JOURNAL OF ENERGY IN SOUTHERN AFRICA

Vol.8 No.2 May 1997

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. Creating
opportunities for those they employ
Empowering the lives of those they don't
It makes good sense. Morally
Economically
Business must lead by
example. Create an
environment in which
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
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CAPE TOW
2004

Journal of Energy in Southern Africa

Vol.8 No.2 May 1997

A quarterly publication

Supported by Chief Directorate: Energy, Department of Minerals and Energy

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 Only previously unpublished work will be accepted.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 comments, not exceeding 500 words, on articles published in the Journal are also invited. Items of general interest, news, selected energy statistics, technical notes, reviews and research results will also be included. Announcements of relevant publications, reviews, conferences, seminars and meetings will be included.

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Contents

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.

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Email: yvonne@eri.uct.ac.za Internet: http://www.eri.uct.ac.za/eri.html

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

 ISSN 1021-447X

Profile:
Leake S Hangala

Managing Director,
NamPower (Pty) Ltd

Between 1990 and 1995, Dr Hangala was the Permanent Secretary of Namibia's Ministry of Mines and Energy. From this energy background, he was appointed as Managing Director of NamPower in 1995. On the 1 July 1996, NamPower (Namibia Power Corporation (Pty) Ltd), formerly SwaWek (Pty) Ltd, was officially launched by Dr Sam Nujoma, President of Namibia, under its new name and logo.

Born in 1953, Dr Hangala grew up in turbulent times in what was then South West Africa, a part of South Africa. He was very active in the activities of the South West African People's Organisation (SWAPO) which was fighting for Namibian independence. After matriculating from Oshigambo High School, he worked as a teacher at a SWAPO Education Centre, as well as a broadcaster for the Voice of Namibia, based in Zambia. Thereafter, he went to Finland, where he was secretary-general and president of the African Students Association.

After studying at the University of Helsinki and obtaining a B.Sc.(majoring in geology and mineralogy) and M.Sc. in 1981 and 1983 respectively, Dr Hangala's involvement in the energy field could be said to have begun in 1984 when he worked at the Natural Resource and Energy Division of the U.N. Secretariat based in New York. In 1987, he obtained his Ph.D. in economic geology and mineralogy. At that time, he was working as a geologist at the Geological Survey of Finland.

With political activity intensifying in the then South West Africa, Dr Hangala returned to Africa, working at SWAPO's Department of Education in Luanda, Angola, in 1988-1989. As independence elections drew closer, Dr Hangala worked for the election campaign at SWAPO headquarters in Windhoek. He represented SWAPO at many national and international conferences before independence, and thereafter as a member of the government of Namibia.

In 1993, Dr Hangala was awarded a Certificate in Management from the John F Kennedy School of Government, Harvard University, U.S.A.

Some of the other positions that he holds include deputy chairman of NAMDEB and chairman of the board of Pandu Holdings. He also sits on the boards of Sanlam Namibia and TransNamib. He is a member of the board of trustees of the Rossing Foundation, the University Foundation and KAYEC.

Dr Hangala is the author of a book, *Structure of the Nambia mineral industry: Strategy option of the institutional framework for mineral sector development for independent Namibia*, published by University Printing Press, Helsinki in 1985.

He is married to Letta Nekulilo, and they have four children. His hobbies include football and reading, with his main interest in economic and political developments, particularly in the Southern Africa region.

An overview of the photovoltaic, wind power, solar water heating and small-scale hydropower supply industries in South Africa up to 1994/95

* G STASSEN and * *D HOLM

Received 5 March 1997
Revised 22 April 1997

This paper contains a broad overview of the South African photovoltaic, solar water heating, wind power and small-scale hydropower industries. Against the general lack of a comprehensive national database on renewable energy supply and demand, this overview attempts to provide general background information on these commercial industries, market trends, local sales figures, export volumes and installed capacity estimates. It also identifies the industries major constraints, as well as their future outlook.

Keywords: photovoltaic industry; solar water heating industry; wind power industry; small-scale hydropower industry; market trends, sales figures; installed capacity estimates; constraints; future

Introduction

South Africa is richly endowed with renewable energy sources that have the potential to make a substantial contribution to the energy economy, yet they only contribute about 10,4% to primary energy and approximately 20,4% of final energy consumption on the national base. Against this background, the paper presents a broad overview of the South African photovoltaic, solar water heating, wind power and small-scale hydropower supply industries which, in general, reflect the following characteristics[1]:

- They are fledging and lack the overall capacity in terms of skills, technical back-up and customer service orientation;
- The estimated contribution of these industries amounted to about R190 million or 0,05% of GDP in 1994;
- Approximately 2 300 persons were employed in these industries by the end of 1995;
- The main barriers experienced in the market place by these industries include (i) the high initial capital outlay of these technologies; (ii) unequitable competition in the energy market; (iii) a lack of access to appropriate finance; (iv) a lack of decision-making and consumer awareness; (v) the tainted image of various sectors within the industry, and (vi) a lack of clear Government policy and programmes on energy in general and renewable energy in particular;
- Very limited resources (in general, negligible) are allocated by the industry for research and development (R&D) within the industry; and
- Renewable energy technologies available on the commercial market, in general, appear to be appropriate for application in South Africa's harsh local environment and are considered to be the least-cost option for a range of energy services in the domestic, institutional and agricultural consumption sectors.

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The photovoltaic (PV) industry

Suppliers of PV equipment in South Africa fall into three broad categories, *viz.*: local assemblers, importers and distributors/installers. Some forty-eight companies were active in this field at the end of January 1995. Local assembling of PV modules started in 1992 with a production capacity of 1,5 MW per single shift per year. During August 1995 another PV module assembly plant was commissioned in South Africa with an annual operating capacity of 0,5 MW per single shift. In general, PV modules are imported from the U.S.A., Europe and Japan. The majority of the balance of the system's components, however, are manufactured locally (for example, batteries, regulators and inverters). The Customs and Excise Division of the Department of Finance records PV imports by means of very vague product categories and codes. This means that the exact number of PV modules imported into South Africa to date cannot be ascertained with any certainty. The annual turnover of the PV industry for 1990-1994 is shown in Table 1.

Year	Annual turnover in Rands (million)
1990	14,9
1991	17,2
1992	15,2
1993	16,1
1994	31,0

Note: The annual turnover excludes satellite industries to the PV industry.

Table 1: Estimated annual turnover of the PV industry for 1990-1994[1]

It is estimated that approximately 1 500 persons in total were employed in the three categories of the PV industry during 1994[1]. The estimated combined sales volumes for the PV industry for the period 1977-1994 are given in Table 2.

As can be seen from this table the PV industry in South Africa enjoyed a fairly progressive growth rate over the past eighteen years. The deep economic recession experienced by South Africa in 1992 and 1993 also had a marked effect on PV sales volumes for the corresponding period. The dramatic upturn in sales figures for 1994 is mainly due to the acquisition of some 8 000 PV systems by

Year	Total sales volumes (kWp)
1977	4
1978	8
1979	15
1980	23
1981	68
1982	128
1983	172
1984	338
1985	237 *
1986	273 *
1987	314 *
1988	362 *
1989	416 *
1990	478 *
1991	550 *
1992	450
1993	460
1994	800

Note: *The figures for this period are based on the growth assumption by Botha[2]

Table 2: Estimated total sales volumes for the South African PV industry, 1977-1994[1]

Telkom for communication purposes at polling stations in off-grid areas during the general election in April 1994. Compared to the world PV market of 69,44 MW for 1994[3] the South African PV market in 1994 constituted about 1,2% of world production[1]

The breakdown of PV sales per module technology for monocrystalline, polycrystalline, amorphous silicon and CdTe (cadmium telluride) is given in Table 3. It is interesting to note that there has been a significant increase in the use of monocrystalline silicon modules in the local market since 1991 at the expense of both polycrystalline and amorphous silicon module sales. The average sales price for PV modules in 1994 amounted to about R22/Wp, and it is not uncommon to find price mark-ups of up to 55% for the bigger distributors/installers and up to 100% for the smaller distributors/installers.

PV systems are also exported, mainly to Sub-Saharan countries, such as Zimbabwe, Botswana, Mozambique, Malawi, Namibia, Kenya and the Commores. It is estimated that approximately R3 million or 10% of the PV industry's turnover for 1994 can be ascribed to export earnings.

PV technology	Year	Sales volumes (kWp)	% of total
Silicon:	1991		
Monocrystalline		253	46
Polycrystalline		198	36
Amorphous		99	18
Silicon:	1994		
Monocrystalline		488	61
Polycrystalline		208	26
Amorphous		96	12
CdTe *		7	~1

Note:* For high technology market applications only.

Table 3: Breakdown of PV sales volumes per technology for 1991 and 1994[1]

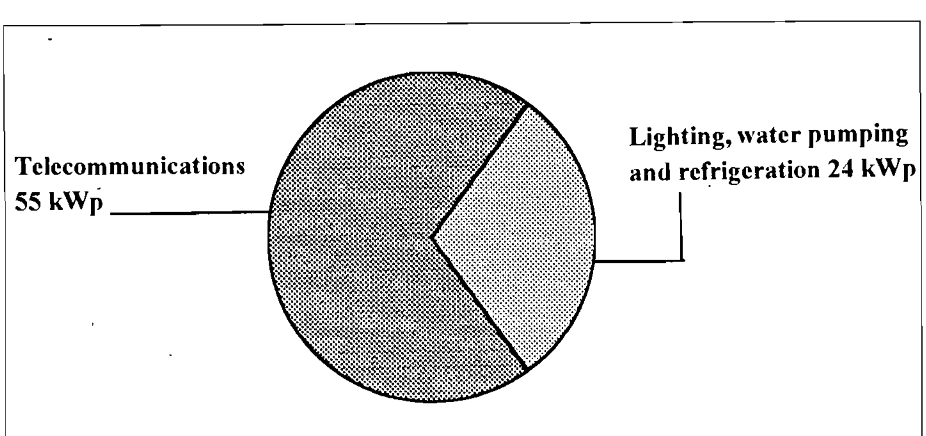

Figure 1: PV export sales volumes (kWp) per application for 1994[1]

The export sales volumes for 1994 are shown in Figure 1.

The total installed PV capacity in South Africa at the end of 1994 was about 5,1 MW, which represents 0,013% of the total power station nominal capacity of 37 840 MW in 1994[1]. Another estimate by the Department of Minerals and Energy[4] put the total installed capacity at 3,1 MWp in 1993.

A breakdown of the installed PV capacity per application at the end of 1994 is given in Table 4. It is also clear from this table that the three dominant applications in the local market are telecommunications, domestic lighting systems and water pumping for both potable water supply and irrigation purposes. Assuming that the average domestic PV lighting system is based on a 40 W module, the figure of 1,581 MW translates to some 39 500 domestic systems for South Africa, which represents a domestic market penetration of less than 0,5%.

Several major constraints currently face the local photovoltaic industry which also reflect the situation of the wider renewable energy industry in South Africa. These are[1]:

(1) The high initial capital outlay of PV systems. This is one of the key growth inhibitors in the PV market. The high capital costs of PV systems, which render them unaffordable to many potential consumers in off-grid areas, can mainly be ascribed to:

- The unfavourable Rand exchange rate, which severely inflates the costs of PV modules;
- Rapidly escalating production costs of locally manufactured balance-of-system components;
- Marketing practices, where agents do the actual sales and installations in the field, and, in many instances, are solely responsible for setting highly inflated retail prices to consumers; and
- The overdesign of PV systems for specific applications, resulting in underutilised capacity.

(2) Unequitable competition in the energy market. The energy market in South Africa reflects a situation where conventional grid electricity is given an unfair advantage over renewable energy sources. This is evident through, amongst others:

- The price structure of conventional grid electricity, that aims to provide electricity at some of the cheapest rates in the world by utilising enormous cross-subsidisation within the electricity industry as part of the electrification drive. The fact that current electricity prices do not reflect the true costs to society is also apparent when one considers that externalities, such as environmental pollution and the depletion of the country's coal reserves, are not discounted for. From an economic point of view, this leads to gross distortions in the energy market. This has a negative effect on the gradual change-over to a sustainable development system in South Africa, of which the application of renewable energy sources to their full potential will be one of the cornerstones.

- The preferential treatment, over the years, of the conventional electricity supply fraternity in the form of:
  - huge amounts of R&D funding from outside and within the industry;
  - Government guarantees for overseas loan funding for Eskom;
  - the exemption of Eskom from paying tax;
  - vested interest lobbying power by the financially strong, well-organised, centralised and monopolistic electricity supply fraternity; and
  - mutuality of interests with coal mines.

(3) Lack of access to appropriate finance: This factor appears to be the most important constraint to the PV industry at present. Although finance is available to the end-consumers of energy, mainly as instalment sale agreements with short-term financing periods and high interest rates, it is not deemed appropriate against the inherent characteristics of PV energy supply options and the needs of disadvantaged communities in South Africa. Moreover, financing packages for conventional grid electricity supply are structured, in general, around the economic lifespan of the assets (20-25 years) to be funded while this is not the case for PV as indicated above.

(4) Lack of decision-makers and consumer awareness: At present there exists a lack of general awareness amongst decision-makers and consumers in the South African energy market with regard to performance, reliability, durability, availability and cost-effectiveness of PV applications under local conditions.

(5) Tainted image of the PV industry: Customer confidence in certain quarters (such as, domestic and clinic applications) has been eroded over the years, resulting in a negative perception regarding PV applications. These negative perceptions in the market can be mainly ascribed to the following:

- fly-by-night SWH companies who installed badly designed and poor quality solar water heaters and who did not uphold guarantees created a very unfavourable perception of solar water heating. Since there is a lack of public awareness, the PV industry is very often associated with SWH. This is reflected in the word of mouth approach commonly found in the market that 'solar' does not work;
- several badly designed and installed PV systems which did not operate reliably, efficiently and economically, clearly revealed a lack of proficiency and technical back-up as a major shortcoming in the local PV industry. The lack of technical back-up also shows that the PV industry is still a long way off from becoming a fully fledged service-orientated industry;
- a severe lack of adopting a common goal approach within industry to promote the application of solar energy in general. This is further evident in a lack of formal cooperation and coordination within the PV industry, resulting in disjointed marketing and an inability to control poor quality PV products being offered to the market;
- a multitude of trading levels caused by numerous agents/installers operating in series leads to artificially high prices and fragmentation of the market. Moreover, with so many makes of PV modules available on the local market, the customer is confused rather than provided with a multiple choice.

Application	Installed capacity (kWp)	% of total
Telecommunications*	2 550	50
Lighting:		
Domestic	1 581	31
Schools, clinics, etc.	153	3
Water pumping	714	14
Recreational	102	2
Total	**5 100**	**100**

Note:* Includes applications for Telkom (80%), Transnet and the National Defense Force.

Table 4: Estimated total installed PV capacity per major application area - 1994[1]

"The (PV) industry envisages a growth rate of approximately 20% per annum in the foreseeable future. The biggest market growth areas are strongly linked to reconstruction and development initiatives, and includes PV electrification for telecommunications, schools (including distance education), clinics, households and water pumping. A considerable increase in export opportunities for PV systems into Africa and other developing countries is also foreseen."

(6) Lack of clear Government policy and programmes on energy in general and renewable energy in particular: South Africa still lacks a comprehensive renewable energy policy and programmes which will provide clear direction for the industry. These would assist it in identifying and prioritising areas of development support, the channelling of resources for that purpose, and the creation of capacity within industry to sustain these development processes.

