traditional resources are however dwindling. The country has substantial hydropower potential which will become more important in the future. At present, four hydro schemes with a total rating of 3.41 MW and a generating potential of 13.3 GWh per annum are on stream. The massive Lesotho Highlands and Oxbow Schemes still under construction will divert water to South Africa while providing Lesotho with an additional 500 GWh of electricity per annum.

Energy Planning and Policy

Broadly stated, the energy policy of the government of Lesotho is to secure the energy supply for all sectors of the economy and in all regions of Lesotho at the minimum social and economic cost without the destruction of the environment. In 1984, The

Kingdom of Lesotho and the Federal Government of Germany entered into a project agreement to produce a coordinated energy plan for the country. The first step in this project was to collect information on the energy resources, energy technology and present and projected demands. The initial surveys included:

- qualitative household surveys;
- quantitative household surveys;
- service station surveys;
- surveys in the commercial, industrial and public sector;
- an electricity consumption survey; and
- cow dung potential study.

This information, together with other energy data has been stored on a computerised data base known as the Lesotho Energy Information System (LEIS) and is available for continuous updating. A computer model has been developed which uses this data base to allow the long-term projection of a number of energy scenarios for Lesotho. These have recently been published in the 1988 Lesotho Energy Master Plan (LEMP).

Key elements of the 25-year LEMP projection are:

- Although the proportion of the total national energy consumption due to household energy needs will reduce slightly, the actual consumption for this sector will increase. Household consumption will continue to account for the major portion of the total national energy consumption.
- Notwithstanding the country's massive hydropower potential, the cost of providing electricity to the whole population would be prohibitive. Similarly, the high price of imported petroleum based fuels would suppress a spontaneous switch to paraffin and gas.
- Household energy needs will continued to be met largely from biomass sources such as wood, shrubs, dung and agricultural residues.
- Biomass is at present being consumed at rate above the sustainable level and with no tree planting programmes, all fuelwood resources will have been depleted by the year 2006.
- Without a sustainable fuelwood supply, the consumption of marginal fuels such as shrubs, dung and agricultural residues will increase with potentially devastating ecological consequences.

The Lesotho Energy Master Plan identifies a number of key areas for action. On the "demand" side, measures to be taken include:
- energy conservation in buildings;
- energy conservation in commerce and industry;
- energy saving in rural households;
- energy conservation in the transport sector; and the
- substitution of commercial energy sources by solar energy.

Supply side objectives can be achieved through:
- accelerated afforestation programmes;
- decrease in the use of marginal fuels such as shrubs, crop residues and dung;
- introduction of biogas digesters in industry and in rural areas;
- expansion of hydropower potential;
- expansion of mini-hydro potential;
- establishment of a strategic fuel depot; and
- exploration of fossil fuel potential.

The fuelwood "crisis" is already evident in many parts of the country. In a recent study in rural Lesotho (Gay & Khoboko,1984), householders ranked fuel shortages as third in the list of the most pressing perceived problems with women ranking fuel collection as their most arduous task.

To address the need for fuelwood, the LEMP indicates that it will be necessary to plant some 5 000 ha per year of fast-growing, well managed trees, far above the current planting rate of 1 500 ha per annum. Some 7 500 ha/yr will be needed to supply wood as well as discourage the ecologically negative use of marginal fuels such as shrubs, dung and agricultural residue.

MINISTRY OF INTERIOR, CHIEFTAIN AFFAIRS AND RURAL DEVELOPMENT:

APPROPRIATE TECHNOLOGY SECTION

ADDRESS: ATS
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Maseru
Tel: 316253 / 314539

LOCATION: Main Road North
Khubetsoana
Maseru

CONTACT PERSON: Mr M.M. Ntja, Senior Engineer

FUNDING: Govt. of Lesotho

DURATION: 1978-

OBJECTIVES:

The ATS was created in an effort to improve the quality of life and increase incomes and employment opportunities of the rural population of Lesotho through the application of energy saving appropriate technologies. As such the aims of the ATS are:

- to design, improve and provide technical assistance in the use of appropriate technologies for, among others, fuel saving, food growing, vegetable drying and energy efficient housing;
- to research and assess the needs of the rural population with respect to the further development of appropriate technologies; and
- to disseminate and train people in the commercial manufacture and production of ATS developed technologies.

SUMMARY:

The ATS began at the Ministry of Co-operatives and Rural Development with an expatriate Helvetas aid staff member experimenting with various forms of stoves and solar water heaters and cookers. It received a major impetus with the commencement of the RET project (see Eberhard,1984) in 1981 and became the office through which this project was directed. The ATS now operates under the auspices and funding of the Ministry of Interior, Chieftainship Affairs and Rural Development and operates from their offices, workshop and testing facility at Khubetsoana, five kilometers outside Maseru. ATS also runs a well stocked library on renewable energy resources and technologies, and has a further workshop at Malefiloane in the Mokhotlong district. The ATS is divided into four units and staffed as follows:

-Research and Development Unit, 2
-Production Unit, 5
-Dissemination Unit, 6
-Administration Unit, 17

Activities for the first approximately 5 years were taken up largely with designing and developing specific technologies, particularly while the RET programme was operative. These included the stone paola (stove), the improved metal paola, the RET metal stove, the earthen stove, solar ovens, retained heat cookers, water heaters, food dryers, grow-holes, and energy-efficient buildings.

Since the RET programme, no new technologies or devices have been developed. At this stage, the ATS feels that the technologies with the most potential have been identified and that most of the technical problems with individual devices have been ironed out. Work is therefore being directed at improving the aesthetic appeal and ease of manufacture of various technologies devices and their active dissemination. The devices now being actively disseminated are the two-pot metal Mabotle stove, the stone paola, the retained heat cooker, grow-holes and food dryers.

PROJECTS:

Fuel-Efficient Stoves

Stove development at the ATS began in Lesotho in 1979 but gained greater emphasis under the RET project between 1982 and 1984. During this time, the two most promising designs developed were the two-pot metal stove or "Mabotle" (the Beauty) and the single-pot stone paola. The earthen stove and the improved metal paola, while performing well in lab and field tests under the RET programme, did not prove to be very popular in initial dissemination trials where rural people viewed them as being somewhat primitive. When requested, the ATS will assist in the training of mud-stove builders but these two types are not actively disseminated.

a) The Stone Paola

The stone paola was derived by ATS from a combination of the traditional method of building out-door cooking fires behind a stone wind-break and the commonly used bucket brazier. The term "paola" comes from the Sesotho name for a bucket or pail. The stone paola consists of a square or cylindrical stone and mud structure with internal dimensions dictated by the size of the pot to be used. It is commonly used with a cast-iron three-legged pot. The pot sits inside the paola, supported on a triangular arrangement of steel bars, approximately 25 to 30 cm above the grate. There are openings to the fire-box to allow fuel feeding and controlled air intake with another hole beneath the grate to allow for ash removal. The paola can be built easily from local materials with the exception of the grate and pot support which are made from 12 mm steel reinforcing rods and can be constructed by local artisans. The stone paola can burn wood, scrub, agricultural wastes and dung.

Since these stoves are large and not portable, it was initially felt that they would be most useful at schools where large quantities of grain and legumes are cooked for long periods. The Lesotho Save the Children Fund (SCF) feeding scheme has been responsible for building more than 1 300 stone paolas at 312 schools throughout the country. The SCF plans to build at least 2 000 more such stoves by the year 1993. Apart from schools, many rural women have expressed interest in building the stoves. In 1987, some 212 stone paolas were built under the supervision of ATS-trained Village Health Workers in 29 villages in the Mokhotlong district. There are an estimated 1 000 stone paolas in homes throughout the country.

b) The ATS Two-Pot "Mabotle" Metal Stove

This metal stove has been designed to accommodate three-legged cast iron cooking pots and the increasingly popular flat-bottomed aluminium pots and pans. The Mabotle stove is basically the RET Model 3 with further aesthetic improvements. It is constructed from sheet metal and has overall dimensions of approximately 600 mm x 300 mm and stands 450 mm high. It consists of an insulated fire-box with an ash-catcher below, the door of which serves as a primary air control. Hot gasses are directed into the stove body and the heat transmitted to the stove top. The hot gas and smoke passes over two baffles, one under each plate, before exiting at the opposite end into the flue and out through the chimney. The stove can burn wood, scrub or dung.

The main hurdle facing this stove in wide-scale dissemination is its more complicated manufacture which requires skilled artisans and a well equipped workshop. Initially, production of the stoves was carried out at the ATS workshops at Khubetsoana and Malefiloane, where 42 stoves were built between 1983-85. The ATS has also trained artisans in small workshops. Twenty-four stoves were built at private workshops and training institutions. The feasibility of mass production inside Lesotho has been investigated and 256 stoves have been produced in a trial run at Lesotho Steel, Maseru. At present, the demand for the stoves is not great enough to sustain large scale manufacture but is at the same time too large to allow the continued subsidised manufacture by ATS workshops. It is hoped that more intensive advertising will help to create an awareness of, and a demand for the stove and make commercial production (both small and large scale) viable. Although the stove is relatively cheap, it is estimated that the Mabotle stove has less than 7% of the market share of stoves other than paraffin. The price of the Mabotle is around M130, while imported coal stoves from South Africa cost in the range M300 to M850.

The stove is sold throughout the country from 25 outlets which include trading stores, co-ops, workshops and private traders. Although complete figures are not available, it is estimated that some 300 of these stoves have already been sold. Figures available indicate a sale of 23 stoves for the month of January 1989.

An independent assessment of the stove's market performance (Peat Marwick Mitchell & Co.,1987) recommended the addition of a hot-water tank and an oven to the Mabotle stove, but while this may increase its appeal it would also lead to a more costly and more complex construction. As it is, the stove is fairly difficult for local artisans to manufacture, and a further study (Karekezi,1987) has recommended the development of labour-saving jigs and fixtures that would result in cost reductions and productivity improvements.

c) The Single Pot Metal Stove

In order to fill the gap between the two-pot Mabotle stove and the commonly used but grossly inefficient metal brazier, the ATS is in the process of developing a single-pot fuel-efficient metal stove. Prototypes have already been tested and have shown efficiencies of between 16% and 26%, depending on the fuel used and the size of pot. The fire-box is constructed of a double skin of 2 mm sheet steel, the 20 mm gap between the walls being filled with clay packing. The stove top is 3 mm sheet steel and the pot hole arranged to accommodate cast-iron No.2 and No.3 three-legged pots as well as flat-bottomed pots or pans. Below the grate is an ash catcher, the door of which acts as the primary air control damper. Spent flue gas is led out through a chimney. The overall dimensions of the stove body, excluding the legs, are about 320 mm x 320 mm x 320 mm.

The stove is still in the development phase, one of the problems being cracking of the clay lining. Tests will be done using other linings.

The Retained Heat Cooker

The retained heat cooker (RHC), also known as a hay-box or fireless cooker is a proven technology that has been successfully used in many countries. The RET programme experimented with a number of different designs and tested a number of different insulating materials. It also produced an instruction and recipe booklet which included traditional meals. The ATS has since actively disseminated the technology through demonstrations at rural centres, training courses etc. The ATS assists existing "Income Generating Groups" in the rural areas with advice and loans for materials. There are at present about 10 groups involved in the manufacture and sale of RHCs and the price of a RHC is around M18.

The RHC technology is simple and the product very popular, in peri-urban as well as rural areas. Despite this, the manufacture and distribution is not always smooth, although this has more to do with the lack of financial and management skills among members of the income generating groups. Unfortunately, ATS assistance and training cannot extend this far.

Solar Ovens

Two types of solar ovens were tested by the ATS under the RET programme, one a locally developed model and the other an Indian model. The motivation for pursuing research in this direction was largely due to the fact that Lesotho's climate makes solar energy technology very attractive. Attempts to disseminate solar ovens however have not been successful. At present they are not actively promoted by the ATS.

Food Dryers

Food drying is an accepted method for preserving food in Lesotho. Traditionally, the food (fruit or vegetable sliced thinly) is simply placed on metal sheets or cloth on the ground or roof and allowed to dry. Meat is often also hung out in the open to dry. Villagers also recognise that these methods allow birds, flies or dust to degrade the quality of the dried product. The ATS has developed a number of designs of enclosed food dryers, ranging from cheap home-made cardboard box types to expensive models from sheet steel or fiberglass. Essentially, it consists of a box with a mesh or grid onto which the slices of food are placed. A removable glass or plastic cover protects the food while allowing the sun to penetrate. Ventilation holes allow air circulation.

One of the most popular models is a portable wooden type which is purchased in kit form from local artisans and is then assembled at home. Dissemination methods involve advertising through ATS publications, radio broadcasts etc. Training courses in the manufacture of kits or complete units are offered to groups in an attempt to encourage a sustainable manufacturing basis. As with the RHC, the ATS offers the small manufacturers practical assistance in obtaining materials and financial assistance in the form of loans or guarantees of sale. Commercially made food dryers are sold at between M25 and M65, depending on the type and the size.

The Dept. of Agriculture also offers training courses in the manufacture of the dryers, while the ATS is training representatives from other government departments and NGO's.

Grow Holes

Much of Lesotho is prone to frost or cold dry conditions which are not conducive to food growing all year round. A grow-hole, also known as a cold-frame, consists of a shallow wall built around the seed bed. A removable glass or plastic cover protects against frost, desiccation and animal damage while allowing the sunshine to penetrate. The grow hole is suitable for the raising and protection of seedlings in early springtime, the late ripening of crops and growing out-of-season vegetables such as tomatoes, spinach, onion, carrots etc. The grow-hole is usually a stone or brick wall onto which is placed clear plastic sheeting stretched over a wooden frame.

Dissemination methods are similar to those used in promoting the RHC and the food dryers and these have largely been taken over by the Department of Agriculture with ATS providing a back-up service. A grow-hole kit can be purchased from around M15.

Energy-Efficient Housing

Plans and guidelines for improving existing traditional house designs as well as new low-cost houses for urban areas were developed under the RET programme. A demonstration house incorporating a number of passive solar principles including a Trombe wall has been built at Khubetsoana. Since then there has been little development. Energy efficient building is not actively promoted at present although the concepts involved and certain building tips are advertised in the ATS publications from time to time.

DISSEMINATION:

Dissemination at present forms a large part of the work being done by the ATS. Most of the effort is put into a few technologies which have been identified as having the greatest potential. These are listed below.

- the Mabotle two-pot metal stove
- the stone paola
- the retained heat cooker

- the food dryer
- the grow hole

The ATS has used a number of different methods to disseminate technology. Some are listed below.

- Representatives or "multipliers" from rural villages attend courses at ATS in which they are demonstrated the benefits of various technologies, or trained in their construction. These people are usually already involved in village life as community workers, health workers, leaders of social groups etc. On their return to their village, they are expected to promote the energy saving technologies.
- Field workers from ATS hold demonstrations at rural centres, schools etc.
- Village artisans and self-help groups are trained in the manufacture of RHCs, food dryers etc. and are then given assistance to start commercial production of these items.
- Government departments and NGO's involved in rural work are offered training courses and backup support.
- Advertising and educational programmes are broadcast over the radio in Sesotho in a 15-minute weekly slot.
- ATS produces a six-monthly newsletter containing technical and educational articles, letters, adverts etc. This newsletter is not confined to the activities of the ATS but also provides information on tree growing, agroforestry, biogas, etc.
- Promotional materials such as posters, tee-shirts and calendars are produced and distributed from time to time.

The different methods have had various success rates and the ATS plans to conduct an evaluation in the near future.

PUBLICATIONS:

ATS Newsletter, published in June and December each year.

PEAT MARWICK MITCHELL & CO (1987) Metal Stove Production and Marketing Study for the ATS, UN Agency for International Development.

GAY, J. & KHOBOKO, M. (1982) "Village Energy Survey Report", ATS, Min Coops and Rural Development, Maseru.

