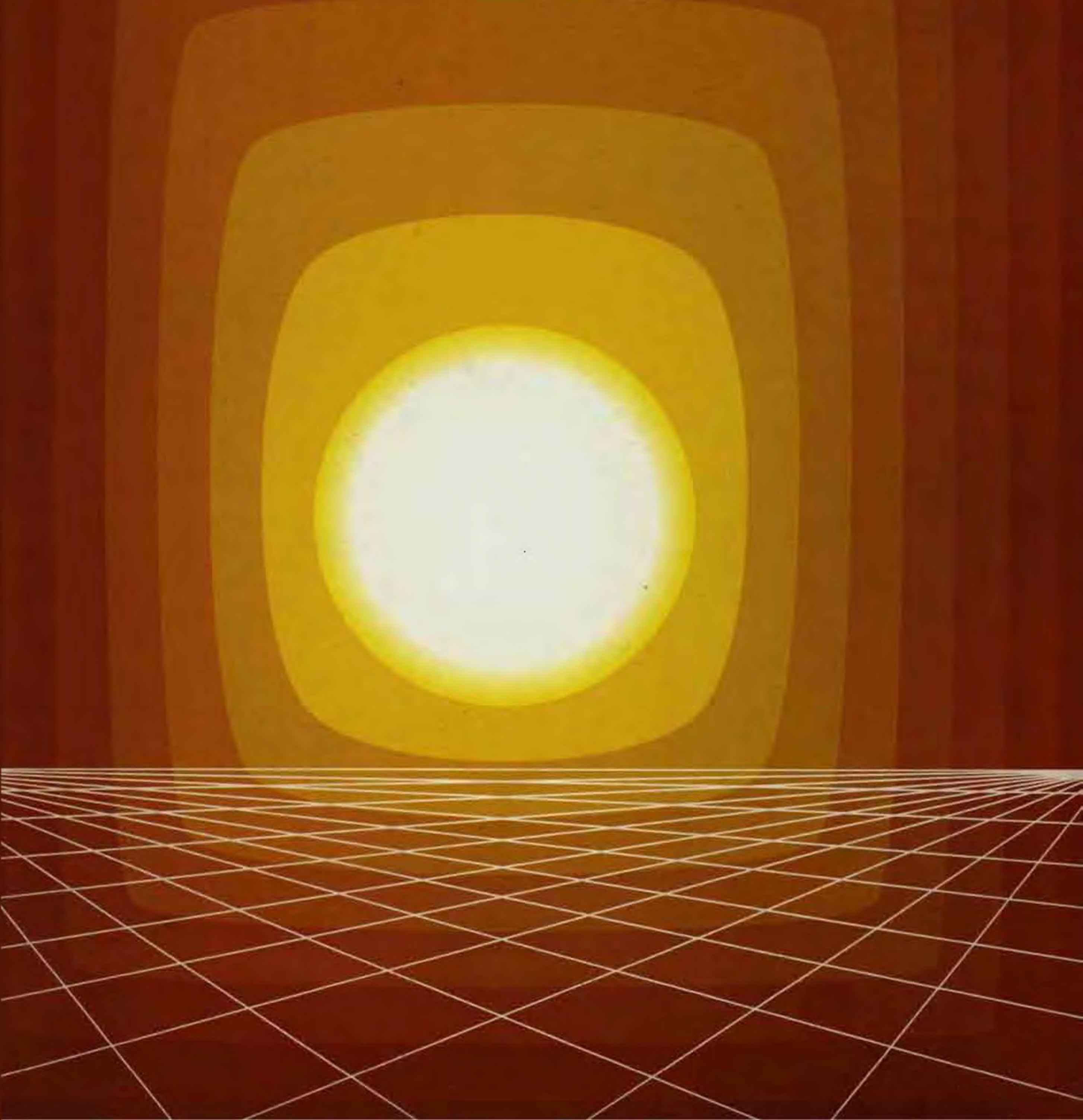
# JOURNAL OF ENERGY IN SOUTHERN AFRICA

Vol.7 No.3 August 1996




LEADERSHIP IS ACTION
NOT POSITION
"Traditionally business has measured market leadership in volume
and sales and the bottom line. No longer good enough. Righ
now in South Africa the success of a business will als
be gauged by how it values people. Creatin
opportunities for those they employ
Empowering the lives of those the
don't. It makes good sense
Morally. Economically
Business must lead b
example. Create a
environment in whic
all people can reach fo
better things. And grasp
them. This is the lea
Caltex has taken. For withou
action, position means nothing.
Mike Rademeye
Chairman and Managing Directo
Caltex Oil South Afric
CALTEX
PROUD SPONSOR OF THE SOUTH AFRICAN TEAM
TO THE 1996 OLYMPIC GAMES IN ATLANTA
NO ORDINARY COMMITMENT

# Journal of Energy in Southern Africa

Vol.7 No.3 August 1996

*A quarterly publication*

**Supported by Chief Directorate: Energy, Department of Mineral and Energy Affairs**

**Financial assistance from the Foundation for Education, Science and Technology is gratefully acknowledged.**

**Accredited by the national Department of Education for university subsidy purposes.**





It is the policy of the Journal to publish, as far as possible, papers covering the technical, economic, political, environmental and social aspects of energy research and development carried out in or applicable to Southern Africa, and of general interest to Africa. Only previously unpublished work will be accepted. However, conference papers delivered but not published elsewhere are also welcomed. Short discussions, not exceeding 500 words, on articles published in the Journal are also invited. Items of general interest, news, technical notes, reviews and research results will also be included. Announcements of relevant publications, reviews, conferences, seminars and meetings will be included.

Those wishing to submit contributions for publication should refer to the guidelines set out in *Information for Authors* on the inside back cover of the Journal. All papers are refereed before publication.

The Editorial Committee does not accept responsibility for viewpoints or opinions expressed, nor the correctness of facts or figures.

## Contents

72 PROFILES:
Mr K Sithole, Chief Executive Officer, Botswana Power Corporation
Mr M Golding, Chairperson: Mineral & Energy Portfolio, National Assembly, SA Parliament

*Research articles*

73 DUTKIEWICZ R K
Energy demand and supply in Sub-Equatorial Africa

85 WENTZEL M
Solar cooking: Exploring the possibilities and limitations

*Review articles*

89 Managing Eskom's impact on the environment: Air pollution. Extracts from Eskom's 1995 Environmental Report

91 LENNON S J
Recent trends in air pollution

93 S.A. Government's Energy Efficiency Business Plan

*General*

95 ENERGY STATISTICS
Comparative energy costs in South African cities related to heating value

96 Eskom statistical overview

97 ENERGY NEWS IN AFRICA

99 DETAILS OF AUTHORS

100 FORTHCOMING ENERGY AND ENERGY-RELATED CONFERENCES

101 RECENT ENERGY PUBLICATIONS

**Subscriptions (1997)**

| | |
|---|---|
| Individuals (Africa) | R114/year or R38/single copy |
| Individuals (Foreign) | US$85/year or US$30/single copy |
| Corporate (Africa) | R225/year or R75/single copy |
| Corporate (Foreign) | US$170/year or US$60/ single copy |

Includes VAT, postage and packing in Africa. Elsewhere, the subscription includes airmail postage and packing. All cheques to be made payable to the **University of Cape Town** and to be sent to the address below.

Enquiries may be directed to:
The Production Editor, Journal of Energy in Southern Africa,
Energy Research Institute, University of Cape Town,
P O Box 207, Plumstead 7801, South Africa.
Tel.: (+27) (21) 705 0120
Fax.: (+27) (21) 705 6266
Email: yvonne@eri.uct.ac.za

This Journal is abstracted and indexed in *Environment Abstracts* and *Index to South African Periodicals*.


ISSN 1021-447X

# Profile:

## Ketane Sithole
## Chief Executive Officer,
## Botswana Power Corporation

Ketane Sithole was born in Francistown, Botswana in 1952. After matriculating from the Gaborone Secondary School, he studied science at the universities of Botswana, Lesotho and Swaziland respectively. He then completed a B.Sc.(Hons.) (Electric and Electrical Engineering) at the University of Ile-Ife, Nigeria. In 1990, Mr Sithole was awarded a Master in Business Administration from the University of Wales' College of Cardiff, in the United Kingdom.

He joined the Botswana Power Corporation in 1978 as an engineer and spent time in various sections of the Corporation, particularly at the power station at Selebi Phikwe and the Distribution department in the Northern and Southern divisions respectively. Mr Sithole was then seconded to British Electricity International from 1980-1981 where he was given formal training at several of the Board's Training Schools on a broad spectrum of subjects.

He returned to the Botswana Power Corporation in 1981, where he was appointed Assistant Engineer (Planning). His responsibilities included calculating the fault levels and setting protection gradings on all feeders. He also produced standards for various services and substation layouts, as well as cost estimate formats. Based on the SABS standards for overhead lines, he modified them for use in Botswana, resulting in a saving in costs to the Corporation.

In 1982 he was appointed Assistant Engineer (Operations and Maintenance) and in 1983, Services and Commissioning Engineer, which made him responsible for all the Corporation's operations, services and maintenance activities, as well as village and rural departmental activities.

Mr Sithole was appointed Distribution Engineer in 1985 and Distribution Manager in 1989, where he was responsible for national distribution networks policy formulation, the setting up of standards of design, planning, construction services, and the commissioning of all networks and plant.

In December 1990, Mr Sithole was appointed Deputy Chief Executive of the Corporation, a position which he held until May 1992 when he was appointed Chief Executive Officer. His present responsibilities include the planning, organising, developing and managing of the operations of the Botswana Power Corporation.

Ketane Sithole has attended various conferences and presented several papers at many of these conferences. He has also been extensively involved in the formation of the Southern African Power Pool and continues to participate in its development and participation. He is a member of the Institute of Electrical Engineers (UK) and the South African Institute of Electrical Engineers.

He is married to Mmalledi and they have three children. Mr Sithole's hobbies are karate, judo, squash and badminton.

# Profile:

## Marcel Golding
## Chairperson:
## Mineral & Energy Portfolio Committee,
## National Assembly, S A Parliament

Marcel Golding has beer involved in the labour movement in South Africa for more than a decade. He joined the National Union of Mineworkers (NUM) in 1985 and became the Assistant General Secretary in 1987. He has since been elected for three consecutive terms of office.

Mr Golding has also been a member of the Council of South African Trade Unions' (COSATU) Central Executive Committee since its inception in 1985 and has served on its Executive for many years. He also serves as an Executive member of the Southern Afican Miners Federation (SAMF) and has been responsible for many of the Federation's Technical Commissions. He has served on the Miners International Federation's (MIF) Executive Committee and participated in many of their Commissions.

Mr Golding has also been a research writer for the *South African Labour Bulletin*, a journal specialising in labour matters, as well as publishing many articles in the Journal. He has also published articles in various books and publications. He has delivered many papers at various local and international conferences on mining, labour, economic and developmental issues since 1985.

Marcel Golding is unmarried and his hobbies include running and generally keeping fit.

# *Energy demand and supply in Sub-Equatorial Africa

**R K DUTKIEWICZ

This paper describes the resources and demand of the countries making up the SADC countries***, together with Zaire. The region is well endowed with most energy resources, with the exception of oil, though fuelwood is not evenly distributed.

Although there is a shortage of oil as a reserve, the region is unduly dependent on oil. However, the region will have to diversify its energy demand to meet possible problems when the oil price increases. It is shown that there are large reserves of hydropower which can be developed with potential for a large trade in electricity throughout the region.

Coal as an energy source is likely to increase with a significant growth in the export potential of the region. The change in the energy mix will be accelerated by the need to move away from depleting traditional energy forms. Coal is likely to take up some of this change in energy mix.

With a growing industrialisation of the region it is expected that each of the countries will move towards an energy mix similar to that of South Africa.

Various scenarios are used to determine the possible energy demand and sectorial mix up to the year 2020. These scenarios consist of different economic growth assumptions.

It is shown that there is a large potential for regional co-operation in energy matters to the benefit of each of the countries and of the whole region. For example, in the longer term, the Zaire River will contribute most of the electricity in the region, but this will need to wait for the economy of the region to grow significantly to the levels at which large blocks of electrical generation will be required.

**Keywords:** energy supply; energy demand, Sub-Equatorial Africa; Angola; Botswana; Lesotho; Malawi; Mozambique; Namibia; South Africa; Swaziland; Tanzania; Zaire; Zambia; Zimbabwe; energy resources; traditional energy; regional co-operation

## Introduction

The countries covered in this paper include the countries south of the equator but exclude some of the smaller equatorial countries, such as Burundi and Rwanda. Kenya is excluded even though it is strictly a sub-equatorial country. The countries covered therefore are the following:

Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zaire, Zambia, Zimbabwe

These countries include most of the SADC countries and Zaire. A comparison of population and income of the countries is given in Table 1 (1993 values), together with values for South Africa and for some developed countries.

The size of the South African economy is some three times the size of the economy of the rest of the region, but it is small in comparison with other developed countries and is smaller, in per capita terms, than Greece, one of the poorest countries in Europe.

The energy resources of the region are large, with the exception of oil which is only found in exploitable quantities in Angola and, to a smaller extent, in Zaire. The regional resources will be analysed in the discussion on each of the countries and will be summarised later.

**Angola** is well endowed with natural energy resources, with considerable hydroelectric potential, large petroleum reserves and abundant fuelwood resources. However, these are not well distributed, leading to surpluses in certain parts of the country and shortages in other areas.

The electricity sector is characterised by over-capacity and a poor state of maintenance. However, in spite of the over-capacity, a new power station, the Capanda power station on the Kwanza River, is partially completed. This station will have four 130 MW units, virtually doubling Angola's capacity. There is a possibility that this power could be exported to either Namibia or South Africa. Electricity generation is divided into three utilities separated geographically.

The cost of all energy forms is controlled by the Ministry of Energy and Petroleum. The electricity tariffs have not changed since the 1960s. It is estimated[1] that these tariffs are some one-eighth of the true cost of electricity and that in 1985 the utilities had a net deficit of US$46,7 million[1].

Angola has large reserves of oil, with the 1985 proven recoverable reserves being 156 million tons (Mt). The main production is in Cabinda Province where most of the exploration has taken place. Exploration is slowly being expanded southwards. Angolan oil appears to be attractive to overseas oil companies because of the favourable geological terrain, low production costs, and the Government's enlightened attitude to profit sharing and profit repatriation. The oil sector is run by an oil company, SONAGOL, which is an administrative wing of the Ministry of Energy and Petroleum.

Gas reserves are estimated at 30 000 million $m^3$, though they have not yet been adequately explored. Most of this gas is in association with crude. Much of the current gas use is for oil-well injection in order to improve oil yields. Some liquefied petroleum gas (LPG) is currently produced offshore and is exported to Brazil. Consideration is being given to the production of LPG for local consumption.

**Botswana** has large deposits of coal which are not yet adequately developed and it presently has to import coal to meet its needs. Coal deposits have been identified in ten areas, with the main deposits being in the Greater Morupule and Mmamabula areas of eastern Botswana. Coal is produced at the Morupule colliery, which is operated by the Anglo American Corporation of South Africa. Coal from this colliery is used in the Morupule power station. There is no supply of washed coal for industrial and domestic

* Updated paper originally presented at the 16th Congress of the World Energy Council held 8-13 October 1995 in Tokyo, Japan.

** Energy Research Institute, University of Cape Town, P O Box 207, Plumstead 7801, South Africa

*** Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe

| | Population (Millions) | % | GNP 1993 US$ per capita | Billion | % |
|---|---|---|---|---|---|
| Angola# | 11,2 | 6,5 | 880 | 9,9 | 6,2 |
| Botswana | 1,4 | 0,8 | 2 790 | 3,9 | 2,4 |
| Lesotho | 1,9 | 1,1 | 650 | 1,2 | 0,8 |
| Malawi | 10,5 | 6,1 | 200 | 2,1 | 1,3 |
| Mozambique | 15,1 | 8,8 | 90 | 1,4 | 0,8 |
| Namibia | 1,5 | 0,9 | 1 820 | 2,7 | 1,7 |
| South Africa | 39,7 | 23,2 | 2 980 | 118,3 | 74,0 |
| Swaziland | 0,9 | 0,5 | 1 190 | 1,1 | 0,7 |
| Tanzania | 28,0 | 16,4 | 90 | 2,5 | 1,6 |
| Zaire# | 41,2 | 24,1 | 192 | 2,5 | 4,9 |
| Zambia | 8,9 | 5,2 | 380 | 3,4 | 2,1 |
| Zimbabwe | 10,7 | 6,3 | 520 | 5,6 | 3,5 |
| **Region** | **171,0** | **100,0** | **285** | **31 000** | **100,0** |
| Australia | 17,6 | | 17 500 | | |
| Belgium | 10,0 | | 21 650 | | |
| Greece | 10,4 | | 7 390 | | |
| Japan | 124,0 | | 31 490 | | |
| Sweden | 8,7 | | 24 700 | | |
| U.K. | 57,9 | | 18 060 | | |
| U.S.A. | 258,0 | | 24 740 | | |

# Estimated

*Table 1: Country characteristics*

use and such coal has to be imported from South Africa and Zimbabwe.