Considerable growth is foreseen for the world PV market and it is envisaged that the South African market will also experience sound continued growth provided that the above market barriers are removed. The industry envisages a growth rate of approximately 20% per annum in the foreseeable future. The biggest market growth areas are strongly linked to reconstruction and development

Year	Total sales volumes (m^2)
1975	2 160
1976	3 340
1977	9 800
1978	10 000
1979	14 500
1980	18 600
1981	21 939
1982	24 166
1983	27 786
1984	20 077
1985	14 100
1986	12 000
1987	15 000
1988	26 000
1989	32 700
1990	40 981
1991	43 652
1992	47 117
1993	47 688
1994	52 983

Table 5: Total annual sales volumes for the South African SWH industry, 1975-1994[5,7]

initiatives, and includes PV electrification for telecommunications, schools (including distance education), clinics, households and water pumping. A considerable increase in export opportunities for PV systems into Africa and other developing countries is also foreseen.

The solar water heating (SWH) industry

It is likely that individual enthusiasts put together homemade SWH systems before any organised research, development or manufacture was done in South Africa. A few commercial systems were available before the 1973 energy crisis. However, since 1973 SWH became freely available on a commercial basis in South Africa. The number of companies that imported, manufactured, distributed and/or installed SWH totalled about 85 in 1977, 59 in 1985 and 47 by January 1995[5,6].

Year	Domestic SWH systems (glazed) Integral (m^2)	Domestic SWH systems (glazed) Close coupled (m^2)	Total domestic SWH (m^2)	% of total SWH sales
1975	–	–	1 560	72,2
1976	–	–	2 840	85,0
1977	–	–	4 500	45,9
1978	–	–	5 700	57,0
1979	–	–	12 000	82,8
1980	–	–	16 600	89,2
1981	–	–	19 250	87,7
1982	–	–	21 100	87,3
1983	3 400	21 520	24 920	89,7
1984	1 600	16 550	18 150	90,4
1985	–	–	12 705	90,1
1986	–	–	6 600	55,0
1987	–	–	6 800	45,5
1988	–	–	10 400	40,0
1989	–	–	11 450	35,0
1990	357	8 160	8 517	20,8
1991	485	6 086	6 517	14,9
1992	307	8 039	8 346	17,7
1993	1 362	8 130	9 492	19,9
1994	1 662	10 565	12 227	23,1

Table 6: Approximate annual sales volumes of glazed domestic SWH, 1975-1994[5,7]

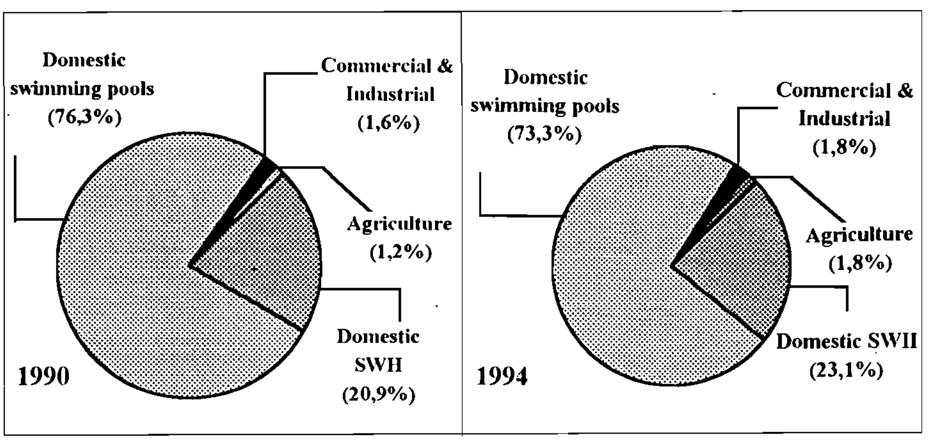

Figure 2: The market share of the various SWH applications for 1990 and 1994[5]

During 1994 seventeen companies were active in the market as SWH manufacturers and importers[7]. Out of these seventeen companies, nine deal only in unglazed SWH collectors comprising five importers and four local manufacturers. Of the thirteen companies dealing in glazed SWH collectors, in significant volumes, ten are local manufacturers and three import systems. The estimated annual turnover for the South African SWH industry in 1994 amounted to about R143 million. It is further estimated that close to 700 persons were employed in the SWH-related industry in 1994[1].

The 1973 and 1979 energy crises, and the subsequent escalation in conventional energy costs in South Africa, resulted in a relatively high public interest in SWH during the late 'seventies and early 'eighties. However, the technical sophistication, design and quality of most of the available products were low. Also, the systems were often installed by unscrupulous agents during this so-called 'bandwagon' phase in the history of the SWH industry[5]. A substantial number of SWH companies disappeared from the scene, during this so-called 'shake-out' phase, particularly over the last ten years.

Up to 1983, the market for SWH experienced tremendous growth. Although no official sales volumes are available for the period 1985-1989, indications by sources within the industry are that this period was characterised by a heavy decline phase (1985-1986) and a slow recovery phase (1987-1989). According to the latest market survey conducted and completed by March 1995 on behalf of the Department of Minerals and Energy, the SWH industry enjoyed an average growth of about 6% per annum for 1990 to 1994[7].

Approximate total SWH sales volumes comprising domestic, commercial and pool heating systems for 1975 to 1994 are given in Table 5.

The approximate annual sales volumes of domestic SWH systems for 1975-1994 are shown in Table 6. As can be seen from this table, close coupled SWH accounted for between 85%-95% of total domestic SWH sales during the last five years. Although the sales of integral SWH systems have risen steadily from approximately 4,2% in 1990 to about 13,6% in 1994, this is still well below the 1983 figure of 3 400 m^2. Approximately 75% of domestic solar water heaters are locally manufactured, with an annual percentage increase of 25% in this sector from 1991 to 1994. It is also interesting to note that the total domestic SWH sales declined as a percentage of total SWH sales from as high as 90% in 1985 to 23,1% in 1994[7].

The annual commercial and industrial SWH sales accounted for as much as 54,1% of total SWH sales in 1977 but that figure has since decreased to approximately 1,8% in 1994, as reflected in Table 7.

The estimated total unglazed SWH sales volumes for 1986 to 1994, primarily for domestic swimming pool heating and greenhouse heating in agriculture, is shown in Table 8.

As can be seen from Table 8, approximately 73% of all SWH sales for 1994 occurred in the domestic swimming pool heating market, which is regarded as a luxury market category. This trend has emerged strongly over the last 9-10 years. The unglazed SWH market averaged a 5% growth rate per annum for 1990 to 1994. In 1990 about 60% of all unglazed SWH systems sold were manufactured locally, with the balance imported. Since then this trend has been reversed, with imports accounting for 64% of all unglazed SWH system sales in 1994[5].

In summary, the individual market share of the various SWH applications for 1990 and 1994 is shown in Figure 2.

SWH systems are mainly exported to Sub-Saharan countries, such as Zimbabwe, Namibia, Botswana, Lesotho and the Seychelles. The export sales volumes for both glazed and unglazed SWH systems for 1990 to 1994 are shown in Table 9.

The export volumes as a percentage of total SWH sales volumes for 1990 to 1994 is presented in Figure 3. As can be seen the SWH export market enjoyed a fairly constant growth rate since 1990.

The estimated SWH collector area installed in the various SWH market segments is shown in Table 10.

Based on an average domestic SWH collector area of 3 m^2, the installed collector area at the end of 1994 represents some 73 000 domestic SWH systems, with the overwhelming majority being installed in the mid-high income household category. Based on the projected housing stock of 8,9 million for 1994[6], this figure represents a market penetration of 3,5% for the formal mid-high income household category, and a penetration of only 0,8% for the total housing stock in South Africa. The latter figure highlights the market decline of SWH systems over the last ten years when compared to the market penetration rate of 1,3% at the end of 1984[3]. Assuming an average collector area of 20 m^2 for domestic swimming pool collectors, some 11 000 systems had been

Year	Total commercial and industrial sales volumes (m^2)	% of total SWH sales volumes
1975	500	23,2
1976	1 500	44,9
1977	5 300	54,1
1978	4 300	43,0
1979	2 500	17,2
1980	2 000	10,7
1981	2 689	12,3
1982	3 066	12,7
1983	2 866	10,3
1984	1 927	9,6
1985	1 349	9,6
1986	1 020	8,5
1987	1 125	7,5
1988	1 040	4,0
1989	800	2,5
1990	642	1,6
1991	708	1,6
1992	693	1,5
1993	745	1,6
1994	976	1,8

Table 7: Estimated sales volumes of SWH in the commercial and industrial sectors, 1975-1994[3,5]

Year	Domestic pool heating (m^2)	% of total SWH sales	Agricultural applications (m^2)	% of total SWH sales	Total unglazed SWH sales (m^2)
1986	4 380	36,5	–	–	4 380
1987	7 050	47,0	–	–	7 050
1988	14 560	56,0	–	–	14 560
1989	20 440	62,5	–	–	20 440
1990	31 260	76,3	472	1,2	31 732
1991	35 893	82,2	480	1,1	36 373
1992	37 868	80,4	210	0,4	38 078
1993	36 891	77,4	560	1,2	37 451
1994	38 850	73,3	930	1,8	39 780

Table 8: Estimated total unglazed SWH sales volumes for the domestic swimming pool and greenhouse heating market, 1986[5]

Year	Export volumes (m^2)		
	Glazed	Unglazed	Total
1990	1 405	890	2 295
1991	2 019	1 040	3 059
1992	2 528	1 190	3 718
1993	3 281	2 160	5 441
1994	2 651	1 663	4 314

Table 9: Total SWH export volumes for 1990 to 1994[5]

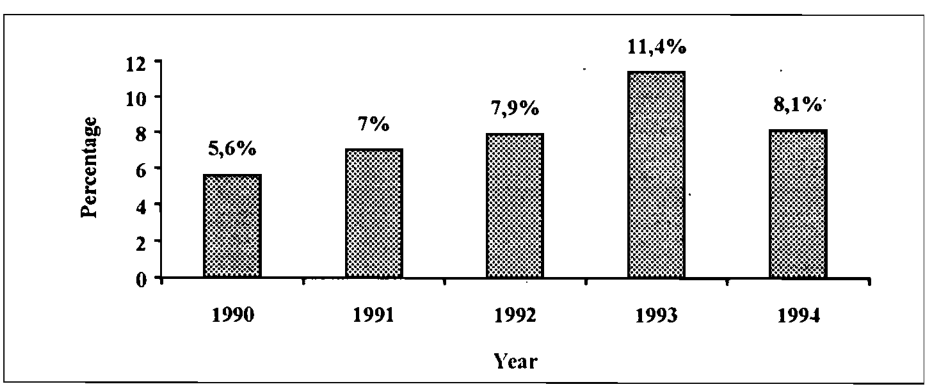

Figure 3: Export SWH volumes as a percentage of total SWH sales volumes, 1990-1994

Market segment	Installed collector area (m^2)	% of total installed area
Domestic SWH	220 000	45,5
Domestic swimming pool	227 000	46,9
Commercial & Industrial	34 000	7,0
Agriculture	2 600	0,6
Total	483 600	100

Table 10: Estimated SWH collector area installed in South Africa up to 1994[1]

Year	Solar stills sales volumes (m^2)
1993	20
1994	60*
1995	200 - 300**

* Approximately 70% of sales are for producing drinking water for humans (predominantly) and animals in arid regions, such as the Kalahari farming areas. The balance of 30% is for telecommunication purposes (Telkom) employing PV systems with storage (batteries).

** Projected figures. The bulk of sales (80%) would still be for human and animal water consumption purposes.

Table 11: Solar stills sales volumes, 1993-1995[1]

Concentrating solar cookers (parabolic dish reflector)	Retail price (including VAT) (Rands)	Number of $1m^2$ and $2\ m^2$ systems sold per annum
Size: $1m^2$	395	12
Size: $2m^2$	625	

Note: The retail price excludes the cost of transport.

Table 12: Typical costs of concentrating solar cookers for the first quarter of 1995[1]

installed in the formal mid-high income group by 1994. Based on the national figure of 450 000 domestic swimming pools, the 11 000 systems represents a market penetration of 2,4%.

Imported domestic SWH systems (about 3 071 m^2 in 1994) and pool heating SWH products (close to 25 000 m^2) available on the local market originate from various countries, such as Switzerland, the U.S.A., Australia, Israel and Germany. Actual sales and installation in the South African SWH market are done mainly by independent agents, who purchase from the various manufacturers and importers and ultimately set the prices to consumers[5]. The general tendency, as found in the 1980s[3] and which is still continuing to this day, is that the average mark-up for domestic SWH systems from manufacturing/importation to the fully installed price, as set by agents, is in the order of 200%.

Other solar heating products

The local solar industry also supplies solar stills and solar cooker/ovens as commercial products. There is currently only one local manufacturer of solar stills in South Africa. The technology employed, one which was developed in collaboration with the Council for Scientific and Industrial Research (CSIR), is based on an inclined wick still. This solar still is (i) light and easily portable, (ii) has an expected lifetime of 15 years plus, (iii) if properly maintained, has an efficiency of about 30%, and (iv) provides for a daily distillate output of 2-5/m^2, depending on solar radiation levels. The solar still retails (distributor price, VAT inclusive) for about R1 175, which translates into R839/m^2. However, the cost of water from such a still (R170 - R420/litre) precludes its use for anything other than producing water for human and animal consumption[1]. The estimated sales volumes (m^2) for solar stills for 1993-1995 are shown in Table 11.

Solar cooking devices which are available on the local market fall into two categories, viz., solar concentrators and solar ovens. There is currently one manufacturer of concentrating cookers which is active in the market. The design of this system is based on the use of a parabolic dish reflector made of fibreglass covered with aluminium foil. Although the system is robust, it is bulky, making it cumbersome to transport and also negatively affecting the transport cost thereof. The costs and sales volumes of these systems are shown in Table 12.

Locally manufactured solar ovens, on the other hand, are essentially boxes consisting of wooden or plastic bases and sides (painted black or covered with aluminium foil), with glazed acrylic opening lids, which are well insulated on the inside to prevent heat loss. At least two manufacturers of solar ovens are currently active in the local market and the prices of solar ovens in 1995 ranged from R100-R251 per oven. Approximately 3 000 systems are being sold annually[1]. The solar oven, which requires much less attention than the concentrating solar cooker, has been more accepted and is more 'widely' used in the local market as a cooking device in the recreational market (affluent camping fraternity) and within some rural communities. In the latter situation, it is used as a supplementary cooking device to conventional and traditional cooking systems. The costs of locally available solar cookers are presently too high for many of the poor residing in the rural areas of South Africa, especially taking into consideration that solar cookers cannot perform all the functions of traditional cooking systems as perceived by these communities.

The major constraints faced by the local SWH industry are similar in nature and extent to those pertaining to those already described for the PV industry. Very limited growth is foreseen for the local SWH industry in the near future as it is predominantly locked into the mid-high income housing category. One of the major contributing factors to this observation is the marketing approach being employed by the SWH industry, resulting in exorbitant cost structures. However, should the constraints inhibiting the growth be adequately addressed and removed, and SWH becomes an integral part of an energy demand-side management strategy for South Africa, then a substantial diversification of growth areas into the other housing categories could well be realised in the future. It is foreseen that swimming pool SWH applications will remain the mainstay of the industry for the meantime. Commercial and industrial applications will probably remain dormant, fluctuating around the 8% market share level, as they have to compete with low cost coal and electricity in a distorted energy market.

The wind power industry

The wind power industry in South Africa is comprised of two components, viz.; a wind-driven water pumping component employing windmills, and a wind turbine component for remote area power supply (RAPS). Windmill use in South Africa dates back to the previous century during which time all windmills were imported mainly from the U.S.A., Australia and the United Kingdom. The demand for windmills continued and during World War II the local manufacturing of windmills commenced. There are currently four reputable manufacturers of windmills in South Africa which distribute/install them through many outlets. The estimated annual turnover for the windmill industry in 1994 amounted to about R8 million, and it is further estimated that some 100 persons are employed in the production of windmills by the local industry. Total sales volumes dropped from about 6 000–7 000 units in 1985 to about 1 200 in 1994. Virtually no growth has been experienced in the market over the period 1990–1994. Approximately 3% of total sales are exported to a number of African countries. The total production capacity of the industry is severely underutilised at present by approximately a factor of three[1].