GAY, J. (1984) "Lesotho Household Energy Survey", ATS, Min of Coops and Rural Development, Maseru.

NTJA, M.M. (1988) "Stove Development in Lesotho", ATS, Min of Interior, Chieftainship Affairs and Rural Development, Maseru.

MINISTRY OF WATER, ENERGY AND MINING:

DEPARTMENT OF ENERGY

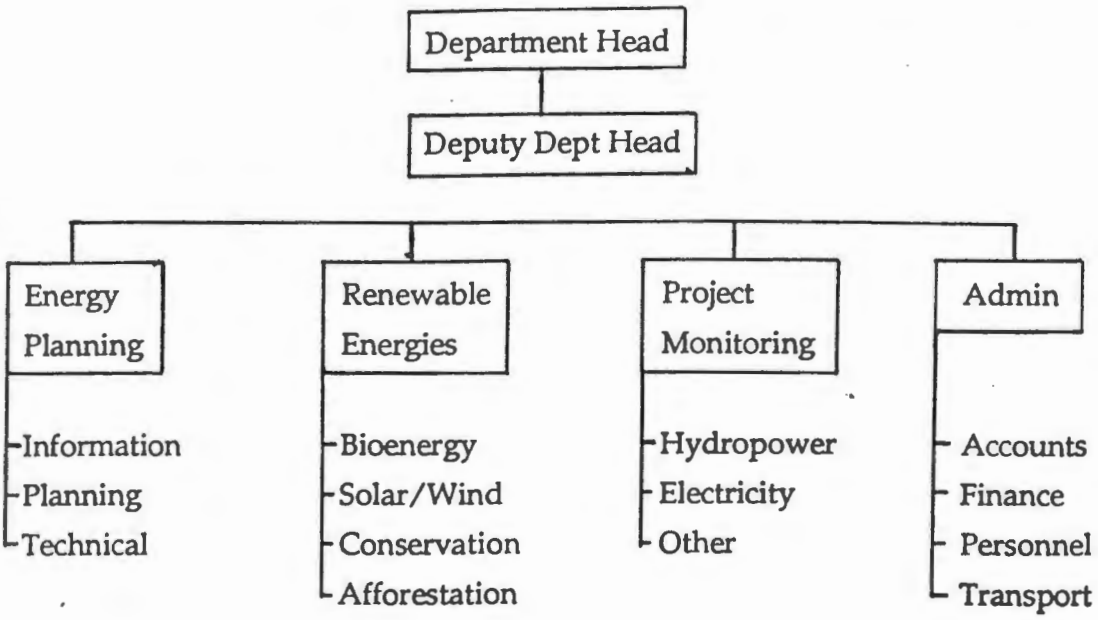
ADDRESS:	P O Box 772 Maseru 1000 Tel: 322614 / 322242 Telex: 4330 LO	Pvt.Bag A91 Maseru 1000
LOCATION:	High Court Road, Maseru	
CONTACT PERSON:	Mr B. Kanetsi, Department Head Mr D.T. Lekoetje, Deputy Head Mr. Phuroe, Renewable Energy Div.	
DURATION:	1985 -	

SUMMARY:

The Department of Energy (DOE) is the key energy institution in Lesotho and is charged with:

- Coordination of all energy activities in the country.
- Establishment of short and long term energy plans and formulation of requisite energy policies and action plans.
- Development of indigenous and renewable energy resources.

The Departmental structure is shown below. However due to shortage of funds and qualified personnel, some of the posts are not filled or are seriously understaffed.



The DOE has placed considerable emphasis on the conservation and development of biomass energy and strongly backs biomass energy technology research and dissemination.

PROJECTS:

Renewable Energies Committee

The DOE has also led the formation of the Renewable Energies Committee (Chair: Mr. B. Kanetsi) which has its membership open to all institutions involved in renewable energy. The committee aims to coordinate all renewable energy activities in the country, promote cooperation and information sharing between different government departments and NGO's, and to assist the DOE in formulation of policies around renewable energy.

The RE Committee meets four times a year and runs seminars from time to time. It has three sub-committees involved in:

- passive solar heating and energy conservation in buildings,
- the development of renewable energy technologies (biogas, wind, solar, hydro),
- the overall dissemination of renewable energy technologies.

Micro-Hydro

a) Tlokoeng & Qacha's Nek

A contract was signed in 1980 between the French Agency for Technical, Industrial and Economic Co-operation, Sogreah Consulting Engineers and the Government of Lesotho (Min. of Water, Energy and Minerals) which led to the identification of 9 potential micro-hydro sites in the Highlands areas. Construction has been underway at the Tlokoeng and Qacha's Nek sites since 1986 with commissioning expected in 1989. The Tlokoeng plant is rated at 650 kW and the Qacha's Nek plant 1 000 kW. The French contribution is FF 20 200 00 while the Lesotho Government will contribute M 3,3 million.

b) Semonkong & Mantsonyane

After a micro-hydro feasibility study financed by the Norwegian Agency for International Development in 1983, contracts were signed in 1985 for the construction of the above two projects. The project is not yet complete and costs expected to be in the region of 57 million Norwegian Kroner are now running at around NOK 70 million .

The Semonkong unit will have a 180 kW capacity from a head of 10 m and a 120 kW diesel unit for dry periods and peak loads. An 11 kV line will supply the isolated local grid. Negotiations are currently underway to increase the capacity with a small storage dam and a second 180 kW Francis turbine.

The Mantsonyane unit has two turbines generating 2 MW from a 37 m head. Power from the unit will be transmitted along a 33 kV line to feed into the national grid.

c) Quthing

A feasibility study in 1984 financed by the Austrian government and completed by the Agricultural University of Vienna identified a site at Quthing, although the study was later found to be inaccurate. Preparations are underway to upgrade this study with more hydrological data.

PUBLICATIONS:

MINISTRY OF WATER, MINING AND ENERGY (1988) Lesotho Energy Masterplan - Final Report 1988, Kingdom of Lesotho/Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) Lahmeyer International - consulting Engineers.

KHOBOKO, M. (1986) "Quantitative Survey in Households", Dept. of Energy, Min of Water, Energy and Mining, Maseru.

KANETSI, B. (1988) "Review of Renewable Energy Technology in Lesotho", Dept. of Energy, Min of Water, Energy and Mining, Maseru.

MINISTRY OF AGRICULTURE:

FORESTRY DEPARTMENT: FUELWOOD AND POLES PROJECT

ADDRESS:	P O Box 774 Maseru 100 Lesotho
LOCATION:	Constitution Rd. Maseru
CONTACT PERSONS:	Mr E.T. Senekani, Chief Officer . Mr Thulo (Acting) Mr E.D. May, Forestry Adviser
FUNDING:	Overseas Development Administration Government of Lesotho, GTZ, KFW and World Food Programme
DURATION:	1 July, 1987 -

OBJECTIVES:

- To promote the development of forestry in Lesotho.
- To establish woodlots for the provision of fuel and building materials.
- To provide trees for the stabilisation of catchment areas.

SUMMARY:

The establishment of woodlots started as early as 1936 but received a major impetus with the establishment of the Lesotho Woodlot Project (LWP) in 1973, financed largely by the Overseas Development Administration. Apart from afforestation, the LWP aimed to create in Lesotho a well trained, well balanced technical and administrative infrastructure, and a rational afforestation policy in terms of Lesotho's economic and ecological needs. These aims were to a large extent fulfilled by 1987 when the LWP was

terminated after over 14 years of operation. The Fuelwood and Poles Project (FPP) is the result of the integration of the LWP into the Forestry Division, created as a separate entity in 1986.

Afforestation is promoted in order to:

- reduce the use of dung and agricultural waste as a fuel allowing it to be recycled in the fields;
- retard the collection of scrub vegetation for fuel, particularly on erodible sites; and
- substitute the importation of fuels, fencing, hut and other poles and building materials.

The total area of plantation is now over 7 000 ha within a gazetted Forest Estate of over 10 000 ha. An estimate of the area required for afforestation was put at 50 000 ha (based on 1 tonne of fuelwood/family/year), but the latest Energy Master Plan estimates that 200 000 ha is required by the year 2010. Between 1984 and 1987, approximately 850 ha were planted per annum, which is some way short of the Energy Master Plan estimated requirement of 7500 ha per annum.

Initially much of the planting programme was based upon eucalyptus (favoured, in part, due to their coppicing ability and growth potential) and in particular on E.viminalis, although problems with Snout Beetle and severe drought led to more emphasis on conifer species. Over the last two years, the emphasis on conifers has been criticised by the major donors. Stock in 1986 was approximately 60% eucalyptus, 32% pine and 8% other species. The Forestry Division has a nursery capacity exceeding 4 million trees which are used for woodlots or sold to the public. In the latter case, there is a lot of interest expressed in the more familiar silver wattle and poplar species. There is an ongoing research programme including 58 Permanent Sample Plots providing detailed information on growth of the principle species, investigations into cold-resistant E.gunnii and E.dalrympleana and other genera, including Casuarina and Allocasuarina, and for donga stabilisation, Salix, Populus, Robinia, and Gledetsia.

The extension policy of the FPP (and the LWP before them) has been to stress the importance and advantages of woodlots and then to leave the request for their establishment to the chiefs and villagers themselves through their Development

Councils. In no instances has a higher authority been asked to impose a land use policy on the local communities. Once a request has been made and the agreement signed, the area is declared a Forest Reserve under the Forest Act by His Majesty the King. This guarantees security of tenure and the continued management and regeneration of the forest reserves while allowing the villagers to retain ownership of the land. At present there are roughly 380 Forest Reserves throughout the country, concentrated mainly in the Lowlands and Foothill zones. The encouraging rate at which communal land is allocated for woodlots derives not only from a need for fuelwood and poles but also from the expectation of employment and income resulting from the woodlot establishment and eventual wood sales.

Once an area has been declared a Forest Reserve (often a degraded or eroded site) it is cleared, prepared and planted by the Forestry Division. Usually, labour is supplied by local villagers and is paid on a food-for-work basis under the World Food Programme (at scales equivalent or better than the cost of casual labour). Villagers are also subsequently involved in weeding, stumping, coppice reduction etc. and possibly harvesting of the trees. They are also involved in road building and maintenance and partly in fencing and safeguarding the woodlots. The more mature woodlots are often opened to cattle for controlled grazing, which is particularly beneficial to the villagers in springtime when lands are being ploughed.

Wood sales are held from mature woodlots by the local forestry officer when sufficient demand is shown. Thirty kilogram headloads of branches are sold for around 50 lisente and stems at M17.50 per m^3. Twenty percent of the revenue is returned to the communities for use under approved community development schemes while 80% goes to the Forest Fund for further afforestation. This situation is not ideal since many of the poorer villagers do not have the ready cash to purchase fuelwood stocks to tide them over till the next sale. Another problem is the often remote location of the woodlots.

PROJECTS:

Pole Treatment

Although priority is always given to local demand, some pre-sale cutting has been carried out to meet demand at the Forestry Division's pole treatment factory in Hlotse, Leribe and that of a private firm in Maseru. The plant at Hlotse, based on a Swaziland specification, was opened in October 1987. It uses a fairly simple technique and can creosote poles of up to 9.5 m in length.

Charcoal Research

Although there is no tradition of charcoal use as a domestic fuel in Lesotho the possibility of wood supplies in excess of demand in certain areas have prompted some initial experimentation in charcoal production. Two retorts were made out of old oil drums welded end-to-end and although there were problems with maintaining an air-tight seal, a reasonable quality charcoal was produced. Plans are being made to continue this research but the feasibility of production would depend on either stimulating a domestic market or exporting.

Community Forestry

Towards the end of the Lesotho Woodlots Project tenure a project proposal for further funding was drawn up including programmes in social forestry, agroforestry, woodlots and a commercial sawtimber plantation. On appraisal by the major overseas donor, interest was expressed in mainly the woodlot programme with limited support in the other areas. Despite this, there is a feeling in some quarters that social forestry and agroforestry should be encouraged with more participation and control from the communities, particularly in view of the high administrative costs of a centralised bureaucracy. Some of the problems with the present form of management that could possibly be addressed by an approach based more strongly in the communities are:

- underutilisation of some woodlots;
- illegal grazing inside the woodlot boundaries causing damage to trees;
- damage to fences and theft of fencing material;
- illegal felling; and
- malicious damage to trees and arson, often due to disputes over land ownership.

Extension efforts in this direction include:

- tree-planting competitions at schools;
- forestry workshops at farmers training centres; and
- articles in newsletters.

PUBLICATIONS:

LESOTHO WOODLOT PROJECT (1987) Annual Report 1986/87 and Review 1973 to 1987, Ministry of Agriculture, Kingdom of Lesotho, Maseru.

MINISTRY OF AGRICULTURE:

BIOGAS PROGRAMME

ADDRESS: Agricultural Research Division
P O Box 829
Maseru 100

LOCATION: Lesotho Agricultural College
Airport Road
Maseru

CONTACT PERSON: Mr M.G. Sello

FUNDING: Government of Lesotho
Government of China 1986/87

OBJECTIVE:
To test the technical and economic feasibility of biogas technology and to encourage farmers to adopt the technology through a programme of demonstration, training and extension.

SUMMARY:
Biogas technology was first introduced in Lesotho through two projects, one funded by UNESCO and coordinated through the National University of Lesotho (NUL) and the other funded by the UN's Food and Agricultural Organisation (FAO) and coordinated through the Ministry of Agriculture (see Eberhard,1984). Funding and technical support from these sources was terminated in 1985 although work is continuing at NUL. The biogas programme under the Agricultural Ministry was extended until the end of 1987 with financial and personnel support from the Government of China.

There was a clear preference in the UNESCO/FAO biogas programmes for the Chinese-type digester. The chief advantages were seen as low construction costs and better ground insulation, and therefore higher temperatures and gas production during

winter. These type of digesters however require well trained builders to ensure that no leaks develop. Those digesters whose construction has been supervised by the project leader have performed well, and those built by villagers have generally developed leaks. The results of the UNESCO/FAO digesters were not very promising. Of the 24 digesters built between 1982-86 inclusive, only seven were operating by March 1987.

With extended Chinese support (including three Chinese biogas experts), a further 10 digesters were built in 1987 and 10 masons trained (two per district). These are listed below:

District	Village	Digester Size (m^3)
Maseru	Lihaseng	10
"	Ha Makhalanyane	6
Berea	Lithabaneng	10
"	Ha Lekafola	8
Leribe	Mathokoane	10
Buthe-Buthe	Ha Nqabene	10
"	Ha Klamoho	10
Quthing	Majakaneng	10
"	"	10
Leribe	Ha Leshoele	8

As was the case with the UNESCO/FAO programme, the dissemination strategy was to build as many digesters (and train operators, masons etc.) as possible in each of the 8 Districts and in this way spread the technology through a "demonstration" effect. It is possible that the rush to build digesters while support was available led to a lack of research into the attitudes of the villagers towards this technology and little

dissemination of information about its benefits. When in 1988, twenty-two biogas digesters were visited by members of the Department of Energy, only 6 were operative.

This rather sorry statistic was said to be due to:
- improper handling and lack of maintenance;
- lack of time available on the part of the villagers for running the digester; and
- lack of basic information on the operating principles of biogas.