There are no known oil or gas deposits, although suitable geological conditions have been found. Further exploration is required. All oil products are imported from South Africa as refined products(2).

Due to its lack of rivers with sufficient assured flows, there is no hydro potential in the country. Electricity is generated mainly in coal-fired power stations with an installed capacity of 220 MW, of which 7 MW is diesel and the rest coal. The expansion of the Morupule power station will add an additional 70 MW. There is also a 132 kV interconnection between Botswana and South Africa which can supply up to 31 MW.

The rapid economic growth has led to a considerable increase in the demand for all forms of energy, with a 32% increase over a seven-year period from 1982 to 1989. Over this period electricity consumption increased by 54%, oil increased by 42% and coal by 9%.

**Lesotho** has few natural resources and imports its energy requirements almost exclusively from South Africa. Lesotho's options for reducing its dependence on South Africa for energy is limited; inter-fuel substitution possibilities are almost non-existent. The Lesotho Highlands Water Project will tap some of Lesotho's hydro potential and will reduce its dependence on South Africa for electricity.

Most of Lesotho is bare and mountainous with temperature fluctuations between 30°C in summer to below 0°C in winter. Thus fuelwood is in short supply and Lesotho relies on South Africa for most of its requirements. There is some potential for reforestation and a woodlot project has been started, but progress is slow.

Although some geological exploration has shown that there are strata suitable for petroleum, it is considered that the chances are very small for finding oil. At present Lesotho obtains all its refined products from South Africa.

Whilst there are some small outcrops of coal, these are considered unsuitable for mining, and coal has to be imported from South Africa.

Hydropower is the only energy source worth exploiting. A potential for 450 MW of plant has been estimated, though the cost of exploiting most of this is high. The first stage of the Lesotho Highlands Water Project includes a 75 MW hydropower station. The full project, which will be completed in 30 years time, will include a total of 200 MW of hydro plant.

Most of the final demand for commercial energy is based on oil products which provide 78% of final demand.

**Malawi** has some hydro potential and has limited amounts of coal. However, at present most of its commercial energy is imported. As in most other African countries, fuelwood accounts for the greatest portion (90%) of total final consumption, being used mainly for domestic consumption.

In recent years Malawi's energy sector has suffered severe supply problems and rising import costs. In the past all of Malawi's oil demands were imported via the Beira-Blantyre railway line. This line came under attack from the guerrilla action in Mozambique from the late 1970s, and the line has been completely closed from 1979. Although alternative routes are now used, continuity of supply is a permanent headache for the Government and the disruptions in supply seriously affect the economy. In order to reduce its reliance on imported transport fuels Malawi has been using ethanol as a blend with gasoline.

Coal imports have also been disrupted, although local production from 1986 has gone some way to relieve the situation.

Electricity is distributed by an interconnected grid from Rumphi in the north to Nsanje in the south, and from Chiponde in the east to Mchinji in the west. In addition there is a small isolated system in the far north. The interconnected system consists of 145 MW of hydro plant, 15 MW of gas turbine and 8,9 MW of diesel plant. The far north system has 0,7 MW of diesel capacity. Of total electricity sales 99,7% came from hydropower.

In spite of the difficulties of obtaining oil, reliance in the final energy demand is still mainly on oil, to the tune of 65% of commercial energy.

**Mozambique** is potentially rich in energy resources, with hydropower, coal, and gas being available. There is also a reasonable chance of finding oil. At present the energy sector has under-utilised facilities due to the poor state of the economy. Disruptions in transport and distribution have stopped the operation of the Moatize coal mine and generation from the Cahora Bassa project, which is designed to export power to South Africa.

Energy production and distribution have been under rigid central control, but have been very fragmented and inefficient. The main energy source is fuelwood, which accounts for some 90% of total final demand. There are serious shortages of fuelwood near the main urban regions, although there is a surplus in the northern region. It is no longer considered a sustainable commodity, and the poor economic conditions together with diminishing supplies of fuelwood are causing changes in people's dietary habits.

Oil provides 76% of commercial energy in final demand, with coal providing 9% and electricity providing 15%.

**Namibia** has large energy resources in the form of hydropower, offshore gas and uranium. It has a small deposit of coal, but this is very deep and is not considered exploitable. Traditional energy forms are less important than in other African countries. There is little traditional fuel used in the south of the country since most of the inhabitants are employed on commercial farms and are provided with commercial energy. In the north of the country there are areas which are being progressively stripped of wood. However, there are also areas close by where non-indigenous wood is becoming invasive and there is the possibility of eradicating this wood while at the same time providing fuelwood for the areas where shortages occur.

Oil supplies 20% of total final commercial energy demand, with electricity supplying 77%. Electricity is generated by the NAMPOWER (previously known as SWAWEK) generating authority which has 360 MW of installed capacity, of which 240 MW is hydro capacity at the Ruacana power station and 120 MW is coal-fired thermal plant at the Van Eck power station in Windhoek. In addition, use is made of 46 MW plant at Walvis Bay and there is a 200 MW interconnector with South Africa. Maximum demand in 1991 was 240 MW. Surplus power was exported to South Africa and this amounted to 12% of total sales[3].

**South Africa** has a First and Third World energy mix with some 14% of total energy being based on traditional energy, such as fuelwood and dung. Its consumption of commercial energy per capita is higher than that of any of the other countries in the region and it has a well developed energy infrastructure.

The main energy form is coal, accounting for approximately three-quarters of primary energy and some one-third of final energy demand. Coal is inexpensive because of the shallow depth of coal mines and the thick seams normally exploited. In recent years most of the larger coal mines have been based on open-cast mining techniques making them cheap to operate. Coal quality is poor and coal for export has to be beneficiated to meet client requirements for calorific value and ash content. There are still large reserves of coal and it is anticipated that there will not be any shortage until around 2025. It is anticipated that the last coal-fired power station will be built around 2020.

South Africa does not have any indigenous crude oil and the threat of sanctions and the oil crises of the 1970s resulted in the construction of the Sasol oil-from-coal plant and the Mossgas oil-from-gas plant. Neither of these plants is competitive with crude oil at today's prices, but the capital has been committed and with capital considered as sunk the synthetic fuel plants show a positive cash flow. The percentage of synthetic fuel of total oil products peaked at 45% in 1994 and is now decreasing.

Electricity is produced by the parastatal, Eskom, and by a number of municipalities. Eskom has now reached the size that it produces over 95% of the country's demand and also exports to surrounding countries. With the change in South Africa's role in the region it is to be expected that electricity exports will rise in the short and medium term, though in the long term it is expected that South Africa will be a net importer of electricity mainly from the hydro potential of countries such as Namibia, Angola and Mozambique, from the Zambezi Valley and, later, from the large resources of Zaire.

There is currently only a small demand for gas. Natural gas is used at Mossgas for the production of petrol and diesel, and coal-based gas is produced as a by-product of the Sasol process and distributed to industry. There is a large potential for the importation of gas from the Pande fields in Mozambique and from the Kudu fields in Namibia.

**Swaziland** presently imports 40% of its energy requirements. However, it has large potential energy resources and could become more independent if the economics are favourable. It has large coal deposits, significant hydropower potential and viable biomass resources, all of which could be used to substitute for imported energy.

Biomass energy sources provide some 65% of final energy and are used both for domestic consumption and for industrial applications. Consideration is being given to the use of ethanol, produced from molasses, for blending with gasoline to reduce imports of petroleum products.

Coal has been mined in Swaziland since 1964. Its quality is different to that of South African coals and many of the boilers used in Swaziland do not operate adequately on the local coals. Swaziland therefore finds itself in the situation that it imports more coal than it produces, and it exports and imports coal simultaneously.

Prior to 1973 Swaziland provided all of its own electricity, but has since found that it is cheaper to import electricity from South Africa. Two 132 kV lines have been constructed to import power to a total of 62 MW. In 1989 Swaziland was importing 60% of its electricity consumption.

Swaziland imports all of its oil demand in the form of refined products from South Africa.

**Tanzania** has large and diverse energy resources which have not been adequately exploited or explored. It has a large hydro potential, with gas and coal reserves. However, Tanzania's commercial energy sector is highly dependent on imported petroleum products, which account for 60% of foreign exchange earnings.

Traditional fuels account for 92% of the total final energy demand. However, a major problem facing Tanzania is the depletion of its forests, resulting in fuelwood no longer being a self-sustaining commodity.

In the use of commercial energy in the final demand sector oil accounts for 85%, coal for 2% and electricity for 11%. An attempt has been made at reducing dependence on oil imports and on fuelwood by using increased amounts of electricity. Tanzania has its own oil refinery at Dar-es-Salaam, but its production does not meet its product demand and additional amounts of products, such as gasoline and diesel, have to be imported, whilst residual fuel has to be exported.

Electricity is generated mainly from hydro sources and there is 326 MW of hydro capacity, the main component being the Kidata Dam project with an installed capacity of 280 MW. The maximum demand on the system was 250 MW in 1990. In addition to the hydro plant there is 186 MW of plant based on fuel oil.

Coal plays a minor role in the energy sector even though resources are high. All of the coal is used in industry in the Mbeya region where the coal deposits are situated.

**Zaire** has resources of oil, a small amount of coal, gas associated with the oil finds, some geothermal potential, and dissolved gas in Lake Kivu.

Onshore exploration for oil was begun in the 1920s, though most of the finds are based on exploration in the 1950s. Original proven reserves were 127,7 million barrels in offshore fields and 101 million barrels onshore. Half of the offshore oil and 2% of onshore oil has been extracted.

There are an estimated 54 Mt of recoverable coal deposits in the eastern part of the country. The coal is of low quality with an ash content of 20%-28%. There is a further potential coalfield in the northeast of the country, near Lake Kivu, but little is known about the quality or quantity.

By far the largest energy potential is from hydropower based on the Zaire River. Estimates of recoverable energy vary widely from 530 000 GWh to 750 000 GWh. Using the higher figure would allow an installed capacity of 85 000 MW. Of this capacity approximately 45 000 MW is available in a short section of the river below Kinshasa at the Inga Falls. This latter plant would be run-of-river plant.

In spite of these large resources, the main energy sources are fuelwood and charcoal, with consumption estimates varying from 75%-90% of total demand. The country is very poor and most people cannot afford electricity even it were available. This means that even within cities the number of people connected to electricity is small. In Kinshasa it is estimated that only 15% of the people use electricity, with the greatest use being made of wood and charcoal.

**Zambia** has large reserves of coal, hydropower and fuelwood, though it has to import all its oil requirements. At independence Zambia was heavily dependent on Zimbabwe for its commercial energy requirements, with coal being imported from Hwange and electricity from the Kariba power station. The situation has now changed, with Zambia being a net exporter of electricity, with its own coal industry and its own refinery which obtains its crude through a pipeline from Tanzania.

Whilst there are no oil reserves in the country, the geological formation of the Zambezi Basin appears to be suitable for oil or gas, and exploration has started.

The main source of commercial final energy demand is oil, which contributes 45% to total demand. Electricity contributes 39% and coal the remaining 16%. The main electricity generating capacity is at the Kariba Dam power station (which is owned jointly with Zimbabwe), at the Victoria Falls power station and at the Kafue Gorge power station. Including its share in the joint Kariba power station, the installed capacity is 2 235 MW, of which 50 MW is waste heat plant (most of which is more than 40 years old), 80 MW is gas turbine and the rest is hydro plant. In addition to its own plant, Zambia has links with the Shaba Province in Zaire and with Zimbabwe via the Kariba station.

**Zimbabwe** has no domestic oil or gas reserves but has large deposits of coal, substantial fuelwood resources and abundant hydropower potential. Final energy consumption figures show that traditional fuels contribute 38% of total demand. Coal supplies 48% of final total demand of commercial energy, whilst oil provides 28% and electricity contributes 24%.

The main imported energy is oil which is transported from the Mozambique coast by pipeline. Zimbabwe has its own refinery, but this ceased operation following sanctions on Zimbabwe after its Unilateral Declaration of Independence. It has not been reopened due to the costs involved and because it was not designed to treat the type of crude which is now available. Also, it would not be able to provide the mix of products necessary to satisfy local demand.

Coal has been mined in Zimbabwe since the beginning of the century. Coal is used for industry and as steam coal for power generation. In addition, there is also a large market for coking coal. Zimbabwe has been a significant exporter of coal and especially of coking coal, which is in short supply in the surrounding countries, and particularly in South Africa. More coal could be exported, but the cost of transport is high and up to now the political problems in the surrounding countries have ruled out coal exports on a guaranteed basis.

The installed capacity of electricity generation is currently 1 966 MW, of which 666 MW is hydro plant and 1 300 MW is thermal plant. A small amount of electricity is imported from South Africa to the Beit Bridge area and an additional link is being constructed from South Africa through Botswana. There is also a plan to bring power to Zimbabwe from the Cahora Bassa dam in Mozambique.

# Resources

### *Introduction*

The region has large resources of energy in various forms, with possibly the largest source being hydropower. This is concentrated mainly on the central African rivers of the Zambezi and Zaire, although there is additional potential in a number of other countries. The region is well endowed with coal, though it is not uniformly distributed. Only Namibia and Angola appear to have no exploitable coal reserves.

The problem with utilising these resources is that they are often far from the point of demand and that for many of the potential schemes a large plant is required to make it and the necessary transmission system financially viable. The countries of the region are also some of the poorest in the world, with little access to the sort of funding which would be required to develop the potential. To complicate the issue, the region has been, politically unstable for many years, with government systems which did not allow the development of energy sources in economically acceptable ways, especially to investment institutions.

Because of the poverty of the region and the lack of incentives to develop energy resources, the exploration of the region has been poor and the assessment of the resources is currently inadequate. Due to lack of work in the area and the lack of funding for systematic analysis, much of the published data is speculative and order-of-magnitude rather that statistically valid information.

The hydro resources have also not been adequately classified, especially in relation to the economics of each of the potential sites. In particular, the largest potential, that of the Zaire River, has not been sufficiently defined. However, the amounts are so large that even a 50% overestimate still leaves the Zaire River as a very large resource.

### *Fuelwood*

Table 2 shows the reliance placed on the role of traditional fuels in the countries of the region, together with an estimate of woodlot areas available and also the percentage of electrification of households, which is a measure of the potential for replacing fuelwood or charcoal with electricity.

## *Coal*

The region's coal resources are summarised in Table 3. The coals are tabulated in the various resource categories already described above. In view of the lack of adequate exploration in the region the quantities, especially the probable and hypothetical amounts, are of order-of-magnitude only. The one exception is South Africa, where a large amount of exploration has been carried out. It is anticipated that there may still be some quantity available in the hypothetical category in South Africa, but this will be small compared with the proven quantities.

No distinction is made in Table 3 in terms of the quality of the coals in the various countries. For instance, the Swaziland coals have a high percentage of anthracitic coals which are unsuitable for use as steam coal in the conventional boilers designed for coal use in South Africa and in other countries of the region. Zimbabwe has a large percentage (10%) of coking coal which is in short supply in the region.

The Southern African coals are, in general, very different from northern European or American coals. Most of them are high-ash and low-volatile coals, with a low sulphur content. Seams are thick over most of the area and are situated at a low depth. A large amount, especially in South Africa, is available as open-cast mines with modern mining-technology.

## *Hydropower*

The hydro potential of the region is dominated by Zaire, but many of the countries of the region have some hydro potential. A number of the countries share a common river and their hydro potential is a shared amount governed by international treaties. When assessing the region's potential it is sometimes difficult to ensure that the potential claimed by adjoining countries is in fact each country's share of a common potential, and there is thus the possibility of double counting.