Some 280 000 windmills were in operation throughout South Africa by 1985[7]. Assuming a growth rate of 2,0% per annum for 1986-1989 some 303 000 were installed by 1990 and a total of 309 000 by the end of 1994, based on average sales volumes of 1 200 units per annum for the period 1990-1994. If it is further assumed that 90% of all windmills installed are fully operational, then some 278 000 windmills were in operation by the end of 1994. A recent survey in the Eastern Cape has shown that approximately 1 200 windmills have been installed, of which less than 11% are operational largely due to lack of maintenance[8]. The estimate of 278 000 windmills also correlates with an earlier estimate that there were some 300 000 farm windmills operational in South Africa, Namibia, Botswana and Zimbabwe by 1991[9].

Hydropower category	Turbine type	Total installed capacity (MW)	
Micro hydro (<100 kW):	Pelton	0,200	
	Cross-flow	0,188	
	Francis	0,03	
	Centrifugal pumps	0,05	0,468
Mini hydro (100 kW):	Cross-flow		–
	Francis		–
	Pelton		1,450
Small hydro (<10 MW):	Francis		62,800
	Grand total		**64,720**

Table 13: Estimated total installed capacity of small-scale hydropower in South Africa up to 1993[1]

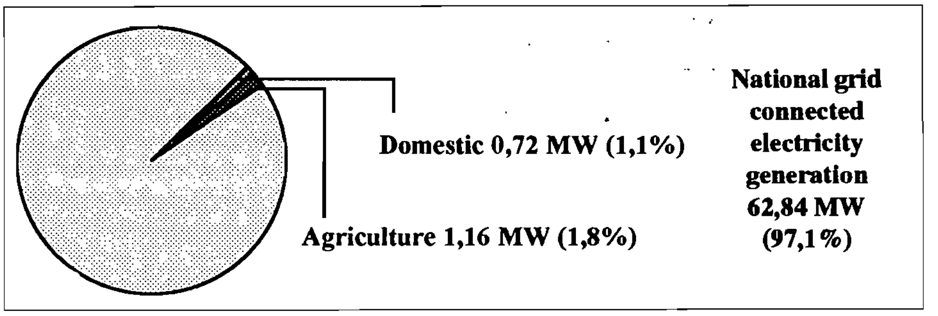

Figure 4: Estimated breakdown of small-scale hydropower installed capacity by 1993[1]

Windpumps are applied in South Africa to supply water for small-scale irrigation (very limited application), human requirements and livestock. It is also interesting to note that in certain areas of South Africa, especially the North West Province, a tendency has developed over the last number of years to make more extensive use of windmills for community water supply projects vis-à-vis livestock requirements. The static sales tendencies experienced by the windmill industry over the last five years are mainly ascribed to: (i) the economic recession; (ii) the inroads made by the national electrification drive; (iii) PV water pumping in the traditional windmill market.

The future outlook for the local windmill market, however, should be put into proper perspective, particularly as seen against the national electrification drive, which will most definitely impact negatively on possible future growth in the windmill industry. Nevertheless, it is foreseen that some growth could be experienced in the export market as this market is presently relatively underdeveloped. It is also envisaged that the tendency to employ more windmills for community water supplies in certain areas in South Africa will continue for the foreseeable future.

There are currently four active importers/distributors/installers of horizontal axis wind turbines in South Africa. One company in the mid-1980s locally developed and marketed a small wind turbine (1 kW and 3 kW), known as the Aerogen, which was not successful and was subsequently withdrawn from the local market. The majority of small machines are imported from the U.S.A. and Denmark, and range from 50 W up to 10 kW in size. The local market for wind turbines never experienced real growth and is regarded as a dormant and even declining market. The major applications are predominantly for remote farmhouse power supplies, the leisure marine market (yachting) and telecommunication purposes. Total wind turbine sales volumes were in the order of 30 kW in 1994 with an estimated turnover of close to R10 million. Approximately 50% (15 kW) of the sales were for telecommunication and the leisure marine market. It is envisaged that sales could be close to 40 kW for 1995 [1]. This is well below the sales figure of 86 kW reported for 1984[7].

The total installed capacity of small wind turbines in South Africa at the end of 1985 was about 200 kW[7]. Estimates for the total installed capacity by 1994 ranged from 200 kW to as high as 1 MW[1]. Other forecasts put the total installed capacity at 800 kW by 1990[7]. However, in view of declining sales volumes and based on average sales volumes of about 25 kW per annum for the period 1986 to 1993, a more realistic estimate appears to be in the order of 430 kW by the end of 1994.

The small-scale hydropower industry

Some four local designers and manufacturers of micro-scale hydropower (on demand) have been active in the local market for more than ten years. One company has been active since the late 1970s in the local development, manufacturing and installation of the Pelton wheel and cross-flow turbines in South Africa (mainly in the Eastern Cape). Imported turbines, such as Ansaldo and Ossberger turbines, are also available on the local market on demand. Eskom, through their Rotek subsidiary, is considering the commercialisation of a locally produced Francis turbine with a load capacity of 5 kW. The Department of Agricultural Engineering has also been active in the development of cross-flow turbines and the application of centrifugal pumps as turbines. In order to get an idea of the extent of the local small-scale hydropower market, it is necessary to quantify the total installed capacity of hydropower installations in South Africa. A summary of this quantification is presented in Table 13.

The estimated percentage breakdown of the total installed capacity per application sector is given in Figure 4.

Total installed costs for local micro hydro plant were in the order of R1 500/kW by 1989 and running close to R4 000/kW by 1995[1]. A typical percentage cost breakdown for local micro hydro installations would vary as follows:

Mechanical and electrical equipment	: 40 - 50%
Penstock	: 20 - 30%
Civil work	: 15 - 20%
Engineering supervision	: 8 - 10%

Although it is very site specific, it appears that in many instances small-scale hydropower at a typical unit cost of 22 c/kWh would be the least-cost option for remote area power supply. There appears to be at least 6 000 to 8 000 potential sites for micro hydro applications employing mainly a range of low head turbine types[10]. From these observations, it is clear that the South African market for micro hydro applications holds significant potential. There also appears to be significant export potential for these applications into Sub-Saharan African countries.

Conclusion

A number of important trends, market constraints and opportunities in terms of local market growth and exports have been highlighted. It is clear from this overview that the South African renewable energy industry is still in a fledgling state and faces serious development constraints. However, it has the inherent potential to make a significant contribution to economic and human development within the overall South African development context.

References

(1) STASSEN, G. Towards a renewable energy strategy for South Africa. Unpublished Ph.D. thesis. University of Pretoria, 1996.

(2) BOTHA, A P. A report on a market survey and technology audit on amorphous silicon-Phase II. Technoscene report no: 91 ID01/2. Technoscene, 1991.

(3) BOTHA, A P. Analysis of photovoltaic module shipments in the world market: 1986 - 1994. Technoscene report no: TS-032-000-000-001-rep-01. Technoscene, 1995.

(4) SOUTH AFRICA (DEPARTMENT OF MINERAL AND ENERGY AFFAIRS). Personal communication. 1995.

(5) STASSEN, G. The solar water heating market in South Africa. *In*: EBERHARD, A A and WILLIAMS, A. Renewable energy resources and technology development in Southern Africa. Elan Press, 1989.

(6) SOLAR ENERGY SOCIETY OF SOUTHERN AFRICA. List of suppliers of renewable energy equipment. Solar Energy Society of Southern Africa, 1995.

(7) CAWOOD, W N. Solar water heating production statistics-1994. Final draft report. Department of Mineral and Energy Affairs, 1995.

(8) NATIONAL ELECTRIFICATION ECONOMIC STUDY. Household electrification scenarios. Report no. F&T 01. Public Sector Economic Impact Study Team. National Electrification Forum, 1993.

(9) STASSEN, G. Die regering se rol in die ontwikkeling en implementering van alternatiewe hernubare energiebronne in Suid-Afrika. M.Phil. Verhandeling. Randse Afrikaanse Universiteit, 1986.

(10) TRADENET INTERNATIONAL. Airstream: The latest development in alternative energy resources. Tradenet, 1993.

(11) VILJOEN, R P. The diffusion of wind energy technology in Southern Africa. *In:* VAN HULLE, F J L, SMULDERS, P T and DRAGT, J B. Proceedings of EWEC 91. Wind energy: Technology and implementation. EWEC, 1991.

(12) ESKOM (TECHNOLOGY RESEARCH AND INVESTIGATIONS). Personal communication. 1995.

Clean coal technology choices relating to the future supply and demand of electricity in Southern Africa

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Received 28 October 1996
Revised 8 April 1997

The finalisation of the United Nations Framework Convention on Climate Change (UNFCCC) has catalysed a high degree of debate and interest in the future of coal-fired power generation. Fossil fuel combustion is responsible for a significant percentage of pollutants emitted globally, and coal will continue to play a major role in the energy portfolios of many countries. This is particularly true for developing countries.

This fact has resulted in a major focus on technologies which improve the efficiency of coal combustion and conversion to electrical energy, as well as technologies which directly or indirectly reduce overall emissions. The issues around clean coal technologies (CCT) and their evolution, development and uptake in both developed and developing countries are complex. This paper addresses these issues in a Southern African context, viewed from the policy perspective of developing countries and presented in the framework of electricity supply and demand considerations in the region.

The principal climate change policy elements proposed for South Africa are presented in the context of the current electricity supply and demand situation in the region.

The means of addressing the supply and demand needs of the region are presented in the context of Eskom's Integrated Electricity Planning (IEP) process including the environmental considerations inherent in decision-making processes. The potential future role of CCT, barriers to their introduction and potential measures to facilitate their accelerated adoption are discussed.

Keywords: clean coal technologies; electricity supply; electricity demand; Southern Africa; Eskom; integrated electricity planning; forecasts; demand-side management; power station emissions; carbon dioxide; climate change; South Africa

Introduction

The finalisation of the United Nations Framework Convention on Climate Change (UNFCCC) has catalysed a high degree of debate and interest in the future of coal-fired power generation. Whilst it is accepted that fossil fuel combustion is responsible for a significant percentage of pollutants emitted globally (>50%), it is also recognised that coal will continue to play a major role in the energy portfolios of many countries. This is particularly true for developing countries with their primarily fossil-based energy reserves and a limited technological, financial and skills base to deploy more advanced alternatives.

This fact has in turn resulted in a major focus on technologies which improve the efficiency of coal combustion and conversion to electrical energy, as well as technologies which directly or indirectly reduce overall emissions. The issues around these so-called clean coal technologies (CCT) and their evolution, development and uptake in both developed and developing countries are complex. This paper addresses these issues in a Southern African context, viewed from the policy perspective of developing countries and presented in the framework of electricity supply and demand considerations for the region.

It must be stressed that this study, as well as the figures presented, do not necessarily reflect fully the quantitative picture of the region due to the difficulty in accessing data. The figures for South Africa are accurate. However, the regional assessments are at best qualitative. In addition, whilst every attempt has been made to obtain comment on this document, the views reflected are primarily those of the author.

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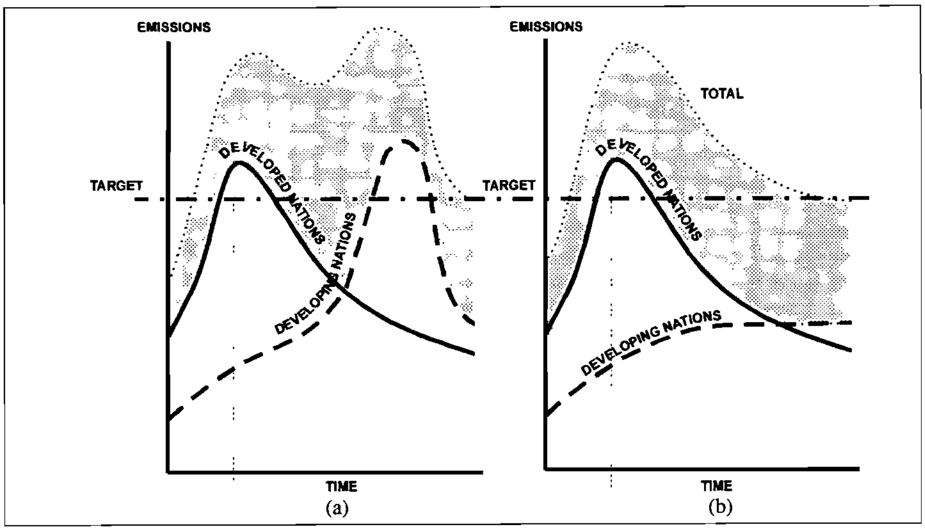
A background to climate change policy in the region

The perspective presented in this study needs to be viewed in the context of the major climate change policy elements of developing countries. As such, decision-making criteria would clearly be fundamentally different to those applied in developed countries.

The principal elements of a national climate change policy proposed for South Africa are[1]:

- A holistic approach, recognising that a proposed action in one area, e.g. local, could impact on another area, e.g. regional or global.
- Sustainable development as a goal which dictates the wise use of renewable and non-renewable resources in developing the country. In this regard emphasis would be placed on the socio-economic development priorities of South Africa.
- The 'win-win' approach, which is based on the principle of no regrets. This is defined as taking timely action based on current knowledge that is justified on environmental, economic and political grounds whether climate change impacts are significant or not. Implicit in this approach is the understanding among developing countries that the responsibility for major precautionary actions and costs rests with the developed countries.
- Legislation and control should be used only as a last resort and should be guided by national priorities.
- Long-term projects should take the possibility of climate change-induced impacts into account but not be driven by these considerations.
- Energy policy should promote the wise use of electricity and high-priority electrification programmes. At the same time the potential to reduce



Figures 1(a) and 1(b): Non-optimised and optimised positions regarding emissions in developed and developing countries

Country	Thermal	Hydro & pumped storage	Nuclear	Geo-thermal	Total	% of total
Angola	125	201	–	–	326	0,71
Botswana	172	–	–	–	172	0,38
Congo	18	89	–	–	107	0,23
Kenya	100	570	–	45	715	1,56
Lesotho	2	3	–	–	5	0,01
Malawi	25	165	–	–	190	0,41
Mauritius	278	54	–	–	332	0,72
Mozambique*	97	2 293	–	–	2 390	5,21
Namibia	147	240	–	–	387	0,84
South Africa	30 612	2 249	1 840	–	34 701	75,66
Swaziland	10	40	–	–	50	0,11
Tanzania	139	375	–	–	514	1,12
Zaire	38	2 442	–	–	2 480	5,41
Zambia	84	1 670	–	20	1 774	3,87
Zimbabwe	1 056	666	–	–	1 722	3,75
Total (MW)	**32 903**	**11 057**	**1 840**	**65**	**45 865**	**100**

* includes Cahora Bassa

Table 1: Net maximum generating capacity (MW)

Country	Gross domestic production	Imports	Exports	Total available	% of total	Peak demand (MW)	kWh per capita	Total - electricity sold (GWh)
Angola	1 042	0	0	1 042	0,50	138	99	902
Botswana	1 017	382	0	1 399	0,67	204	999	1 208
Congo	354	166	0	520	0,25	?	226	336
Kenya	3 678	187	0	3 865	1,86	605	148	3 222
Lesotho	0	435	0	435	0,21	80	217	380
Malawi	861	0	1	860	0,41	149	108	731
Mauritius	1 047	0	0	1 047	0,50	201	952	899
Mozambique	365	608	0	973	0,47	104	56	701
Namibia	1 259	767	0	2 026	0,97	277	1 447	1 795
South Africa	174 715	172	3 047	171 840	82,70	25 133	4 373	153 547
Swaziland	110	597	0	707	0,34	118	862	603
Tanzania	1 791	11	0	1 802	0,87	?	68	1 523
Zaire	5 379	53	1 278	4 154	2,00	?	110	?
Zambia	8 116	0	1 067	7 049	3,39	1 108	766	6 171
Zimbabwe	7 811	2 312	46	10 077	4,85	1 617	969	9 036
TOTAL	**207 545**	**5 690**	**5 439**	**207 796**	**100**	–	–	–

Table 2: Production and trade of electricity (GWh)

costs and increase competitiveness through improved energy efficiency will ensure compatibility with climate change issues.