NATIONAL UNIVERSITY OF LESOTHO

ADDRESS: National University of Lesotho
P O Roma 180

CONTACT PERSONS: Dr F.M. Mochaba, Dept of Biology
Prof. A.T. Hutcheon

SUMMARY:

Work in two fields of appropriate energy is being done, namely solar energy and biogas. This work follows a UNESCO/FAO funded project which ran from 1982 to 1985 under the direction of G.A.Gaillard of the UNDP. Under this project; some initial work was done in establishing a solar laboratory for the testing of solar water heaters, PV panels, solar dryers, solar stills etc. With respect to biogas, the main function of the University in the UNESCO project was to construct and operate a number of prototype digesters in order to advise on the most suitable design for dissemination in the rural areas of Lesotho. This work was done on a 1 m^3 Indian-type, a 6 m^3 Chinese-type and a 10 m^3 Fry-type digester all built in the vicinity of the Roma campus. The UNESCO project also included the building of a number of other digesters (mostly Chinese-type), training of villagers and the purchase of laboratory equipment. From 1985, with the departure of the UNDP adviser, activities in this project were transferred to the Department of Energy. However, by this stage the majority of the digesters built had run into disrepair and it was felt that the aims of the programme were in need of re-evaluation. Difficulties with biogas highlighted by the DOE included:

- No clear economic benefit for the user since construction costs are fairly high and alternative fuel sources cheaper.
- Many of Lesotho's rural population do not own enough livestock to adequately run a digester. Cattle are also not always kraaled making dung collection difficult.
- Many rural villages have inadequate water supplies.
- Low winter temperatures, particularly in the highlands, mean low gas production rates or sophisticated heating systems.

However, the Department of Biochemistry is at present doing some research on gas production rates with various types of substrate. The three biogas digesters in Roma are being monitored and there is also some work being done on solar cookers.

PROJECTS:

Gas Production Rates

The Biology Department has run batch tests in the laboratory in "mini-digesters" using different substrates on order to study the effect of different manure types on gas production. Results are summarised below (approximate figures).

TIME (Days)	GAS PRODUCTION RATE (cm^3/h)				
	Pig	Cow	Sheep	Chicken	Mix
5	37	18	2	2	8
10	84	56	16	10	21
19	106	88	39	27	36
40	140	107	45	40	49

Digester Monitoring

Of the 15-odd digesters built during the UNESCO project, only a very few are still operational. Three digesters of different types located in the Roma area have been closely monitored by university personnel. Results of the monitoring programme are summarised below.

An Indian-type $1m^3$ capacity digestor was constructed from the halves of two unequal diameter galvanised water tanks, with the larger diameter half forming the slurry tank, and the smaller diameter half inverted to form the gas collector. Both tank-halves were coated with bitumen. Feed displaces slurry by gravity flow, and stirring is effected by rotating the gas collector which is fitted with small paddles below the liquid level. Four steel rods are mounted on the side of the slurry tank, projecting upward. The gas collector is held upright while floating in the slurry tank by eyes which fit onto the steel rods. Gas pressure is regulated by the floating gas collector and can be adjusted by adding or removing hanging weights from the gas collector. The unit was originally fed

with horse manure but this was found to form surface scum. On switching to cow manure feed, this problem was largely eradicated. When fed regularly twice weekly at a rate of 1 kg/day (dry solids basis) and at a temperature of 20 °C, it produced about 0.15 m^3 of gas daily. This particular unit is sited inside a greenhouse and thus has a higher operating temperature with less fluctuation than the outdoor normal ambient. At peak conditions, it has produced up to 0.5 m^3/day.

A Chinese-type digester with 6m^3 capacity was constructed by the so-called integrally-cast method, i.e from poured concrete using the earth as a mould. The mould for the walls was excavated approximately 0.1 m wide, 1.5 m deep and with a diameter of 2.5 m. The digester was fed with a 10% manure slurry at a feed rate of about 1 kg/m^3 of digester volume per day. Gas production during summer with an average temperature of 21 °C, was around 0.16 m^3/m^3 volume per day, while in winter, with a temperature of around 10 °C it dropped to 0.09 m^3/m^3/day.

A 10m^3 Fry-type digester consisting of a rectangular concrete tank 10 m long an with 1 m^2 cross-section was constructed. Before casting the digester floor, a closed circuit heat exchanger made of 12 parallel half-inch water pipes was laid down and the floor slab cast over it. The underfloor heat exchanger was connected to a 24 m^2 solar collector panel mounted on the sloping ground below the digester. The whole structure was enclosed in a "greenhouse" made of plastic sheeting and the walls facing the sun were painted black while those in shade insulated with polystyrene sheets. Gas was collected in two 5 m^3 butyl rubber balloons and gas pressure was provided by weights lowered onto the balloons. Cow manure was diluted to an 8% slurry and allowed to stand in the green-house for a few days to pre-heat. It was then passed through a course sieve before being fed to the reactor. Gas leaks were frequently experienced due to the deterioration of the rubber balloons. The solar water heater maintained digester temperatures at between 36 °C (summer) and 29 °C (winter). Feed rates of around 2 kg dry solids per m^3 digester volume per day gave a gas rate of 0.3 m^3/m^3 volume/day which rose to 0.5 m^3/m^3 volume/day at feed rates of around 3 kg/m^3 volume/day.

While the Fry-type proved to give the highest gas production rates, it was also the most expensive to build, and required the most operational care and maintenance. The cost of materials for the Indian and Chinese digesters was about the same (R160 in 1982), and the Fry-type was approximately 20 times more expensive.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
Farm Improvement with Soil Conservation Project	Tree planting
Food Security Assistance Programme	Tree planting
Integrated Community Forestry and Agric. Resource Management Project	Nurseries
International Fund for Agric. Dev.	Agroforestry
Lesotho Catholic Bishop Conference	Village water supply Rural industry
Lesotho National Development Bank	Loans for rural development
Lesotho Save the Children Fund	Biogas Solar water heating
Ministry of Interior Village Water Supply Project	Windmills Hand pumps
Plenty (Lesotho)	Forestry
Qeme Soil Conservation Project	Agroforestry Forestry
Red Cross, Lesotho	Tree planting
Support to Soil and Water Conservation Project	Tree planting
Thaba Khupa Ecumenical Centre	Renewable energy sources
Thabana Morena Rural Dev. Project	Tree planting

COMMERCIAL EQUIPMENT SUPPLIERS

Name of Organisation	Field of Interest
Electric Centre (BP Solar Agent)	PV lighting
Lesotho Helios Power	PV systems
Maseru Pump and Plastic	Hand operated pumps
	PV pumping systems

MALAWI

INTRODUCTION

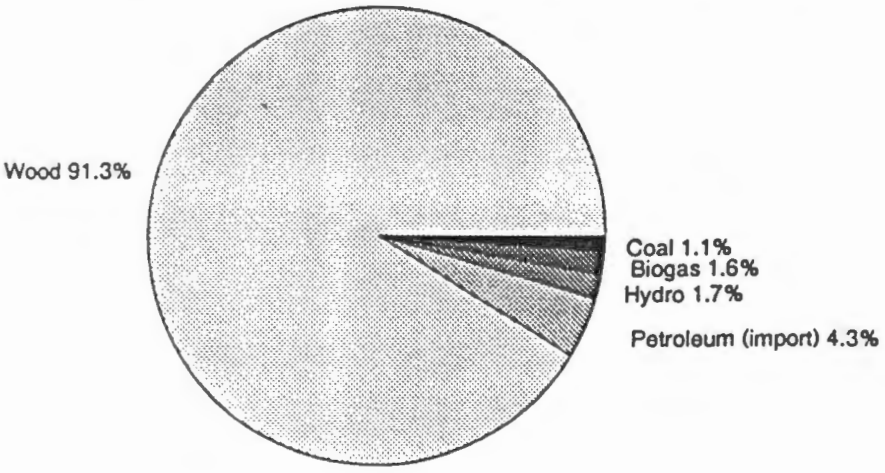
The Country

Malawi is a land locked country with a surface area of approximately 119 000 square km of which about 80% is land and the remainder the waters of Lake Malawi. It had a 1988 population of about 8.5 million people with a current growth rate of 3.7% per annum. Only 12% of the population is concentrated in the urban areas. Unlike some of its neighbours, Malawi has no substantial mineral resources and its economy is largely based on agriculture, which in 1982 accounted for 43% of the GDP and occupied 85% of the labour force. Malawi is a poor country as reflected in the 1983 GDP of roughly US$ 1217 million, or US$ 143 per capita. This however hides the productive activities of subsistence farmers making up the major part of the population. Chief exports are tea, tobacco and sugar which together account for about 85% of the total export earnings.

Energy Consumption and Resources

The relative importance of the different primary energy sources in Malawi is indicated in the chart below:

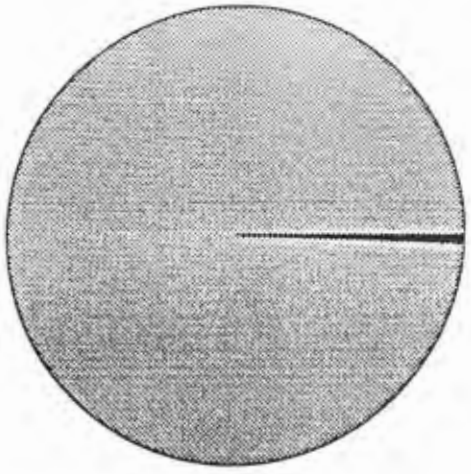
Figure 1. Primary Energy Consumption in Malawi by Source



Source: SADCC (1989a) and SADCC (1989b)

The total national energy consumption is around 116 PJ of which roughly 66% is consumed by households. Household energy needs are almost entirely met by biomass, except for a small amount of paraffin used for lighting. Only about 2% of the nation's households are connected to the electricity grid. Household energy consumption by fuel is indicated in the table below:

Figure 2. Household Energy Consumption in Malawi by Fuel Type



Source: SADCC (1989c)

Wood and derived fuels obviously play the major role in energy provision in Malawi. Apart from households, it is also used extensively in the tobacco and tea industry for curing and drying. With favourable soils and a good climate, the country has well stocked natural forests, although there are indications that consumption at present levels is not sustainable, and that forest cover is disappearing at roughly 3.5% per year.

Wood consumption has shown an upward trend and is presently estimated to be around 10 million m^3 per annum (7.1 million tonnes). On a national scale, there may be many areas where wood is in good supply. The main problem is the rapid rate of urbanisation which is accompanied by an increase in energy consumption, but not a corresponding switch to commercial fuels. Per capita wood consumption in rural areas is estimated at 0.8 m^3 (568 kg) per year compared to 1.4 m^3 (994 kg) per year in urban areas. In rural areas, only dead wood is used as fuel or to make charcoal, and

deforestation is largely a result of need for agricultural land. However, the felling of live trees has resulted in severe deforestation in the rural and peri-urban areas surrounding the larger centres.

Hydro installations on the Shire River supply virtually all the electricity consumed in the country. There are a total of 125 MW hydro installations, 15 MW gas turbines and 6 MW diesel generators. The last two are used only as standby generators. Total electricity consumption in 1987 was 465 GWh of which 69% was consumed by industry and 17% by households. Grid supply is limited to centres in the southern and central regions.

All petroleum used in the country is imported and a large portion of the final price is due to transport costs over long distances. Most of the fuel is used in the transport sector. Only a very small amount of paraffin for household use is imported.

Malawi has an estimated 3 million tonnes in coal reserves. Approximately 16 000 tonnes per annum is currently produced from one mine, providing roughly half of the total demand. The coal is not of a very good grade.

New and renewable energy technologies are not well developed although there is considerable potential. Average insolation ranges from 26 to about 17 MJ/m^2 per day. There is some research into solar technology at the university but most of the development in this field has been left to the commercial sector. There are some manufacturers of solar water heaters but the market is very small. There is also a small market for photovoltaic panels, mainly to provide power for communications networks in remote areas. The wind regime over Malawi in general is poor. Although there are a few wind-driven boreholes, the potential market is very small and there are no manufacturers of wind-power products.

Ethanol is produced from sugar-cane molasses at Dwangwa. Production is currently around 13 million litres per year, the bulk of which is blended for automotive fuel in a 2:8 ethanol/petrol ratio. Some trial marketing of rectified spirit to replace paraffin and LPG has been conducted.

Energy Planning and Policy

The overall responsibility for the planning and utilisation of energy resources falls to the newly created Energy Planning Unit (EPU) within the Economic Planning and Development Division of the Office of the President and Cabinet. National energy policies for Malawi are currently being formulated by the EPU on the basis of the National Energy Plan 1988-1997. These include programmes to expand and economise the electricity supply network, to create a strategic petroleum fuel reserve, and to proceed with coal and oil exploration. With regard to rural energy, a coherent policy formation has been constrained by incompleteness of wood and biomass inventories.

Although the Government supports a number of rural development programmes, most of these are aimed at education, health care and increasing agricultural productivity. There is as yet no distinct policy for the development of rural energy supplies. Rural development is directed through government-created district development committees which act as the bridge between government policy and community needs by advising government and assisting in the implementation of policy at local level.

Rural energy projects are carried out by separate institutions, and although they may be working towards similar goals, are not strongly centrally controlled. The conservation, development and utilisation of wood resources in rural areas, for example, is the responsibility of the Ministry of Forests and Natural Resources, while the utilisation of wood wastes is controlled by the Ministry of Agriculture. With the creation of the Energy Planning Unit it is envisaged that energy matters will be more closely monitored and more efficiently directed. A significant constraint at present is the staff and budget shortfall in the EPU. A study is underway to investigate and plan the institutional requirements of the EPU to include training of personnel and increased participation of the private sector.

The most important of the rural energy programmes at present are those involving fuelwoods. In this regard, activities at a national level include:

- programmes to increase wood supply through woodlots, plantations, farmer training etc.
- development of fuel efficient stoves,
- improved management of forest reserves,
- improved charcoaling techniques
- improved wood use efficiency in the tobacco curing process,
- rural energy surveys
- forestry research
- forester training

AGRO-ENERGY CONSERVATION INDUSTRY

ADDRESS: PO Box 1866
Blantyre
Tel: 632 758
Telex: 44222

CONTACT PERSON: Mr C. Kawerawera

SUMMARY:

The Agro-Energy Conservation Industry is currently involved in the production and dissemination of a single-pot charcoal cooker, the Malawi Ceramic Mbaula, for urban household use. The Mbaula was developed as part of the Wood Energy Project and production and marketing is now largely privatised. So far some 3 400 units have been sold.

ETHANOL COMPANY LTD.

ADDRESS: Ethanol Co. Ltd.
PO Box 919
Blantyre
Tel:633 432

SUMMARY:
The Ethanol Company produces ethanol from molasses waste at the Dwangwa Sugar Estate. Production commenced in 1982 with 6.3 million litres and was planned to reach 13 million by 1989.

Most of the product is blended with petroleum and sold to the transport sector. However, there has been some research into the blending of ethanol with paraffin for household use under Prof. Njojo at Chancellor College (PO Box 280, Zomba, Tel:522 222). According to Dr. John Harris of the Malawi Polytechnic (Priv.Bag 303, Chichiri, Blantyre 3, Tel:670 411), this has not been as successful as pure ethanol cookers which are being marketed by companies such as the Energy and Minerals Development Co. (EMDCO) in Blantyre. The blending of ethanol and paraffin requires anhydrous ethanol which is expensive to produce. There can also be problems of water separation from condensation of water in containers. Bulk storage inevitably leads to separation problems which can be dangerous when the mixture is used in combustion applications such as hurricane lamps. Straight ethanol can be used as rectified spirit, which is cheaper and safer, and has a degree of water tolerance.

The company is currently experimenting with 100% ethanol driven tractors and other vehicles on their farm

INDEFUND LIMITED

ADDRESS: PO Box 2339
Blantyre
Tel: 622 0055 / 620 353

CONTACT PERSON: Mr C. Kawerawera

SUMMARY:
Indefund Ltd. aims to provide financial, technical and institutional support to small rural industries, specifically with the aim of making them more energy efficient and thus more economically viable.

Support has been directed at:
- Solar water heating systems and fuel efficient stoves for hotels in rural areas;
- Investigation into the energy use in fish drying and smoking industry;
- Improved energy use in brickmaking;
- Coal briquetting;
- Distribution and marketing of softwood charcoal in collaboration with the Ministry of Forests and Natural Resources;
- An energy audit of 59 small rural industries; and
- Introduction and marketing of small PV powered irrigation units.