The best estimate of hydro potential in the region is given in Table 4. The quantities quoted are the estimates of that capacity which would be economically viable if the load were available. It does not include micro- and mini-hydro schemes,

| | **Trad. energy as a %age of total demand** | **Potential fuelwood area (000s ha.)** | **Percent homes electrified** |
|---|---|---|---|
| Angola | 60 | 105 000 | |
| Botswana | 52 | ? | 4 |
| Lesotho | 76 | 0 | 2 |
| Malawi | 91 | 4 000 | 2 |
| Mozambique | 93 | 57 000 | 3 |
| Namibia | 9 | ? | |
| South Africa | 11 | ? | 33 |
| Swaziland | 65 | 52 | 9 |
| Tanzania | 92 | 44 000 | 13 |
| Zaire | 88 | 122 000 | 4 |
| Zambia | 72 | 41 000 | |
| Zimbabwe | 48 | 4 840 | |

*Table 2: Traditional energy as a percentage of total final energy demand, potential areas suitable for fuelwood and degree of electrification*

| | **Probable hypothetical** | **Proven** | **Proven usable** |
|---|---|---|---|
| Botswana | 450 549 | 116 | 92 |
| Lesotho | 0 | | 240 |
| Malawi | 800 | 0 | 2 |
| Mozambique | 2 424 | 7 107 | 240 |
| South Africa | 2 282 | 121 218 | 55 333 |
| Swaziland | 884 | 116 | 92 |
| Tanzania | 1 596 | 304 | 200 |
| Zaire | 720 | 86 | 54 |
| Zambia | 222 | 58 | 29 |
| Zimbabwe | 27 008 | 2 194 | 1 097 |
| **Total** | **486 485** | **131 199** | **57 379** |

*Table 3: Coal resources of the region (PJ "in situ" except for the proven usable which is saleable coal)*

| | **Annual capability (GWh)** | **Possible capacity (MW)** | **Present installed (MW)** |
|---|---|---|---|
| Angola | 70 000 | 16 000 | 156 |
| Botswana | 0 | 0 | 0 |
| Lesotho | 2 000 | 450 | 2 |
| Malawi | 7 000 | 1 000 | 145 |
| Mozambique | 60 000 | 12 500 | 2 655 |
| Namibia | 6 970 | 1 565 | 240 |
| South Africa | 5 550 | 2 960 | 540 |
| Swaziland | 1 800 | 330 | 41 |
| Tanzania | 20 000 | 6 000 | 333 |
| Zaire | 750 000 | 85 000 | 2 381 |
| Zambia | 21 406 | 3 924 | 2 045 |
| Zimbabwe | 13 285 | 2 515 | 633 |
| **Total** | **958 011** | **132 244** | **9 168** |

*Table 4: Hydro potential of the region on an assured basis*

| | Proven (Mt) | Reserve to production ratio (years) |
|---|---|---|
| Angola | 156 | 6,9 |
| Zaire | 24 | 16,3 |
| **Total** | **180** | **178** |

*Table 5: Petroleum resources in the region (Mt)*

| | Probable | Proven | Total |
|---|---|---|---|
| Angola | 21 000 | 9 000 | 30 000 |
| Mozambique | 320 000 | 65 000 | 385 000 |
| Namibia | 210 000 | 70 000 | 280 000 |
| South Africa | | 28 000 | 28 000 |
| Tanzania | 26 000 | 163 000 | 189 000 |
| **Total** | **577 000** | **335 000** | **912 000** |

*Table 6: Gas resources in the region (Million $m^3$)*

| | Probable | Proven | Total |
|---|---|---|---|
| Namibia | 77 000 | 133 000 | 210 000 |
| South Africa | | 432 000 | 432 000 |
| Zaire | | 1 800 | 1 800 |
| **Total** | **77 000** | **134 800** | **211 800** |

*Table 7: Uranium resources in the region (t)*

| | Coal | Oil | Gas | Total |
|---|---|---|---|---|
| Angola | 0 | 6 535 | 345 | 6 880 |
| Botswana | 2 304 | 0 | 0 | 2 304 |
| Lesotho | 0 | 0 | 0 | 0 |
| Malawi | 42 | 0 | 0 | 42 |
| Mozambique | 6 033 | 0 | 2 494 | 8 527 |
| Namibia | 0 | 0 | 2 686 | 2 686 |
| South Africa | 134 059 | 0 | 1 074 | 135 133 |
| Swaziland | 2 304 | 0 | 0 | 2 304 |
| Tanzania | 503 | 0 | 6 254 | 6 757 |
| Zaire | 20 279 | 1 005 | 0 | 21 284 |
| Zambia | 712 | 0 | 0 | 712 |
| Zimbabwe | 27 566 | 0 | 0 | 27 566 |
| **Total** | **174 865** | **180** | **3 004** | **178 049** |

*Table 8: Proven recoverable reserves (PJ)*

although these could be very attractive in local situations. The quantities of annual capability and possible capacity refer to future installations and do not include plant already commissioned. The last column in Table 4 gives the present installed capacity. It is obvious that Zaire is the giant in the potential hydro capacity. However, even without Zaire, the region has used only 15% of its total potential capacity. With Zaire, the figure becomes 6%. With the exception of Botswana, each country still has some potential hydro capacity that it can develop. The largest capacity potential, in order-of-magnitude, is:

Zaire, Angola, Mozambique, Zambia, Tanzania, Zimbabwe,

with each of the others contributing less than 5% to the regional potential.

### *Petroleum*

Only two countries in the region, Angola and Zaire, have any proven oil deposits. The quantities of reserves are shown in Table 5.

Little exploration has been carried out up to now, but work is now accelerating. The reserve to production levels are low, as shown in Table 5. Exploration is also being carried out in a number of other countries. Namibia and Mozambique are the two most promising areas for oil.

### *Gas*

Five countries in the region have gas and some exploitation is taking place, but nothing on the scale that is occurring in other parts of the world. It is considered, therefore, that there is significant potential for the future development of the gas fields.

The estimated reserve capacities are shown in Table 6. It has been arbitrarily assumed that for Namibia 25% of the quoted values for the Kudu gas field are proven reserves and 75% fall into the probable category.

### *Uranium*

Zaire, Namibia and South Africa have exploitable uranium deposits. These resources do not affect the energy supply and demand in the region since they are presently exportable as raw material and possibly later, as value-added material. However, having the resources does not affect the use or non-use of nuclear power. The resources are given here for the sake of completeness.

### *Summary of resources*

The resources of the region are summarised in Table 8 in terms of PJ of energy.

In terms of proven recoverable reserves, approximately 98% is in the form of coal, 0,1% is in gas, and 2% is in oil.

# Energy supply and demand

## *Present situation*

In the region traditional energy forms account for around 45% of total final demand, or 80%, if South Africa is excluded. Most of this energy is in the form of fuelwood, but in certain countries, such as Zaire for example, significant use is made of charcoal. With the general deterioration of the supply of traditional fuels, there will be an increasing dependence on commercial energy forms. This will, in time, significantly change the energy mix in the region. In terms of commercial energy, oil is the highest energy carrier in the region (57% of final demand), followed by electricity (22%) and coal (34%). However, this regional analysis of energy demand masks the large variations between countries.

Table 9 shows the energy demands of each of the countries for 1990, the last date for which energy demands are available for all the countries. The information has been obtained from the SADCC figures[5], from the International Energy Agency (IEA) energy balances for developing countries[6] and from various sources for South Africa.

| | Coal | Oil | Gas | Electricity | Traditional | Total |
|---|---|---|---|---|---|---|
| Angola | 0 | 46,6 | 0 | 2,3 | 63,5 | 112,4 |
| Botswana | 4,8 | 12,7 | 0 | 2,8 | 22,4 | 42,7 |
| Lesotho | 1,3 | 4,5 | 0 | 0,6 | 20,3 | 26,7 |
| Malawi | 1,3 | 6,2 | 0 | 1,9 | 96,6 | 106,0 |
| Mozambique | 1,5 | 12,3 | 0 | 2,5 | 205,2 | 221,5 |
| Namibia | 0,1 | 0,4 | 0 | 1,4 | 1,7 | 3,6 |
| South Africa | 681,3 | 598,1 | 21,0 | 439,6 | 208,9 | 1 948,9 |
| Swaziland | 6,0 | 5,7 | 0 | 2,5 | 26,5 | 40,7 |
| Tanzania | 0,7 | 35,1 | 0 | 4,7 | 446,4 | 486,9 |
| Zaire | 8,6 | 47,8 | 0 | 18,6 | 258,1 | 333,1 |
| Zambia | 9,1 | 26,1 | 0 | 22,8 | 152,4 | 210,4 |
| Zimbabwe | 64,3 | 37,1 | 0 | 32,5 | 125,0 | 258,9 |
| **Total** | **779,0** | **832,6** | **21,0** | **532,2** | **1 837,6** | **4 002,4** |
| **%age** | **19** | **21** | **1** | **13** | **45** | **100** |
| **Total(excl. SA)** | **97,7** | **234,5** | **0** | **92,6** | **1 628,7** | **2 053,5** |
| **%age** | **5** | **11** | **0** | **5** | **79** | **100** |

*Table 9: Energy balances in 1990 for the countries of the region in terms of the final energy demand (PJ)*

## *Future energy situation*

There is obviously an over-dependence on oil in the region. With the present low price and ready availability of oil, there are no major forces pushing the region to energy diversification. However, these prices are unlikely to be maintained and in the future it will be necessary for the region to become less reliant on oil.

Coal has a large share in the final energy demand of Botswana, Swaziland and Zimbabwe. It is noteworthy that these are the three richest countries in the region in terms of GDP per capita. It may be expected that the other countries of the region would move in the direction of greater coal utilisation if coal was readily available. It is also to be expected that as the countries increase their industrial economic sector, the use of electricity will also increase.

The change in the mix of energy carriers will also be accelerated by the need to move away from depleting traditional fuel resources to commercial forms. If coal is readily available, it is to be expected that there will be a move, in the first place, from wood to coal for domestic purposes, followed by a move to electricity. The rate of change from traditional to commercial energy forms will be affected by the growth in the economy of the region, with the ability to supply electricity to a growing section of the population, and with the availability of coal.

At present little gas is used in the region, except in South Africa, where it is produced from coal. The region has large resources of gas and it is likely that more will be discovered. In the developed countries of the European OECD, the percentage of gas in final demand is 17,6%. Table 10 shows the percentage of gas used in various countries of the world.

| | Percent |
|---|---|
| Australia | 15,0 |
| France | 16,4 |
| Italy | 23,8 |
| Japan | 4,8 |
| New Zealand | 15,7 |
| Spain | 5,4 |
| U.K. | 28,3 |
| U.S.A. | 22,0 |
| U.S.S.R. | 27,7 |
| Brazil | 3,0 |
| Indonesia | 20,0 |
| Chile | 6,5 |
| OECD Europe | 17,6 |

*Table 10: Percentage of final commercial energy demand supplied by gas (1988 values)*[8]

It appears that the saturation level for gas, in those countries that have large gas fields of their own or are close to piped gas, is approximately 25% of total final energy demand. For the European OECD countries as a whole, gas contributes nearly 18% of total energy. It is, therefore, likely that gas will play an increasing role in the energy supply in the region if the transport of gas can be arranged. Already there are discussions on the importation of gas into South Africa from Mozambique and from Namibia. With gas being additionally available in Angola, Tanzania and South Africa, it is to be expected that gas will play an increasing role in the energy economy, taking over some of the supply by oil and, to a smaller extent, by coal.

With the growing industrialisation of the region and with a growing economy, it is expected that the sectorial energy demand of many of the region's countries will tend towards that of South Africa. In South Africa itself, ignoring for the moment the impact of gas, the saturation levels for final energy demand will be 33% for electricity, 34% for coal, and 33% for oil and gas[7]. If gas is more readily available, it will make an impact on the coal share of the market where it will be used as a heating source, especially in situations where a clean form of heat is required, and will replace oil as a source of fuel for the production of heat.

The future energy demands in the region have been assessed using the energy intensities and energy elasticities for each of the countries as appropriate. These values yield the energy demand in the region as indicated in Table 11. These are based on the "business as usual" situation but for different GDP growth rates. Scenario 1 is for an energy growth rate rising from 1% in 1989 to 2,5% in 2020. Scenario 2 has a growth rate starting from 2,3%, rising to 3% in 1996 and remaining constant thereafter. Scenario 3 starts at 2,3% and rises progressively to 5% in 2016. No account is taken of inter-fuel substitution in this analysis.

The traditional energy consumption is based on population growth figures and therefore is unaffected by the differences in the three economic growth scenarios. It is obvious, however, that the resources of fuelwood will not be able to match the increase in demand forecast in Table 11. It is likely therefore that the traditional component will be taken up by commercial energy sources. The change from traditional to commercial energy forms will be accompanied by an increase in the efficiency of conversion to useful energy, and therefore the total final energy will decrease over that of Table 11.

It is assumed that for the region as a whole, traditional energy will progressively decrease as a percentage of final demand as supply shortages due to non-sustainability become worse. It is assumed for the purpose of this paper that traditional energy will reach a figure of 50% of present consumption in spite of an increasing population. This would mean that, for the medium scenario, by the year 2020 traditional energy consumption would be 15% of total final demand instead of the present 52%.

It is also assumed that by 2020 the region as a whole will attain the energy mix of that of South Africa but with the addition of gas, which will contribute 10% to total demand. It is also assumed that gas will take over from coal and oil, with 6% of the 10% consumption coming from coal and 4% from oil. It is evident that the largest growth rate is in the contribution of gas, but it is starting from a low base. For the region as a whole, oil has a progressively decreasing contribution, though the growth is still substantial due to its continuing dominance of the transport sector. However, if the regional infrastructure existed, there would be a significant increase in coal utilisation throughout the region.

Electricity also grows significantly, with a figure of between 348% and 684% of the 1988 figure by 2020. The source of this electricity will depend on the economics of alternate schemes, such as gas-fired combined cycle plant and the large hydro potential of the central region. The amount of hydropower that will be used will depend on the political stability of the region and on the ability to fund the very large capital projects required to realize the potential.

# Regional energy interchange and co-operation

## *Introduction*

The opening up of the region to trade enables the transfer of energy throughout the region to be considered. Since the scale of construction necessary to make many of the schemes economically viable requires a large base demand, South Africa, with its large energy demand, becomes an enabling factor in the energy development of the region. Once the large generation capacity is set up, smaller users can be incorporated on a meaningfully economic basis. Much of the interest in energy trade is based on the potential for electricity transfer, especially from the hydro-rich countries of the region to South Africa. The possibility for such a network of regional power transmission has been made possible by the developments in high-voltage transmission over large distances. South Africa has already operated the 1 360 km 533 kV DC line between Gauteng and the Cahora Bassa dam in Mozambique. Zaire has also operated the Inga DC line to Shaba Province in the south-east of the country. This line was rated at 1 120 MW, though currently it has been downgraded to 560 MW. More recent developments in other coun-

| | COMMERCIAL | | | TRADITIONAL | | |
|---|---|---|---|---|---|---|
| | South Africa | Other | Total | South Africa | Other | Total |
| Scenario 1 | | | | | | |
| 1995 | 46 | 16 | 62 | 7 | 62 | 69 |
| 2000 | 52 | 21 | 73 | 8 | 71 | 79 |
| 2005 | 58 | 27 | 86 | 8 | 80 | 88 |
| 2010 | 67 | 35 | 102 | 8 | 90 | 98 |
| 2015 | 77 | 44 | 121 | 8 | 101 | 108 |
| 2020 | 86 | 55 | 142 | 8 | 111 | 119 |
| Scenario 2 | | | | | | |
| 1995 | 52 | 18 | 69 | 7 | 62 | 69 |
| 2000 | 62 | 25 | 87 | 8 | 71 | 79 |
| 2005 | 74 | 33 | 107 | 8 | 80 | 88 |
| 2010 | 88 | 43 | 131 | 8 | 90 | 98 |
| 2015 | 102 | 56 | 158 | 8 | 101 | 108 |
| 2020 | 118 | 72 | 190 | 8 | 111 | 119 |
| Scenario 3 | | | | | | |
| 1995 | 53 | 18 | 71 | 7 | 62 | 69 |
| 2000 | 68 | 26 | 94 | 8 | 71 | 79 |
| 2005 | 88 | 38 | 126 | 8 | 80 | 88 |
| 2010 | 112 | 53 | 165 | 8 | 90 | 98 |
| 2015 | 134 | 74 | 214 | 8 | 101 | 108 |
| 2020 | 178 | 105 | 283 | 8 | 111 | 119 |

*Table 11: Total final energy demand for various scenarios (Mtoe per annum)*

tries mean that there are no technical obstacles to the transfer of large blocks of power over long distances.

Although electricity is likely to be the most dramatic interchange in the next decade, there is also scope for energy trade in coal and gas. The energy carriers to be considered as potential for trade therefore include oil, gas, electricity and coal. Fuelwood and charcoal will not be considered since the potential for interchange is small due to the low cost requirement for such fuels and the high cost of transporting a low-grade energy source. Some interchange of traditional energy forms already occurs, but it is very site-specific and is not significant in terms of its effect on the economies of the countries of the region.

| Country | Capacity (MW) | Percent of region |
|---|---|---|
| South Africa | 30 817 | 75,1 |
| Zaire | 2 584 | 6,3 |
| Mozambique | 2 383 | 5,8 |
| Zambia | 1 966 | 4,8 |
| Zimbabwe | 1 632 | 4,0 |
| Angola | 523 | 1,3 |
| Tanzania | 326 | 0,8 |
| Namibia | 360 | 0,9 |
| Botswana | 204 | 0,5 |
| Malawi | 170 | 0,4 |
| Swaziland | 50 | 0,1 |
| Lesotho | 5 | 0.0 |
| **Total** | **41 020** | **100,0** |

*Table 12: Installed electrical capacity in 1990*

## *Electricity*

At present the sum of the total electricity installed capacity in the region is around 45 000 MW, of which 74% is in South Africa. With the exception of South Africa, the largest installed capacity is of the order of 2 500 MW. The installed capacity, as at the end of 1990, for the various countries of the region is as shown in Table 12. There is already some electricity interchange in the region, but on a limited scale. For instance, of Mozambique's installed capacity of 2 358 MW, the Cahora Bassa power station with an installed capacity of 2 075 MW has been built specifically to transmit power to South Africa through a 533 kV DC transmission line rated at 1 920 MW. This line, unfortunately, has been largely out of commission due to sabotage resulting from guerrilla activities within Mozambique. There is also electricity interchange between South Africa and its neighbours, and between other countries in the region. There is, however, much scope for increasing this interchange which would enable more efficient utilisation of resources and increased reliability of supply.

The hydro potential of Zaire alone is some 85 000 MW, of which 45 000 MW is possible in a short stretch of the river at Inga, downstream of Kinshasa. Thus, from this one stretch alone, Zaire could provide the electricity demand of the whole region. There are, however, limits to the amount of electrical capacity which any country would be prepared to import from one source, and this total potential capacity is not realisable in the near future.