- Public awareness, education and training are essential in ensuring the success of any policy.
- Factual information is a prerequisite for decision-making. As such, research and monitoring are important components of policy.
- International and particularly regional cooperation are important mechanisms for responsible development.
- Technology transfer and development are essential in avoiding the mistakes of developed countries and in ensuring that development is achieved with an optimised increase in emissions.

In essence, the policy position of developing countries is to focus on local and regional issues, especially in the localisation and/or regionalisation of climate change impacts, and determining how to anticipate, adapt to and, if possible, take advantage of such impacts. At the same time they need to maximise international cooperation to ensure that development is optimised and that ultimately the objective of the UNFCCC is met without compromising their development. This cooperation should include the transfer of CCT from developed countries.

This position is illustrated in Figure 1[(2)], where Figure 1(a) indicates a non-optimal position with developing countries' emissions overshooting before stabilising. In this case the errors of developed countries are repeated. Figure 1(b) reflects an optimised situation where state-of-the-art technology is accessed during development, with full incremental costs being borne by the developed countries, and 'Activities Implemented Jointly' (AIJ) are credibly and effectively applied. In this context it is clear that advanced and highly efficient CCT for power generation have an important role to play.

The current electricity supply and demand situation in Sub-Saharan Africa (1995 figures)

Tables 1 and 2 reflect the 1995 situation for electricity supply and demand in the Sub-Saharan African countries listed[(4)].

Eskom's Integrated Electricity Planning process

In order to clarify the position presented in the following sections, it is considered useful to place this information in the context of Eskom's Integrated Electricity Planning (IEP) process.

The role of IEP is to:

- provide the context for business planning
- identify short-, medium- and long-term resource needs
- operate as a planning matrix across generation, transmission and distribution
- act as a mechanism to test options holistically and recommend an optimal development plan.

In particular, the objectives of IEP are to:

- align supply and demand options with goals and priorities
- provide an accurate and documented, least-cost package of options
- satisfy customer needs by providing the optimal value of electricity
- ensure the financial viability of the utility.

The process of IEP is as follows:

- **Forecast energy and load shape**
  A forecast cone (range) is developed for both maximum demand and load factor. This forecast is undertaken on the basis of a base case which excludes interventions such as demand-side management (DSM).

↓

- **Identify demand-side options**
  The potential means of modifying customer behaviour and usage patterns are identified and costed out.

↓

- **Identify supply-side options**
  All viable means of meeting demand with new capacity are identified and costed out.

↓

- **Determine least-cost combination of the supply and demand options**
  The relative merits of all options are assessed and a least-cost package of supply- and demand-side options is compiled. The impact of these options on the demand forecasts is quantified and modelled.

↓

- **Evaluate risk and uncertainty**
  The risks and uncertainties inherent in the least-cost package are assessed to determine the probability of the successful implementation of the plan.

↓

- **Evaluate environmental impact**
  The positive and negative environmental impacts of both the demand- and supply-side options are quantified and costed out if possible.

↓

- **Select and justify the preferred plan**

In applying the IEP process, a rigorous analysis is undertaken of all possible options open to the industry. In this regard it is clear that CCT are assessed using the same criteria as all other options. This leads to the logical conclusion that the uptake of CCT is a direct function of their ability to compete with other options (both supply and demand) on a cost, availability and reliability basis.

It should be noted that there are discussions at government level regarding the desirability of opening up the generating sector to private and foreign ownership, as well as restructuring the distribution sector. This would clearly impact the IEP process.

The supply and demand projections

The figures in Table 3 assume a long-term economic growth rate of between 1,5% and 3,5% for South Africa. The midpoint of these economic projections has been used. The Southern African perspective is presented in a qualitative sense only.

These figures include a possibly optimistic reserve margin of 12% but exclude DSM measures aimed at reducing peak demand by 7 300 MW by 2015.

The increase in electricity demand in the region is expected to be a relatively small percentage over and above the figures presented in Table 3 due to the far lower demand in other countries in Southern Africa.

In addition to the above, it should be noted that significant overcapacity exists

	Actual	Projected			
	1995	2000	2005	2010	2015
Capacity required (MW)	29 500	32 000	39 500	47 000	53 200
Capacity available (MW)	36 314				
Annual maximum demand (MW)	25 133	30 000	35 250	41 500	47 500
Energy (GWh)	153 547	180 000	220 000	240 000	270 000

(Source: Eskom Integrated Electricity Plan - 5)

Table 3 : South African electricity demand projections

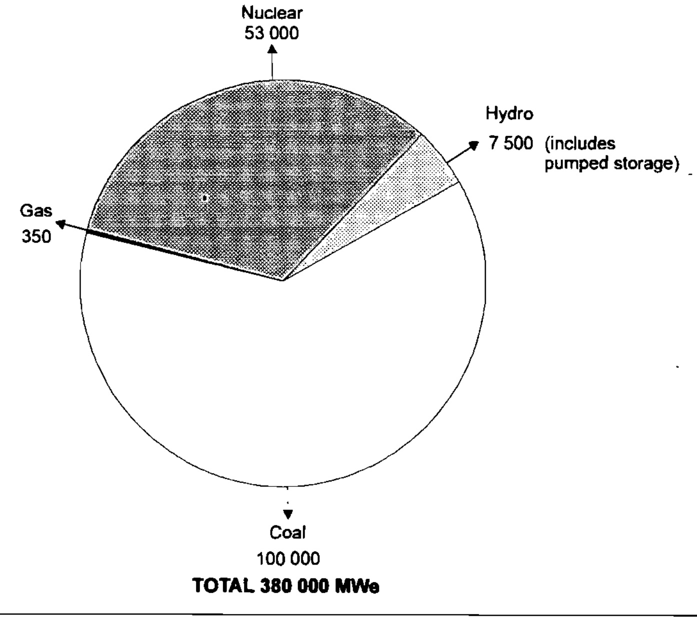


Figure 2: South African energy reserves (MWe)

	Potential reserves (MWe)	Current installed capacity (MW)
Thermal		36 826
– coal	160 000	
– oil	2 130	
– gas	7 600	
Nuclear	70 000	1 840
Hydro	142 000	9 206
Geothermal	?	50

Table 4: Energy reserves and electricity capacity for Sub-Saharan Africa

DSM technique	Impact by 2015(MW)
Interruptibility	200
Load shifting	600
Energy efficiency	500
TOTAL	**1 300**

Table 5: Demand-side management targets

in the region as a whole. This would enable utilities in the region being able to sell their excess capacity to utilities in neighbouring countries, thereby avoiding the construction of new power generation plant in those countries.

Electricity capacity

Under the current scenarios it is unlikely that additional capacity will be required in the region before the year 2010. In particular, the excess capacity in the region may be optimally utilised via the Southern African Power Pool. Issues such as the reliability of long transmission lines, coupled with individual national priorities could, however, result in additional capacity being built before 2010. In about 2014 additional peaking plant could be required in South Africa once plant in storage has been recommissioned. This is likely to be pumped storage. Mid-merit/peaking plant, however, may be required before this date, depending on the success of planned DSM interventions.

Coal is likely to remain the primary source of electricity in South Africa given the significant low cost reserves available, as illustrated in Figure 2. This figure relates the electricity-based energy potential of reserves in South Africa, with the potential for nuclear generation also being significant. Clearly the potential in South Africa for gas and hydro is limited. Other renewable energy sources have not been included.

In Southern Africa the primary growth is likely to be in hydro power, with some (limited) potential for growth in natural gas, and some coal-based capacity in Botswana and Zimbabwe.

The current energy reserves and electricity capacity for Sub-Saharan Africa are reflected in Table 4.

Meeting future electricity demand

The prime source for meeting electricity demand in the region in the short to medium term is the current excess capacity in the region. Any increase beyond this capacity will, in all likelihood, be met predominantly by coal in South Africa and by hydro power in the other Southern African countries.

In addition, a DSM programme in South Africa has targeted certain alternatives to capacity expansion shown in Table 5.

In spite of this situation, future supply-side options for South Africa are currently being evaluated for future application. In particular, the highly uncertain range of potential growth in demand dictates a proactive and flexible approach to supply-side alternatives.

These options being evaluated fall into three main categories:

(1) **Plant in storage**
The technical and commercial basis for recommissioning some 3 540 MW of mothballed plant is being established.

(2) **Established technologies for new plant.**
Options are evaluated on the basis of life cycle costs, unit size and lead times. These options currently include:
- Conventional (supercritical) coal-fired
- Combined cycle gas turbine
- Conventional nuclear (PWR)
- Hydro
- Independent power production
- Cogeneration
- Power imports.

(3) **New technologies**
This category assumes a new capacity requirement in the first or second decade of the next century and consists of the evaluation of a variety of new (for South Africa) and emerging technologies with the objective of reducing:
- lead time
- capital and operating costs
- environmental impacts

and optimising unit size and load-following capability.

Technologies to be investigated include:
- Fluidised bed combustion plant (utilisation of discard coal)
- Integrated gasification combined cycle (IGCC) plant
- Gas-cooled (pebble bed) nuclear reactor plant
- Underground compressed air energy storage plant
- Underground high head pumped storage plant
- Coal-fired gas turbine plant
- Municipal and industrial waste: Combined heat and power plant
- Solar thermal power plant.

Important factors in technology choice

The choice of technology for future capacity is guided by numerous decision-making factors. These are listed in approximate order of importance below:

- Capital and operating cost
- Plant reliability and availability
- Access to indigenous, low cost fuel
- Lead times
- Operational flexibility (base load versus peaking etc.)
- Water availability
- Environmental considerations (likely to move up in order of importance with time)
- Security of fuel supply
- Local capacity to sustain technology (skills, infrastructure etc.)
- Funding availability
- Political considerations.

Environmental considerations in capacity choice

Environmental considerations play an extremely important role in expansion planning. In developing countries, this role is at a far more operational level than for developed countries. In this regard, the focus is on local and regional environmental impacts and benefits, with lower priority being given to global impact. For example, the introduction of low-smoke coals to reduce urban air pollution will in effect increase CO_2 emissions because of the energy required in the devolatilisation process, as well as the lower energy content of the product. The primary environmental issues are presented with a South and Southern African perspective(3). It should, however, be noted that the attention given to environmental matters varies considerably from country to country in the region.

These issues clearly receive varying attention as components of environmental impact assessments on a project by project basis.

- **Water quality and availability**
  The availability of water is one of the critical environmental issues in Southern Africa. Water supplies are highly variable, both in terms of quality and quantity. Technology choices are often strongly influenced by the amount of water used as well as the impact on water quality.

- **Land management/ecological impacts**
  Whilst land is generally readily available, the ecological impacts of a particular technology require assessment, especially in areas where ecotourism is an important consideration. The inundation of land by hydro projects is an issue which requires particular attention.

- **Air quality**
  Power plant emissions receive varying degrees of attention. In general, a holistic approach is adopted with respect to air quality. In South Africa air quality is assured via the use of a 'best practicable means' approach. This implies that primary attention is paid to particulate removal, and then the impacts of SO_x and NO_x are managed via ambient air quality requirements. The Department of Environmental Affairs and Tourism is currently investigating this management process. Acceptable air quality levels are maintained via the combustion of low-sulphur coals and the use of tall stacks. It should be noted that extensive research into air quality has been undertaken in the main power generation region, Mpumalanga, over a 15-year period. This research has clearly demonstrated the efficacy of the current air quality management processes in containing local and regional air and rain qualities to acceptable levels. Air quality in this area has improved by an average of 4% p.a. for the last 10 years, greatly allaying concerns related to exceedance of local and regional air pollution standards. WHO levels for ambient air quality are rarely exceeded.

> "Clearly the most significant barrier to the uptake of CCT in Southern Africa is the current excess of generating capacity in the region, coupled with generally energy intensive economies and a significant potential for financially viable demand-side measures. It should, however, be noted that projections for economic growth in the region are highly variable with 'aspiration figures' as high as 6% being quoted. Given the fact that economic growth and electricity demand growth are still directly correlated, a 6% growth rate would create the need for major capacity expansion (up to 2 300 MW p.a.) from the year 2004. This clearly offers immense opportunities for economically competitive CCT."

- **Waste management**
  The production of waste, especially large quantities of fly ash from the combustion of high ash coal, requires careful management. Ash disposal, utilisation and rehabilitation of disposal sites is an important component of technology assessment. In addition, the water used in waste transport and disposal is an important consideration in technology choice.

- **Socio-economic impacts**
  Socio-economic development is the highest priority in the region. As such the choice of a supply-side option and the attendant environmental controls, is strongly dependant on its impact on society as a whole. For example, if it is a matter of choice between utilising resources for an electrification programme versus fitting additional pollution control equipment, where such equipment is an environmental luxury, then the former has precedent. The term 'environmental luxury' implies a 'nice to have' which is not justified on scientific or economic grounds. This example is well-illustrated in South Africa where, due to the combustion of low-sulphur coal, coupled with tall stack dispersion, air and rain quality levels are maintained at acceptable levels. As such, the motive to install additional environmental controls, e.g. desulphurisation, is limited, especially when one considers the alternative application of resources. In particular, it has been shown that, in the long term, electrification of urban areas results in a significant improvement in currently unacceptable pollution levels due to the domestic combustion of coal. In this regard, electrification may be regarded as a CCT.

  It should be noted that a significant percentage of people (69%) are unlikely to get rid of their coal stoves in the short to medium term, even after electrification. Therefore, in the interim (medium-term) an integrated approach of continued electrification, fuel optimisation (low-smoke fuel and combustion appliance improvement) and housing energy efficiency (insulation) will be followed to reduce the unacceptable urban residential air pollution levels.

- **Servitudes**
  The routing of transmission lines through ecologically sensitive areas is the subject of comprehensive environ-

mental impact assessments in some countries in the region. Some projects to increase the capacity of other countries to undertake such studies are currently underway. Soil erosion initiated by poor servitude management can be a particular problem, as can the impact of structures and power lines on the local ecology, especially wildlife, such as birds.

- **Global impacts**
  As developing countries, the issue of CO_2 emissions from generating plant receives relatively limited attention. The approach typically adopted is one of striving to improve plant efficiency, reliability and availability, with attendant CO_2 emission reduction benefits. There is little motivation to select a technology which produces less CO_2 merely for the sake of it or at a cost premium.

  Whilst policies are still being formulated, it is considered that, if full incremental costs are covered by the developed countries, CO_2 emission technologies could be viewed with more favour.

Some potential developments to 2015

- Industry restructuring will play an important role for the next five years.
- Environmental pressures, regulation and requirements will increase.
- The Southern African Power Pool will play an important role in balancing supply and demand.
- Natural gas may be used for power generation.
- Coal and hydro will continue to be the main sources of primary energy for power generation.
- CCT will only be introduced once increased capacity is required and if they meet cost and reliability criteria.

Barriers to the introduction of advanced coal-fired power generating technologies

Clearly the most significant barrier to the uptake of CCT in Southern Africa is the current excess of generating capacity in the region, coupled with generally energy intensive economies and a significant potential for financially viable demand-side measures. It should, however, be noted that projections for economic growth in the region are highly variable with 'aspiration figures' as high as 6% being quoted. Given the fact that economic growth and electricity demand growth are still directly correlated, a 6% growth rate would create the need for major capacity expansion (up to 2 300 MW p.a.) from the year 2004. This clearly offers immense opportunities for economically competitive CCT.