MINISTRY OF FORESTRY AND NATURAL RESOURCES: FORESTRY DEPARTMENT - WOOD ENERGY PROJECT

ADDRESS:

Wood Energy Division
P.O. Box 30048
Capital City
Lilongwe 3
Tel:734 144

PROJECT FUNDING:

- WEP Phase I
  US$ 10 million (World Bank, IDA)
- WEP Phase II
  US$ 16.7 million (World Bank, IDA)
- Blantyre City Fuelwood
  US$ 7.65 million (NORAD)
- Pilot Charcoal Production
  US$ 1.1 million (IDA)
- Viphaya Wood Industries
  US$ 16.19 million (KFW)

DURATION:

Phase I - 1979 to 1986
Phase II - 1986 to 1992

CONTACT PERSON:

Harry Chitenge
Lewis Mhango
Rodney Mhango
M.C. Kazembe, (Blantyre City Fuelwood Project)

OBJECTIVES:

The Wood Energy Project (WEP) operates from within the Forestry Department. Broadly, the project aims to establish and develop a sustainable wood production programme to meet the present and future demands for fuelwood and building poles,

while conserving and rehabilitating the natural forests and environment. These aims are achieved by:

- increasing wood biomass stocks through private and government initiatives,
- enhancing the economic utilisation of fuelwood through the promotion of energy efficient technologies, and
- improving the natural forest ecosystems through good management and protection of indigenous forest reserves.

SUMMARY:

The first phase of the WEP started in 1979, and the second in December 1986. The first phase of the project concentrated, firstly, on establishing fuelwood and pole plantations close to urban centres and, secondly, on setting up a network of nurseries which would sell seedlings at highly subsidised prices. By the end of the first phase, 15 000 ha of plantations and 88 retail nurseries had been established. The success of the project however, was limited. Sales of seedlings was low and so were wood yields from government plantations, 4.6 m^3/ha/yr against a predicted 10 m^3/ha/yr. In all, the project provided little incentive to plant trees and the forestry service found its manpower and financial resources stretched to the limit. Phase II of the project began in December 1986 and hoped to overcome the major problems encountered in the first phase.

The main target groups in WEP II are small-holder farmers and commercial wood users, including tobacco farmers. Extension services are provided and incentives offered for planting and care of trees. Energy saving technologies are being developed and promoted. There are four main components of the WEP II which are briefly discussed below.

1. The development of policy, structures and institutions that would encourage spontaneous tree planting and energy saving initiatives. Activities include the policing and management of forests and plantations, control of commercial wood price, extension services, data collection and analysis, and setting priorities of action.

2. Efforts to increase wood production through a number of means including:
   - A further 60 nurseries have been added to the 80 established in phase I of the project. In addition to fuelwood species, nursery stocks include those suitable for fruit, fodder, hardwood and traditional medicine. Seedlings are sold at highly subsidised prices.
   - Demonstration woodlots are being established on farms of leading "extension contact" farmers and around some nurseries. About 110 ha have been established for demonstration.
   - To further encourage farmers to plant and grow trees, a small cash bonus (5 tambala) is paid for each tree planted that has survived for two years. This gives farmers an intermediate (though small) financial return on their investment. It is hoped that incentives such as these will reduce the need for Government plantations, and in fact resources earmarked for plantation development have been redirected into the bonus incentive scheme.
   - Around 4 500 ha has been allocated for a Government plantation to supply wood to Malawi's largest city, Blantyre. Official policy is that provision of fuelwood and building poles is best done by the public, while the Government concentrates on protecting and improving the environment for sustained development.

3. The strengthening of research and training support structures. Forestry research is conducted through the Forestry Research Institute of Malawi. Priority research topics include soil surveys, improving seed sources of Eucalyptus, growth rates, agroforestry potential and disease control. Special emphasis is placed on research into the social aspects of forestry including needs assessment, fuelwood marketing structures and woodland management. The WEP II funds the training of foresters, extension workers, nurserymen and forest guards at the Malawi College of Forestry. Informal training is also given through touring workshops and seminars.

4. The development of techniques and practices for more efficient use of fuelwood. These efforts arise not only from the need to reduce fuelwood consumption in general, but also to relieve hardship in areas where severe wood shortages exist. Three aspects of this are the development of fuel efficiency in the tobacco industry, the country's largest industrial wood consumer; the development of more efficient

charcoaling methods; and the development and dissemination of fuel efficient stoves to the general public. These three projects will be discussed in more detail below.

PROJECTS:

Energy Studies Unit

The main function of the Energy Studies Unit (ESU) is to conduct surveys, promote energy saving technologies, evaluate public response to various initiatives and advise WEP management. The establishment of the ESU came about from the realisation in the WEP I that success in the aims of the project depended on a thorough understanding of the social and economic aspects of widespread public participation in afforestation programmes. The ESU has carried out a number of energy surveys and is also currently involved in training Mozambican refugees in the production of fuel efficient woodstoves.

Malawi Charcoal Project

A pilot charcoal production project under the Department of Forestry (Ministry of Forests and Natural Resources), was launched at the Viphaya Plantation in 1987. The pine plantation is essentially dedicated to supplying wood for the plywood, blockboard and sawn timber industry but the large quantities of waste generated from the thinning and clear felling logging operations made the charcoal pilot plant viable.

Several kilns have been built at the plantation from locally available bricks. The kilns, known in Malawi as the "Half-Orange Brick Kiln" were based on the South American "beehive" design. The design was chosen for its relative cheapness and high conversion efficiency. Logging and loading is done manually with the help of oxen.

Trials to date have produced a good quality charcoal with a fixed carbon content of 85%, a volatile content of 12% and a 3% ash content. Conversion efficiency by weight is around 35%.

The charcoal has been successfully used in tobacco curing barns and preliminary results from use in other industrial applications are encouraging. There have also been steps to

encourage household use of charcoal together with a cheap and efficient one-pot charcoal stove.

Energy Efficient Household Cooking Stoves

The development and dissemination of an energy efficient one-pot charcoal cooker has accompanied the charcoal project. Developed by a Kenyan company, the "Malawi Ceramic Mbaula" has been found to be over 30% more efficient than the traditional charcoal cooker.

The stove consists of an outer metal casing made from scrapped oil drums and a ceramic inner. The project includes the training of tinsmiths and traditionally skilled women potters to make the stoves. Production costs are around US$ 4. Quality tests indicate that the ceramic liner would have to be replaced about every three years while the metal casing would last for up to ten.

So far there are three pilot production centres and marketing has been successful. Some 80 000 stoves will be produced over the next three years and it is hoped to privatise the production centres in the near future. Wood equivalent to 2 000 ha of clear felled forest is expected to be saved by this project.

Tobacco Industry Energy Efficiency Project

The tobacco industry is a vital component of the economy of Malawi. It also accounts for about 30% of the national wood consumption. Wood is used in drying and curing the tobacco. Since the cost of converting to other fuels is prohibitive and electricity supply is not available, wood will continue to be used in large quantities. The project has thus concentrated on developing ways in which wood could be used more efficiently. Improved curing barn and furnace design, and better process management have indicated that the mean wood consumption in the industry could be reduced from 42 to 12 m^3 stacked wood/tonne tobacco cured. If the recommendations and improvements are implemented throughout the industry, an estimated 600 000 m^3 stacked wood/annum could be saved, the equivalent of 11 000 ha of clear felled natural woodland. Developments are disseminated through extension work, publications and workshops.

Blantyre City Fuelwood Project

The Blantyre City Fuelwood Project (BCFP) is part of the SADCC co-ordinated "Urban Fuelwood Project" to be implemented over a six year period under a Norwegian grant (NORAD). It was started in 1986 and supports the overall objectives of the Wood Energy Project as well as having the following four main goals:

- To raise living standards by creating job opportunities, providing an affordable and assured fuelwood source, and improving social and recreational facilities;
- To establish 10 000 ha of well managed, ecologically sound plantations for fuelwood, while managing a further 10 000 ha of indigenous forest for the City of Blantyre and the Township of Zomba;
- To conserve and ameliorate damage to ecosystems in the project area through efficient management, controlled exploitation and prudent protection of the land and aquatic resources;
- To promote improvements in the living standards of women by involving them in project activities, including planning and implementation, and creating specific income generating activities for them.

The project has so far established 1 800 ha of plantations and 12 nurseries which have provided over 13 million seedlings at the subsidised price of one Tambala each (approx. one cent). Damage to indigenous forest ecosystems has been cut due to management and control. Women now make up 27% of the labour force and this is to be increased to 35%.

PUBLICATIONS:

ENERGY STUDIES UNIT (1982) "Malawi Smallholder Tree Planting Survey".

ENERGY STUDIES UNIT (1984) "Malawi Urban Energy Survey".

ENERGY STUDIES UNIT (1986) "Malawi Flue-Cured Tobacco Use Survey".

FORESTRY DEPARTMENT (1987) "A summary of Yield Forecasts for Wood Energy Phase I Plantations".

FORESTRY DEPARTMENT (1987) "Blantyre Charcoal Stoves Pilot Project Progress Report".

EMRICH, W. & ZIEROTH, G.H. (1987) "Charcoal Production from Plantation Wood: A Guide to the Development of Small-Scale Charcoal Industries", Malawi Charcoal Project/IPC.

TOBACCO INDUSTRY ENERGY EFFICIENCY PROJECT (1988) "Support to Fuelwood Saving Research in Tobacco Curing in Malawi", Quarterly Report.

HARDCASTLE, P.D. (1977) "A Preliminary Sivicultural Classification of Malawi", Forestry Research Inst. of Malawi, Report No.57

OFFICE OF THE PRESIDENT AND CABINET: ENERGY PLANNING UNIT

ADDRESS: Private Bag 30136
Capital City
Lilongwe 3
Tel:722 277 / 731 777
Telex:74 389 PRFCSMI

CONTACT PERSON: Mr Bernhard Romahn (Energy Advisor)

SUMMARY:

The Energy Planning Unit (EPU) has recently been set up with German funding to co-ordinate the drawing up of an Energy Master Plan for Malawi. This is due for completion some time in 1990. The EPU will monitor and co-ordinate the governments activities in the energy field. The overall responsibility for rural development lies with the Rural Development Section of the Office of the President and Cabinet.

SMALL ENTERPRISES DEVELOPMENT ORGANISATION OF MALAWI

ADDRESS: PO Box 525
Blantyre

SUMMARY:

The Small Enterprises Development Organisation of Malawi (SEDOM) is engaged in the funding of indigenous Malawian entrepreneurs and has supported a number of energy related projects including:

- Training and setting up of village artisans in the manufacture of ceramic charcoal stoves;
- Promoting efficient energy use in the manufacture of bricks, and;
- Production of soft-wood charcoal from plantation thinnings.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
Adventist Rural Health Centres	PV lighting
Catholic Church	Solar water heating
Christian Service Committee	Wind power water pumps
Church of Central Africa, Presbyterian	PV lighting PV refrigeration
Dept of Lands Valuation and Water Water Resources Branch	Rural water supplies
Electricity Supply Commission of Malawi (ESKOM)	Rural electrification
LEPRA Missions	PV refrigeration
Malawi Development Corporation	Financial aid for rural industry
Ministry of Agriculture	Animal power
Ministry of Health	Remote power supplies for rural clinics

COMMERCIAL EQUIPMENT SUPPLIERS AND MANUFACTURERS

Name of Organisation	Field of Interest
Automotive Products Ltd.	PV water pumps
	PV lighting
Brown and Clapperton Ltd	Solar water heaters
	Waste-fired stoves
Circle Plumbing	Solar water heaters
Chloride Batteries	Deep discharge batteries
	PV cells
Cattle Feedlot Co.	Biogas
ECO-Systems Ltd.	Solar water heaters

SWAZILAND

INTRODUCTION

The Country

The Kingdom of Swaziland, with a land area of only 17 394 square km, is one of the smallest countries in Africa. It has a population of around 0.7 million of which about 92% is rural. It is completely landlocked and surrounded by the Republic of South Africa except for 100 km of eastern border with Mozambique. The country straddles the Drakensberg escarpment and is subject to a variety of geographical and climatic zones, from the temperate highveld grassland (1 300 m) in the west to tropical lowveld bush (200 m) in the east. Annual rainfall varies from 1000 mm on the highveld to 700 mm on the lowveld. Seasonal temperature ranges are between 5-25 °C and 8-28 °C respectively for the two regions.

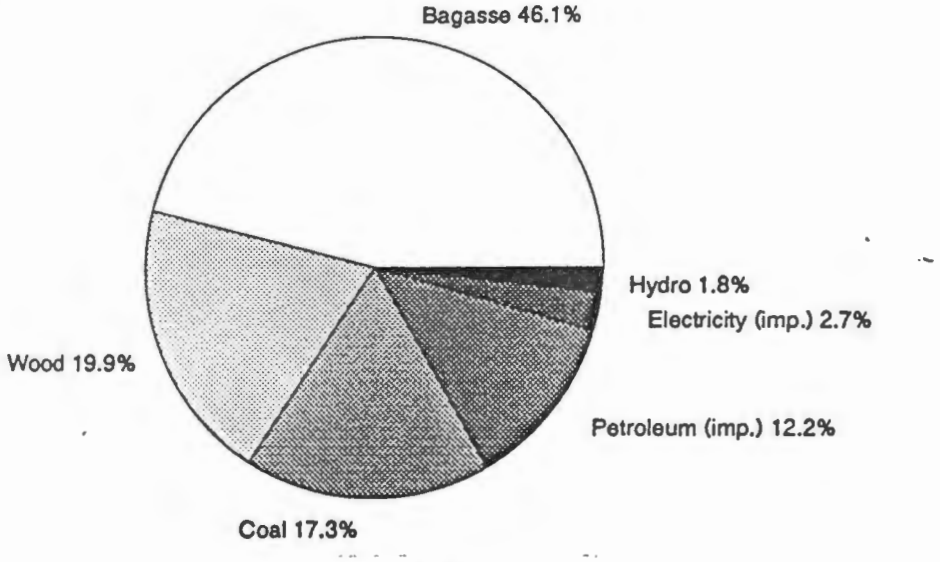
Swaziland is well endowed with natural resources. A number of substantial rivers flow into the country from west to east, experiencing a rapid altitude drop which provides significant hydropower potential. The good water supply together with a varied climate allows a thriving agricultural industry which includes forestry, fruit and vegetables, cotton, sugar-cane and livestock. Exploitable mineral reserves include coal, asbestos ore, clay and diamonds. The country has a relatively well developed transport network of roads and railways.

Swaziland is a relatively prosperous country. In 1984, its mean per capita income of US$800 was among the highest in Sub-Saharan Africa. It has an open economy with a very high dependence on trade with imports slightly above exports. The apparently well balanced economy is however based on the development of only a few key industries and agricultural activities. Swaziland's participation in the Rand Monetary Area and the Southern African Customs Union mean that the country's economy is closely linked to that of the RSA. In 1983, the GDP was US$ 528 million, or US$ 754 per capita.