In addition to the hydro potential of the Zaire River, there is potential on the Zambezi, the Cunene and other rivers in the region. Angola has already started the construction of a 4 x 130 MW power plant on the Kwanza River, all of which will be surplus to its own requirements. Namibia has also recently approved the construction of the Epupa hydropower station on the Cunene River. Again, the market for this power is seen as being South Africa. If South Africa were prepared to accept, say, 15% of its total maximum demand from external sources, this would mean a market for some 3 000 MW of maximum demand and, if operated as a base load, would result in sales of 20 000 GWh per annum. At the present electricity cost of production in South Africa, this would amount to US$600 million per annum, which is some 10% of the total GDP of Angola, Zaire or Zimbabwe.

In addition to supplying South Africa, the installation of transmission lines in the form of a super-grid would make electricity available to countries and areas through which the lines would pass, as well as earning them revenue. The interconnection of the national grids of a number of countries would also allow for the use of lower installed capacities, since standby capacity could be shared between the various utilities, increasing reliability of supply.

The above calculation has been carried out on the basis of a 15% uptake into South Africa. The amount of imported capacity which a country would be prepared to accept would depend on the financial position of the country and the perceived political stability in the region. Thus countries with a poor balance of payments situation or with lack of access to foreign borrowings could accept higher levels of imported power. If political stability were considered to be high, the amount of 15% quoted could possibly be increased.

Including the South African demand, demand from other countries and growth to the end of the century, there is therefore a potential market for some 5 000 MW of transmitted power in the region, an amount which can grow as the demand in the region increases with time. Of this amount, some 2 500 MW is already in place, including the various inter-country interchanges and the 1 920 MW of Cahora Bassa. There is, therefore, room for an additional 2 500 MW of electricity trade in the region. However, because of the economic downturn in the region, there is significant spare capacity, especially on the South African grid, and therefore any increase in trade will have to wait until the spare capacity is used up. In the case of the South African grid, it is estimated that additional capacity will be required by around 2005.

## *Coal*

In 1988 the region, including South Africa, consumed approximately 780 PJ (31 Mt) of coal, of which South Africa consumed 88%. Half of the coal was used for electricity generation and the remainder mainly for industrial applications. In addition, there was an amount of 1 168 PJ (47 Mt) which was exported out of the region. If more use were made of the hydropower potential of the region, less steam coal would be used, thus extending the life of the coal reserves and allowing a greater volume for export.

Because of infrastructure limitations in the region, oil is often used for heating purposes since coal is not available. It is estimated that for heating purposes in Southern Africa, heat generated from pit head coal is approximately 15% of the cost of heat from heavy fuel oil. For railage distances of 1 600 km (e.g. from Johannesburg to Cape Town) the economics are worse, with coal costing 60% of oil costs. Most of the countries south of the equator are within a distance of less than 1 500 km of one or other of the coalfields in the countries having the largest coal resources in the region, namely, South Africa, Botswana, and Zimbabwe. Thus there is an incentive to use more coal where it can be railed or shipped at reasonable cost.

The barrier to a satisfactory trade in coal in the region is the lack of an adequate railway system and the political situation in the region. Whilst there is a rail link between most of the countries in the region, most of the main links, such as the Benguela Railway between Zambia and Angola, and the link between Mozambique and Malawi, have been closed because of sabotage to the line and ongoing guerrilla activities. With a general improvement in the political situation in the region, these disruptions should shortly be a thing of the past. However, even when the links are again open there is a chronic shortage of rolling stock, a shortage of skilled technical staff and also a shortage of managerial skills to operate the links adequately at an efficiency figure acceptable to the coal trade.

The need for coal trade will increase with the general deterioration in the fuelwood situation in the region. With fuelwood no longer being a sustainable commodity, the traditional energy sources are rapidly being replaced by the most expensive forms of commercial energy, such as paraffin and candles. Under these circumstances the use of coal is a cheaper alternative to supplying the basic energy needs of the developing sectors of the community.

It is difficult to estimate the possible amount of coal trade that could take place if the infrastructure were in place to support such an interchange. However, it could be argued that since South Africa has adequate access to coal, its final energy mix could be taken as representing the optimum mix for other countries in the region - if they could use coal. Using South Africa's energy carrier mix and assuming that those countries that have coal resources (as given in Table 8) would produce more for their own consumption, then the calculation shows that there is a potential for a coal trade of approximately 3 Mt of coal per year. The main importers would be Angola, Kenya, Namibia and Uganda. The shift to coal would be at the expense of oil imports. The amounts of coal trade would in fact be greater than this due to the fact that some countries, such as Zaire, may not be able to expand their coal production and may find it more economic to import coal.

In addition, there is the additional coal market that will be created by the move away from traditional fuels, such as fuelwood and charcoal, as these become scarcer. The traditional energy for the region amounts to 1 840 PJ and amounts to 45% of total energy usage (79% if South Africa is excluded). Assuming that if coal were used in place of traditional energy forms, it would be accompanied by an increase in the efficiency of utilisation because of improved stove design, then the traditional energy consumption component would decrease to about 600 PJ (24 Mt). Of the coal amount, again discounting those countries which would be self- sufficient in coal production, some 180 PJ (7 Mt) could be traded on a regional basis. Thus the additional coal trade would amount to 6 Mt per annum of coal. However, a significant amount of the replacement of traditional energy will eventually be taken up by rural and peri-urban electrification, and thus the coal trade would be significantly reduced from the upper limit of 6 Mt of coal.

Thus the potential trade for coal is likely to be between 3 Mt and 6 Mt of coal per annum. The source of this coal would be South Africa, Botswana and Zimbabwe, and to a lesser extent, Mozambique, Swaziland and Tanzania.

## Gas

Gas is the growing energy source of the world and is taking over from oil and coal. Where gas has been adequately developed in other parts of the world, it amounts to between 15%-20% of total final consumption of commercial energy. In the region, gas has been found in Mozambique, Namibia, South Africa and Tanzania, and associated with oil resources in Angola and Zaire. Investigations are currently under way on the potential of gas trade between Namibia and South Africa, and between Mozambique and South Africa. If South Africa were to follow the path of, say, Australia in its utilisation of gas, then it may be assumed that gas could supply 15% of commercial energy, amounting to approximately 260 PJ. This gas would be supplied from the Kudu gas field off Namibia, and from the Pande field in Mozambique. In view of the distances involved, the Namibian gas would be used in the south-western part of South Africa, whilst the gas from Mozambique would be used in the industrial centre of South Africa on the Highveld. In view of the relative economic activity in these two separate parts of South Africa, it is estimated that some 30 PJ of gas could be used in the south-west and 230 PJ on the Highveld, of which 21 PJ is already being consumed based on gas produced from coal. The estimate for the south-western area assumes that a significant amount of coal could be replaced due to the high cost of transporting coal over 1 500 km from Johannesburg, compared with gas being transported from Namibia over a distance of 750 km. These amounts are for final consumption and therefore exclude any gas for power generation.

The gas from Mozambique could also be routed to Swaziland, as a spur from the South African pipeline. Mozambique could also supply Zimbabwe and Zambia if projects with a significant gas demand were to be started.

Tanzania has large gas resources and could supply the surrounding countries, such as Kenya and Malawi. However, it is likely that only Kenya would have enough gas demand to warrant possible development of the Tanzanian capability. The export to Kenya would amount to approximately 15 PJ.

## Oil

There are only two countries producing oil in the region - Angola and Zaire. Of the two, the Zairean production is declining and is unlikely to be a significant source of oil for the region. The Angolan production is sold on the open market and there is no incentive for Angola to supply oil directly by rail or pipeline to other countries in the region since the sea trade in crude is well established and it does not matter to an importer where the oil originated.

There is, however, potential for a rationalisation in the supply of refined products to make optimal use of the refineries in the region. At present a number of refineries are not working or are working at much reduced capacities because of maintenance problems, due to lack of skilled manpower and due to difficulties in obtaining foreign exchange. Trade in oil products is therefore an attractive possibility as opposed to the construction of new refineries.

## Regional co-operation

It has been recognised for some time that the region can progress on the economic front only if there is a pooling of resources. Thus the Preferential Trade Area (PTA) and the Southern African Development Co-ordination Conference

(SADCC) were both formed to increase the capability of the member nations for economic growth. Whilst South Africa was seen as one of the forces against which co-ordination was required, it is now recognised that South Africa, as the dominant economic entity in the region, has an important role to play in regional development. The entry of South Africa to the Southern African Development Community (SADC) (previously SADCC) was therefore inevitable, and the amalgamation of SADC and the PTA could result in the birth of a powerful conglomerate of Southern African countries which would in turn form part of a Sub-Saharan grouping. The role of energy in this conglomerate will be significant and could well be one of the first examples of successful co-operation.

The financial requirements of the energy industry in the region will be substantial and will not be available from within the region, though there is a realisation that local financial bodies, including those in the private sector, should be used to the maximum before overseas financial aid is requested. Therefore there is a very large role to be played by the development banks in the region. It is envisaged that the various development banks will need to pool their resources rather than being in competition - there are enough capital projects which will require funding.

Besides the need for finances for the capital projects, regional co-operation is also required for the development and pooling of manpower skills, for the setting of regional standards, and for the interchange of information. The immediate priority in the region is for economic growth to support the urgent need for human development, to alleviate the widespread poverty and increase access to essential services and goods. To facilitate economic growth it is necessary to assure an adequate supply of energy in the appropriate form and in the most efficient and cost-effective manner possible. The region has an abundance of commercial energy resources, but they are not uniformly distributed with regard to form or locality, and a number of supply constraints exist. The realisation of the potential for trade in energy within the region is of key importance in guaranteeing the supply of sufficient commercial energy in a sustainable manner and ensuring the efficient utilisation of the region's resources.

## Acknowledgements

The author would like to acknowledge the support - financial and informational - of the Department of Mineral and Energy Affairs, the Development Bank of Southern Africa and the South African National Committee of the World Energy Council.

### References

(1) WORLD BANK (1987). Angola: Issues and options in the energy sector. Report No. 7408-ANG. UNDP/World Bank Sector Assessment Program. May.

(2) GIELINK M I and DUTKIEWICZ R K (1991). Energy Profile: Botswana. ERI Report No. IER 049. Energy Research Institute. December.

(3) SWAWEK (1991). Annual Report. SWAWEK. September.

(4) DUTKIEWICZ R K (1991). Energy Profile: Zimbabwe. ERI Report No. IER 041. Energy Research Institute. August.

(5) SOUTHERN AFRICAN DEVELOPMENT COORDINATION CONFERENCE (TECHNICAL AND ADMINISTRATIVE UNIT)(1990). Energy Statistics Yearbook. SADDC. December.

(6) INTERNATIONAL ENERGY AGENCY (1991). Energy statistics and balances of non-OECD countries 1988-1989. OECD.

(7) DUTKIEWICZ R K and STOFFBERG T C (1991). Electricity saturation in South Africa. ERI Report No. GEN 146. November.

(8) INTERNATIONAL ENERGY AGENCY (1990). Energy balances for OECD countries 1987-1988. OECD.

# Solar cooking: Exploring the possibilities and limitations

* M WENTZEL

Interest in solar cooking is gaining rapid momentum in South Africa and other developing countries to address the problems of wood scarcities, the high cost of fuelwood, environmental degradation, forest denudation, as well as health concerns such as, malnutrition, lung disease caused by smoke, burns from open fires, and clean drinking water. However, specific limitations and problems exist surrounding the promotion and use of solar cookers, notably issues of social acceptability, training, support and evaluation. The lack of adequate training and educational material are often cited as the most important reasons for the failure of solar cookers. This paper examines the potential contribution of solar cooking in the domestic energy sector, as well as problems surrounding the use and introduction of solar cookers. A brief description is also provided on current activities in South Africa to promote the use of solar cookers.

**Keywords:** domestic energy; solar cookers; solar ovens; parabolic reflector cookers; South Africa

## Introduction

All the earth's energy originates from the sun. Solar energy, in particular, is increasingly being utilised for various applications to provide hot water and electricity for lighting, refrigeration and entertainment. The possibility also exists to utilise the sun's energy for cooking purposes.

Two billion people world-wide use wood for cooking and over one billion tons of fuelwood are cut every year. This leads to deforestation, denudation and concomitant environmental degradation. It also places a great burden on women who have to collect the wood and spend more time than previously to collect adequate supplies. Solar cooking, although hampered by various factors, is generating considerable interest as a means of addressing the cooking needs of the rural poor in particular.

## A brief history of solar cooking

According to Halacy and Halacy[4], the first scientist to experiment with solar cooking was a German physicist named Tschirnhausen (1651-1708). He used a large lens to focus the sun's rays and boil water in a clay pot. His experiments were published in 1767 by a Swiss scientist Horace de Saussure who also discovered that the wooden "hot boxes" he built generated sufficient heat to cook fruit. The French scientist Ducurla improved on the hot box design by adding mirrors to reflect more light and insulating the box. The first book on the subject, *Solar energy and its industrial applications*, was published by August Mouchot. In 1877 Mouchot designed and built solar cookers for French soldiers in Africa which performed very well. The first solar cooker to be used on South African soil was probably by Sir John Herschel during a scientific expedition to the Cape of Good Hope in 1885.

By the early 1930s renewed interest in solar cooking resulted in many cookers being sent to French colonies in Africa. India also began investigating the use of solar energy as a substitute for dwindling fuelwood resources. By the early 1950s, Indian scientists had designed and manufactured commercial solar ovens and reflector cookers. In the 1960s the concentrator type of cooker was introduced in Mexico and in the 1980s the Chinese produced over 1 000 of the concentrator type cookers, although little use had been reported outside the country[14]. Early solar cooking devices were bulky, heavy and expensive. Recent technological advances and new materials have, however, put solar cooking within the reach of more and more people.

## Types of solar cookers

Solar cookers utilise the simple principles of reflection, concentration, glazing, absorption and the greenhouse effect to produce heat. Various types of solar cookers exist, harnessing one or more of these principles. These are:

Solar box cookers or solar ovens
Parabolic reflector cookers/ovens
Indirect types of solar cookers

### *Solar box cookers or solar ovens*

A **solar box cooker** is an insulated container with a glass (or other transparent material) cover. This kind of cooker depends on the greenhouse effect, in which the transparent glazing permits the passage of the shorter wavelength solar radiation, but is opaque to most of the longer wavelength radiation coming from heated objects which have relatively low temperatures. Mirrors may be used to reflect additional solar radiation into the cooking chamber[1]. A double-walled insulated box can also serve to hold the heat inside the cooker. A solar box cooker can easily be assembled by households following simple instructions or bought in a complete assembled form as found in India[9]. Disadvantages include a slow cooking process due to low temperatures with the concomitant danger of contamination of food. Advantages include: (i) simplicity of construction and operation with minimal attendance required during the cooking process; (ii) the cookers are also more stable, can keep food warm for a long time, produce no glare and present no risk of fire and burns[3].

A **solar oven** is somewhat similar to a hot box cooker in that it is an insulated container with a glass cover. Oven cooking chambers are generally smaller than hot box interiors and the glazed cover is also considerably smaller. The major difference is in the mechanism for directing solar radiation to the cooking area. Solar ovens use several mirrors to reflect additional radiation into the cooking cavity. Due to increased radiation penetration and decreased cooker area for heat losses, very high temperatures can be achieved[1]. The ovens generally have to be moved

* Energy for Development, Chief Directorate: Energy, Department of Mineral and Energy Affairs, Private Bag X59, Pretoria 0001, South Africa

periodically throughout the day to follow the sun's path and therefore, require more attention than solar box cookers. They also require more sophisticated materials and are more expensive than solar box cookers.

### *Parabolic reflector cookers/ovens*

Spherical parabolic cookers are direct concentrating cookers with a dish-type reflector directing most of the intercepted solar radiation to a point of focus. The cooking vessel is supported at this focus point, thus creating a heating situation very similar to traditional open fire cooking[1]. The concentrators can vary in form from shallow to deep dish shapes, and they can have a continuous reflecting surface or concentric rings, which are supported to focus the radiation. Dish-type concentrators require direct sunlight to function and must be frequently orientated towards the sun[10]. Advantages include high cooking temperatures, virtually any type of food can be cooked in them, and short heat-up times are possible. Disadvantages are their size, cost, the risk of fire and burns, and the inconvenience of having to adjust the cooker. Most direct-focusing cookers are also unstable at wind speeds exceeding 10 km/h[7] and are sometimes considered inconvenient to use because the glare can blind the cook[3,8].

### *Indirect solar cookers*

In indirect solar cookers the pot is physically displaced from the collector and a heat transferring medium is required to convey the heat to the cooking pot. The solar Garg steam cooker and the Brace steam cooker are of this type[7]. Steam is produced by flat plate collectors or concentrators and piped to a chamber containing the cooking pot. The cookers however, seldom reach temperatures above 100° C and a problem exists with internal condensation on the top glazing collector.