If one assumes such opportunities for CCT, then consideration must be given to other potential barriers to their introduction. These include:

- Perceptions of unreliability and high operating costs
- Limited local skills to adapt to new technologies
- Limited support infrastructures to cater for new technologies
- Competition from other technologies and fuels, such as hydro, gas, and possibly nuclear
- Need to assess performance in a Southern African environment, e.g. combustion of local low-grade coal etc.
- The relative efficiency of current plant (34,3% average for 1995).

It is considered unlikely that CCT will displace existing plant, especially given current plant efficiencies.

The relatively young age of current operational coal-fired power stations in South Africa (11-15 years) precludes their upgrading to CCT without efficiency or water consumption penalties. It is therefore necessary for CCT to replace this plant once it requires replacement, i.e. on decommissioning or to penetrate the growth market. CCT could also replace current older plant which has been in storage (mothballs) for several years now and which could be usefully repowered with a technology such as fluidised bed combustion.

It should further be noted that the current South African practice of burning low-grade (high-ash, low-sulphur) coals for power generation, results in extremely low primary energy costs. This makes it difficult for competing technologies utilising other fuels to penetrate the power generation market - as they are 2-3 times more expensive on life cycle costing. Clearly CCT combusting low-grade coal, with more favourable capital costs and efficiencies, will receive serious consideration for replacement plant.

Clearly the major energy resources in Southern Africa are coal and hydro. As such, the focus in the region outside of South Africa will be on hydro development. Individual national priorities and non-optimal commercial attitudes can, however, act as obstacles to this development.

Political issues are considered to present a minor, non-resistant barrier to the introduction of CCT. Resources, especially funding, are often major constraints in any supply-side option in Sub-Saharan Africa. In this regard innovative funding options/aid packages are required.

Role and measures for government in accelerating the adoption of CCT

In assessing the options open to both government and industry in facilitating the rapid uptake of CCT, it is assumed that the need for additional, or replacement, capacity exists. This is clearly not the case in Southern Africa given the current excess capacity, potential for DSM and the hydro capacity in the region. Nevertheless, some ideas from the perspective of a developing country are presented below.

- **Catalyse economic growth**
  In a Southern African context it is obvious that economic growth is an important driver in increased electricity demand, which is an obvious precursor for the uptake of CCT, once excess capacity is exhausted. As an important component of this growth, international trade protocols and the need to avoid discriminatory trade practices, especially on environmental grounds, require attention.

  It should, however, be stressed that catalysing economic growth by government and industry in developing countries is no guarantee that CCT will be adapted to meet electricity demand. There are numerous selection criteria (as detailed in previous sections of this study) which will be applied. Some of the measures which follow are proposed to enhance CCT in the selection procedures.

- **Application of the United Nations Framework Convention on Climate Change (UNFCCC)**
  Two of the most important criteria for power generation technology selection are cost and reliability. In this regard developing countries feel that the UNFCCC should be far more rigorously applied by the governments of developed countries in meeting the

full incremental costs of more efficient CCT over current conventional technologies. If this involves additional costs of redundancy to ensure reliability levels equivalent to current plant, then such costs should also be covered.

It is not considered appropriate or equitable for the governments of developing countries to fund the 'premium' costs of CCT.

In addition, the current pilot phase of 'Activities Implemented Jointly' (AIJ) should include an assessment of the potential for CCT to be used as future AIJ projects.

- **Research, development and demonstration**
  Whilst it is accepted that virtually all CCT are at or beyond the advanced pilot or demonstration stages, it is essential that such programmes be undertaken in a variety of countries. The perceptions around costs, availability and reliability will only be addressed if pilot projects are undertaken in the countries of final application, especially developing countries. This will also allow CCT to be tailored to meet unique local conditions and develop enabling capacity for ultimate application. It is thus essential that incentives for CCT pilot plants in developing countries be developed.

- **Technology transfer**
  In most countries, especially developing countries, current technological infrastructure and capacity are aligned with current technologies. There are limited skills available to develop parallel capacity in CCT. As such, it is suggested that intensive technology transfer programmes are entered into to develop this capacity. Technology transfer from developed to developing countries must take into consideration:
  - funding
  - long-term training in the receiving nation
  - development of a technological support infrastructure
  - technology adaptation to local conditions
  - life cycle funding.

  It must be stressed that technology transfer has to be applied in the most holistic sense possible. It is necessary to have systems in place that support the technology for its life cycle, not merely to the commissioned stage. In this regard, the ongoing capacity building component of technology transfer is a critical success factor.

- **Costs, availability and reliability**
  In order for CCT to penetrate the market they must clearly demonstrate business advantages over current technologies. Thus further efforts to reduce costs and improve availability and reliability should be intensified. CCT must demonstrate significant advantages over current technologies before they will be widely applied in developing countries. In this regard the pilot programmes mentioned above could have an important role to play.

- **Direct intervention**
  In developing countries, the government is often the main catalyst of new energy development, motivated by a variety of political factors and rarely driven by economic considerations. Whilst direct intervention is obviously a potential mechanism to increase the speed of application of CCT, it is generally non-sustainable in economic terms, especially where excess capacity exists.

- **Development of human capacity**
  In many utilities in developing or underdeveloped countries, significant efficiency improvements are possible via the effective application of current technologies, i.e. what is already in place. Therefore more attention needs to be placed on the training of skilled technical and managerial personnel. In particular, organisational skills in initiating and managing inter-utility projects across national boarders need to be developed. The greater local availability of such skills would be extremely useful in optimising efficiencies in a region such as Southern Africa.

References

(1) SHACKLETON, L, LENNON, S J and TOSEN, G R. Global climate change and South Africa. Environmental Scientific Association report, 1996.

(2) LENNON, S J. The enhanced greenhouse effect and the Southern African power industry. *Journal of Energy in Southern Africa,* 1993, **4**(1), pp. 22-26.

(3) LENNON, S J and DU TOIT, J. Energy and the environment in Southern and East Africa. *Journal of Energy in Southern Africa*, 1995, **6** (1), pp. 43-46.

(4) ESKOM. Statistical yearbook 1995. Eskom, 1996.

The micro hydropower supply scheme in

Figure 1: *Ntonyelana dam site*

Figure 2: *Ntonyelana turbine site*

Figure 4: *Dam construction*

Figure 5: *Dam viewed from up*

the KwaZulu-Natal Drakensberg

Figure 6: Completed dam viewed from downstream

Figure 8: Turbine and generating plant

am before fitting the plastic liner

Figure 9: Single Wire Earth Return Transmission line

Implementation of a micro hydropower supply scheme in the KwaZulu-Natal Drakensberg

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Received 25 February 1997
Revised 29 April 1997

Eskom has implemented a 5 kW micro hydropower supply scheme in the KwaZulu-Natal Drakensberg. The scheme supplies electrical power to five schools using a Single Wire Earth Return (SWER) transmission line. This paper describes the implementation of the scheme and covers the social aspects, the mechanical, civil and electrical works, and also scheme economics. The main aim of this project was to obtain experience in the design and implementation of a micro hydro system, both technologically and socially, so that the technology could be used with confidence in Eskom's non-grid electrification programme.

Introduction

This paper describes the implementation of a micro hydropower supply scheme in the KwaZulu-Natal Drakensberg. The scheme produces 5 kW of electrical power that is used to supply electricity to five schools. Electricity is distributed at 12,7 kV by means of a Single Wire Earth Return (SWER) transmission line system.

Eskom has committed itself to the electrification of schools as part of the South African Government's Reconstruction and Development Programme (RDP). Many of these schools are situated far from the national electricity grid, which makes the use of remote area power supply systems (RAPS) the most cost-effective option for electrification. Presently photovoltaic (PV) modules coupled with battery storage are mostly used for this purpose. Although photovoltaic technology is tried and tested and widely accepted it is not necessarily the most cost-effective option in all cases. It is therefore necessary to investigate other RAPS options which could be suitable for this electrification programme. One such option is the use of a hydro-powered turbine driving an electrical generator. Due to the small load demands of the schools, the turbines considered are relatively small and are known as micro hydro turbines. The applicability of hydropower is determined by the site, with a constant supply of water falling through a reasonable head being necessary.

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In order to determine whether micro hydropower is a feasible option for remote area power supply in Southern Africa it was deemed necessary to implement such a system as a pilot project. The main aim of the project was to obtain experience in the installation and implementation of a micro hydro system, both technologically and socially, so that the technology could be used with confidence in Eskom's non-grid electrification programme.

It was decided to concentrate on the area known as the Upper Tugela Location in the KwaZulu-Natal Drakensberg during the site selection process. This area is the only area of the KwaZulu-Natal Drakensberg with a permanent population. It is extremely underdeveloped, even for an area in the foothills of the Drakensberg. Sites in the area were visited and investigated as to their suitability for the application of the technology.

For the successful implementation of the scheme a great deal of effort had to be put into gaining the acceptance of the local community. Due to the remoteness of the area and the fact that the community would have to maintain the scheme, a sense of ownership of the scheme had to be instilled. This was done by using local labour during the construction phase, and by making the labourers and community feel part of the decision-making process. Where possible low cost, labour-intensive technology was used in the construction of the scheme, including the utilisation of local labour.

The feasibility of micro hydropower as a RAPS option is dependent mainly on the costs of implementing, operating and maintaining such a system. The costs are presented as a unit energy cost that is compared to other electrification options suitable for the area, such as grid extension and photovoltaics.

Site selection

As part of Eskom's non-grid electrification programme, schools without electricity were identified across South Africa. Some of these schools were located in an area of the KwaZulu-Natal Drakensberg known as the Upper Tugela Location. As already mentioned, this is the only area in the Drakensberg with a permanent population. Two main rivers flow through the area, namely, the Mnweni and Ntonyelana. Consultation with the local population, the study of topographical maps and documented hydrology data[3] showed areas that could be considered favourable for micro hydro application.

Mnweni River

An investigation conducted in 1992 by Eskom had found a site on the Mnweni River suitable for a micro hydro application. This site was surveyed and a scheme designed[4]. Electricity was to have been supplied to a group of nine dwellings in the vicinity of the site. The scheme was not implemented for reasons discussed below.

With Eskom's non-grid electrification programme for schools becoming a priority in 1995, it was decided that the site surveyed in 1992 would be ideal for the implementation of a micro hydro pilot project. Electricity would be supplied to a school (the Nsetheni Primary School) in the vicinity, instead of to the dwellings previously earmarked for electrification.

With the permission of the local community the site was surveyed and a scheme designed. Construction began in October 1995. Late in November 1995 the area experienced heavy rainfalls with severe flooding. The Mnweni River could not be crossed to gain access to site and work had to be stopped. The floods also showed that any dam built on the Mnweni River would have to be a properly designed and constructed concrete structure. The dam planned for this scheme was to be a low cost weir constructed from gabions and rocks that could be installed and maintained by the local community. It became apparent that if low cost technology was to be used a new site had to be found. It was decided that although the Mnweni River had at first appeared suitable, it was too large and uncontrollable for micro hydro application.

Ntonyelana River

After investigating various other sites pointed out by the local community and not finding any of these suitable, a 1:50 000 topographical map was studied and a few sites on the Ntonyelana River earmarked for further investigation. A dam site particularly suitable for utilising low cost materials in construction was found approximately 3 km from the Ntonyelana School. At this site a dam could be built parallel to the main river that would greatly reduce the chances of damage from flood waters and rocks brought down by these flood waters. Another feature of the site was that the river was partially blocked off with large boulders that could be used to support the dam wall (Figure 1).

From the topographical maps it was determined that the river fell 20 m in 800 m. This was checked using an altimeter. Once a preliminary site for the turbine had been decided upon the route was surveyed using a dumpy level. The turbine site is shown in Figure 2.

The pipeline route was marked out using string and pegs once the hydraulic gradient had been plotted and the head confirmed.

Social aspects

In 1992 Eskom began negotiations with the local community on the implementation of a micro hydro scheme on the Mnweni River, close to the settlement of Nsetheni. The area is inhabited by the Amangwane tribe. It was proposed that the scheme would supply power for lighting to dwellings situated on a hill above the scheme. Following an extensive site survey a scheme was designed and presented to the community for approval. After discussions with various parties attached to the tribe, the scheme was rejected. The main reasons for the rejection of the scheme were that the community was not consulted as to whether they even wanted such a scheme, nor was the technology properly explained to them. Another factor influencing the decision was that only a small section of the community would benefit from the scheme, which seemed unfair to those that would not.

In March 1995 Eskom Community Development, based at the Drakensberg Power Station, organised a demonstration of micro hydro technology using the test site at the power station. Representatives of the local population in the area where the technology was felt to be applicable were invited to attend.

The technology was demonstrated by powering a TV set, a kettle and an electric heater. The principles of micro hydropower were explained to the representatives. Great interest was shown and the suggestion was made to Eskom that such a system be installed on their river. The representatives would, however, first have to discuss this with the community.

Six months of negotiations with the community and various community-appointed committees were necessary before permission was obtained to implement a micro hydropower supply scheme.

Due to the remoteness of the area and the fact that no Eskom technical support structure was presently in place to assist if any problems were experienced in the running of the scheme, it was imperative that the local community be involved in the implementation process.

The Upper Tugela Location is populated mainly by subsistence farmers. It was felt that by using local labour two main objectives could be met. Money spent on labour would directly benefit the community and the labour force would gain experience in the installation of a micro hydro scheme. This experience would be invaluable if the system was to be maintained by the local community. The use of local labour would also enhance the feeling of ownership.

A team of labourers, with a foreman, was organised through the Mabulisini Development Committee (MDC). It had been decided between Eskom and the MDC that any decisions pertaining to the project would be relayed through a community-appointed representative. The chairman of the MDC was chosen as this representative and would also double as the foreman. By working through the Committee, Eskom was perceived to be helping the community implement the scheme rather than forcing the scheme on the community. Eskom could thereby also detach itself from any local politics, and the effect of Eskom's limited experience in local customs and traditions would be minimised.

In addition to the 'permanent' labourers, others had to be employed to transport the pipes to the site. These labourers were organised by the foreman and were paid per pipe delivered.

Throughout the duration of the project, technical decisions were relayed to the labour force and an explanation given as to why certain decisions were made. This generated a basic understanding of the engineering principles of micro hydropower generation, which was necessary if the community was to maintain the scheme in the future without external help. A sense of having an input other than just manual labour was also generated in the workforce by means of this process, thereby enhancing the sense of ownership.

Civil works

Description of the scheme

From the survey, the length of the waterways was determined to be 806 m. This consisted of a headrace of a 250 mm diameter pipe, 746 m long, a surge tank

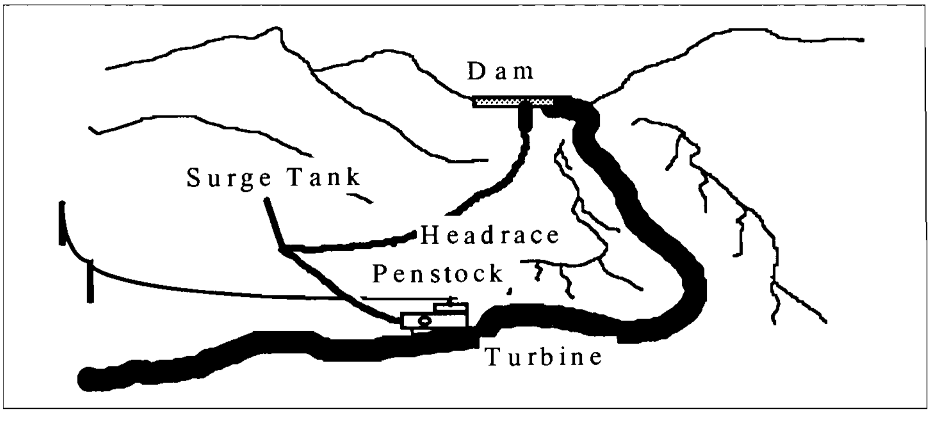

Figure 3: Components of the Ntonyelana micro hydro scheme

consisting of three lengths of 250 mm diameter pipe and three lengths of 400 mm pipe, giving a total surge tank length of 36 m. The penstock is 60 m long and was constructed from 200 mm diameter pipe.