Energy Consumption and Resources

The relative importance of the different primary energy sources in Swaziland is indicated in the chart below:

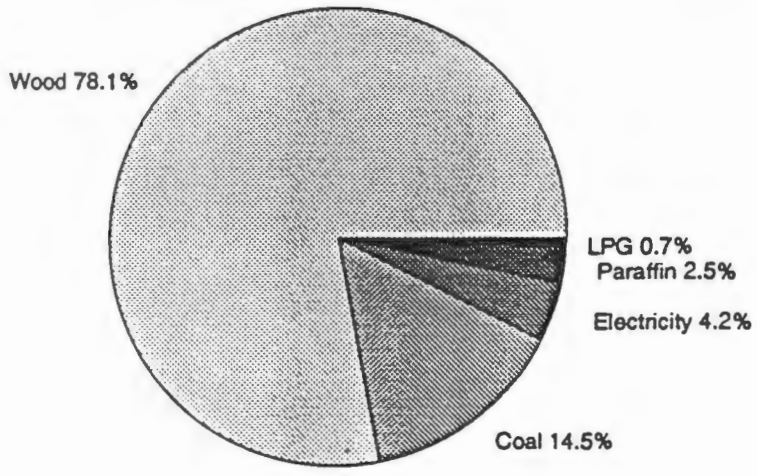
Figure 1. Primary Energy Consumption by Source



Source: SADCC (1989a)

The total national energy consumption is estimated at around 30 PJ of which about 25% is consumed by households according to the fuel types indicated below:

Figure 2. Household Energy Consumption by Fuel Type



Source: SADCC (1989a)

The consumption of electricity, coal, paraffin and LPG is largely confined to urban households. Few in the rural areas have access to electricity or to cheap commercial fuels. In addition, most rural areas have an abundant supply of wood. Rural fuel use is shown in the table below:

Table 1. Rural Household Energy Consumption by Fuel Type

FUEL	%
Wood	99.3
Coal	0.5
Paraffin	0.2

Source: Gajo (1989)

Compared to other African countries, the proportional contribution of wood to total energy consumption (as in Fig.1.) is fairly low. This is based on an outdated consumption estimate of around 3 m^3 per household annually, or assuming an average household size of eight, about 0.4 m^3 per person. A recent survey (Gajo,1989) in Swaziland gives a range from 0.7 - 1.8 m^3 per capita per year depending on geographic region, season and the importance of wood in the total household fuel budget. These latest estimates would place wood consumption in a more significant position. No comprehensive survey of forest stocks has been undertaken in Swaziland but recent estimates (World Bank,1987) show indigenous forests as being the major source of fuelwood followed by wattle forests and wood residues from commercial forestry. On the whole, the country does not seem to have a "serious" fuelwood shortage, although it is evident in some areas. However, a recent rural energy survey noted that the majority of households complained about the effort spent collecting wood and also claimed that it was more difficult to procure wood now than it was five years ago.

Proven coal reserves are estimated to be around 567 million tons of fairly good quality anthracitic coal, though with a relatively high ash content. Production in 1987 was 166 000 tonnes from a single mine. The domestic use of Swazi coal is low. Of the

tonnage mined, about 95% is exported while local demand is met from an additional 200 thousand tonnes imported from the RSA. This anomalous situation exists because most local industrial coal users have SA designed and built boilers which do not fire well with the local grade coal.

About 60% of the nett grid power is imported from South Africa (Eskom) with the remainder being made up from hydro and thermal installations. The 1000 m escarpment traversing the country, down which several major rivers and many smaller ones flow, offers considerable potential for hydro-power. However this is somewhat uncertain since all the major rivers flow into the country from the RSA where they are subject to significant abstractions for agriculture and powerstation cooling. Uncertainty is also introduced by periodic floods and droughts. Hydro installations could potentially generate between 550 and 700 GWh/year, although only 330-480 GWh/year is potentialy available for "large" installations. The Swaziland Electricity Board (SEB) supply capacity currently amounts to 110 MW, of which 40.5 MW is supplied by hydropower, 9.5 MW by diesel generators and 60 MW in cross-border links. The substitution of imported power is at present uneconomical. There are also a number of private industries producing their own electricity from mainly bagasse, wood waste and coal. Non-SEB generation capacity amounts to 57 MW, roughly half of SEB's supply capacity. Seventy-five percent of this is generated by steam plant fired on bagasse or wood waste in the sugar and wood-base industries. Most of these industries also purchase some power from the SEB.

All petroleum products are imported and account for 90% of the total energy import bill. This is primarily used by the transport sector. Petroleum imports amount to approximately 4.4 PJ.

Energy Planning and Policy

Energy matters in Swaziland have only been consolidated under one body since the creation of the Energy Planning Unit (EPU) in 1986. Although different ministries still retain control over various energy-related functions, central co-ordination is through the EPU under the Ministry of Natural Resources and Energy. The role of the Unit is to formulate energy policies and strategies, to co-ordinate, monitor and appraise all energy activities in the country and to facilitate energy research programmes.

Swaziland does not as yet have a formal energy policy for future action and the main task of the EPU at the moment is to build up an information base for this purpose. A number of surveys on energy use, particularly in the household sector are underway.

COUNCIL OF SWAZILAND CHURCHES: ENVIRONMENTAL CARE PROJECT

ADDRESS: PO Box 1095
Manzini
Tel: 53 628 / 53 931
Telex: 2398

CONTACT PERSON: Mr E. Chiya

SUMMARY:
The Council of Swaziland Churches is the first NGO in the country to become directly involved in rural afforestation projects. Their activities started in 1989 with teaching primary school heads the importance of the natural environment and how to plant trees. The primary aim of the tree-planting programme is to improve the standard of living of rural people by improving their natural environment.

The Council plan to provide funds to establish nurseries in rural areas, and to involve school pupils, students and women in tree-planting activities. The trees will be used for erosion control, windbreaks, shade, building materials and fuel. They are currently using the services of Forestry Section staff as resource persons.

MINISTRY OF AGRICULTURE AND CO-OPERATIVES: FORESTRY SECTION

ADDRESS: P O Box 162
Mbabane
Tel: 42731

LOCATION: Government Offices
Usuthu Link
Mbabane

CONTACT PERSON: Mr D.A. Gwaitta-Magumba

OBJECTIVES:

Since most of the forestry activities in the country are centred around commercial forestry, and since the rural population in most parts of the country do not suffer from a fuelwood shortage, there is relatively little work on woodlots development. The Forestry Section is however charged in terms of the Swaziland Forest Policy to provide extension services to farmers by establishing woodlots for firewood, building poles, control of soil erosion and income generation.

SUMMARY:

The total area under private forests in 1984 was 101 000 ha. Most of the wood products from this source are used for sawmilling and pulp & paper manufacture. Wattle jungles, mostly on the highveld, cover about 7 500 ha, of which about 5 000 ha can be found on "National Land" where the fuelwood demand is greatest. The extent of other wood resources, indigenous forests and scrubland have not been determined, although a forest inventory is pending.

Apart from its other forestry activities, the Forestry Section runs five small nurseries which supply seedlings free of charge for small private and community woodlots mostly on Swazi National Land. Tree species mostly used are Eucalyptus sp. and to a lesser extent Casuarina cunninghamiana. On approaching the Forestry Section, the chief or

community leader is encouraged to form a Woodlot Committee which is then advised by an extension forester on initial problem identification (fuelwood, building poles, soil erosion), site and species selection, land preparation, fencing, planting, weeding and woodlot protection. Due to problems encountered with the management of community woodlots, the Forestry Section is now directing efforts at encouraging the establishment of individual woodlots.

PROJECTS:

Research

Trial plots of Eucalyptus, Acacia, and Casuarina were planted in 1983 to provide information on their suitability for fuelwood, poles and land stabilisation. More than half of these plots were destroyed by fire in 1984. A five year SADCC project (No.606) on "dry zone and high altitude" fuelwood species (funded by FINNIDA) will soon commence. Another SADCC project is the establishment of the National Tree Seed Centre (funds from CIDA) to ensure good genetic and physiological qualities in nursery stock.

Forestry Section personnel have been involved in a national biomass assessment survey commissioned by the Technical and Administrative Unit (TAU) of the SADCC Energy Programme. This assessment will provide a key input into the development of regional biomass programmes.

Awareness Programmes

A committee has been formed to co-ordinate activities around National Tree Planting Day which was first instituted in 1981. The committee consists of representatives from various government departments and NGO's and has the responsibility of managing tree awareness programmes.

Charcoal Production

Charcoal demonstration projects started in 1974 using pit kilns but these were discarded in 1981 because of their physical immobility, long burning periods required and maintenance. In 1981, trials were conducted on a 7 m^3 Mark V kiln and this eventually led to a joint project including the Forestry Section, the Commonwealth Secretariat, the

National Industrial Development Corporation of Swaziland and a private timber company. Three 14 m^3 Mark V type kilns operated using mill wastes from the Tonkwane Saw Mill, Eucalyptus saligna logs unfit for poles, and wattle logs after stripping. Two kilns were also to be used by local farmers on a co-operative basis. Since there is no traditional use of charcoal as a domestic fuel in Swaziland it was planned to produce for the export market. Although there is still some production by a private company, production by the two farmers co-ops has been suspended largely because:

- the market was irregular and production was not big enough to meet minimum order requirements.
- final product was marketed through a monopoly which was inefficiently run.
- supervision and labour input was inadequate.
- raw material and final product were stored for long periods in the open with no shelter from the rain.
- the price paid to workers and co-op members was not attractive enough and in some cases payment was delayed.

Village Woodlots

In order to ensure a stable balance between consumption and production of trees, the Min. of Agriculture has undertaken the development of village woodlots on steep slopes, in gullies, major boundaries and all other areas in the rural lands not arable or suitable for pastures. Priorities include the establishment of 5 000 ha of community forest lots, the introduction of a wattle forest extension management programme, and the replacement of under-utilised wattle "jungles" with improved black wattle seedlings. The mechanisms for the operation of this section are still under review.

PUBLICATIONS:

FAO (1986) A report on Forestry and Technical Specifications for Inventory in the Wattle Jungles and Indigenous Forests in Swaziland, Rome, Italy: FAO.

GWAITTA-MAGUMBA D.A. (1983) Woodfuel and Other Energy Sources in Swaziland, Conf.Proc. SADCC Energy Sector Seminar 1983, Luanda, Angola.

GWAITTA-MAGUMBA D.A. (1984) Afforestation of Marginal Land for Commercial Timber Production and to Meet the Needs of the Rural Community in Swaziland, Conf.Proc.9th Regular Meeting of the SARCCUS Standing Comm., Lilongwe, Malawi.

GWAITTA-MAGUMBA D.A. (1989) Assessment of Biomass/Woodfuel Situation in Swaziland, SADCC Energy Sector.

LUX Development (1982) Charcoal Production Centres in Swaziland: A Feasibility Study.

MINISTRY OF AGRICULTURE AND CO-OPERATIVES, Forestry Section (1986) Annual Report, Mbabane.

MINISTRY OF NATURAL RESOURCES, LAND UTILIZATION AND ENERGY:
ENERGY PLANNING UNIT

ADDRESS: P O Box 57
Mbabane
Swaziland
Tel: 46244 / 42436

CONTACT PERSON: Mrs June Richards, Planning Officer

OBJECTIVES:

- To formulate energy policies and strategies that best meet the social, environmental and economic needs of Swaziland.
- To co-ordinate all the energy related activities in the country.
- To develop analytical and consultative procedures in support of energy policy making and planning.
- To appraise and monitor energy projects for the purposes of providing policy advise.
- To initiate research and pilot projects in the field of consumption and utilisation, especially in the rural and household sectors.
- To maintain and increase sources of energy available to the majority of rural people and reduce the time and ecological damage involved in collecting firewood.

SUMMARY:

Energy matters were transferred from the Ministry of Commerce, Industry, Mines and Tourism to the above ministry which was created in December 1983. The Energy Planning Unit (EPU) was established in 1986 to serve as the focus for national policy and operational activities pertaining to energy resources. However activities are severly hampered by a shortage of skilled staff.

In 1982, a study examining the availability and security of present sources of supply and future alternative scenarios was commissioned (Ministry of Commerce, Industry, Mines and Tourism,1982). It was felt that this report was not adequately grounded on hard data and recommendations therefore did not address real issues. Since then a number

of reports and surveys have been commissioned. A household energy survey has been completed to the draft stage and a forest inventory is pending, as is a SADCC project on energy audits and energy conservation measures in industry.

There is as yet no formal co-ordination between various institutions involved in new and renewable energy technologies although through the efforts of the EPU this is being done on an informal basis.

PUBLICATIONS:

GAJO, M. (1989) Energy Consumption and Demand in the Domestic Sector in Swaziland: A Socioeconomic Study, Final Draft Report (Report GTZ-PN:85.2204-03.106) for Min. of Natural Resources, Land Utilisation and Energy, Kingdom of Swaziland, Deutsche Gesellschaft fur Technische Zusammenarbeit, Federal Republic of Germany.

MINISTRY OF COMMERCE, INDUSTRY, MINES AND TOURISM (1982) Swaziland Energy Masterplan, Final Report prepared by Fichtner Consulting Engineers, West Germany, for the Kingdom of Swaziland, Mbabane.

RICHARDS, J.N. (1987) Energy Policy Issues in Swaziland, Energy Planning Unit, Ministry of Natural Resources, Land Utilization and Energy, Mbabane.

UNDP/WORLD BANK, (1987) Swaziland: Issues and Options in the Energy Sector, Report No.6262-SW, UNDP/World Bank Energy Sector Assessment Program.

RURAL WATER SUPPLY BOARD

ADDRESS: P O Box 961
Mbabane
Swaziland
Tel: 23231

LOCATION: Millers Mansions, 4th Floor
Mhlonhlo St, Mbabane

CONTACT PERSON: Mr Ngwenya, Senior Design Engineer

SUMMARY:
The Board is responsible for village water supply and has instituted roughly 200 supply schemes so far. Gravity feed systems are used where possible in the highveld and middleveld regions but the majority are borehole schemes in the lowveld. The type of system chosen depends largely on the demand for water, the yield of the borehole, and the preferences of the community. Technologies used include spring protection, gravity fed systems, ram pumps (Blake Hydrorams), diesel pumps, handpumps, electric pumps (mainly submersibles), windmills, and an animal driven pump from RIIC in Botswana which has been installed at Ekuphameni Village at Makanyane (this pump ran well for 3-4 years but frequent snapping of the link-chain has now put it out of action).

Initially many of the boreholes used pumps directly coupled to a diesel engine but these have been phased out where possible due to the high operating and maintenance costs. Where diesel (generally Lister) is used it has been found preferable to link it to a small generator which then supplies power to a submersible electric pump. Photovoltaic-powered pumping has been considered but is at present thought to be too expensive.

SWAZILAND ELECTRICITY BOARD

ADDRESS: Elubaneni
P O Box 258
Mbabane
Swaziland

CONTACT PERSON: Mr S H Nkambule, General Manager

SUMMARY:
The Swaziland Electricity Board (SEB) was formed in 1963 and is responsible to the Swaziland Government for the generation and distribution of electricity in the Kingdom. In early 1986, SEB supply capacity amounted to 110 MW made up from 40.5 MW hydropower, 9.5 MW diesel and 60 MW in transmission links with the Eskom grid. As the Eskom tariff structure has a relatively high demand charge and low energy charge, the SEB operates its system so as to maximise the capacity factor on Eskom. Consequently Eskom capacity carries the base load with the hydro stations meeting fluctuations from this base and the diesel generators being used only to meet extreme peaks in demand. Since 1980/81, the system load factor has remained around 57%.

Swaziland has an extensive network of 66 and 11 kV lines. The SEB considers an area covered if it is within 10km from an 11 kV line and by this definition, considers 80% of the country to be covered. Only about 10% of the population has direct access to electricity although since many large industrial and agricultural consumers purchase power in bulk which they then redistribute to their employees, this figure is more likely to be in the region of 20%. The SEB has no active policy of rural electrification. Legislation require it only to make electricity available within 100 yards of its grid supply lines, beyond which the consumer may be required to pay part of the capital costs involved in extension. However such costs are allowed to be repaid over two years. The lack of any rural electrification programme and the absence in rural Swaziland of typical village groupings means that rural supply is usually confined to schools, clinics, churches, water supply schemes and other public undertakings.