## Motivation for the promotion of solar cooking

In the world's energy supply, fuelwood is far more important than nuclear energy. Over one billion tons of fuelwood are cut every year, mostly for cooking and two billion people cook with wood[3]. The picture is not hugely different for South Africa. Domestic consumption of fuelwood in South Africa is 11,2 million tons (Mt) or 840 000 m$^3$ per annum. Most of the fuelwood is used for cooking. It is further estimated that 95% of the rural population of South Africa is dependent on fuelwood for cooking[15].

Traditionally, fuelwood has been regarded as a "free" wood harvested from the natural vegetation. Over-exploitation of this resource as a result of high population densities and overgrazing progressively results in shortages, severe environmental degradation and hardship. Estimates indicate that at the current rate of utilisation the country will be completely denuded of natural woody vegetation within the next 30 to 40 years. Rural people, already desperately poor, are forced to spend up to 20% of their meagre household income on commercial fuels when their supply of "free" wood runs out[13].

> "A very important factor emerging from past experiences with solar cooking highlights the importance of a well-planned and well-executed dissemination and support campaign. The failure of solar cooking programmes can often be traced to inadequate information, lack of access to support, and little or no monitoring and evaluation carried out during the dissemination campaign."

In virtually all cooking systems other than solar cooking, the fuel requires some human input in transporting it from the place of origin to the point of use. Interventions do not only require human input but most often a substantial financial expenditure to secure cooking fuel for the household.

The reasons for promoting the use of solar energy for cooking are therefore numerous and include the following:

* Promotion of the use of renewable energy
* Conservation of scarce energy resources
* Reduction of a dependence on expensive commercial fuels
* Resultant fuel savings for poor households
* Reduction of environmental degradation and desertification
* Health improvements in general because of the reduction in indoor air pollution, as well as an improvement of the health of women who often suffer during the wood-collecting activity itself
* Reduction in the workload of the women and children who have to collect the wood
* Improved safety through reduced risk of fire and burns
* Cooking with solar energy requires less water than with conventional fuels, which is beneficial in areas with water scarcities
* Water can be purified through boiling in a solar cooker.

Solar energy for cooking can also be used for certain commercial uses, for example, the baking and heating of food to be sold, and the building and selling solar cookers.

If the benefits of solar cooking are so numerous, the questions that must arise are why solar cooking is not being practised on a larger scale and why the introduction of solar cookers has never really been very successful. Lessons learnt from past experiences highlight various problems with regard to the social acceptability of solar cookers.

## Social acceptability of solar cookers

Much effort has been expended in developing solar cookers of various types, but there has only been limited success in encouraging their use. This has sometimes been due to the inefficiency of the devices and their failure to meet anticipated performance levels, but social, economic and psychological factors have also prevented the adoption of the technology. The main criticism against the use of solar cookers is that as they depend on direct solar radiation, they can therefore only be used on sunny days when there is little or no cloud cover. Thus cooking must take place out of doors, preferably during the hottest time of the day if cooking time is to be kept to a minimum. Solar cooking time will be much longer than if wood fires or conventional cookers are used, and food preparation habits will need to be changed. Lastly, when compared to the cost of an ordinary fire, a solar cooker is quite expensive [5].

The social acceptability of solar cookers can thus be summarised in two simple requirements[2]:

(a) solar cookers must be easy to use;

(b) solar cookers must be affordable.

*(a) Ease of use*

Initially, many solar cookers were bulky, big and uncomfortable to use. Ideally, a solar cooker should be foldable, portable, rugged and durable, requiring minimal maintenance. Few or no adjustments should be necessary to operate the cooker. However, regular re-orientation towards the sun is necessary to maintain maximum temperature.

The quality of the food cooked in a solar cooker should not differ from that prepared with conventional fuels. A problem could arise in certain areas when a particular cooking method is preferred, for example, most solar cookers are not suitable for frying[11]. Another disadvantage is that, in general, food takes a long time to cook in solar cookers. However, certain staple foodstuffs such as, porridge, beans, stews and samp, require a slow cooking time, thus making solar cooking a most suitable cooking method.

Cooking in a solar cooker also requires some form of change in cooking technique. Once the food has been placed in the cooker, no stirring is necessary and little or no supervision is required since the food cannot burn. Adequate information and training should therefore, be provided to users to facilitate the adjustments required.

Solar cookers should also be safe to use. Radiation-type cookers hold the danger of burns, can blind the cook, and are unstable in windy conditions. Other types of solar cookers are relatively safe to use without risk of injury (burns), and no pollution or bad smells originating from the cooker. In terms of safety, care should always be taken that the cooker's temperature does not fall below 55°C, as bacterial growth is highest around this temperature. Food may, however, be kept above 70°C for at least six hours.

*(b) Affordability*

Solar cooking will never displace all other cooking methods. It should, however, be regarded and promoted as an important, albeit complimentary, energy- and time-saving option under appropriate conditions.

Since it is the very poor segment of communities that is usually targeted for the promotion of solar cooking, innovative ways should be explored and offered to make solar cookers easily available and affordable. The means of lowering capital- and operating costs and ensuring reliability of supply are necessary if the poor are to gain access to these technologies[12]. Credit funds and credit systems geared to these conditions should also be available as a support mechanism to users and to facilitate the wider promotion of solar cooking.

### *Promoting the use of solar cookers*

The failure of numerous well-intentioned appropriate technology projects and in particular, previous attempts to introduce solar ovens in the developing areas, can be traced to the imposition of an unfamiliar technology without the social interplay and development of self-reliance[6]. Interest in solar cooking seems to be spreading faster than its use. Most promotion responses are cautionary, encountering unexpected stumbling blocks. These fall mainly into two categories; consumer needs and promoter needs.

A very important factor emerging from past experiences with solar cooking highlights the importance of a well-planned and well-executed dissemination and support campaign. The failure of solar cooking programmes can often be traced to inadequate information, lack of access to support, and little or no monitoring and evaluation carried out during the dissemination campaign. Lessons from the past point to several important aspects listed below to be considered in order to promote solar cooking.

## Important aspects to consider

As previously mentioned, success in the promotion of solar cooking depends on various factors concerning consumers and promoters. They can be summarised as follows:

### *Consumer success factors*

* A concern, not just a mild interest or curiosity, is required. One must have a very good reason and/or fairly quick benefits to justify the start-up costs and effort to learn the techniques of solar cooking. Thus consumer motivation must be confirmed. Even where interest in solar cooking appears to be high, there may be other more immediate demands on scarce time and resources. Making assumptions about people's needs and planning programmes without adequate community participation will lead to failure.
* A sunny climate.
* An appropriate solar cooker. That is, the cooker must be durable, affordable and suitable for local climatic conditions and cooking customs.
* Continuing instruction while learning these new cooking habits. This must be in the language(s) of the locals, with recipes for local foods, and presented by experienced solar cooks with skills in two-way learning exchanges.

### *Promoter success factors*

* Preparation. A sequence of training, (i) for consumers, (ii) for experienced cooks to become teachers, (iii) for experienced teachers to become trainers of teachers.
* Products. Quantities of regionally appropriate cookers or materials with which to build them.
* Provision of suitable educational materials describing the care and use of solar cookers.
* Dissemination strategies, where materials must be tested with the intended users input and modified where necessary. Researchers need to gather abundant feedback by working closely with consumers.
* Pooling experience. This is to avoid mistakes and to build on each other's strengths, and to fill gaps in support services.

### *General guidelines for promoting the use of solar cookers*

Solar cooking can bring direct and immediate benefits to individuals and environments, but the natural spread of new ideas is usually slow. The following are suggested as useful guides to accelerate the spread of the knowledge and use of solar cookers:

* Start where people are and respond to their needs;

* Adapt cookers to foods favoured in the area, utensils, cooking habits and climate;
* Work through local organisations;
* Raise public awareness through the media;
* Have experienced users teach others;
* Offer "hands-on" participatory workshops;
* Avoid give-aways, "value-added exchanges" are the best;
* Facilitate the availability of "loan-" and "rent-to-own" cookers;
* Involve end-users in the evaluation of solar cookers and the ways in which the information is spread.

## Current solar cooking activities in South Africa

The Directorate: Energy for Development of the Department Mineral and Energy Affairs is investigating the dissemination, impact and acceptability of solar cookers through various projects. These projects focus on the dissemination of the Sunstove - a very affordable, robust solar oven - in four rural areas of South Africa. The institutional use of the Sunstove is also being investigated through a project at the Tigerkloof School near Vryburg where certain meals are being cooked in the Sunstove. Innovative ways of making the Sunstove accessible are being explored by investigating different credit mechanisms and methods of dissemination. Training and support is being provided throughout the project by Margaret Bennett of the Sunstove Organisation.

The Department of Mineral and Energy Affairs is also involved in a collaborative effort with the Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) to investigate the acceptability of various solar cookers through extensive field testing and monitoring. It is envisaged that the project will lead to large-scale dissemination of solar cookers in South Africa.

## Conclusion

This paper has attempted to discuss a number of aspects which need to be considered when investigating the possible contribution of solar cookers to the domestic energy sector in general, and to South Africa in particular. It should be borne in mind that the solar cooker is only one alternative technology to be considered as a means of improving domestic energy consumption in developing communities. Other aspects to be taken into consideration are basic conservation, economic empowerment of the poor, diversification of energy resources and reforestation. It must be remembered that technology is only the tool, not the solution!

### References


(1) ALWARD R (1982). Solar cooker manual. Brace Research Institute, Macdonald College of McGill University Quebec.

(2) BERNARD R (1987). A handy solar cooker. *Sunworld*, Vol.11 No.2, pp.50-51.

(3) EUROPEAN COMMITTEE FOR SOLAR COOKING RESEARCH (ECSCR) (1995). Second International Solar Cooker Test. Summary of results. ECSR, Germany.

(4) HALACY B and HALACY C (1992). Cooking with the sun. Jack Howel, Lafayete, California.

(5) JONES A (1994). Sounding out the solar cooker. *Appropriate Technology*, Vol.21 No.2, September, p.31.

(6) KAMMEN D M and LANKFORD W F (1990). Cooking in the sunshine. *Nature*, Vol.348 No.29, November, pp.885-386.

(7) KHALIFA A M A, TAHA M M and AKYURT M (1984). Solar cookers for outdoors and indoors. *Energy*, Vol.10 No.7, pp.819-829.

(8) LUSH D and CAMPBELL J (1985). Solar energy applications. *Overseas Building Notes*, No 192. February.

(9) INDIA (MINISTRY OF ENERGY) (1983). The layman's guide to solar cookers. Department of Non-Conventional Energy Sources, Ministry of India. New Delhi.

(10) MULLICK S C, KANDAL T C and SUBODHI K (1991). Thermal test procedure for a parabolic concentrator solar cooker. *Solar Energy*, Vol.36 No.3, pp.139-144.

(11) NAHAR N M (1990). Performance and testing of an improved hotbox solar cooker. *Energy Conversion*, Vol.30 No.1, pp.9-17.

(12) UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT (OTA) (1992). Fuelling development: Energy technologies for developing countries. Congress of the United States, Washington, D.C.

(13) *Plant for Life* (1994). The Biomass Initiative Newsletter. Progreen, Johannesburg.

(14) SBCI (1993). Solar box cooker leader's manual: How to make, use and teach others about them. Sacramento, California.

(15) VILJOEN R P (1994). Rural wood and fuelwood survey: National comparative report. Department of Mineral and Energy Affairs, Pretoria.

# *Managing Eskom's impact on the environment: Air pollution

**Keywords:** Eskom; air pollution; power station emissions; air quality; gaseous emissions; ash

## Introduction

Eskom supplies more than half of the electricity consumed in Africa. Its total of 19 power stations have a nominal capacity of 37 840 MW, and its total network comprises 241 802 km of powerlines. Of these 19 power stations, 12 are coal-fired, 2 gas turbine, 2 hydroelectric, 2 pumped storage schemes, and 1 nuclear.

Eskom produces more than 95% of South Africa's electricity. Its retail customer base is more than one million. Most mines and many industries are supplied direct, while more than 43% is sold to local authorities who in turn retail it to end-users.

Eskom has committed itself to minimise the inevitable environmental consequences of its operations, to contribute to the enhancement of the population's quality of life, and to contribute to sustainable development.

### *Air pollution management: Progress on targets and objectives*

Coal-fired power stations release various emissions into the atmosphere, for example, particulate matter (seen as visible smoke), sulphur oxides ($SO_x$), nitrogen oxides ($NO_x$), and carbon dioxide ($CO_2$). These emissions contribute to the overall greenhouse effect and the formation of acid rain. To minimise these impacts, Eskom has devised various programmes to reduce particulate emissions, such as the installation of equipment at power stations to monitor these emissions.

The following are some of the initiatives undertaken by Eskom in the short term (1995) and those proposed for the medium- and longer term (to the year 2000) to combat air pollution from its power stations:

| GASEOUS EMISSIONS | | | |
|---|---|---|---|
| Year | $CO_2$ (Mt) | $SO_2$ (000 t) | $NO_2$ (000 t) |
| 1990 | 132,75 | 1 088,32 | 553,09 |
| 1991 | 132,23 | 1 064,48 | 538,09 |
| 1992 | 132,81 | 1 074,25 | 540,83 |
| 1993 | 141,03 | 1 134,02 | 582,11 |
| 1994 | 142,94 | 1 166,80 | 581,77 |
| 1995 | 146,95 | 1 198,17 | 602,81 |

*Table 1: Annual Eskom emission data 1990-1995 (calculated)*

| | 1995 | | | 1994 | | |
|---|---|---|---|---|---|---|
| Station | Ash emitted (kt) | Ash allowed (kt) | Ash compliance | Ash emitted (kt) | Ash allowed (kt) | Ash compliance |
| Arnot | 10 | 13 | 0,76 | 11 | 13 | 0,83 |
| Duvha | 9 | 19 | 0,48 | 8 | 21 | 0,38 |
| Hendrina | 46 | 18 | 2,49 | 50 | 26 | 1,94 |
| Kendal | 5 | 12 | 0,39 | 5 | 11 | 0,43 |
| Kriel | 9 | 23 | 0,40 | 10 | 25 | 0,43 |
| Lethabo | 6 | 15 | 0,43 | 5 | 14 | 0,38 |
| Matimba | 21 | 36 | 0,59 | 22 | 36 | 0,63 |
| Matla | 4 | 30 | 0,13 | 5 | 28 | 0,16 |
| Tutuka | 5 | 12 | 0,46 | 6 | 9 | 0,66 |
| **Total** | **115** | **178** | | **122** | **183** | |

*Table 2: Compliance with CAPCO limits*

### *Short term (1995)*

* ***The installation of continuous gaseous emission monitors at 3 coal-fired power stations.***

  Continuous gaseous emission monitors were installed at Majuba and Lethabo power stations in 1995. Gaseous emissions at Eskom's other power stations were calculated as shown in Table 1.

* ***Phasing out of chlorofluoro carbons (CFCs).***

  Where necessary, Eskom has put phase-out plans into place for ozone-depleting substances. Existing stock will be used until depleted, but the relevant equipment will be retrofitted so that ozone-friendly substances can be used.

* ***Submission of air quality performance reports.***

  Air quality performance reports were submitted on a monthly basis to the Chief Air Pollution Control Officer (CAPCO) of the Department of Environmental Affairs & Tourism and to Eskom's senior management. Compliance with the registration certificate limits as prescribed by CAPCO is reported as the ratio of actual ash emitted against the ash emission allowance. If the legislation is to be complied with, this ratio must remain below 1,0. If the limit is exceeded, the authorities may call for the station's closure. Table 2 shows the emissions in kilotons (kt) allowed by the CAPCO certificate against the actual performance of each coal-fired power station.

* Extracted from Eskom's 1995 Environmental Report, pp.12-16. Following this extract, Dr Steve Lennon of Eskom's Technology Group discusses recent trends in air pollution.

| Station | 1995 | 1994 | 1993 |
|---|---|---|---|
| Arnot | 2,60 | 2,42 | 2,35 |
| Duhva | 0,46 | 0,37 | 0,82 |
| Hendrina | 4,12 | 4,19 | 3,14 |
| Kendal | 0,23 | 0,24 | 0,42 |
| Kriel | 0,57 | 0,79 | no data |
| Lethabo | 0,33 | 0,31 | 0,33 |
| Matimba | 0,88 | 1,00 | 1,28 |
| Matla | 0,20 | 0,24 | 0,28 |
| Tutuka | 0,31 | 0,33 | 0,23 |
| **Weighted average** | **0,77** | **0,83** | **0,84** |

*Table 3: Relative performance: Particulate emissions 1993-1995 (kg/MWhSO)***

| Year | $CO_2$ (tons/GWh) | $SO_2$ (kg/GWh) | $NO_2$ (kg/GWh) |
|---|---|---|---|
| 1990 | 985,2 | 8 077 | 4 105 |
| 1991 | 974,1 | 7 842 | 3 964 |
| 1992 | 970,6 | 7 851 | 3 953 |
| 1993 | 969,2 | 7 793 | 4 000 |
| 1994 | 965,8 | 7 884 | 3 931 |
| 1995 | 968,8 | 7 899 | 3 974 |

*Table 4: Relative performance: Gaseous emissions (1990-1995)*

## Medium term (1995-1998)

* ***Further development of baseline information on all emissions to enable Eskom to set internal targets for improvements in performance.***

  Relative performance, which compares emission mass from the chimneys with units of electricity sent out, is used as an indicator for long-term performance improvement. In Table 3 it can be seen that relative performance on particulate emissions has continuously improved since 1993 at all but two of the power stations. For example, Duvha power station's decreased performance during 1995 was the result of problems experienced with the pulse-jet fabric filters. However, Kriel and Matimba power stations each showed the substantial improvement on 1994 performance figures and this, together with lesser improvements at the other power stations, produced an overall result of 0,77 kg/MWh during 1995. This represents a 0,06 kg/MWh improvement on 1994 performance (0,83 kg/MWh).