A 2,1 m high dam feeds the water intake to the pipeline. A valve was fitted at the dam in case it is ever found to be necessary to shut down the water supply.

A net head of 17 m is obtained and with a flow rate of 56 litres/second the power output at the generator is 5,9 kW. The design of the scheme is described in detail in another publication[1] by the author.

The dam

The dam collects diverted flow from the river at sufficient depth for the water intake to draw water without the creation of vortices. The dam wall is approximately 20 m long and the dam is 2 m deep at the water intake. It was constructed using labour-intensive, low cost technologies and consists of rock-filled gabions covered in plastic sheeting.

Sediment and rocks on the river bed behind the natural dam were removed and a trench cut into the right bank of the dam.

A rock footing was packed on the dam floor in order to obtain a level surface on which the dam could be built

The gabion was cut so as to sit flat on the rock footing and is supported from behind by the two large rocks forming the natural dam. The gabion was filled with rocks collected from the river bed (Figure 4).

The intake screen was constructed using two 1m high gabion pods fitted one on top of the other. The bottom half was filled with rocks to keep the screen in place. The screen was then covered in wire mesh. Figure 5 shows the dam before the fitting of the plastic dam lining.

Plastic dam lining material was used to seal the dam wall. A trench was dug in the river bed into which the lining was placed. This was then packed with rocks so as to prevent water from flowing through under the dam.

The dam wall was covered with rocks to protect the plastic sheet from UV radiation and also to add strength to the dam. Also, the rocks make the dam seem less obtrusive from an environmental point of view (Figure 6).

During construction most of the dam side water flow was channelled back into the river. For dam filling purposes the water was channelled into the dam. The inflow into the dam is controlled by channels formed with packed rocks.

Water intake

The water intake is the inlet to the pipeline. It consists of a custom-made bellmouth fitted to a 90° bend of a 250 diameter uPVC pipe.

The water intake was fitted in between the two layers of gabion (wire cage). The top gabion was cut to fit around the pipe. The bellmouth inlet was fixed by means of a bolt only after the dam lining and intake screen had been fitted.

The valve

The valve is installed in case it becomes necessary to shut down the flow, for example, if maintenance on the pipeline or turbine is undertaken. The valve is of the lever-operated butterfly type.

The valve was the last component to be fitted. A thrust block was cast with protruding brackets in place. These brackets would keep the valve in place and transfer opening and closing forces to the thrust block and not to the pipe.

The pipeline

The headrace is a low pressure pipeline that conveys water from the dam to the surge tank. The headrace is 746 m long and consists of a 250 mm diameter uPVC Class 4 pipe.

After completing the survey of the pipeline route, the route was marked with line and pegs. A 760 m long trench, 400 mm deep by 400 mm wide, was dug in which to lay the pipeline. Excavation was done by hand, using only shovels and picks.

Most of the route is relatively flat, except for the penstock section. Rocks were removed by hand with the aid of a crowbar. Rocks too heavy to be lifted from the trench were moved into holes dug to one side. Part of the route runs through a section of the river that is dry for most of the time, except when the river is in flood. The pipeline route through this area was made to hug the river bank and a retaining wall was built to protect the pipe.

A 10 m long sandstone ledge at the dam had to be excavated to a depth of 0,5m. This was done using electric breakers powered by a portable generator.

The pipeline was installed using a crowbar and a wooden block. Once positioned the pipes were pushed home.

Backfilling was done by using soil removed from the trench that was replaced and tamped thoroughly. Care was taken to ensure that no rocks were in contact with the pipeline.

The penstock is the pipe that conveys water under pressure to the turbine. For this scheme the penstock is 60 m long and constructed from a 200 mm diameter uPVC pipe.

From the surge tank, the penstock route runs down a hill of 17,5° before crossing 3 m of flat terrain and then dropping to the turbine. The penstock was installed from the turbine side and ends at the cast iron T-piece for the surge tank connection.

Vacuum breakers are required immediately downstream of the isolating valves and at high points along the pipeline route to expel air during the partial or complete emptying of the pipeline. The vacuum breakers consist of 2 inch pipes, open to the atmosphere. The pipe height is determined so as to be level with the full supply level of the dam.

The surge tank

The surge tank regulates flow variation and is required for the stable operation of the turbine/generating plant. It is manufactured from uPVC Class 4 pipe. Three 6 m lengths of 250 mm diameter pipe are connected by means of a specially manufactured reducer to three lengths of 400 m diameter pipe. The opening is covered with a mesh screen upon which rocks are packed.

The surge tank was installed on a hill of 22.7°. A cast iron T-piece connected the surge tank to the penstock. A mesh-covered welded grid was fitted to the open end of the surge tank, which was then covered with rocks.

Mechanical design and works

The turbine

In this application the turbine used was a locally developed Francis turbine. Instead of the spiral casing usually found on Francis turbines, a less expensive front barrel design was used. Water flow into the runner is controlled by means of adjustable guide vanes. These guide vanes are set for optimum performance at a specific site and are not meant to be used for governing purposes. The runner was manufactured from cast aluminium bronze. The turbine is of a standard design suitable for a head range of between 15 m and 35 m.

Typical performance figures for full load are shown in Figure 7.

Mechanical works (Turbine installation)

The turbine foundation was constructed in three steps. Holes were drilled into the base rock into which steel reinforcing bars were grouted. The reinforcing frame was constructed by fixing horizontal supports to the vertical bars with wire. A chipboard shutter was placed around the reinforcing on the rock. Concrete for the foundation was made using cement, clean river sand and pebbles. The reinforcing for the thrust block was left open. Afterwards the turbine was fitted into place and the thrust block cast.

The turbine was installed in the middle of the rainy season. With the river in flood it was found that the turbine was covered by water. Although the water would not reach the generator, this state of affairs was considered unacceptable. In order to obtain a drop in the water level it was decided to widen the river at the turbine site. Approximately three meters of the river bank was removed. It was also noticed that during floods a part of the river would travel straight across the bank furthest from the turbine, joining the rest of the river further downstream. A shallow channel was thus cut into this path making it easier for the water to flow straight over the bank. This channel was opened up substantially by further floods. Since effecting these modifications, turbine submergence has not reoccurred.

Commissioning of the turbine and pipeline

In order to remove any debris that might have collected in the pipeline, the line was flushed, with the turbine removed for a period of 24 hours. After flushing, the turbine was replaced.

The turbine was run without the generator during commissioning. A head of 204 kPa was obtained. This was measured with a calibrated pressure gauge attached to the turbine.

Once it had been determined that the pipeline was leak-free, all uncovered pipe was covered with rocks. This is necessary to protect the pipe from UV radiation. An added benefit of the covering is that the system makes very little visual impact on the environment.

After commissioning, the generator, dummy load and electronic load controller were fitted. A shelter was constructed to offer a degree of protection from the elements. This shelter was not enclosed as damage during floods was feared. The turbine and generating plant is shown in Figure 8.

Net head (m)	Turbine speed (rpm)	Flow rate (litre/s)	Alternator (kW)
15	2 126	52,7	4,4
20	2 155	60.8	6,7
25	2 745	68,0	9,4
30	3 007	69,4	11,5
35	3 248	59,5	11,5

Figure 7: Full load performance figures for the turbine

Electrical power generation and transmission

Overview

The turbine shaft power is transmitted to a single-phase synchronous generator by means of a flat belt and pulley drive. This arrangement enables the individual speeds of both turbine and generator to be optimised by changes in pulley diameters. The generator speed and frequency are controlled using an electronic load controller that presents a constant electrical load to the generator. This is done by employing a 'dummy' load into which all or part of the generator output can be 'dumped' using a frequency-sensing thyristor controller. The sum of the actual load and the 'dumped' load is always constant. In this particular case the dummy load is a 6 kW water-cooled heater element. The constant electrical load is converted by the generator into a constant mechanical load that, with fixed turbine guide vane settings and fixed water supply head (pressure), will result in constant speed.

The electrical power generated is fed at 230 V, 50 Hz to a pole mounted step-up transformer. The voltage is stepped up to 12,7 kV and transmitted by means of a Single Wire Earth Return transmission line to the five schools. The line is constructed using steel staywire as conductor that is strung on 11 m poles using conventional mounting hardware. The earthing for the earth return is obtained using an earth electrode at each transformer. The start of the transmission line at the turbine is shown in Figure 10.

The line and generator are protected using a current monitoring relay that will disconnect the system from the generator if pre-set current and time values are exceeded. In the event of such a disconnection the turbine and generator will continue to run at normal speed with the entire power output being dumped into the water-cooled resistor. Lightning protection is provided by using lightning arrestors on the high voltage line at each transformer.

The system has the capacity to provide each school with 1 kW of power. This allows for lighting in six classrooms (4 x 20 W fluorescents per classroom, a total lighting load of 480 W per school) and also for educational appliances, such as a TV (150 W), a VCR (150 W) and an overhead projector (300 W). Load limiting is provided on the socket outlet circuits through the use of 2,5 ampere circuit breakers used in conjunction with the earth leakage protection units. This provision will limit long-term power consumption to approximately 1 kW at each school. The turbine and generator have adequate excess capacity to cater for the starting loads of devices such as overhead projectors. The high voltage transmission system has capacity for double the output that can be obtained from the present turbine and generator combination. This situation is not intentional but came about because smaller transformers were not readily available at the time of line construction. The school wiring is conventional and is done strictly in accordance with SABS specification 0142[5].

The line was installed by a contractor. Local labour was used for the digging of holes, pole planting and transport of poles and equipment.

The electrical configuration is shown in Figure 10.

System economics

It is necessary to justify the financial feasibility of the scheme if micro hydro is to be taken seriously as a RAPS option. The Ntonyelana micro hydro plant is compared to grid electrification and photovoltaic systems that could also have been used to electrigy the schools. The costing methodology used was obtained from Cowan *et al.*[1]

The following assumptions are made for the calculations of the unit energy cost:

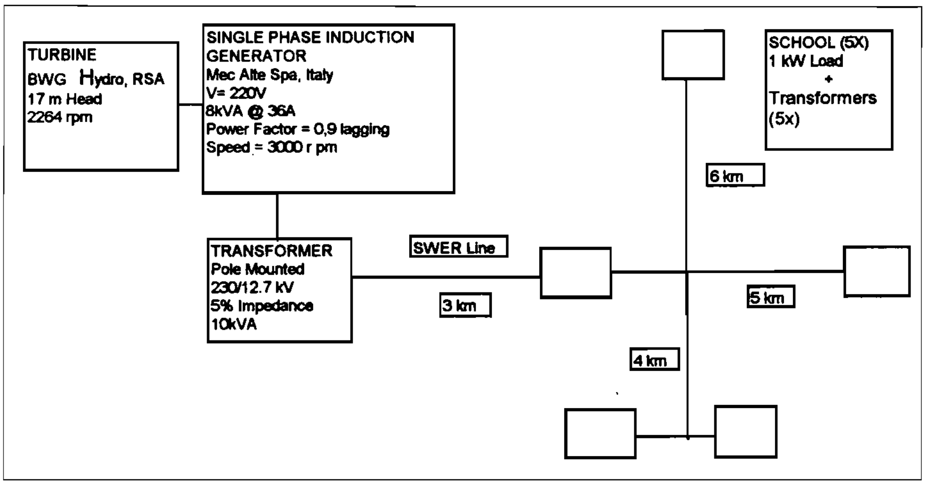

Figure 10: Basic electrical configuration of the scheme

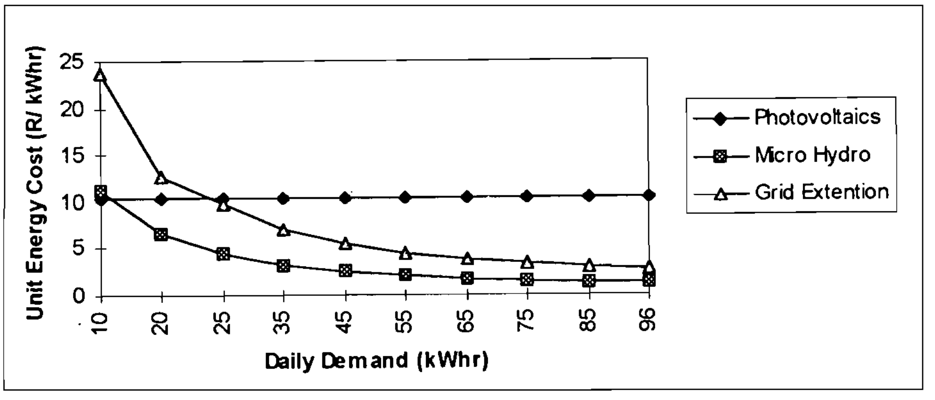

Figure 11: Comparison of electrification costs for schools in the Ntonyelana Valley

- The load requirement is for 365 days per year.
- For the micro hydro scheme a value of R5 000 is allowed for system maintenance every five years. The capital costs of R500 000 used in the calculation is the sum that was spent on the research project. This value could be halved on a pure implementation project.
- For the photovoltaic systems, a value of R3 000 per school is allowed for maintenance every year, which is in line with what is being paid on the NGE school electrification programme. A capital cost of R50 000 per school is used.
- The distance used for the grid extension is 20 km, which is the distance of the school furthest from the grid. The closest school is 13 km. Eskom rural tariff "D" is used to calculate costs.
- A discount rate of 5% is used.
- An operating lifetime of 20 years is used in the cost calculations.

Figure 11 compares the unit energy costs of micro hydropower generation, photovoltaics and grid extension for the five schools electrified in the Ntonyelana Valley.

Conclusion

Discussion

The benefits of the scheme

Although the Ntonyelana micro hydro project was in effect a case study, the technical methodology followed for implementation could be applied to similar projects. Technical experience gained in implementing the scheme could be used as the basis for the implementation of other such schemes. The social experience gained was invaluable and the lessons learned should be applied in Eskom's non-grid electrification programme.

From Eskom's point of view, the goodwill and trust that has been established in the community can be used to Eskom's advantage for the implementation of other RAPS projects. The scheme and its implementation can also be used as an example of Eskom's commitment to the RDP.

Eskom's capital investment in electrifying the five schools by means of hydropower was approximately double what it would have been to supply photovoltaic systems of the same size as installed at other rural schools. It must, however, be borne in mind that much of the cost is associated with meeting the research goals and the learning curve in installing such a system. If a structure existed within Eskom that concentrated on electrification using hydropower and it had all necessary resources at its disposal, the costs would be greatly reduced and would compare favourable with other options on a captial cost basis. Notwithstanding the above and using the total research project value as the basis, the costs per kWh were less for the hydro scheme than for other electrification options. The added benefits gained from the scheme such as, water pumping and battery charging capabilities, possible development of small factories, increased peak load capability and community self-sufficiency in terms of maintenance costs, can be considered as the justification for the high capital costs.

By using, in this case, the most cost-effective option for its non-grid electrification programme, Eskom is keeping its mandate to its customers to strive to keep down the real price of electricity.