TINKHUNDLA REGIONAL ADMINISTRATION, NORTHERN RURAL DEVELOPMENT AREA: VILLAGE TECHNOLOGY UNIT

ADDRESS: Northern RDA
Project Centre
Entonjeni
Swaziland

CONTACT PERSON: Mr Colin Tshabalala
Home Industries Officer

SUMMARY:

The project grew out of the UN funded Women in Development (WID) programme initiated in 1975. It was taken over by the Ministry of Agriculture in 1977 and in 1987 by Tinkhundla (Regional Administration). The main activity at the centre is the training of women in skills such as dressmaking, sewing, knitting, batik and carpentry with the aim of encouraging home industry.

The Village Technology Unit aimed at supporting the installation of renewable energy and labour-saving devices but in fact there is no active dissemination of technology from the centre. There are a number of devices on demonstration, most of which are included in the UNICEF funded Village Technology Unit in Nairobi's catalogue, "Appropriate Village Technology for Basic Services", and include solar dryers, solar water heaters, growholes, sawdust and brick stoves, a biogas digester, hand operated corn grinders and shellers and concrete water tanks.

Artisan training originally included a welding and carpentry workshop although only the carpentry workshop is being utilised.

There are no plans at present to resurrect the village technology section in the near future.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
UNDP, Hhohho Rural Dev. Project	Fuel-efficient stoves

COMMERCIAL EQUIPMENT SUPPLIERS

Name of Organisation	Field of Interest
Alho Electrical (Pty) Ltd. (BP Solar)	PV lighting systems
Amanzi (Pty) Ltd.	Hand operated pumps
	Ram pumps
	PV powered pumps

ZAMBIA

INTRODUCTION

The Country

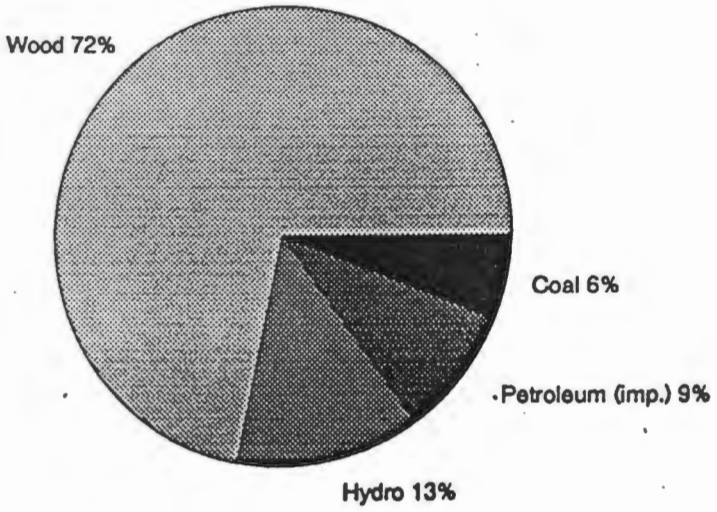
Zambia has a land area of about 752 000 square km and a population of approximately 7 million people. Some 57% of the total population live in rural areas but there is a significant migration towards urban centres. Annual population growth is estimated at 3.5%. The majority of the population is engaged in agriculture which is split between large-scale commercial operations concentrated around the central railway line, and small, mostly subsistence plots. Tobacco, maize and sugar are some of the important cash crops. The dominant influence in the economy, however, is the mining industry. Copper is currently the major foreign exchange earner with smaller quantities of lead and cobalt also being exported.

The country's economic performance in the past has been highly dependent on the copper production costs and the world copper prices and following the world copper price slump in 1975, the economy has suffered a steady decline. The government now aims to reduce the dependence on copper by promoting import substitution and export orientation based on the maximum use of local agricultural and mineral raw materials. There are also plans to diversify the country's economic base and to pay special attention to the choice of technology with regard to available raw materials and needs of the domestic market. The GDP in 1983 was US$ 3 342 million although by 1985, this had dropped to US$ 2 591 million, or approximately US$ 370 per capita.

Energy Consumption and Resources

The relative importance of the different primary energy sources in Zambia is indicated in the chart below:

Figure 1. Primary Energy Consumption by Source

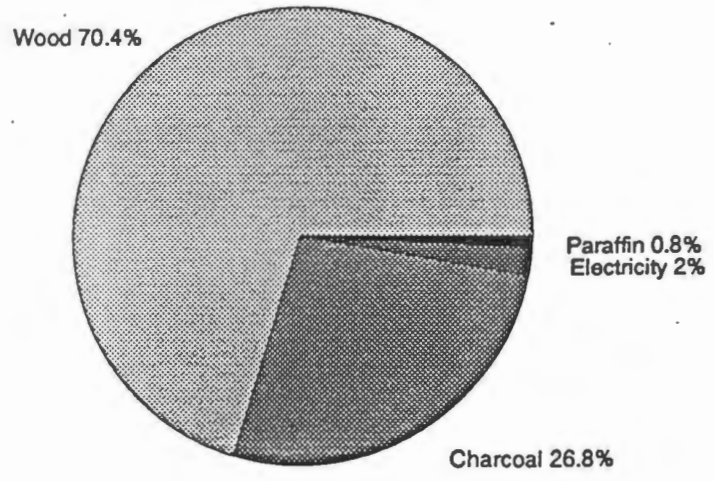


Source: SADCC (1989d)

The total production and importation of energy in 1986 was just over 267 PJ while actual consumption was only 174 PJ. A significant amount of electricity and refined petroleum products is exported to other SADCC countries. Of the total energy consumption, households account for 58%, mining 17%, commerce and industry 12%, transport 7%, agriculture 5% and government and services the remainder.

Energy use in the household fraction is split according to different fuel types in the chart below:

Figure 2. Household Energy Consumption by Fuel Type



Source: SADCC (1989a)

Wood in the form of fuelwood and charcoal, accounts for the major portion of the country's energy consumption both nationally, and in the household sector. Estimates of annual national wood consumption vary from 7 million m^3 (World Bank,1983) to just under 17 million m^3 (SADCC,1989), reducing to a rough per capita consumption of between 710-1700 kg/year. Of the total wood consumption, about 43% is used as "wood" by rural households, 54% is converted to charcoal for urban household consumption, and the remainder used in commerce and industry. The country's urban population is growing at the rate of about 6% per year and it is envisaged that wood (or charcoal) will remain an important fuel source. At present, Zambia does not experience a national wood shortage although there may be individual areas that are being rapidly denuded, particularly since charcoal is an important urban fuel and charcoal-making methods are still rather inefficient. Total woodland reserves are estimated at around 41.3 million ha.

Hydro-power in the form of electricity is the second largest energy source. Current installed hydro capacity is 1 624 MW generating 8 306 GWh/yr. A small amount of electricity (20 GWh/yr) is generated by fuel oil plants. About 19% of the electrical

power generated is exported. Of the power consumed internally, the mining industry accounts for 72%, other industries and services 20%, and households for the remaining 8 percent. The country is drained by two major river systems, the Zaire and the Zambezi, and there is considerable hydro potential that is unexploited. Estimates give a hydro potential of 3 924 MW generating around 21 406 GWh, some two-and-a-half times greater than present hydro capacity.

Although no electricity is produced from coal, Zambia has extensive coal reserves, estimated at some 95 million tonnes although this could be much greater. The country's only mine produces 0.5 million tonnes of coal per year the major portion of which is used in industry.

Zambia has no known petroleum reserves although there are a number of sedimentary basins which could show potential. So far some 3200 km^2 has been surveyed and two wells drilled. All petroleum is imported in the form of crude oil (0.67 million tonnes/yr) and refined inside the country. Some diesel and petrol is exported while the rest is used mainly by the transport sector.

Energy Planning and Policy

Rural development in Zambia is directed according to its national policy of humanism and socialism as an instrument for building a humanistic and classless society. Since most of the population is rural, state planning focuses on rural development in order to make rural areas more attractive. This is done through the promotion of self-reliance projects, improvement of the rural infrastructure, development of village and small-scale industry, and the promotion of agro-industry.

The responsibility for planning, co-ordination and implementation of energy affairs on a national scale rests with the Department of Energy (DOE) within the Ministry of Power, Transport and Communications. However due to the inevitable fragmentation of energy responsibility, such as the Ministry of Mines (coal) and the Department of Forestry (fuelwood), a separate body, the National Energy Council performs an advisory role to the DOE and other departments involved in energy.

Up till now, the major portion of the DOE's budget has gone to financing electrification schemes.

HUMAN SETTLEMENTS OF ZAMBIA (HUZA)

ADDRESS: PO Box 50141
Lusaka
Tel: 218 660

CONTACT PERSON: H.E. Jere, Executive Secretary

PROJECTS:

HUZA is involved in a number of development projects in rural areas in Zambia, some of which are energy related.

Improved Charcoal Stoves

With the aim of reducing the wasteful consumption of charcoal, the School of Engineering at the University of Zambia developed and tested a prototype improved charcoal stoves. In August 1986, HUZA was given the responsibility to train local tinsmiths and provide an extension service. Up till now some 1 000 of these stoves have been made and sold. Estimated charcoal savings are 35% to 40%.

MINISTRY OF LAND AND NATURAL RESOURCES
FORESTRY DEPARTMENT

ADDRESS: Forestry Department Headquarters
Ndola

SUMMARY:

The Forestry Department (FD) has the overall responsibility for managing the country's woodlands. It comprises of various technical, administrative, research and training divisions, and a field division in each of the nine forest provinces. Fuelwood activities of the provincial divisions include the management and allocation of licences for private charcoal burning operations. Much of this involves the control of illegal and indiscriminate felling of trees for charcoal burning in the Copperbelt and Central provinces. That the Department does not have sufficient staff for this work is reflected in the discrepancies between recorded wood harvesting and actual charcoal output from forest reserves and natural woodland.

The research division is involved in the testing and demonstration of improved charcoal kilns and in other wood energy projects. It has also investigated the use of local wood for the construction of windmill towers.

MINISTRY OF POWER, TRANSPORT AND COMMUNICATIONS

DEPARTMENT OF ENERGY

ADDRESS: PO Box 50065
Lusaka
Tel: 213 211
Telex:41 680 ZA

CONTACT PERSON: Wilfred Serenge

SUMMARY:

The Department of Energy was created in 1983 to plan, co-ordinate and implement energy programmes consistent with the overall development aims of the country, and to provide input to the preparation of projects and policies for the country's National Development Plan.

The DOE has stressed the importance of promoting new and renewable energy resources. Emphasis has been put on the adaptation and demonstration of already proven energy technologies that can be produced and maintained locally.

Up till now, the major portion of the DOE's project budget has gone to the financing of rural electrification projects.

The 1989 budget of ZK15.5 million included a provisional amount of ZK3.5 million for a coal briquetting pilot plant to be the constructed by the National Council for Scientific Research.

NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

ADDRESS: PO Box 30162
Lusaka

PROJECTS:

Biogas

In order to develop and promote biogas technology for rural areas, the NCSR constructed two digesters, both of the same $7m^3$ Indian type design. The unit at Chalimbana Farm is fed on cow dung and has been successfully supplying gas to three households on the farm. The cost of the digester was estimated at ZK 1 500 (1983). The unit at Nkumba Piggery was fed with pig manure and also connected to three houses on the farm. Apparently due to a shortage of water, the digester failed to operate well and has now been abandoned.

Two $9m^3$ Indian-type digesters were built at the Kasisi Agricultural Training Centre and fed with pig manure. In an attempt to find an alternative to the costly metal gas tank, one of the digesters was fitted with a ferro-cement lid. The lid however proved to be too heavy and the digester did not operate successfully. Only one is now operating well and is in good condition.

Support has now been received to construct a further 14 pilot digesters in the rural areas. The digesters will be $3.5m^3$ family size units or $12m^3$ units for communal use. The construction of one $11m^3$ unit and one $9m^3$ unit in the rural areas has already been completed.

NATIONAL ENERGY COUNCIL

ADDRESS: The Chairman
c/o Department of Energy
PO Box 50065
Lusaka

SUMMARY:
The National Energy Council (NEC) was established by Act of Parliament in 1980. It comprises 12 part-time representatives from government, parastatal, private and academic institutions appointed by the Minister of Power, Transport and Communications. The NEC meets on a regular basis to discuss energy matters and reports directly to the Minister while its members also report to their respective agencies. The NEC has the power to call for reports, data and information relating to energy from any person or organisation in the country. Once a year a report on energy requirements and other national needs is submitted to the Minister.

UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING / TECHNOLOGY DEVELOPMENT ADVISORY UNIT

ADDRESS: PO Box 32379
Lusaka

SUMMARY:

The Engineering school and the Technology Development Advisory Unit have carried out a number of research projects involving solar energy, wind energy and ethanol production. Most of the projects are of an academic nature and often suffer from a lack of continuity from year to year.

Projects completed include:

- Development of a simple solarimeter;
- Development of a solar water heater;
- Development of a solar crop drier;
- Design and optimisation of an ethanol distillation plant; and
- Design and development of improved animal drawn carts and improved draught animal harnesses and yolks.

Current and planned projects include:

- Design of an ammonia/water solar absorption refrigerator;
- Establishment of a solar field testing facility; and
- Design and building of a prototype low-velocity windpump.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
Development Bank of Zambia	Loans for rural development
Forestry Department	Animal power
Kasisi Agric. Training Centre	Animal power
Katopola Agric. Engineering Centre	Animal power
Looma Training Centre	Animal power
Magoye Farm Machine and Tillage Research Station	Animal power
Mindola Ecumenical Foundation	Sawdust-fired stove
Appropriate Technology Centre	Animal power Solar cooker
Ministry of Agriculture and Water Development	Rural water supply
Mpongwe Mission, Ndola	Solar water heating Wind generator Biogas
Mseckochika of Chipata	Animal power
Mt. Makuku Research Station	Animal power
Munkuye Resettlement Scheme, Kaoma	PV water pumping Wind power water pumping
Zambia Alliance of Women (ZAW)	Solar cookers
Zambia Electricity Supply Corp.	Rural Electrification
ZIMCO	Loans for rural development

COMMERCIAL EQUIPMENT SUPPLIERS

Name of Organisation	Field of Interest
BP Solar International Ltd.	Photovoltaics for - lighting - refrigeration - battery charging - water pumping - domestic power
Kensid Traiding Co. Ltd.	Solar Water Heating PV lighting PV refrigeration
Phillips Electrical (Zambia) Pty. Ltd	Photovoltaics for - lighting - water pumping - refrigeration Solar Water Heating

ZIMBABWE

INTRODUCTION

The Country

Zimbabwe is a landlocked country with a land area of about 391 000 square km. The climate over most of the country is temperate with dry, cool winters and hot, rainy summers. Rainfall ranges between 300 mm to 1000 mm with the lowest average in the west and south. Much of the country is savanna woodland although tree cover reduces with reducing rainfall.

The population of approximately 9 million is concentrated in the eastern and central provinces of the country. Population growth rate is around 3.5%. About 23% of the population live in urban areas and the remainder live rurally. There are two types of agricultural practice in the country:

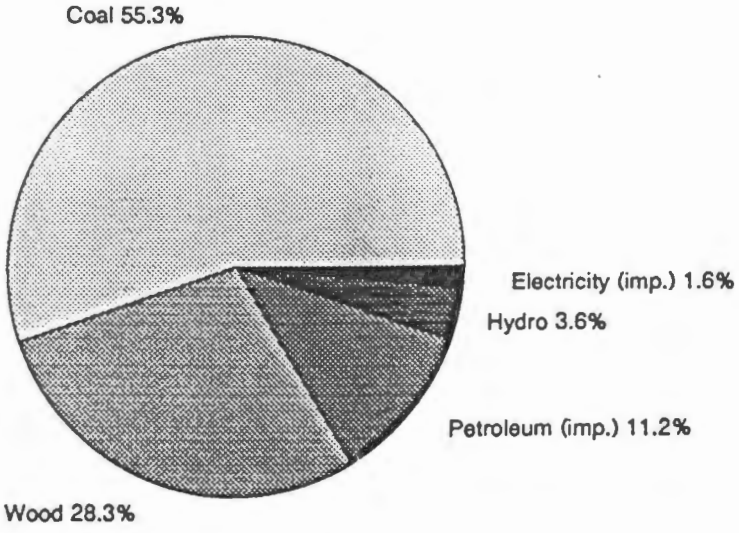
- Communally owned land constitutes about 42% of the total land area but much of it lies in unfavourable climatic zones. Population densities are high (up to 60 per km^2) where fertility is good. Production is mainly at a subsistence level.
- Commercial farms occupy about 43% of the land area. Farms are generally very large (2 500 ha average) and in fertile areas. This sector employs about 1.3 million people and contributes to major export produce such as tea, cotton and tobacco.