  As can be seen from Table 2, the total particulate emissions for Eskom's coal-fired power stations decreased from 122 kt (1994) to 115 kt (1995). As 151 730 GWh of electricity was generated in 1995 (compared with 148 003 GWh in 1994), this is a definite indication of overall performance improvement. Figures for relative performance of gaseous emissions are given in Table 4.

* *The fitting of enhanced dust removal equipment to identified coal-fired power stations to further reduce emissions.*

  Arnot, Hendrina and Duvha power stations were scheduled for the fitting of pulse-jet fabric filters from 1994 onwards. Three of the units at Duvha power station received fabric filters in 1994. However, the operation of the fabric filters was found to be unsatisfactory. In September 1995, two units were closed down because of premature fabric filter failure which caused high ash emissions. These units were then refitted with new fabric filters and brought back into service. In 1995 one of the units at the Hendrina power station was fitted with fabric filters.

* *Contribution to South Africa's strategy on the Framework Convention on Global Climate Change.*

  Eskom was able to offer assistance in the U.N.'s Convention on Climate Change in terms of defining future priorities and activities for South Africa.

## Long term (1995-2000)

* *Monitoring and evaluating air quality trends and influences on the Mpumalanga Highveld.*

  Eskom is evaluating and determining air quality trends and influences on the Highveld in conjunction with other research bodies and regional air quality forums. Although the results were not compared to international trends, Eskom's air quality network conforms to internationally accepted standards. It provides data on ambient air quality for national and international research purposes, which has assisted in the steady improvement of the region's air quality.

* *Research on local and regional climate change factors.*

  This consists of local and regional scale modelling which is being undertaken in conjunction with the Foundation for Research Development and the universities of Cape Town, Witwatersrand and Natal.

* *Ongoing training of operating staff.*

* *Ongoing investigation of alternative generation and operation technologies to reduce gaseous emission levels.*

  These include nuclear and hydroelectric alternatives.

* *Particulate emissions.*

  Particulate emissions have been reduced by up to 50% on a single casing at Matimba power station by intentionally skewing the gas flows entering and exiting the electrostatic precipitator, a technique which will be implemented at other power stations.

* *Ongoing research is being undertaken on gas cleaning techniques.*

* *Several proposals and pilot projects are being considered to enable practical and inexpensive uses to be found for the excess heat produced by power stations.*

** MWh sent out

# Recent trends in air pollution

* S J LENNON

**Keywords:** Eskom; air quality; Mpumalanga Highveld

## Introduction

The extract from Eskom's 1995 Environmental Report provides an insight into the air quality performance measures used by the utility in measuring its performance and in ensuring that its environmental compact to have a net positive impact on the environment is met. The Environmental Report, however, provides, by necessity, only a brief picture of the situation. The background and implications of some of the points mentioned in the extract are discussed below.

## Air quality trends in Mpumalanga

Over the last 15 years Eskom has been monitoring air quality trends in the Mpumalanga Highveld. The extract from the Environmental Report presents the trends in emissions from Eskom power stations but only briefly touches on the attendant air pollution trends. It is, after all, the quality of ambient air pollutants which defines the impacts. These trends are the subject of the most detailed analysis ever undertaken in South Africa in a recently published book entitled, *Air pollution and its impacts on the South African Highveld*[1]. This book shows how air pollution levels in the region have consistently improved over the last ten years. A positive trend of a 4,7 % reduction in pollutants, as well as visibility improvement, is reported. These trends are particularly encouraging when they are coupled with the fact that the internationally comparable guideline levels for pollutants established by the Department of Environmental Affairs and Tourism (DEAT) are very rarely, if ever, exceeded. In fact, these levels are rarely even approached. This definitive work goes a long way to addressing the concerns and questions raised in its predecessor - the so-called *150 Report*[2] - and provides factual information upon which to base both policy and actions.

* Technology Group, Eskom, Private Bag 40175, Cleveland 2022, South Africa

It is encouraging to see that the air quality management approach adopted by Eskom and the DEAT is having the desired results. The use of technologies, such as tall stacks, combustion of low-sulphur coal, particulate removal technologies and efficient coal combustion have ensured that air pollution impacts in this region, where there are so many power stations, are minimised. This in turn avoids the need to take pollution control measures to uneconomical extremes. This approach mirrors that of many nations far more developed than South Africa - especially in the strategy of reducing emissions through the combustion of low-sulphur coal - a strategy has been adopted at the outset in South Africa.

> "It is well known that urban air pollution is one of the greatest threats to the South African environment, as well as having severe health impacts. The source of this pollution is typically the domestic combustion of coal. Electricity, if available and widely used, can improve urban air quality considerably. This has been seen in established electrified areas. The electrification programme that is currently being implemented in South Africa should therefore have major benefits in this regard. The transition is, however, very slow and it could take up to 20 years before a significant improvement is attained. The use of alternative smokeless fuels is therefore an important area for development and application."

If one looks to the future of power generation in South Africa, it is clear that air pollution degradation in Mpumalanga is likely to become less and less of an issue. The technologies currently being evaluated by Eskom all use fuel even more efficiently and cleanly than the currently already efficient plant. These technologies include:

* supercritical pulverised fuel plant
* integrated gasification combined cycle plant
* natural gas-fired combined cycle plant
* hydro power stations outside South Africa's borders
* direct coal-fired gas turbines
* future nuclear power plant, such as modular gas-cooled reactors
* solar thermal plant
* future energy storage technologies, such as high head pumped storage and compressed air energy storage
* cogeneration.

The introduction of some of these technologies in the future generating mix will ensure that the air quality improvements measured to date are sustainable. It should be stressed that current generating plant still have a lifetime in excess of 20 to 30 years and that future plant would only be required in the first decade of the next century, given current load forecasts. The need for future plant may be further deferred as Eskom's demand-side management programme gains momentum.

## The role of electricity in urban air quality

It is well known that urban air pollution is one of the greatest threats to the South African environment, as well as having severe health impacts. The source of this pollution is typically the domestic combustion of coal. Electricity, if available and widely used, can improve urban air quality considerably. This has been seen in established electrified areas. The electrification programme that is currently being implemented in South Africa should therefore have major benefits in this regard. The transition is, however, very slow and it could take up to 20 years before a significant improvement is attained. The use of alternative smokeless fuels is therefore an important area for development and application.

It should be stressed that the electrification programme is an important strategy in Eskom's environmental programme. It is clear that if a holistic approach is adopted to the environment then the use of precious resources is optimised. It has already been established that additional pollution control is not required at power stations. It is clearly preferable to allocate resources to electrification than to luxury controls at power stations. It should be noted that, if the consumer is educated in how to use electricity, electrification may be accompanied by a reduction in energy consumption - yet another step in attaining the goal of sustainable development.

## The role of efficiency

The 1995 Environmental Report extract mentions emissions which have historically not been viewed as pollutants but which now give rise to concerns relating to global warming. The main emission mentioned is carbon dioxide. As a developing nation, South Africa's priority is clearly development while issues such as global warming are relatively low on the agenda. It would be easy to ignore this issue, leaving it to the developed nations to address the impacts of their historical excesses. The fact is, however, that development should be optimised via learning from the mistakes of the developed nations. This will mean that South Africa will be able to develop whilst maximising the benefits of the resources used. At the same time, this country should not be wasting scarce local resources on international issues whilst local demands are so pressing. The approach adopted by Eskom is a win-win one, in which local, regional and global benefits may be realised whilst developing society and the economy. This approach is clearly illustrated by developments such as:

* the electrification programme, which also results in improved efficiencies and reduced emissions;
* improved plant efficiencies, which reduce operating costs and result in a relative reduction in emissions;
* demand-side management programmes, which reduce costs to Eskom and the consumer whilst improving efficiencies.

Clearly the future technologies mentioned above will have similar impacts. This pragmatic approach will go a long way to ensuring that South Africa is able to achieve its developmental priorities without compromising environmental sustainability.

## The role of research

Eskom's environmental research programme is widely recognised both locally and internationally for its credibility and comprehensiveness. It is only through research into a wide variety of environmentally related phenomena that a proactive approach can be successful. In this regard detailed research programmes have been established in the fields of:

* air and rain quality monitoring and modelling
* water quality and availability
* waste management and utilisation
* global and regional impacts
* environmental management tools
* electromagnetic fields.

The results of this research are widely published in order to ensure credibility as well as to facilitate debate in this important area. A summary of research outputs is also published annually for general information[3].

### References

(1) HELD G, GORE B J, SURRIDGE A D, TOSEN G R, TURNER C R and WALMSLEY R D (EDS.) (1996). Air pollution and its impacts on the South African Highveld. Environmental Scientific Association.

(2) TYSON P D, KRUGER F and LOUW C W (1988). Atmospheric pollution and its implications on the Eastern Transvaal Highveld. South African National Scientific Programmes, Report No.150.

(3) LENNON S J (1996). Research Report. Technology Group, Eskom.

# S. A. Government's Energy Efficiency Business Plan

**Keywords:** energy efficiency; Energy Efficiency Business Plan; energy conservation

The Department of Mineral and Energy Affairs' Sub-Directorate: Energy Efficiency recently released details of its five-year Energy Efficiency Business Plan. The overall vision of the plan is the formulation and implementation of a national energy efficiency policy to obtain general national development supported by a decrease in energy intensity and the more effective use of energy. This is going to be undertaken by promoting effective integrated and balanced energy use on a sustainable basis in the industrial, commercial and domestic sectors of society, based on economy, equity and environmental considerations.

The rationale behind the Business Plan is the effective management of energy efficiency policies and programmes. A 10%-20% saving through energy efficiency measures could an effective increase of 1,5%-3% in the GDP within the time-frame that the energy savings occur.

The consumer will also benefit from improved energy efficiency in South Africa. Lower energy expenditure will result in an increase in the standard of living. Also, the competiveness of South African industries in the international market will be enhanced through improved energy efficiency.

The Sub-Directorate: Energy Efficiency will establish a strategy which will reflect a pro-active energy efficiency programme, in which local and international communities' needs will be analysed and input into the programme.

The process developed for the programme's implementation over the next five years is shown in Figure 1.

This process focuses on ten selected programmes which have been identified and prioritised in terms of the available information on their energy efficiency potential suitable for government intervention. The approach would be market-oriented to ensure that the policy options included in these programmes are implemented.

### *Programme 1: Support activities*

The main purpose of this programme is to make a contribution to the general responsibilities of the Chief Directorate: Energy. The Sub-Directorate: Energy Efficiency will respond to information from the Minister, other Sub-Directorates, other Government Departments and at an international level. Most of the activities will involve information-gathering and exchange, the development of expertise and increasing of the knowledge base by means of attendance of workshops, seminars and conferences, management of the various aspects of the programme (e.g. personnel, finance, marketing) and planning activities, and capacity building.

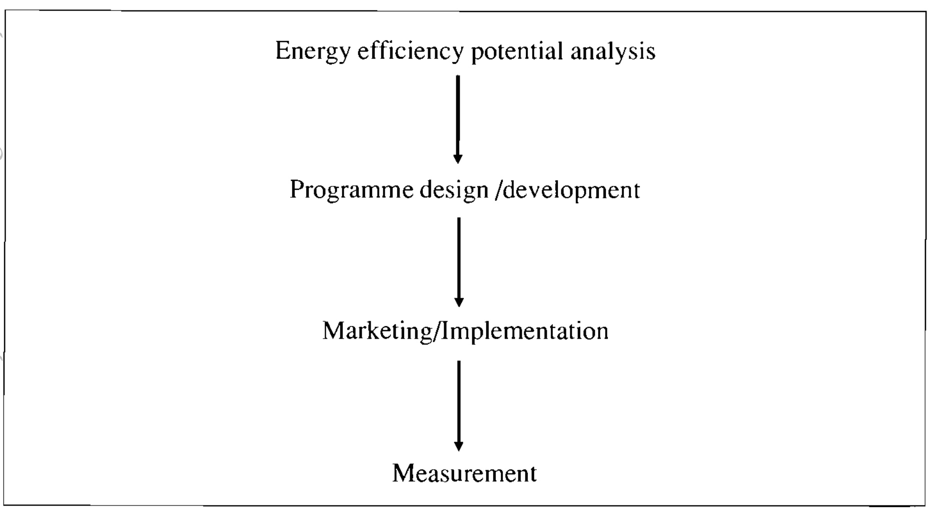



*Figure 1: Energy efficiency implementation process*

### *Programme 2: Energy efficiency potential*

This relates to the identification of the potential for energy efficiency needs in order to design a suitable energy efficiency policy. Various projects have been contracted out in the domestic, commercial and industrial sectors, under the following sub-sections: demand-side management, time-of-use management, energy saving in the commercial sector, and industrial energy audits. The information obtained on the available energy efficiency potential will be evaluated on an ongoing basis and be incorporated into the energy efficiency programme.

### *Programme 3: Energy efficiency education*

The creation of energy awareness at an early age needs to be undertaken urgently and its importance needs to be included into formal education curricula (primary, secondary and tertiary). It is further suggested that demonstration programmes stressing the practicality of energy efficiency measures could be combined with the theoretical information at school level. It is suggested that an energy efficiency information centre for children and adults be set up.

### *Programme 4: Domestic awareness*

This programme follows on from the previous one in the continuation of efforts to create energy awareness. However, this programme is aimed at a wider audience and includes publicity and communication campaigns, focusing on target audiences in the domestic sector. Its primary aim is to create awareness, educate and inform consumers of the benefits of energy efficiency improvements and to ultimately change their attitudes and behaviour towards energy efficiency.

### *Programme 5: Domestic appliance efficiency*

This programme is based on energy use and consumption of appliances in the domestic sector, in which consumers are made aware of the energy consumption of various energy equipment. One of the methods of implementing this is through the introduction of energy labelling of the major domestic electric appliances, which will give the purchaser of the appliance information regarding energy use. Minimum Energy Performance Standards (MEPC) could be developed to enable manufacturers to produce more energy efficient equipment.

### *Programme 6: Industrial energy efficiency*

This programme will be undertaken in three selected industries. A market research/study will be undertaken to establish a benchmark for the monitoring and evaluation of the programme. Complementing this will be the creation of an industrial energy efficiency awareness programme, the conducting of sectorial energy studies, and the initiation of industrial energy audit schemes. The methodology for the establishment of a subsidised energy audit scheme and a sectorial energy audit scheme have been investigated.

A lack of expertise in industry has already been identified as one of the barriers against increased energy efficiency. With a lack of experienced consultants and technical knowledge among managers and technical supervisors in industry, it has been perceived that Government can play an important role in the initiation of formal training schemes together with other stakeholders, and to facilitate the transfer of international expertise to South Africa. This could be done through (i) the implementation of training programmes in conjunction with local and international training and tertiary institutions and organisations, (ii) introduction of technical seminars and workshops on energy efficiency, (iii) the development of technical handbooks.

Based on the recommendations from the sectorial study, additional projects could be initiated for a specific sector, e.g. the development of energy efficiency indicators, energy consumption guidelines, voluntary agreements, demonstration projects.

### *Programme 7: Commercial building energy efficiency*

In order to improve energy efficiency in commercial buildings, a market research/study will be undertaken to establish a benchmark for the monitoring and evaluation of the programme. This will include a needs assessment of the end-user. As with the industrial programme, an energy efficiency awareness programme for the commercial sector will be created. Other strategies will include the establishment of energy efficiency building standards/norms, and as the government controls a large number of the buildings, a programme will be initiated to improve energy efficiency and to reduce energy costs in these buildings. Energy audits and demonstration programmes will also be conducted, and information dissemination will be initiated in the commercial sector.

### *Programme 8: Equipment energy efficiency*

The two main aspects of this programme are the improvement of the energy efficiency in electric motors, and government-promoted financial incentive schemes which could make energy efficiency equipment more affordable to consumers and energy-efficient investments more attractive. Methods to be investigated include import duty relief, tax concessions on energy-efficient equipment, direct investment support, bank loan guarantees, access to international funding, etc.

### *Programme 9: Information, monitoring and evaluation*

The development of a methodology and criteria which can be used to measure the effectiveness of different energy efficiency programmes and the prioritisation of various options is necessary to assist in the assessment of the effectiveness of the Government's energy efficiency policies.

Tools (e.g. an energy efficiency information system) and a methodology are necessary in order to support the development, implementation and measurement of the effectiveness of the various programmes. Linked to this is the need to disseminate the energy efficiency information to the end-user and other interested parties.