Eskom has committed itself to the electrification of rural schools and clinics as part of the RDP. Most of the funding used is aid funding and it is therefore imperative that these funds be used so as to obtain the most benefits for all parties concerned. The system economics show that in this case the scheme is the most cost-effective way to supply electricity to the area. The use of local labour created employment in an area dependent on subsistence farming for making a living. Also, by keeping the community informed on all aspects of the project, a sense of ownership of the scheme was instilled within the community. The performance of semi-skilled tasks as described in the text can be considered as training and thus could be useful when members of the community involved apply for employment in the private sector. Although the full impact of the electrification of the schools cannot be measured at this stage, approximately two thousand pupils are likely to benefit. They will have an improved environment in which to learn and access learning aids such as, TV, videos and overhead projectors. It will now be possible to implement after-hours adult education projects, as well as providing the community with suitable centres that can be used for entertainment and meetings. In addition to the obvious benefits of having battery charging centres in the area, the community will have the means to generate its own funds for the maintenance of the system and other development work. Water pumped to reservoirs at the schools would greatly alleviate the arduous task of drawing water from the river. Permanent employment can be created for a team of people who would be in charge of scheme maintenance and battery charging.

The technical environment

Site selection

In retrospect the site selection procedure followed prior to the choosing of the Ntonyelana site cannot be considered ideal. Although two sites were visited at the start of the project, the fact that a design had already been completed a couple of years previously for a scheme on the Mnweni River, made this site a favourite. This resulted in the investigation as to its suitability being conducted with a bias and the potential of other sites not being fully investigated. As discussed earlier in the paper, this site was later found to be unsuitable for various reasons. By this time, a new design had already been formulated, along with a substantial amount of work in planning for the implementation of a micro hydro scheme at this site.

The techniques and materials employed for the construction of the scheme proved effective. Although some problems were encountered these were surmounted in all cases.

The construction phase of the project was implemented in the summer months of November 1995 to April 1996, during the rainy season. The rainfall experienced in South Africa in 1995/1996 was the heaviest in years. The wet conditions made travelling to the site extremely difficult, with roads usually only being negotiable by means of four-wheel drive vehicles. In order to get to work, most of the workforce had to cross rivers in flood. Understandably, this was not always possible and many man-days of work were lost due to a reduced workforce, or none at all. If it rained at the site, personnel would invariably have to either work in the rain or stand around under what shelter they could find. This made for extremely unpleasant working conditions. Tasks such as the construction of the dam and the installation of the turbine could not be performed with the river in flood, leading to a delay in the completion of the project.

Logistics

The remoteness of the area and the nature of the terrain made site visits and the transport of equipment to the site extremely difficult. A truck or pick-up can travel the dirt road to Ntonyelana School under dry conditions, but if rain falls, within two days, the road becomes very slippery and can only be negotiated, albeit with difficulty, by means of a four-wheel drive vehicle. Under such conditions, the 4 km from Ntonyelana School to the turbine site could only be negotiated by a four-wheel drive vehicle.

Pipes were transported to Ntonyelana School by truck. The first truck, supplied by a courier service, had to be towed along the 60 km dirt road by tractor. A second truck, supplied by the Drakensberg Power Station, delivered the last batch of pipes under drier conditions.

From Ntonyelana School 136 pipes were carried to the site on foot. These pipes weigh 40 kg each and are 6 m long. The pipes for the surge tank, 6m long, weighing 80 kg and being 400 mm in diameter, could not be carried and were transported on the back of a four-wheel drive vehicle.

Future work

The technology has proved to be technically and economically feasible as a RAPS option. It should be implemented as part of Eskom's non-grid electrification programme. Areas deemed suitable for micro hydropower generation should be earmarked. This could be done by either studying topographical maps and identifying suitable sites or by corresponding with Eskom representatives in various areas and requesting them to identify potential sites. These sites should then be investigated for possible application

The concept of using mini-grids for the transmission of remote area electricity from a central supply should also be investigated further.

The use of battery charging centres and other options, such as mills, as means of job creation and giving a community the means to earning an income, should be investigated.

Conclusion

The implementation of a micro hydropower supply scheme on the Ntonyelana River can be considered a success, both from a physical point of view and also in the meeting of the research goals. Notwithstanding problems with the weather and an unsuitable research environment the project implementation ran smoothly. The cooperation of the local population and enthusiasm of the workforce were major factors contributing to the project's success. The work could not have been done without the help of role-players, such as Eskom Community Development, BWG Hydro Developments, Eskom's Distribution Group and Eskom's Technology Group. The importance of the social aspects in this type of work was stressed. Without this phase being conducted properly the project would not have got off the ground.

Acknowledgments

Bruno Graber, BWG Hydro Developments.

Graham Gentles, Eskom Non-Grid Electrification.

Eksteen Dippenaar, Eskom Community Development.

Johan Griessel, Eskom Non-Grid Electrification.

Debbie Handcock, Eskom Non-Grid Electrification.

Barry Neil and his staff, Eskom Survey Office, Ladysmith.

Ian Fergusson and his staff, Eskom Distribution Group, New Germany.

Piet van Dyk and his staff, Eskom Quality of Supply, Bergville Depot.

References

(1) COWAN, W D. *et al.* RAPS design manual. 2 Vols. Energy and Development Research Centre, University of Cape Town, 1992.

(2) DOOGE, G R. Implementation of a micro hydropower supply scheme in the Kwa-Zulu-Natal Drakensberg. Research Report TRR/NGE96/022. Eskom Technology Group, 1996.

(3) FLAKE, D. Micro hydro project of the Tugela River. Eskom Generation Group, Hydro and Water Supply Division, 1992.

(4) FORSYTH, A G. Micro hydro development project report. Eskom Generation Group, Hydro and Water Supply Division, 1992.

(5) SOUTH AFRICAN BUREAU OF STANDARDS. SABS 0142-1987: Code of Practice for the wiring of premises. South African Bureau of Standards, 1987.

SHORT COMMUNICATION

Energy complacency threatens sustainability: WEC message 1997

Keywords: sustainable energy; developed countries; developing countries

The global energy scene

For most people in industrialised countries, energy supplies may not seem much of a problem. They have rarely been so plentiful. Reserves of fossil fuels are abundant. They appear exploitable throughout the next century provided technology advances sufficiently and adequate capital is available. Consumers are therefore complacent – energy supplies are not their concern. The trouble is that the many major issues are not being sufficiently highlighted.

Despite the apparent abundance of fossil fuels, 40% of the world's population – over 2 billion people – mostly in the developing countries, have no access to today's commercial energy and therefore cannot satisfy their basic needs. For them suggestions of complacency are meaningless. These communities are unable to even consider economic development as they are obliged to rely on fuelwood and wastes to supply their energy requirements.

Because the world population is likely to double over the next century, with most of the increase being in the developing countries, the stresses caused by a lack of energy will increase unless tackled with determination. If they are not addressed successfully, the deteriorating longer-term situation could have profound geopolitical consequences, as well as severely adverse environmental impacts, such as deforestation and soil erosion.

However, assuming success in making commercial energy available, most of this additional demand will be taken up by today's developing economies. Developing countries account for 35% of world energy consumption. Many already suffer the effects of poor local air quality. By 2050 they are likely to use over 60% of the world's primary energy. Today the industrialised countries contribute more than any other group of countries to atmospheric emissions from the burning of fossil fuels. By 2020, the primary emitters will have become the developing countries, and their share will continue to grow, although at lower per capita emissions levels than in the industrialised countries.

Even with big improvements in energy efficiency, the world will consume much more energy in the coming decades. Work undertaken by the WEC indicates at least a doubling by 2050 in most scenarios.

> "Because the world population is likely to double over the next century, with most of the increase being in the developing countries, the stresses caused by a lack of energy will increase unless tackled with determination. If they are not addressed successfully, the deteriorating longer-term situation could have profound geopolitical consequences, as well as severely adverse environmental impacts, such as deforestation and soil erosion."

With the continuing advancement of technology and with the investment of the necessary financial resources, there would appear to be adequate accessible oil, gas and coal to supply most of these future needs. There are also non-conventional oil and gas resources on which to draw. However, fossil fuels will continue to dominate energy use into the foreseeable future.

In order to reconcile the increasing use of energy in support of economic and social development with protection of the environment, greater efforts are required. These are:

- to improve the environmental performance of fossil fuels;
- to raise more rapidly the efficiency with which all forms of energy are provided and used;
- to increase the use of non-fossil forms of energy.

Action now

The reconciliation of economic and social development based on increased energy use and the protection of the environment is often referred to as the 'pathway to sustainable development'. It calls for a truly global effort led by the industrialised countries.

The WEC therefore advocates:

- **Creating rapid and effective measures to raise global energy efficiency**. The energy intensity rate (that is, the energy required to produce one unit of gross domestic product) continues to decline at the long-term rate of only 1% in many countries. This performance is far from what is possible by using today's technology more efficiently. Means to achieve increased efficiency include:
  - greater efforts to be given to national education and publicity campaigns;
  - incentives to increase vehicle and electricity generating efficiency;
  - encouragement to industry and end-use consumers to invest in new, energy-efficient capital equipment.

- **Expanding institutional action to improve the transfer of state-of-the-art energy and environmental protection technologies between nations.** Successful examples of existing schemes include the recent electricity Group of Seven initiative and aspects of the European Union Phare project.

- **Encouraging energy prices to consumers to converge on market prices.** This may take time in many countries, especially if it involves phasing out subsidies. But only full market prices will, in the end, discourage waste and inefficiency – and enable the necessary flows of capital to occur which will finance the infrastructure investments required.
- **Making more effective use of research and development expenditure.** By 2050 the world will need to use all forms of energy to satisfy its requirements and continued technological advancement is accordingly required for all forms of energy. Particular attention should be paid to the research, development and demonstration (RD&D) projects and the financing of renewable (solar, wind, biomass, etc.) forms of energy, as these are not yet fully developed commercially. With adequate support the share of new renewable energy supplies, currently only 2%, could reach 5%-8% of increased world supply requirements by 2020. This may be of particular value in many developing countries, and especially relevant in Africa.
- **Taking cost-effective precautionary measures to curb atmospheric emissions.** In particular, accelerated improvements to the environmental performance of fossil fuels are needed through clean coal technology, less polluting petrol and diesel engines, more efficient power stations and better pollution abatement.
- **The extension of the 'polluter pays' principle, and determined efforts to achieve widely accepted standards of measurement, with regard to environmental impacts and costs.**
- **Establishing conditions under which nuclear energy could make an increased contribution to energy supply.** This means securing high safety performance and good operating practices, and demonstrating that nuclear waste can be managed safely. The nuclear industry needs to ensure that these facts are communicated successfully and comprehended by the general public.

The actions proposed can provide the essential basis for future sustainable energy development.

A global commitment is needed

The future resources needed for technology development, project financing, the management of the expansion of energy demand due to population increase and economic development, and improving access to commercial energy supplies for the 2 billion people worldwide without them, are huge. The scale of the requirements means that energy systems can only be changed gradually. Tomorrow's systems will take many years to develop. It takes decades for energy projects to build up the required critical mass to impact on a global scale. Unless action is taken now to accelerate these processes, the future sustainability of energy production and use runs the risk of being badly compromised – to the disadvantage of all.

Acknowledgement

Appreciation is hereby expressed to the World Energy Council for permission to use this information, and to the South African National Energy Association (SANEA) for their assistance.

SHORT COMMUNICATION

South African National Energy Association (SANEA)

Keywords: SANEA

The South African National Committee of the World Energy Council (SANC-WEC) was recently renamed the South African National Energy Association (SANEA). SANEA is the South African member committee of the World Energy Council (WEC).

SANEA's mission

SANEA's main mission is to support the objective of the WEC by promoting the sustainable supply and use of energy for the greatest benefit of all. It ardently supports the WEC and its initiatives, with a focus on South Africa. It also disseminates current energy information through papers and publications, and through forums and stimulating informed discussions creates an awareness of the energy situation and future scenarios.

SANEA is active on several WEC committees, and has permanent representation on the following:

- Financing the global energy sector – The task ahead
- The benefits and deficiencies of energy sector liberalisation
- Global energy perspectives to 2050 and beyond
- Rural energy project
- Performance of thermal generating plant
- Global transport and energy development: The route to the future.

SANEA's focus

Emphasis is placed on energy supply-side aspects and on providing a forum for interaction amongst representatives of all sectors within the South African energy industry. Special consideration is given to overarching energy issues (such as, energy efficiency, environment, sustainable energy supply, etc.) and the role that energy provision plays in a developing nation.

SANEA's strategies

The following strategies summarise the role which SANEA anticipates in and for the South African energy industry:

- to provide an advisory body on energy matters to the National and Provincial Governments, as well as Southern African regional and other organisations
- to create a credible umbrella association representing all energy sectors in South Africa – thus facilitating interaction and cooperation amongst all energy players
- to establish a forum for consultation for the energy industry, the National and Provincial Governments and other organisations on issues of mutual and public interest
- to create a channel for energy industry opinion
- to provide a conduit and network through which support around the world, regionally and nationally, may be obtained or given on energy matters
- to disseminate energy information to SANEA members and throughout the Southern African energy industry
- to act as a catalyst for the stimulation of projects, studies, research and adequate training to ensure the continued strength of South Africa's energy industry
- to align SANEA's mission and strategies with those of other Southern African WEC Member Committees and with regional cooperation activities (e.g. via the Africa Energy Programme)
- to facilitate the harmonising of provincial, national and regional energy policies, strategies and programmes on the basis of common interest
- to form collaborations and alliances with organisations involved with sustainable energy development within South Africa, regionally and internationally, e.g.
  - the SADC Energy Sector's Technical and Administrative Unit (TAU)
  - E7 Group of leading energy services and suppliers
  - environmental organisations

SANEA membership (as at April 1997)

Chairman

Mr A J Morgan
Chief Executive
Eskom

Director

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Organisation	Represented by	Position
Eskom	Mr A J Morgan Mr B T Crookes	Chief Executive Executive Director (Generation)
Department of Minerals and Energy (DME)	Mr J A Basson Dr A Surridge	Chief Director, Energy Director, Electrical Energy
Atomic Energy Corporation (AEC)	Mr K Brown	Senior Manager
CSIR	Mr D Krueger	Manager, Technology for Development (Lubisi Project)
GEC Alsthom International	Mr K Maxted	Resident Director
Industrial Machinery Supplies (IMS)	Mr H Berger Mr C Birch	Executive Chairman General Manager
South African Institute of Electrical Engineers (SAIEE)	Mrs M Davison Mr B Jackson	Immediate Past President Member
Amcoal	Mr H Stacey Mr R Cohen	Marketing Director Consultant: Energy
South African Institute of Mechanical Engineers (SAIME) Energy Research Institute, University of Cape Town	Professor R K Dutkiewicz Professor R K Dutkiewicz	Member Director

Organisation	Represented by	Position
Siemens Limited	Mr F Schutte Mr D Maurer	Divisional Managing Director Business Development Manager
Fluor Daniel SA	Mr M Sterne	Marketing Manager, Power & Maintenance Services
NEI Africa	Mr J Kempster Mr R Dean	Group Managing Director Board of Directors
Rotek Industries	Mr B Perizhorn	Chief Executive
Ingwe Coal Corporation	Mr E Rorke Mr J Pain	Group Manager Projects Senior Project Engineer
Sasol Technologies	Mr J Marriott Mr F Botha	General Manager General Manager
Babcock Africa	Mr B McCabe Mr G Heale	Managing Director Marketing Director
Liquefied Petroleum Gas Safety Association of Southern Africa	Mr C Bain	Managing Director
GEA Aircooled Systems	Mr F Vogt	Managing Director
ABB Powertech Transformers	Mr K Plowden	Deputy Chief Executive
Shell SA	Mr J Dreyer	Managing Director
Southern African Institute of Energy	Mr N Roberts Mr A Tew	President Immediate past president
Department of Labour	Mr B French Mr W Benjamin	Director, Electrical and Mechanical Engineering Deputy Director, Electrical and Mechanical Engineering
Howden Africa	Mr J Moodie Mr J van den Bergh	Group Director Executive Director
Steinmuller	Mr J P Schneider	Managing Director
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GEC Alsthom South Africa	Mr A Tshabalala	Group Commercial Manager

OBSERVERS

Cigré	Mr J Gosling	Technical Resources & Development Manager (Eskom)
SADELEC	Mr I Israelsohn	General Manager

SANEA draws its membership from all segments of the South African energy community – energy producers, energy users, energy associations, financial organisations, engineering firms, educational institutions, equipment manufacturers, and government departments.