The country is rich in minerals and has a fairly well developed industrial base. Mining and industry account for 41% of the GNP. Gold, ferro-alloys and copper are major export items. Agriculture is also well developed with maize being the major crop and tobacco and cotton exported cash crops. Including subsistence farmers, about 80% of the population rely on agriculture for their living although it accounts for only about 15% of GDP. The GDP in 1985 was US$ 5024, or approximately US$ 558 per capita.

Energy Consumption and Resources

The relative importance of the different primary energy sources in Zimbabwe is indicated in the chart below:

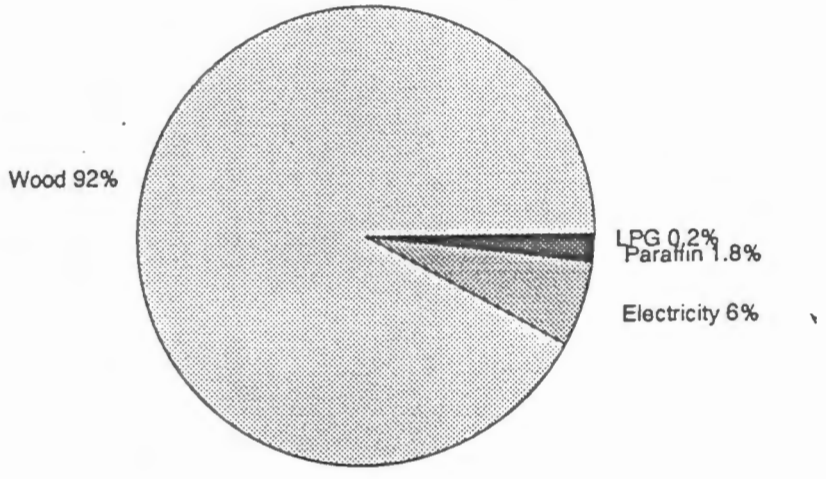
Figure 1. Primary Energy Consumption by Source



Source: SADCC (1989a)

The proportional contribution of wood is considerably lower than that for most African countries and may represent an underestimation. However, the country's relatively well developed industrial and commercial base would explain the high proportion of commercial fuels. The total national energy consumption amounts to just under 252 PJ of which approximately 31% is consumed by households according to fuel type indicated below:

Figure 2. Household Energy Consumption by Fuel Type



Source: SADCC (1989a)

The current total wood consumption is approximately 7.1 million tonnes per annum of which 6.5 million tonnes is consumed by households. The per capita wood use can thus be estimated at roughly 910 kg/yr. The highest wood consumption is found in the rural areas and only about 3% of the total is due to urban consumption.

Zimbabwe does not experience a nationwide wood shortage. Acute fuelwood shortages are evident in certain areas but at present, the problem is one of distribution rather than supply. Wood shortages occur mostly in the populated communal areas, while adjoining private estates often have large, relatively undisturbed natural woodlands. However, except by purchasing wood from these farms, no mechanism exists to allow a transfer of this resource to those who most need it and who can least afford to pay for it. It is estimated that the current rate of consumption outstrips the natural regenerative ability of woodlands and forests.

The major portion of the primary energy consumption is due to coal. The country has 24 identified coalfields with a reserve of about 10 620 million tonnes. The only operational mine at present is at Hwange in the west, which produces about 4.8 million tonnes per year. Roughly half is used to generate electricity and the other half used industrially. A small amount is also exported.

Electric power generation capacity currently comprises of 1 280 MW coal-fired and 666 MW hydro installations. Total electricity consumption is 8 250 GWh of which roughly 59% is generated from coal, 29% from hydro sources, and 12% imported. About 16% of total electricity consumption is due to households with the remainder used largely by mining and industry.

Zimbabwe has no known petroleum reserves. A refinery was opened in 1965 but operated only for one year. The country currently imports refined products. Consumption is accounted for mainly by the transport, commercial agriculture and commercial sectors. Household consumption of paraffin and LPG amounts to less than 6%, in energy terms, of the petroleum fuels imported. This is largely consumed in the urban areas.

Energy Planning and Policy

Rural development in the early stages after independence was focused on the resettlement of people displaced by years of war and the concurrent development of the physical and social infrastructure in rural areas. The current national development strategy is aimed at the parallel development of mainstream industry as well as redressing the inequality between the urban and the rural peasant sectors. Although industry has the leading role, agriculture remains the dominant sector and rural development programmes focus on irrigation, promotion of cash cropping, the development of credit organisations, and the improvement of services such as roads, electricity and water supply as well as health and education.

The responsibility for energy matters on a national scale lies with the Department of Energy under the Ministry of Energy, Water Resources and Development. General energy policy aims to effect an energy transition from oil dependency to maximum possible utilisation of indigenous sources. Within this framework, the government seeks to ensure the security of energy supply and that these supplies are sufficient to fuel economic development. This is to be achieved largely through a controlled energy pricing structure.

DEVELOPMENT TECHNOLOGY CENTRE (DTC)

ADDRESS: c/o University of Zimbabwe
PO Box MP 167
Mount Pleasant
Harare
Tel: 303 211

CONTACT PERSON: A. Scott

FUNDING: NORAD

SUMMARY:

The DTC is an autonomous department within the university specialising in energy conservation. Work has concentrated on the development of fuel efficient stoves. Already in production is the single-pot "Basic Tsotso". Three other stoves are still being developed and tested, namely:

- the Institutional Tsotso which is a portable scaled-up version of the single pot cooker;
- the Twin Plate Tsotso which is also portable and is based on the single pot model but with a hot-plate and flue added; and
- the Twin Plate Insert Tsotso which is based on the portable twin plate design, but consists only of the inner core around which a simple mud support is built.

PROJECTS:

Basic Tsotso

This is a small metal portable single-pot stove developed it the Centre in conjunction with Jetmaster Company between 1984 and 1986. It is constructed from 3mm and 1.5mm mild steel with vermiculite insulation separating the inner and outer cylindrical walls. The outer wall extends up around the pot and serves as a wind shield.

The fire is made on a wire-mesh grate at the bottom of the inner cylinder and the pot is removed before adding wood. The stove is specifically designed to burn small twigs, waste scraps and briquettes, and has been shown to use half the wood and cook 30% faster than the traditional outdoor fire

The stove is currently being manufactured by Jetmaster, a private company. The stove sells ex-factory at Z$29 and to the consumer at Z$39. Around 6 000 stoves have been sold and are used by households mainly in the rural areas. Despite the popularity of the stove, follow-up research has pointed to a number of possible improvements.

HLEKWENI FRIENDS' RURAL SERVICE CENTRE

ADDRESS: P O Box 708
Bulawayo
Zimbabwe
Tel: 73162

CONTACT PERSON: Mr. Philip Ngwena

PROGRAMME DURATION: 1967 -

EXTERNAL SUPPORT: Oxfam, Christian Aid
Bernard Van Leer Foundation
Quakers

SUMMARY:
This 1 800 acre Quaker run farm 12.5 km outside Bulawayo on the Plumtree road provides training courses in agriculture, book-keeping, carpentry, metal-work and other skills. It has an appropriate technology workshop which is involved with the design, testing and dissemination of village technologies, many of them energy related.

PROJECTS:

Mudstoves

The Centre has worked to develop a mudstove in conjunction with staff from the Organisation of Rural Associations for Progress (ORAP). Since 1982, over 400 people, including groups from government and non-government organisations, have attended stove building courses at the Centre. It is not known how many stoves have been built as a direct result of training, nor what the performance of the stoves has been. It is generally accepted that the durability of the stoves is in part a function of the quality of clay used and the skill of the builder.

Stoven

In a joint venture starting in 1985 with the Lutheran World Federation (LWF), a Christian organisation working in the field of integrated rural development, the Centre installed and evaluated 70 prototype stoves leading to the development of the "Stoven", a stove/oven combination. The objective in this case was not so much to save energy as to improve standards of living.

The Stoven consists of a brick body, metal grate, sheet-steel stove- top (with space for three pots) and galvanised metal chimney. The oven was originally a separate unit operating on the "retained heat" principle, but has now been modified as a direct heat unit. To use the oven, the stove top is removed and the metal oven-box is placed inside the fire-box chamber. Total cost including labour is around Z$60.

So far some 700 stoves have been disseminated to church members at a 50% subsidised price and there are plans to sell a further 4 000. The metal kits are manufactured at the Centre and a local steel fabrication company, and the LWF has trained builders to install the stoves. The Stoven has been well received and users cited the ability to bake as a major advantage of the unit.

HOLLOW CORE (PVT) LTD.

SUMMARY:
Hollow Core is a small private company involved in the design, construction and marketing of waste burning stoves. The stove is based on a simple but widely used technique of burning particulate waste matter. The stove is essentially a hollow metal cylinder enclosing a smaller diameter solid core. The waste fuel (sawdust, husks, straw etc.) is packed into the space between the two cylinders and tightly stamped down. To operate, the inner core is removed and a small fire made at the base of the stove with twigs or a small volume of paraffin. The hollow core of compressed fuel produces a draught due to its chimney effect and maintains a strong heat at the top of the stove while the fuel burns out radially. Heat is controlled by opening or closing the air inlet at the bottom. Operation is continuous and dependent on the size of the core and the type of fuel used.

The company manufactures three models:
- The "Vakomana" (young man) is the smallest model with outer cylinder dimensions of 28"x12". Retail cost is around Z$225.
- The "Gocha Standard" is a larger family sized unit. Outer cylinder dimensions are 36"x18", and retail cost is around Z$295.
- The "Gocha" model is the largest available and is a sealed unit with a chimney and a hot water geyser. Retail price is around Z$450.

The stoves are made from 4mm steel plate and are supplied with all the necessary tools for compacting the fuel and controlling the fire. The stoves are well made (perhaps even over designed) and should last up to ten years. The stoves have performed well with almost all types of waste fuel. One exception is the burning of bagasse which produces a highly acidic residue that tends to corrode the metal. Problems may arise with fuels that produce toxic or irritating smoke.

The company has sold some 1 200 of these stoves, all of them to large agricultural concerns and mines that produce a suitable waste on-site. There are no direct sales to the public and the only users are mine and farm labourers who have been provided with the stoves and with free supplies of waste fuel. Despite the imaginative concept, reaction to the stove has not been very favourable. Problems cited by some users included problems with the smoke produced, inability to control the heat, the danger of burns, and the unpleasant chore of packing the stove. Some of these problems could be rectified through redesign, while others relate to the type of fuel used. Negative reaction to the stove has also been due to the high-handed way in which they were forced on the farm workers, without consent or participation.

MINISTRY OF COMMUNITY AND COOPERATIVE DEVELOPMENT

ADDRESS: Pvt Bag 7735
Causeway
Harare

SUMMARY:
The German Agency for Technical Co-operation (GTZ), working through the Ministry of Community and Cooperative Development, runs an integrated rural development project in Gutu district.

PROJECTS:

Fuel Efficient Stoves

A pilot project in 1986 built, disseminated and evaluated a number of brick stoves. The design was based on the Department of Energy Chingwa Stove. Essentially made of brick and cement/mud plaster, the stove is constructed around a pre-cast iron grate, and the stove-top cement cast using pots as a mould. As with the DOE Chingwa Stove, the stove-top is subject to cracking after only a few months operation and is not easily repaired.

The project has built 218 stoves and trained 22 builders who charge Z$10 per stove built. Materials are a further Z$9. In terms of the project, the GTZ aimed for a 100% saturation in Gutu Ward 35. Stoves were built in almost every house (whether wanted or not) and the traditional fireplaces sealed up. The success of this project rested largely on the popularity and dedication of the area's GTZ extension officer. However, it would appear that considerable political pressure was put on those, particularly the elderly, who were not in favour of the "new" stoves.

MINISTRY OF WATER AND ENERGY RESOURCES AND DEVELOPMENT: DEPARTMENT OF ENERGY

ADDRESS: Private Bag 7712
Causeway
Harare
Tel: 707 861
Telex: 22 141

CONTACT PERSON: Mr J. Chirara
Mr J. Chigwada

SUMMARY:
The Ministry, through the Department of Energy (DOE) is responsible for a number of energy related activities. With regard to appropriate technologies, these activities are co-ordinated by the Wood and Alternative Energy Section of the Department, and have been concentrated in the field of improved woodstoves and biogas. Its stove programme must be considered as the most important attempt at widespread dissemination of this technology in rural Zimbabwe.

PROJECTS:

The Chingwa Improved Stove

This stove is based on the Indian Herl Chula with slight modifications developed through prototype testing. The stove kit consists of a cast-iron grate, hotplate, chimney mould and damper. Trained builders construct the stove in-situ from bricks and mud/cement mix. First the base and walls are built around the grate. Next, chicken-wire reinforcing and cardboard shuttering is placed on top of the brick sides. The pots are placed in position and a mud/cement mix is cast over and around this. Brick and mud are used to build the chimney around the chimney mould, after which it is removed.

The stove is marginally more efficient than an open fire and if used correctly can be made smokeless. The major problem with this type of stove is cracking of the stove top. These are generally not repaired unless the householders are trained in this art.

Around 1 500 Chingwa stoves have already been disseminated. Many of these have been supplied free with the Department paying for the kit (Z$10) and labour (Z$10). Others have been partially subsidised. Some 150 people have been trained to build stoves and many of then work now as private stove builders.

Biogas

The Department of Energy actively promotes the use of biogas mainly through:

- funding for research and development in this area;
- negotiating aid funding for biogas projects;
- running and testing its own installations; and
- subsidising biogas projects in the form of free advise and donations of pipes, fittings and other components.

Substantial R&D work has been done, mainly on testing different feedstocks to Chinese and Indian type digesters. Feedstocks tested include waste from beer and coffee processing; pigeon, chicken and cow dung; and municipal and household garbage.

The DOE has also co-operated with Silveira House in the building and testing of a number of digesters.

SILVEIRA HOUSE:
APPROPRIATE TECHNOLOGY DEPARTMENT

ADDRESS: P O Box 545
Harare
Zimbabwe

CONTACT PERSON: Fr Brian MacGarry

DURATION: Silveira House 1964 -
Appropriate Technology Dept. 1980 -

SUMMARY:
Silveira House is a development and education centre run by the Catholic Church. In the past it has supported agricultural schemes with 300 cooperatives, many of which are now self-sufficient, and has been involved in nutrition, primary health, youth and industrial relations programmes. The activities of the mission have been concentrated mainly in areas near to the mission farm at Chishawasha. Brian MacGarry heads the Appropriate Technology Department which has been concerned mainly with alternative energy sources and improved sanitation for rural areas. Alternative energy systems investigated include biogas, wood stoves and solar water pumping. Silveira House plays a significant role in the national debate on alternative energy systems.

PROJECTS:

Fuel Efficient Stoves

The mission has trained a number of people in the art of mud-stove construction. These were essentially of the Lorena type and once built, can easily be maintained by the users. The stove has received limited popularity, one of the major complaints about it being the insufficient space heating it provides. A full evaluation of dissemination efforts is not available.

Biogas

The mission offers training courses in the utilisation and construction of biogas plants.

TRIANGLE LTD.