### *Programme 10: Institutional capacity*

A wide spectrum of organisations and institutions, namely, non-governmental organisations (NGOs) and private energy consultants, needs to be involved in order for the energy efficiency programme as a whole to succeed. A project will be initiated to investigate the feasibility of Energy Performance Contracting/Energy Service Company (EPSCO). Also, an Energy Efficiency Agency/Centre could be used as a tool to create institutional capacity for the implementation of energy efficiency strategies and policy. The development of a Business Plan for such an Agency/Centre will be undertaken with overseas collaboration and if shown to be feasible, could be implemented.

## Resources for the Energy Efficiency Business Plan

The budget for the Sub-Directorate: Energy Efficiency for 1996/7 is R1,9 million and the preliminary budget for 1997/8 R2,9 million.

With regard to human resources, the Sub-Directorate presently operates with three full-time staff members.

Under these circumstances, the programmes undertaken will most likely depend on the availability of human and financial resources over the five-year timescale. It must also be remembered that it is a dynamic process, which is subject to change.

Further information may be obtained from:

Dr Rachel Barker, Deputy Director: Energy Efficiency, Department of Mineral and Energy Affairs, Private Bag X59, Pretoria 0001, South Africa.

Tel.: +27 (12) 317 9222
Fax.: +27 (12) 322 5224

## COMPARATIVE ENERGY COSTS IN SOUTH AFRICAN CITIES RELATED TO HEATING VALUE

| AUGUST 1996 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy source | Consumer prices | | | Cost of energy (c/MJ) | | | *Relative heating costs | | | Heating value | |
| | Coast | Inland | Units | C.T. | Jhb | Dbn | C.T. | Jhb | Dbn | | |
| Coal A (Peas) | 297,83 | 87,78 | R/Ton | 1,06 | 0,31 | 0,69 | 3,39 | 1,00 | 2,20 | 28,0 | MJ/Kg |
| Elect. | 22,54 | 24,43 | c/kWh | 6,26 | 6,79 | 6,06 | 19,97 | 21,65 | 19,32 | 3,6 | MJ/kWh |
| Heavy Furnace Oil | 85,57 | 105,52 | c/litre | 2,09 | 2,57 | 2,09 | 6,66 | 8,21 | 6,66 | 41,0 | MJ/litre |
| Illum. Paraffin | 119,28 | 132,84 | c/litre | 3,22 | 3,59 | 3,22 | 10,28 | 11,45 | 10,28 | 37,0 | MJ/litre |
| Petrol (Premium) | 206,00 | 212,00 | c/litre | 5,94 | 6,11 | 5,94 | 18,94 | 19,49 | 18,94 | 34,7 | MJ/litre |
| Diesel (Heating) | 198,25 | 209,65 | c/litre | 5,11 | 5,40 | 5,11 | 16,30 | 17,24 | 16,30 | 38,8 | MJ/litre |
| Power Paraffin | 151,39 | 165,41 | c/litre | 4,04 | 4,41 | 4,04 | 12,88 | 14,07 | 12,88 | 37,5 | MJ/litre |
| LPG | 126,77 | 144,89 | c/litre | 4,63 | 5,29 | 4,63 | 14,76 | 16,87 | 14,76 | 27,4 | MJ/litre |
| Gas Gaskor | – | 18,09 | R/GJ | – | 1,81 | – | – | 5,77 | – | – | – |

This table shows comparative energy costs (in SA cents/MJ) in selected South African cities (coastal and inland) based on a range of energy sources. The following criteria were taken into consideration in the calculation of the cost of energy:

(1) Transport costs for coal were obtained from Spoornet. Railage of coal was calculated from Saaiwater to Cape Town and from Saaiwater to Durban respectively.

(2) The energy cost has been calculated on the bulk delivered price for consumers, i.e. includes 14% VAT and other charges.

(3) All figures for electricity have been based on energy requirements for large commercial users.

(4) Electricity prices have been based on typical monthly accounts for large users (see Table 5 in the Energy Price List in *Selected Energy Statistics: South Africa).*

(5) A 75% load factor has been used in the calculation of the Gaskor prices.

(6) *The relative heating costs are shown in relation to the cheapest source, i.e. coal in Johannesburg.

(Source: *Selected Energy Statistics: South Africa*, No. 38, August 1996)

## Eskom statistical overview

| as at 31 December | 1995 | 1994 | 1993 |
|---|---|---|---|
| **Assets in commission** | | | |
| Nominal capacity (MW) | 37 840 | 37 840 | 39 746 |
| Net maximum capacity (MW) | 35 951 | 35 926 | 37 636 |
| Powerlines (all voltages)(km) | 241 802 | 240 972[(1)] | 238 964 |
| **Operations** | | | |
| Electricity produced (GWh)(net) (all stations) | 164 834 | 160 293 | 154 260 |
| Total electricity sold (GWh) | 153 547 | 149 443 | 143 800 |
| Coal burnt in power stations (Mt) | 79,4 | 76,9 | 75,9 |
| Water consumed by power stations (Ml) | 214 329 | 213 220 | 223 650 |
| Peak demand on integrated system (MW) | 25 133 | 24 798 | 23 169 |
| **Emissions** | | | |
| ***Emissions from coal-fired power stations*** | | | |
| Carbon dioxide ($CO_2$) (Mt) | 146,9 | 142,9 | 141,0 |
| Sulphur oxide ($SO_x$ as $SO_2$) (000 t) | 1 198,2 | 1 166,8 | 1 134,0 |
| Nitrogen oxide ($NO_x$ as $NO_2$) (000 t) | 602,8 | 581,8[(2)] | 582,1[(1)] |
| Particulates (000 t) | 115 | 122 | 122 |
| ***Emissions from Koeberg nuclear power station*** | | | |
| Radiation (mSv)[(2)] | 0,0004 | 0,0005 | 0,0297 |
| ***Liquid discharges from Koeberg*** | | | |
| Silver 110M (GBq)[(3)] | 1,504 | 2,509 | *[(4)] |
| Cobalt 60 (GBq) | 4,705 | 2,535 | |
| Cobalt 58 (GBq) | 7,488 | 10,42 | |
| Zinc 65 (GBq) | 0,04313 | 0,00149 | |
| **Water** | | | |
| Transgression of the Water Act (Ml)(*) | 400,0 | n/a | n/a |
| Incidents of unscheduled water releases (**) | 16 | 6 | 8 |
| **Waste** | | | |
| ***Ash at coal-fired stations*** | | | |
| Ash produced (Mt) | 23,0 | 22,0 | 20,9 |
| Ash sales (Mt) | 0,942 | 0,817 | |
| ***Non-nuclear hazardous waste (*)*** | | | |
| Hazardous waste (t) | 500 | 449 | |
| Hazardous waste (mixed with other materials) (t) | 180,0 | 7,0 | |
| ***Koeberg nuclear power station*** | | | |
| Low level waste ($m^3$) | 73,29 | 85,5 | 101,0 |
| Intermediate level waste ($m^3$) | 28,76 | 43,0 | 38,0 |
| ***General waste (*)*** | | | |
| Scrap metal (t) | 104 000 | 18 000 | n/a |
| Building rubble ($m^3$) | 20 000 | 15 000 | n/a |
| Garden refuse ($m^3$) | 20 000 | 24 000 | n/a |
| **Environmental management** | | | |
| Impact assessment studies undertaken | 44 | 10 | |
| Facilities audited | 67 | 208 | 56 |
| Risk assessment (sites/properties) | 68 | – | – |

(1) Correction

(2) Millisieverts (authorised annual limit is 0,25 mSv)

(3) Gigabecquerel

(4) Liquid discharges for Koeberg for 1993 are not shown as a different calculating method was used.

(*) Generation only

(**) Incidents in 1993 and 1994 only for power stations.

*(Source: 1995 Eskom Environmental Report, pp.30-31)*

# Energy news in Africa

## Coal

A Zimbabwean company, Shanghai Energy Exploration, has announced plans to develop a coal-bed methane gas field which could be operational by 1997. The first production wells have already been dug and drilling is currently being undertaken about 15 km from the Hwange power station. The gas would be used mainly to generate power, as an alternative to coal or hydropower. It could also be used to replace the coke oven gas which Hwange currently burns.

The project is likely to require about $30 million to make it commercially viable.

(Source: Modern Power Systems, June 1996)

## Electricity

### *Botswana*

Two turnkey contracts totalling in excess of R25 million to establish the 400/220 kV Phokoje substation near Selibe-Pikwe in Botswana, have been awarded to a South African company, GEC Alsthom Power Systems, by the Botswana Power Corporation (BPC). The project is due to be completed in December 1997.

It is envisioned that Phokoje, with power supplied by Eskom's Matimba power station near Ellisras, will strengthen the power supplies of both Botswana and Zimbabwe. Excluding substations in South Africa, Phokoje will deliver the highest voltage in Sub-Saharan Africa.

(Source: Mining Mirror, June 1996)

### *Namibia*

NAMPOWER (previously SWAWEK), Namibia's electric utility, has decided to build a 400 kV power line to interconnect its network with that of Eskom, which will make electricity available for the newly established Southern African Power Pool (SAPP). It will also be the first interconnection agreed upon since the establishment of the SAPP. The trade in electricity will be done strictly in accordance with the principles agreed to within the SAPP. The link will have a 400 MW capacity with the possibility of upgrading in the future.

In addition to receiving electricity from Eskom, the completed line will, theoretically, make it possible for NAMPOWER to negotiate power supply agreements with ZESCO from Zambia or even from Inga in Zaire, where surplus hydroelectricity is available. The target date for the project's completion is May 1999.

Some of the main features of the line are that

* it will be constructed from the Aries substation to the Auas substation near Windhoek, a distance of approximately 900 km at a cost of R650 million;
* each utility will finance the section of line in its own country, with Nampower financing the bulk of the project, i.e. R450-R500 million;
* the line will initially be able to transmit 400 MW, but can be upgraded in the future;
* the target date for the completion of the first part of the project is 31 May 1999;
* because of the size of the project, it is expected to attract international competition;
* the configuration of the line is the very newest design available enabling it to carry a "piggy back" rural line to farmers and small settlements;
* the line will make the export of surplus electricity into the SAPP possible if the Epupa hydroelectric scheme or generation from Kudu gas is developed;
* the line could be the first step towards tapping into the hydro resources in the west of Southern and Central Africa, as and when they develop.

(Source: Mining Mirror, Vol.9 No.1, June 1996
Modern Power Systems, June 1996)

### *South Africa*

The American company, Superconductivity, Inc., recently shipped a micro-superconducting magnetic energy storage system (Micro-SMES) to Eskom. The system is to be used at a manufacturing plant located in a semi-rural area, which has frequent voltage dips, resulting in significant production losses at the plant.

(Source: Superconductivity, Inc. News Release, June 1996)

### *Tanzania*

One hundred and sixty-five days after its arrival in Tanzania, the new LM6000 gas turbine-generator began operating at the Ubungo power plant. Two of these gas turbines were purchased as part of the 67 MW expansion of the Ubungo plant (the second turbine began operating in November 1995).

The Tanzanian electric utility, TANESCO, opted for the LM6000s which are designed for dual-fuel operation, using either liquid fuel or natural gas. Although natural gas is not available in Tanzania, the Ubungo expansion is part of the Songo Songo Gas-to-Electricity project. The Songo Songo project will use existing onshore and offshore wells which need repair before a natural gas processing plant and transport pipeline can be constructed.

Once the gas plant and transport pipeline are operational (expected to be in 1998), natural gas will be brought to the Ubungo facility to power the new LM6000 and existing gas turbines. The Songo Songo project is expected to yield enough natural gas to produce power for the country for at least 20 years.

Based on the success of the Ubungo power plant and the availability of natural gas within the country, other gas turbine-based power plants are expected to be brought on-line in Tanzania by the year 2000.

(Source: Modern Power Systems, June 1996)

## Hydroelectricity

The Zimbabwe Electricity Supply Authority (ZESA) has commissioned major uprating and refurbishment on the Kariba power station. The work will include the replacement of the runners and upgrading of its generators from 666 MW to 750 MW.

Along with the refurbishment of the generators to a rating of 138,9 MVA, it will mean that the units will be capable of generating 125 MW each for a maximum station output of 750 MW at net head of 94 m.

The replacement phase of the project is due to finish in 1999.

(Source: Modern Power Systems, June 1996)

The Djoue hydroelectric plant in the Congo has recently re-opened after refurbishment work. The 15 MW plant, near Brazzaville, has been out of commission for five years.

The newly refurbished plant will enable the Congo to reduce its dependence on electricity imported from Zaire by 15%. The Congo presently imports 35% of its electricity needs from Zaire.

(Source: Modern Power Systems, June 1996)

## Oil and gas

### *Congo*

The Congo's downstream oil sector will be privatised but government curbs will also be left in place. A pre-selection for the privatisation of Chorea (Pointe Noire refinery) began in 1995 after it was initially agreed that Elf and Shell would take part. However, a third partner is required before any sell-off can take place.

In negotiating the accord with the IMF, the Congo committed itself to privatising Chorea and the downstream assets of Hydro Congo. The IMF agreement must be signed if payments from bilateral loans are to resume. Candidates will have two months within which to submit their bids, whereafter the Congolese government will negotiate with those offering the best terms. A decision is expected by October 1996. Three candidates will therefore form operating companies for the refinery and tank farms, as well as manage the service station network.

The system, however, aims essentially to protect the Congo's downstream sector from competition, which could be harmful to the refinery. Another fiscal and customs law will provide substantial exemptions for the refining sector, and there will be a law governing the setting of prices with regard to refining, storage, transportation, distribution and service station managers.

The Congo is expected to produce 10 million tons (Mt) a year of crude oil by 1997. However, the desire for better market efficiency and lower consumer prices has been offset by the fear of how market forces would jeopardise the country's energy independence. Since the refinery has never actually processed more than 600 000 t/year when market conditions were favourable, there are questions as to whether anyone will be willing to invest more money into a refinery seen as a "white elephant".

(Source: Africa Energy & Mining, 1 May 1996)

### *Egypt*

Natural gas output from Egypt rose from 12,5 billion m$^3$ in 1994 to 1,8 billion m$^3$ in 1995. This has been attributed to an uninterrupted increase in commercialised production since the mid-1970s. Also, during the past two years, Egypt has doubled its gas reserves.

By the end of 1988, Egypt is expected to export gas.

(Source: Mining Mirror, June 1996)

### *South Africa*

Energy Africa has cut the potential capital expenditure and exploration costs of the Kudu gas project by around $250 million, after farming out 60% of its quarter share to Texaco Namibia Resources Incorporated.

Shell Exploration, which held 75% of the Kudu gas project offshore in Namibian waters, and Energy Africa had held preliminary discussions with Eskom on piping Kudu gas to Saldanha Bay for use in the 1 750 MW power station to supply electricity in the Western Cape. By agreement, Texaco has undertaken to carry Energy Africa's costs to develop the Kudu field off Namibia's coast in exchange for a 15% share of the venture, leaving Energy Africa with a 10% stake.

The capital expenditure for the project, which includes an offshore platform and a 550 km pipeline to Saldanha Bay, will be in the vicinity of $1 billion. The earliest date on which the Kudu gas discovery can be expected can be expected to come into full commercial production will be around 2002. With the commissioning in 1997 of an oilfield in the Bredasdorp Basin off Mossel Bay, Energy Africa's production was expected to rise from 4 000 barrels/day to 11 000 barrels/day.

(Source: Mining Mirror, June 1996)

Engen and Petronas, the national oil and gas company of Malaysia have announced an agreement for co-operation and development in Africa and the Indian Ocean Rim. As part of this agreement, Petronas will acquire a 30% share in Engen.

The alliance between the two companies will enable their shared objectives for growth in Africa to be accelerated and enhanced. Also, both companies are significant refining and marketing companies in their respective markets. The alliance will allow them to pool collective expertise with regards to refining technology, crude sourcing and product marketing. As part of the agreement, both Engen and Petronas will exchange personnel in order to develop joint areas of technical and commercial expertise. Petronas will also support Engen's stated intent to exploit growth opportunities in regional refining and will explore the possibility of refining joint ventures in selected geographic regions.

Engen, through Energy Africa and Petronas, will co-operate in new oil and gas exploration and development opportunities where this could enhance the value of Engen's existing upstream investment in Energy Africa.

(Source: Engen Press Release, 14 June 1996)

## General

Mr Penuell Mpapa Maduna was recently appointed South Africa's new Minister of Mineral and Energy Affairs in the place of Mr Pik Botha when the National Party withdrew from the Government of National Unity.

By profession, Mr Maduna is an attorney. He is presently studying towards a Ph.D. in Constitutional Law. He is also a member of the Faculty of Law at the University of the Witwatersrand.

Born in 1952, Mr Maduna grew up in turbulent times in South Africa. He was very active in student politics, particularly at the University of Zululand, during the "apartheid" years. During the 1970s and 1980s he worked in the underground structures of the African National Congress (ANC) when it was a banned organisation under the previous government. This led to his arrest and prosecution.

In 1980 he went into political exile. Outside of South Africa, he worked for the ANC in Tanzania and Zimbabwe, and was a founder member of the organisation's Constitutional Committee. Mr Maduna played an active role in the negotiation process with the National Party, which included the Harare Declaration, the Groote Schuur and Pretoria talks, the establishment of CODESA, the Record of Understanding, culminating in the talks at the World Trade Centre.