ADDRESS: PO Box 801
Triangle
Tel: 6221

SUMMARY:

This ethanol plant has been running at near full capacity since 1980, producing an average of 38.5 million litres of ethanol per year. The product is derived from the sugar-cane molasses produced by two of the largest estates in the country, and from a small amount imported from Zambia. The raw material used in ethanol production represents only 7% of the total sugar production, the majority of which is sold locally or exported. There are plans to increase ethanol production if the savings from substituting imported petroleum with ethanol outweigh the earnings from exported sugar. Ethanol is used solely as a blend with petrol, and is at present added at about 13%, well below the recommended 20% limit.

ZERO: REGIONAL NETWORK OF ENERGY EXPERTS

ADDRESS: PO Box 5338
Harare
Tel: 732 2858 / 729 343

CONTACT PERSON: Mr S. Moyo
Mr D. Hancock
Mr Y. Katerere

PROGRAMME DURATION: 1987 -

FUNDING: HIVOS (Holland)
Inter-Pares (Canada)
NORAD (Norway)
Panos Inst.

OBJECTIVES:

The objectives of ZERO are broadly:

- to contribute to the development of the SADCC region's capacity to undertake research on energy and environmental problems;
- to develop an information data base and expertise base on energy and environmental issues, and to provide technical support to groups working in energy; and
- to organise and facilitate seminars and workshops with relevant groups on regional and national energy issues.

SUMMARY:

Formerly the Zimbabwe Energy Research Organisation, ZERO has now come to include other SADCC countries to form a regional network co-operating in energy issues. ZERO is a non-profit, non-governmental organisation conducting research in a wide range of energy systems. The organisation is based in Zimbabwe but has members in a number of SADCC countries and works in co-operation with government, NGO,s and international organisations. ZERO functions as the secretariat of the SADCC Regional Energy NGO's Network (SENN).

Apart from its networking role, the activities of ZERO in Zimbabwe are co-ordinated under the ZECON Programme (Zimbabwe Energy Conservation). ZECON runs a number of energy programmes in Zimbabwe focussing on household fuelwood energy conservation and the use of energy in rural institutions and small industries.

ZERO has a library and an energy data bank where publications on energy issues and information on SADCC energy organisations are collected and can be referenced through a computerised system.

PROJECTS:

Stoves and Household Energy (SHE)

A number of organisations have been involved in the design and dissemination of wood-stoves in Zimbabwe with varying degrees of success. ZERO has undertaken a comprehensive study of rural energy needs and stove programmes in an effort to isolate key factors for success. A project to "make stoves available to those who want them" and to educate people on possible "no-cost" methods of reducing fuel consumption is being planned to run in conjunction with an ENDA tree planting project.

Commercialisation of Stoves

A study in 1984 revealed that even in densely populated urban areas, a large number of households rely heavily on wood for cooking and heating. The continued use of wood in the urban areas has led to localised deforestation, and in turn to very high wood prices as vendors have to travel further afield to collect their supplies. This project aims to assist the dissemination of stoves into urban areas by performing a market review, drawing up socio-economic profiles of potential target groups, and evaluating consumer reaction to the introduction of wood stoves. The project includes the participation of a number of NGO's and will promote the "tsotso" stove developed by Development Technology Centre (DTC) and Jetmaster.

Resource Sharing Agreements Programme

In many areas experiencing fuelwood shortages, there are neighbouring areas relatively well endowed with indigenous forests. These are usually large commercial stock farms. On communal land, forest reserves are often not managed in any coherent way. The

aim of this project is to arrange "reciprocal benefit" agreements between parties for the more efficient and equitable distribution of, and access to wood for fuel, and also to improve the standard of woodland management. It is hoped that at a further stage, this project can also incorporate resources other than woody biomass such as water, grazing and soil.

Tree Preferences Institutional Support Programme

While many tree planting programmes have been concentrating on fast growing fuel species, surveys have revealed a distinct pattern of tree preferences among rural households, particularly for fruit trees. The main aim of this project is to support local organisations with obtaining, planting and caring for the tree species that they request.

Domestic Utilisation of Coal

This project aims to replace wood use in "high-density" urban areas with coal. The project is essentially a feasibility study to determine the market, consumer reaction, potential target groups, distribution structures, potential health and environmental problems and various other constraints. The project will make recommendations for future action and outline a possible pilot project.

Rural Institutions Energy Needs Assessment

In the long term, the project objectives are to improve the cooking facilities in rural institutions such as schools and clinics, thereby making them more effective in serving their communities. The first phase of the project will consist of a survey to establish the energy needs of this group and to define parameters for further action.

Low-Cost Electrical Appliances

In order to assist with the development of rural electrification, this project is to investigate the potential for manufacturing low-cost electrical appliances. Initially the project will consist of a survey of present appliance manufacturers, the appliance market and price structure, and consumer requirements. This will provide a project outline for the possible manufacture of low-cost stoves, sockets, etc.

Research Projects

There are currently two major research projects underway:

- Where wood is in short supply, the use of crop residue and cow-dung as a fuel is a natural progression. However, little is known about the possible environmental effects of their use. The research project will evaluate the extent of their use, and their value as fertilisers.
- Most research into afforestation and woodland management has centred around fast-growing exotic tree species. This project aims to establish data on yields, coppice regrowth and natural regeneration rates of indigenous species. In addition certain socio-economic questions around indigenous woodland management will be investigated.

ZIMBABWE ELECTRICITY SUPPLY AUTHORITY

ADDRESS: PO Box 377
Harare
Telex: 24 323

CONTACT PERSON: Dr. Z.S. Gata, General Manager

SUMMARY:
The Zimbabwe Electricity Supply Authority (ZESA) is the only organisation in the country responsible for electrical generation, transmission and supply. About 8 000 GWh per year is consumed of which 16% is due to some 200 000 households, mostly in urban areas and commercial farming districts. Almost all formal urban areas are provided with access to electricity although it is not always used. In low-income suburbs (also called high-density urban areas), most consumers are connected on a "load-limited" tariff, where the monthly charge is fixed. Consumption is not metered, but the control unit does not allow current drawn above a set maximum. The current breaker is set at ranges from 1 to 30 amps and is directly related to the monthly charge. Rural electrification is fairly well developed in some areas but has in the past always been subsidiary to other development efforts. Consequently, rural electrification was confined to areas near mines, industries and large commercial farming concerns.

Rural Electrification Programme

In 1984, a rural electrification programme was initiated, at the directive of the government, for which ZESA has the sole responsibility. In the formulation of a policy for rural electrification, the ZESA management was assisted by the Rural Electrification Co-ordination Committee, charged with the task of reviewing existing programmes and consulting with other rural development organisations to produce a broad plan for implementation within the national Five Year Development Plan. Rural electrification is now at the forefront of the government's development efforts.

Rural electrification is seen as a social service for which the return on investment is negative or non-existent in the short term. A positive financial return is expected within the next 10-15 years as a result of growth in domestic and industrial demand. A further

long term benefit is the replacement with indigenously generated electricity of imported paraffin and diesel fuel.

The selection of areas to be electrified does not involve ZESA. Electrification proposals are put forward by Village Councils which are forwarded up the political hierarchy until reaching the provincial governments which then draw up a priority list of areas to be electrified. Once approval is obtained from Government, the projects are implemented as soon as ZESA can finance them. With the decision-making mechanism not necessarily based on practical or economic considerations, the financial constraints under which ZESA operates can be substantial. There is much room for a reassessment of the way in which areas are earmarked and projects financed.

By mid-1987, 55 centres had been identified as "rural growth centres" although out of these, only 43 had been electrified. Expenditure on the projects was running at Z$18.8 million. The total costs of projects is borne by ZESA, which heavily subsidises the construction of lines and substations. At present, with the standard connection fee at Z$250, the contribution of new users is around 18% of the project's total capital expenditure. The lack of immediate financial return means that the rural electrification project has to be financed through cross subsidies from other consumers. This is proving to be increasingly controversial. In each of the areas electrified, the usual pattern is for the police station, government buildings and local stores and businesses to be supplied first. The number of households connected in the rural areas is generally very small as most cannot afford connection fees. In most cases, initial demand from a rural centre is less than 100kW, and sometimes often less than 50kW.

ZIMBABWE INSTITUTE OF DEVELOPMENT STUDIES: DIVISION OF INDUSTRY, SCIENCE AND TECHNOLOGY

ADDRESS: Century House East
36 Baker Ave.
PO Box 880
Harare
Tel: 729341/4 or 700661/4
Telex: 26422 ZIDS ZW

CONTACT PERSON: S. Ruzvidzo Maya, Head
Dept of Industry, Science & Technology

PROGRAMME DURATION: 1982 -

FUNDING: Zimbabwe Government
(Office of the President and Cabinet)

SUMMARY:
The Zimbabwe Institute of Development Studies (ZIDS) was created to provide the government with a scientific research base from which it could formulate policies relating to the development and transformation of the country. Besides running research programmes in a number of fields, the ZIDS provides courses in development studies, provides a forum for debate on development issues, and is developing a resources capacity and data base. Staffing is currently at 45 of which 25 are full-time researchers.

Research is carried out on a wide range of issues, many relating to rural development, including energy utilisation.

PUBLICATIONS:

Some selected publication titles are provided below.

MOYO, S. (Undated) "Farm Workers and Energy Issues"

ZWIZWAI, B. & MOYO, S. (1985) "Assessment of Human Resources for the Development of Electric Power, Household Energy and Energy Planning in Zimbabwe", Research Paper.

MAYA, R.S. (1988) "Issues and Prospects for Coal Utilisation in Zimbabwe's Rural Households", Working Paper.

ZWIZWAI, B. (Undated) "Towards an Electricity Demand Model for Zimbabwe: A Working Exercise", Working Paper.

PROMOTERS OR USERS OF APPROPRIATE ENERGY SYSTEMS IN RURAL AREAS

Name of Organisation	Field of Interest
Agricultural Finance Corp.	Loans for rural energy projects
Association of Women's Clubs (AWC)	Woodlots Forestry training
Christian Care	Woodlots Wind powered pumping
Environmental Development Activities (ENDA)	Tree planting Biogàs Solar cookers
Grain Marketing Board	Waste briquetting
Inst. of Agricultural Engineering	Draught animal power Solar power pumping
Lutheran World Federation	Stoves
Mary Knoll Sisters	Biogas
Ministry of Health National Health Services	PV power supply for rural clinics
Min. of Lands, Agriculture and Rural Resettlement	Rural development Animal draught power Low-cost Windmills Solar water pumping
Min. of Water Resources and Development	Rural water suplies
National Federation of Women's Institutes of Zimbabwe	Tree-planting Conservation training
Organisation of Rural Associations for Progress (ORAP)	Hlekweni Mudstoves
SEDCO	Loans for rural energy projects
Solar Energy Soc. Of Zimbabwe	Renewable Energy

World Vision	Tree-planting Renewable energy systems Conservation training
Zimbabwe Development Corporation	Loans for rural development
Zimbabwe Forestry Assn.	Rural fuel consumption Conservation

COMMERCIAL EQUIPMENT SUPPLIERS

Name of Organisation	Field of Interest
Capri	Solar water heaters
Ecological Designs	Solar water heaters Solar cookers PV systems
Jetmaster (Pvt) Ltd.	Tsotso stoves Tobacco drying flues
McDairmid & Co.	Solar water heaters PV power systems
Sheet Metal Kraft Ind.	Windmills
Stewards & Lloyds	Windmills
WRS - Aircool (ARCO Solar Agents)	PV systems
WS & G Hi-Tech / Apex Corp.	PV systems mfg.

INDEX

REFERENCE LIST

EARTHSCAN (1984) "Fuelwood: Which Way Out?", Press Briefing Document No.37, International Institute of Environment and Development, London.

EBERHARD A.A. (1984) "A Directory and Review of Appropriate Energy Technology Programmes in Southern Africa", Report No.89, Energy Research Institute, University of Cape Town.

GAJO, M. (1989) "Energy Consumption and Demand in the Energy Sector of Swaziland: A Socioeconomic Study", Final Draft Report GTZ Consultants, Ministry of Natural Resources, Land Utilisation and Energy, Mbabane.

GAY, J. & KHOBOKO, M. (1984) "Village Energy Survey Report", Renewable Energy Technology Project, Appropriate Technology Section, Ministry of Cooperatives and Rural Development, Maseru.

KAREKEZI, S. (1987) "Lesotho: The Biomass Energy Challenge", Draft Report of KENGO Regional Wood Energy Programme for Africa, Mission to Lesotho, 9-17 Dec.

KGATHI, D.L. (1987) "Conventional Solutions Adopted to Alleviate the Rural Energy Problem: The Case of Botswana", Research Notes No.22, NIR, University of Botswana, Gaberone.

KINGDOM OF LESOTHO (1988) "Lesotho Energy Masterplan", Department of Energy, Ministry of Water, Energy and Mining, GTZ Consultants, Maseru.

KINGDOM OF SWAZILAND (1982) "Swaziland Energy Masterplan", Final Report prepared by Fichtner Consulting Engineers, West Germany, for the Ministry of Commerce, Industry, Mines and Tourism, Mbabane.

PEAT MARWICK MITCHELL & CO. (1987) Metal Stove Production and Marketing Study for the ATS., UN Agency for International Development.

SADCC (1987) "Energy", SADC Conference, 5-6 February, Gaborone.

SADCC (1989a) "Energy Statistics - 1987", SADCC Energy Sector, Technical and Administration Unit, Luanda.

SADCC (1989b) "National Survey of Biomass/Woodfuel Activities - Malawi", SADCC Energy Sector, Technical And Administrative Unit, Luanda.

SADCC (1989c) "New and Renewable Sources of Energy in Malawi", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989d) "New and Renewable Sources of Energy in Zambia", SADCC Energy Sector Technical and Administrative Unit, Luanda.

STEELE, R.J.G. & NCHULO, T.G. (1983) "Woodlot Marketing Study - North", Final Report, Ministry of Agriculture, Leribe & Buthe-Buthe Districts, Lesotho.

WICKSTEED, M. (1984) "Woodlot Marketing Study - South", Ministry of Agriculture, Maseru.

WORLD BANK (1983) "Zambia: Issues and Options in the Energy Sector", Report No.4110-ZA, UNDP/World Bank Energy Sector Assessment Programme.

WORLD BANK (1987) "Swaziland: Issues and Options in the Energy Sector", Report No.6262-SW, UNDP/World Bank Joint Energy Sector Assessment Programme.

BIBLIOGRAPHY

Useful additional material that is not referenced in the text or under the "Publications" section of individual project entries is listed below.

CHERNICHOVSKY, D. Et.Al. (1985) "The Household Economy of Rural Botswana", World Bank Staff Working Paper No.715, The World Bank, Washington DC.

GOLDEMBERG,J. Et.Al. (1987) "Energy For Development", World Resources Institute.

HANCOCK,D., KATERERE,Y. & MOYO,S. (1988) "Rural Electrification in Zimbabwe", The Panos Institute, London.

SADCC (1989) "National Survey of Biomass/Woodfuel Activities in Botswana", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "National Survey of Biomass/Woodfuel Activities in Lesotho", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "National Survey of Biomass/Woodfuel Activities in Swaziland", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "National Survey of Biomass/Woodfuel Activities in Zimbabwe", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "New and Renewable Sources of Energy (NRSE) in Botswana", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "New and Renewable Sources of Energy (NRSE) in Lesotho", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "New and Renewable Sources of Energy (NRSE) in Swaziland", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

SADCC (1989) "New and Renewable Sources of Energy (NRSE) in Zimbabwe", SADCC Energy Sector, Technical and Administrative Unit, Luanda.

WORLD BANK/UNDP (1984) "Botswana: Issues and Options in the Energy Sector", Report No.4998-BT.

WORLD BANK/UNDP (1982) "Malawi: Issues and Options in the Energy Sector", Report No.3903-MAI.

WORLD BANK/UNDP (1982) "Zimbabwe: Issues and Options in the Energy Sector", Report No.3765-ZIM.

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FINAL REPORT

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