Mr Maduna was a founder member of the ANC's Department of Legal and Constitutional Affairs in 1985 and was the legal adviser at ANC headquarters. He was also active in the formulation and adoption of the party's constitutional guidelines, the precursor of the ANC's current human rights orientation.

(Source: Ministry of Mineral and Energy Affairs)

# Details of Authors


## DUTKIEWICZ R K

B.Sc.(Eng.)(Wits), M.Sc.(Eng.)(Wits), Ph.D.(Cambridge), Pr.Eng., FIMechE, Hon.F(SA)IMechE, MBIM, FInstE, C.Eng.
Professor of Applied Energy and Director, Energy Research Institute, University of Cape Town, P O Box 207, Plumstead 7801, South Africa
Tel.: (021) 705 0120
Fax.: (021) 705 6266
Email: rkd@eri.uct.ac.za


Professor Dutkiewicz was born in Poland and obtained his schooling in the United Kingdom and South Africa. He received his B.Sc. and M.Sc. degrees from the University of the Witwatersrand in South Africa, and his Ph.D. degree, which was on heat transfer in nuclear engineering, from Cambridge University in the U.K. He joined the General Electric Company in the U.K. as a nuclear engineer and worked on the design of the Hunterston Nuclear Power Station in Scotland and the Tokai Mura Nuclear Power Station in Japan.

He returned to South Africa to what was then the Electricity Supply Commission (now Eskom), and was appointed head of the newly formed Research Laboratory. Promotion saw him in the position of deputy chief mechanical engineer (construction), and later as manager of system planning.

He joined the University of Cape Town in 1975 as Professor of Mechanical Engineering. Whilst in the Department of Mechanical Engineering he started the Energy Research Institute, which is now a separate entity within the Faculty of Engineering. He is currently Professor of Applied Energy and director of the Energy Research Institute.

Professor Dutkiewicz served as president of the South African Institution of Mechanical Engineers in 1978/79. He presently serves on a number of international committees dealing with alcohol fuels, energy demand-side management, environmental matters, etc.


## LENNON S J

B.Sc.(Natal), M.Sc.(Eng.)(Wits), Ph.D.(Wits), Snr Management Programme (Stellenbosch)
Research Manager, Technology Group, Eskom, Private Bag 40175, Cleveland 2022, South Africa
Tel.: (011) 629 5051/2
Fax.: (011) 629 5500


Steve Lennon spent one year with the CSIR's Division of Materials Science and Technology before joining what was then Eskom's Engineering Investigations' Metallic Corrosion Group. One year later, in 1987, he was appointed Head of the Corrosion and Non-metallic Group. In 1989 he was appointed Scientific Investigations Manager, which meant that he was responsible for the chemical, materials, and environmental tests, investigations and research at Eskom. He became Scientific Services Manager in 1991, and Research Manager in 1993. In his present position he has to report to the Executive Director (Technology) of Strategic Research Planning in Eskom. He is also involved with research project management, the technology transfer of research outputs and international technical research liaison.

His interest in environmental matters is reflected further in some of the offices he has held in the past and presently holds. He was Past President of the S A Corrosion Institute and Past Chairman of the S A Electrolytic Corrosion Committee.

He presently holds the position of Chairman of the Energy Use Task Group of the Interdepartmental Co-ordinating Committee for Global Climate Change. Dr Lennon is also a member of the Council for the Environment, the S.A. Global Climate Change Committee, and the S.A. delegation to Climate Change Negotiations (New York and Geneva).

He is Vice-Chairman of the Working Group of the National Science & Technology Forum, and a member of the Advisory Committee for National Research and Technology Audits and the South African Board for the International Council of Scientific Unions.


## WENTZEL M

B.A.(Political Science) (Potchefstroom); B.A. (Hons.) (Development Studies) (RAU); M.A. (Development Studies) (RAU)

Energy Specialist: Energy for Development, Chief Directorate: Energy, Department of Mineral and Energy Affairs, Private Bag X59, Pretoria 0001, South Africa
Tel.: (012) 317 9224
Fax.: (012) 322 5224


Marlett Wentzel is presently studying towards a B. Comm. Honours degree in Energy Studies at the Rand Afrikaans University (RAU).

Marlett's work as an Energy Specialist, involves wide-ranging research programmes into all forms of energy used in the developing areas, as well as renewable energy. The aspects in which she is most active are biomass, biogas, solar cooking, peat utilisation, use of transitional fuels (e.g. paraffin, LPG and coal), and the Low-Smoke Coal Programme. She has also been involved in the consultation process regarding the White Paper on energy.

Her interests and hobbies include reading, art, drama, collecting antique furniture and porcelain.

# Forthcoming energy and energy-related conferences: 1996/1998

## 1996

### SEPTEMBER 1996

2-5

ATC 96: SIXTEENTH ANNUAL TRANSPORTATION CONVENTION Johannesburg, South Africa

*Theme:* Towards integration of Sub-Saharan transportation

Enquiries: Conference Planners,
P O Box 82, Irene 1675, South Africa

Tel.: +27 (12) 63 1681 (Cilla Taylor)
Fax.: +27 (12) 63 1680

18-20

AFRICA UPSTREAM 96 Cape Town, South Africa

Enquiries: B van Gessel, Global Pacific & Partners

Tel.: +27 (11) 781 3358
Fax.: +27 (11) 781 3362

25-27

AFRICON '96 Stellenbosch, South Africa

Enquiries: Daleen Kleyn, Dept. Electrical & Electronic Engineering, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Tel.: +27 (21) 808 4455
Fax.: +27 (21) 808 3554/4981

Email: African@firga.sun.ac.za
Dkleyn@firga.sun.ac.za

### OCTOBER 1996

7-8

2ND ENVIRONMENTAL MANAGEMENT, TECHNOLOGY AND DEVELOPMENT CONFERENCE Fourways, Gauteng, South Africa

Enquiries: Lesley Stephenson, Conference Secretary, P O Box 327, Wits 2050, South Africa

Tel.: +27 (11) 716 5091
Fax.: +27 (11) 339 7835

7-9

AFRICA OIL 96 Cape Town, South Africa

Enquiries: Geoff Davies, AIC Conferences

Tel.: +61 (2) 210 5700
Fax.: +61 (2) 223 8216

### NOVEMBER 1996

20-22

NATIONAL ASSOCIATION FOR CLEAN AIR ANNUAL CONFERENCE Badplaas, Mpumalanga

*Theme:* Clean air and the environment: Responsible empowerment and technology

Enquiries: Melanie Campbell/Katrin Thiesen, National Assocoation for Clean Air (Transvaal Branch)

Tel.: +27 (11) 442 6111
Fax.: +27 (11) 442 5927

## 1998

### MAY 1998

24-26

EFFICIENT ENERGY UTILISATION AND MANAGEMENT : A SEMINAR Johannesburg, South Africa

Enquiries: Rhona Campbell/Pam Rooney, J H Isaacs Group, P O Box 5575, Johannesburg 2000, South Africa

Tel.: +27 (11) 28 1066

### SEPTEMBER 1998

11TH WORLD CLEAN AIR CONGRESS AND ENVIRONMENTAL EXPOSITION Durban, South Africa

*Theme:* Interface between developing and developed countries

Enquiries: Congress Secretariat,
Mrs Ammie Wissing, P O Box 36782, Menlo Park, Pretoria 0102, South Africa

Tel./Fax.: +27 (12) 46 0170

# Recent energy publications

**ANNEGARN H J and KNEEN M A**

Source apportionment of township air pollution. Feb-1996. 33p.
Report No.ES9408

The project's purpose was to perform a source apportionment of particulate and other air pollutants, using existing air quality information for coal burning townships in South Africa, and from these apportionments to specify the minimum improvements in low-smoke fuels. Soweto was chosen as representative of coal burning townships and extensive air pollution data for the area is available. A series model for source apportionment was developed and applied to the hourly average measurements of fine particulate matter, $SO_2$ and $NO_x$. Mean diurnal plots and seasonal trends of the pollutants are presented and interpreted. The source apportionment procedure and time series model are described. Results for source apportionments of the three pollutants are presented as monthly and annual averages. By evaluating the apportioned particulate contributions from coal combustion in relation to health guide-lines, specifications are derived for minimum improvements in emission rates for low-smoke fuels.

**ANNEGARN H J and KNEEN M A**

Impacts of removing air pollution: Physical aspects. Feb-1996. 18p.
Report No.ES9410

Based on the smoke pollution visible over Soweto in winter, the project attempts to quantify the temperature effects caused by infra red absorption by fine particulate matter in domestic coal smoke. A second physical effect of removing the smoke blanket was identified during the project - visibility reduction due to light scattering by fine particulate matter. This would also have implications for traffic safety. The effect is also quantified and evaluated with regard to possible improvements in traffic visibility from reduction of the blanket by a low-smoke coal programme.

**BRITTEN A C and BOLAGNA F F**

The performance of insulators in industrially polluted areas. Apr-1996. 33p.

Describes the research conducted to determine the performance of different makes of non-ceramic insulators and insulator coatings subjected to industrial pollution. In order to evaluate the performance of insulators under the effects of airborne pollutants in industrial areas, an insulator test station was set up in Sasolburg. Insulators of different types and manufacture were energised at 11 kV phase-to-ground for a period of three years. The magnitudes of the leakage currents and surface degradation of all the test samples were investigated. The results show a marked difference in the electrical performance between the various makes and type of the insulators and coatings, as well as between insulators having the same SHED material, i.e. silicone rubber. The results also show that there is an empirical relationship between specific creepage and I-highest.

**HOLM D and HOLM R A**

Passive solar housing demonstration project. May-1996. 38p. + appendices

Based on the shells of five low-cost houses, describes the use of passive solar energy as a means to reduce life cycle energy costs as well as building costs. The report includes the thermal analysis results.

**MEHLWANA A and QASE N**

Social determinants of energy use in low-income metropolitan households in the Western Cape (Phase 1). May-1996. 66p. + appendices
Report No.EO9420

This forms part of a 3-year national study that investigates the energy consumption patterns or usage in low-income urban households in South Africa. The study focuses on the Western Cape, covering electrified and non-electrified settlements, and was aimed at assessing the impact of energy policy actions on consumers over a period of time. The research findings suggest that there are many social and economic factors that determine the energy patterns of urban households in the Western Cape townships. The primary output of the research involved compiling and analysing the data around the determinants of household energy use, the social context of decision-making, the fuel substitution process, as well as the impact of existing and new energy policies on households.

**ROBSON P M**

Feasibility study into the establishment of an integrated energy and development project/centre. Mar-1996. 83p.
Report No.EO9507

Based at the Masakhane Ministry near Graskop, describes the first phase of the project which investigates the feasibility of an integrated energy project with a dynamic demonstration centre. The project envisages the use of alien trees, such as black wattle and blackwood, as a source of fuelwood to the local inhabitants. It will also provide employment for the locals through the clearing of grasslands and the streams of these alien trees.

**SITHOLE J S and ANNEGARN H J**

Low-smoke fuels project: Educational programme proposals. Jan-1996. 24p.

Provides guidelines for an educational programme related to the DMEA's low-smoke fuel programme. The report shows that conventional educational assumptions concerning attitudes, values and behaviour have long been shown to be defective, and suggests an alternative educational strategy. The approach rests on the idea of context and authentic social engagement in the problem-solving process.

**VAN NIEKERK W C A**

Programme to prove efficacy of low-smoke coal. Mar-1996. 26p.

Outlines the design of a macro-scale study to prove the efficacy of low-smoke coal. Data from this study will be used for decisions on possible regulation and critical issues around the implementation of low-smoke coal in South Africa. Emphasises quality assurance and describes sampling and analytical procedures for the acquisition of emission factors.

All these reports are Final Reports (unless indicated) and are the result of research funded by the Chief Directorate: Energy, Department of Mineral and Energy Affairs.

The publications can be ordered from: The Librarian, Chief Directorate: Energy, Department of Mineral and Energy Affairs, Private Bag X59, Pretoria 0001, South Africa, unless otherwise indicated. Prices are available on request from the Department of Mineral and Energy Affairs.

# JOURNAL OF ENERGY IN SOUTHERN AFRICA

Energy Research Institute, University of Cape Town
P O Box 207, Plumstead 7801, South Africa

Tel. +27 21 705 0120
Fax. +27 21 705 6266

For information regarding the submission of papers or subscriptions, please photocopy, complete and fax.

ATTENTION: Production Editor,
Journal of Energy in Southern Africa

## FAX MESSAGE

**From:** Name:

Title:

Organisation/Company:

Address:

Postal Code:

Tel: Fax:

Date:

Please tick ( ✔ )

☐ I am interested in submitting a paper. Please send more details

☐ I want to subscribe to the *Journal of Energy in Southern Africa*. Please invoice me.

# JOURNAL OF ENERGY IN SOUTHERN AFRICA

## INFORMATION FOR AUTHORS

Contributions to the *Journal of Energy in Southern Africa* from those with specialist knowledge in the energy research field are welcomed.

1. All contributions should be submitted in English.
2. Only original work will be accepted and copyright in published papers will be vested in the publisher.
3. The suggested length for articles and research notes is 2 500 to 5 000 words, and for book reviews,approximately 1 000 words.
4. The contribution and references should be typed double-spaced with a wide left-hand margin and single-sided using one of the available word processor packages listed at the end. The name and version of the word processor package used must be indicated on the disk. Illustrations, photographs and diagrams should be submitted on separate sheets.
5. Tables should be numbered consecutively in Arabic numerals and given a suitable caption.
6. All graphs, diagrams and other drawings should be referred to as Figures. These should be numbered consecutively in Arabic numerals and placed on separate sheets at the end of the contribution. Their position should be indicated in the text. All illustrations must have captions, which should be typed on a separate sheet. Graphs, diagrams, etc. should be printed with a laser printer, using the high quality option. If possible, all graphs should be produced with Harvard Graphics, Quattro Pro or Lotus 123.
7. The format for references should follow that as for footnotes where a number, in superscript, indicates the reference, as shown below:

   Louw [(2)] states that ...

   Full references for books and journals must appear at the end of the article in numerical sequence. For references to books, all relevant information should be provided: that is, author(s) surname and initial(s), date of publication, full title (and sub-title, where applicable), place of publication, publisher, and pagination. For conference proceedings, the date, the full title of the conference and the place where the conference was held must also be specified. For journal references, the author(s) surname and initial(s) must be provided, dates, as well as the full title and sub-title (if applicable) of the article, title of the journal, volume number, part, and pagination. Numbers identifying all references at the end of the contribution should be enclosed in brackets.
8. Standard international (SI) units must be used.
9. All mathematical expressions should be typewritten. Greek letters and other symbols not available on the typewriter should be carefully inserted in ink. Numbers identifying mathematical expressions should be enclosed in parentheses. A list of symbols marked for the use of the Production Editor, if not included in the body of the text,should accompany the contribution on a separate page. A nomenclature defining symbols must be included, where applicable. All tables and mathematical expressions should be arranged in such a way that they fit into a single column when set in type. All table columns should have an explanatory heading. Equations that might extend beyond the width of one column should be rephrased to go on two or more lines within column width.
10. Line drawings (not photocopies) and accompanying lettering should be of sufficient size to allow for reduction if necessary. Photographs of equipment must be glossy prints and should be used sparingly.
11. The body of the contribution should be preceded by an Abstract not exceeding 500 words, which should be a resumé of its essential contents, including the conclusions. Below the Abstract, a maximum of six Keywords should be included which reflect the entries the author(s) would like to see in an index. The Keywords may consist of more than one word, but the entire concept should not be more than 30 characters long, including spaces.
12. No contribution or figures will be returned following publication unless requested by the author(s) at the time of its original submission.
13. In a covering letter, the author(s) must state that the contribution has not been published or is being considered for publication elsewhere, and will not be submitted for publication elsewhere unless rejected by the *Journal of Energy in Southern Africa* or withdrawn by the author(s).
14. Authors must supply the following personal information: surname, initials, address, qualifications, occupation and/or employment.
15. Authors whose contributions are accepted for publication will receive a free copy of the issue and 3 copies of their contribution.
16. Neither the Editor nor the Publisher accept responsibility for the opinions or viewpoints expressed, or for the correctness of facts and figures.
17. The Editorial Committee reserves the right to make editorial changes to all contributions.
18. All contributions and enquiries should be addressed to: Production Editor, Journal of Energy in Southern Africa, Energy Research Institute, University of Cape Town, P O Box 207, Plumstead 7800, South Africa.

Contributions must be submitted either on a 5¼ inch floppy disk or 3½ inch disk (stiffy), and use must be made of one of the following word processor packages:

Multimate
Microsoft Word (MS Word)
PC-Write
PFS: Professional
PFS: Write
Wordperfect
Wordstar
XyWrite

If the "Windows" version of these programs is used, the file must be saved in ASCII format. If any other word processing packages are used, other than those listed above, the file should be submitted in ASCII format.

The disks must be adequately packed for postage.

# IT ALSO RELIEVES UNEMPLOYMENT.

By adding value at every step of production we help create jobs for over 160 000 people in South Africa. That's because Sasol beneficiates low-grade coal into more than one hundred and twenty high quality products. Including the raw material for aspirin. Which all go towards improving the health of our economy.

**SASOL**

**INTO THE FUTURE RESOURCEFULLY**

HUNT LASCARIS EMG