Membership of SANEA offers:

- opportunities to influence the energy policy of South Africa by providing input via the South African National Energy Association
- access to networking opportunities with energy decision makers, both nationally and internationally
- rapid access to current and authoritative information on energy statistics and policies
- awareness of energy issues in South Africa and around the world
- being part of the association which is representative of the country's energy needs across the full spectrum
- becoming actively involved in the WEC and SANEA's energy projects and studies.

SANEA is a non-profit organisation funded by its membership and largely based on WEC principles.

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COMPARATIVE ENERGY COSTS IN SOUTH AFRICAN CITIES RELATED TO HEATING VALUE

MAY 1997

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)	317,00	91,20	R/Ton	1,13	0,33	0,73	3,48	1,00	2,24	28,0	MJ/Kg
Elect.	22,54	24,43	c/kWh	6,26	6,79	6,25	19,22	20,84	19,19	3,6	MJ/kWh
Heavy Furnace Oil	95,83	115,78	c/litre	2,34	2,82	2,34	7,18	8,67	7,18	41,0	MJ/litre
Illum. Paraffin	127,26	140,82	c/litre	3,44	3,81	3,44	10,56	11,69	10,56	37,0	MJ/litre
Petrol (Premium)	215,00	222,00	c/litre	6,20	6,40	6,20	19,02	19,64	19,02	34,7	MJ/litre
Diesel (Heating)	209,65	221,05	c/litre	5,40	5,70	5,40	16,59	17,49	16,59	38,8	MJ/litre
Power Paraffin	180,12	194,14	c/litre	4,80	5,18	4,80	14,75	15,89	14,75	37,5	MJ/litre
LPG	145,72	166,78	c/litre	5,33	6,09	5,33	16,35	18,69	16,35	27,4	MJ/litre
Gas Sasol Gas	–	19,95	R/GJ	–	1,99	–	–	6,13	–	–	–

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 Sasol Gas 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. 41, May, 1997)

ESKOM STATISTICAL OVERVIEW

	1996	1995	1994	1993
Assets in commission at 31 December				
National capacity (MW)	38 497	37 840	37 840	39 746
Net maximum capacity (MW)	36 563	35 951	35 936	37 636
Powerlines, all voltages (km)	255 745	241 802	240 972	238 964
Operations				
Electricity produced (GWh net)(all stations)	178 855	164 834	160 293	154 260
Electricity sold (GWh)	165 370	153 547	149 443	143 800
Coal burnt in power stations (Mt)	85,4	79,4	76,9	75,9
Water consumed by power stations (Mlitre)	215 199	214 329	213 220	223 650
Peak demand on integrated system (MW)	27 967	25 133	24 798	23 169
Emissions				
Emissions from coal-fired power stations				
Carbon dioxide (CO_2) (Mt)	159	147	143	141
Sulphur oxide (SO_x) (000 t)	1 295	1 198	1 167	1 134
Nitrogen oxide (NO_x as NO_2) (000t)[1]	647	603	582	582
Particulates (000 t)	112,1	115,3	122	122,2
Emissions from Koeberg nuclear power station				
Radiation (mSv)[2]	0,0006	0,0004	0,0005	0,0297
Liquid discharges from Koeberg				
Silver 110M (GBq)[3]	1,4245	1,504	2,509	[4]
Cobalt 60 (GBq)	7,6664	4,705	2,535	
Cobalt 58 (GBq)	6,6859	7,488	10,42	
Zinc 65 (GBq)	0,0176	0,0431	0,00149	
Water				
Transgression of the Water Act (Mlitres)	14,5[5]	387,02	n/a	n/a
Incidents of unscheduled water releases[6]	4	16	6[6]	8[6]
Waste				
Ash at coal-fired stations				
Ash produced (Mt)	22,2	23,0	22,1	20,9
Ash sales (Mt)	0,995	0,943	0,818	
Non-nuclear hazardous waste				
Hazardous waste (kg)	677 783,7	499 116,3	499 116,3	
Koeberg nuclear power station				
Low-level waste (m^3) (steel drums)	109,06	73,29	85,5	101,0
Intermediate-level waste (m^3) (concrete drums)	35,69	28,76	43,0	38,0
General waste				
Scrap metal (t)	8 825	103 791	18 175	n/a
Building rubble (m^3)	20 446	19 587	14 973	n/a
Garden refuse (m^3)	14 057	19 671	23 980	n/a

(Source: 1996 Eskom Environmental Report, pp. 30-31)

1 Figure calculated
2 Millisieverts (Authorised annual limit is 0,25 mSv)
3 Gigabecquerel
4 Liquid discharges for Koeberg in 1993 not shown, as a different calculating method was applied
5 Figure for generation only
6 Incidents in 1993 and 1994 for power stations only

ESKOM RESIDENTIAL ELECTRIFICATION CONNECTIONS

Year	Connections	RDP targets
1991 - 1992	178 078	–
1993	208 801	–
1994	254 383	250 000
1995	313 179	300 000
1996	307 047	300 000
Total	**1 261 488**	

(Source: 1996 Eskom Environmental Report, p.29)

ELECTRIFICATION STATISTICS

Status of electrification as at 31 December 1995

Province	Type	Population	Houses	Houses elec.	Houses not elec.	% Houses elec.	% Houses not elec.
EASTERN CAPE	RURAL	4 475 073	897 436	51 874	845 562	5,78	94,22
	URBAN	2 149 715	495 315	333 053	162 262	67,24	32,76
	TOTAL	6 624 788	1 392 751	384 927	1 007 824	27,64	72,36
FREE STATE	RURAL	1 300 293	241 852	78 633	163 219	32,51	67,49
	URBAN	1 500 167	357 266	241 532	115 734	67,61	32,39
	TOTAL	2 800 460	599 116	320 165	276 953	53,44	46,56
GAUTENG	RURAL	315 213	68 560	37 262	31 296	54,35	45,65
	URBAN	6 827 915	1 682 288	1 307 335	374 953	77,71	22,29
	TOTAL	7 143 126	1 750 848	1 344 597	406 251	76,80	23,20
KWAZULU NATAL	RURAL	5 188 023	987 188	138 120	849 068	13,99	86,01
	URBAN	3 396 259	808 552	636 551	172 001	78,73	21,27
	TOTAL	8 582 282	1 795 740	774 671	1 021 069	43,14	56,86
MPUMALANGA	RURAL	2 080 631	393 279	146 442	246 837	37,24	62,76
	URBAN	887 545	195 637	116 253	79 384	59,42	40,58
	TOTAL	2 968 176	588 916	262 695	326 221	44,61	55,39
NORTH WEST	RURAL	2 440 829	480 919	98 703	382 216	20,52	79,48
	URBAN	1 081 723	229 120	160 053	69 067	69,86	30,14
	TOTAL	3 522 552	710 039	258 756	451 283	36,44	63,56
NORTHERN CAPE	RURAL	263 247	64 076	30 007	34 069	46,83	53,17
	URBAN	546 799	188 977	90 516	28 461	76,08	23,92
	TOTAL	810 046	183 053	120 523	62 530	65,84	34,16
NORTHERN PROVINCE	RURAL	4 661 202	936 598	221 931	714 667	23,70	76,30
	URBAN	487 023	118 799	84 596	34 203	71,21	28,79
	TOTAL	5 148 225	1 055 397	306 527	748 870	29,04	70,96
WESTERN CAPE	RURAL	574 270	136 086	64 010	72 076	47,04	52,96
	URBAN	3 276 825	797 227	702 351	94 876	88,10	11,90
	TOTAL	3 851 095	933 313	766 361	168 952	82,11	17,89
GRAND TOTAL	**RURAL**	**21 296 781**	**4 250 994**	**866 982**	**3 339 012**	**20,61**	**79,39**
	URBAN	**20 153 971**	**4 803 161**	**3 672 240**	**1 130 941**	**76,45**	**23,55**
	TOTAL	**41 450 752**	**9 009 175**	**4 539 222**	**4 469 953**	**50,38**	**49,62**

(Source: National Electricity Regulator. Electricity supply statistics for South Africa 1995, p.37)

ELECTRICITY STATISTICS FROM SELECTED SOUTHERN AFRICAN COUNTRIES 1990 – 1995

Utility	1990	1991	1992	1993	1994	1995
Botswana Power Corp.						
Maximum demand (MW)	159,60	179,50	193,90	186,90	194,70	n/a
Energy sold (GWh)	1 021,10	1 128,50	1 197,20	1 240,60	1 106,00	n/a
SWAWEK (Namibia)						
Maximum demand (MW)	225,00	240,00	246,00	270,00	251,00	277,00
Energy sold (GWh)	1 790,00	1 919,00	1 747,00	1 747,00	1 753,00	2 015,00
Swaziland Electricity Board						
Maximum demand (MW)	92,00	100,00	103,00	112,00	115,00	117,50
Energy sold (GWh)	444,10	493,60	523,80	555,20	545,80	603,20
Zambia Electricity Supply Corporation						
Maximum demand (MW)	926,10	943,20	993,30	1 003,00	n/a	n/a
Energy sold (GWh)	6 412,57	6 375,42	6 624,99	6 779,69	n/a	n/a
Zimbabwe Electricity Supply Authority						
Maximum demand (MW)	1 575,70	1 607,70	1 478,30	1 553,60	1 615,80	1 744,00
Energy sold (GWh)	8 992,00	9 248,00	7 731,00	8 412,80	9 035,90	9 364,80

Sources: Botswana Power Corporation, Annual Report, 1994.
SWAWEK Annual Report, 1991, 1995
Swaziland Electricity Board, Annual Report, 1993, 1995
Zambia Electricity Supply Corporation. Statistical Report, 1993/94
Zimbabwe Electricity Supply Authority. Annual Report and Accounts, 1993, 1994, 1995, 1996

Reprinted from: *(Selected Energy Statistics: South Africa, No. 41, May 1997)*

Energy news in Africa

Coal

The government in Mozambique is planning to restore the Moatize coal mines in the central part of the country which have been closed for nearly ten years. The first step in the programme is a $30 million project for the restoration of the Nacala Port in the northern province of Nampula. This will include the construction of new facilities and a railway line linking the mines with the port. The new facilities will enable the port to handle about 1 000 tons/hour of coal.

Another part of the refurbishment plan is the $300 million rehabilitation of the Moatize-to-Beira railway line scheduled to begin later this year. Moatize is regarded as an important railway centre as it is situated at the end of the line linking the town of Zambezi to Beira, Malawi and Zambia. Once the railway line is restored it will be possible to begin selling the more than 150 000 tons of coal lying on the mine sites. It has been estimated that there are nearly 200 000 tons of coal stockpiled, worth more than $2,25 million, waiting to be marketed.

(Source: Mining Mirror, April 1997)

Electricity

Niger

Nigelec has been marked down for an IMF/World Bank-type privatisation, together with the water company SNE, and oil storage firm, Sonidep. Seventy percent of electricity used in Niger comes from Nigeria's NEPA, which is also to be privatised.

Plans are already underway to have operating models for the sector and rates to be drawn up by technical and legal consultancies between June and August. The invitation to tender will be issued in late September. The final choice of those on the short list is scheduled only for February 1998.

The World Bank and IMF want decisions on points like the technology to be used for rural electrification and rates to be made at the beginning of the process. This also applies to negotiating a reasonable price formula with NEPA. It is hoped that Niger will eventually invest in hydroelectric schemes. However, the Kandadji project is likely to remain on the shelf even though the African Development Bank examined it two years ago.

(Source: African Energy & Mining, 19 March 1997)

Rwanda

GEC-Alsthom has begun renovating the diesel-powered Ntakura power station situated near Ruhengeri, close to the border with Uganda and Zaire. The power station has been out of service since 1993 when it was sabotaged. Funding was provided by the Caisse Francaise de Developpement, Germany's KfW and the European Investment Bank. Since 1993, Rwanda has been able to generate only 60% the country's required electricity.

(Source: African Energy & Mining, 19 March 1997)

Hydroelectricity

There has still been no agreement on Cahora Bassa. Portugal had hoped to reach agreement on the price of the electricity at a meeting held in March.

There have also been delays in completing the rebuilt HV line. Some 1 500 of 2 000 masts have been installed over a distance of 600 km and conductors have also been installed on part of the section.

(Source: Africa Energy & Mining, 19 March 1997)

Agreements were recently signed between the South African and Mozambique's energy ministers. The first one concerned the Mozal project for an aluminium smelter (245 000 t), which would be built by Gencor. The second one provided for Eskom to launch a feasibility study on the Mepanda Ucuea hydroelectric project downstream from Cahora Bassa on the Zambezi River. This latter agreement was signed in Maputo on 20 March 1997 by Penuell Maduna, South African Minerals and Energy Minister and his Mozambican counterpart.

In the meantime, Eskom is involved in the rehabilitation of the transmission line from Cahora Bassa to South Africa. Success at Cahora Bassa will have a significant effect on what happens at Mepanda Uncua.

(Source: Africa Energy & Mining, 2 April 1997
Eskom Public Affairs document)

Oil and gas

In a recent survey published by Wood Mackenzie on the oil industry in West Africa (covering seven countries, from Cameroon to Namibia but excluding Nigeria), it has been estimated that their recoverable reserves amounted to 6,98 billion barrels (end of 1996). The breakdown was as follows:

Zaire	103 million barrels (7 years' production at last year's rate)
Cameroon	298 million barrels (7,4 years)
Equatorial Guinea	330 million barrels (13 years)

For the bigger producers the totals were:

Gabon	1 055 million barrels (8,1 years of output)
Congo	1 591 million barrels (16,4 years)
Angola	3 601 million barrels (14,2 years)

The estimates concerning reserves are assumptions when they concern recent discoveries, and where operators have not communicated any numbers. Production startups this year will concern fields totalling peak output of 132 300 barrels/day.

(Source: Africa Energy & Mining, 19 March 1997)

Senelec, the Senegalese utility, is to get additional gas from a new gas field discovered near the town of Gadiaga, estimated at 10 billion m³. There is a 50 MW power station built on a BOT basis by GTI with GEC-Alsthom. Senelec's other site at Bel Air has been renovated.

Other gas will be provided by Tullow whose earlier Diam Nadio discovery supplies a 20 MW turbine used at peak times at Cap de Biches.

(Source: Africa Energy & Mining, 19 March 1997)

The uncertainty over where a DRI smelter using gas from the Pande gas field would be located has been cleared up. The Industrial Development Corporation (IDC) has put forward a project for a slurry pipeline to carry 260 million tons of lodestone stored at Phalaborwa to Maputo, where the plant will be built. The pipeline will have a capacity of 6 million tons/year, which corresponds to 4 million tons/year of cast iron. The cost is estimated to be R900 million compared to R750 million for a gas pipeline running to the Phalaborwa plant. The smelter is now estimated at costing over R5 billion compared to the initial R2,5 billion estimate. Pande's development has been estimated at R4 billion. Since another pipeline may be necessary for carrying water from Maputo, as well as a storage dam at the "mineral pipeline's" starting point, the final cost could reach R10 billion.

(Source: Africa Energy & Mining, 2 April 1997)

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Gareth Dooge joined Eskom's Technology Research and Investigations (TRI) (now known as the Technology Group) after graduation in 1991. Between 1991 and 1994 he worked at TRI as an engineer, specialising in fluids and thermodynamics. In 1994, he joined the Technology Group's Non-Grid Electrification section, doing research in the fields of micro hydro power and photovoltaic/diesel hybrid power supply systems.

HOLM D

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After graduating from the University of Pretoria with a B.Arch. degree in 1960, Dietrich (Dieter) Holm undertook several study and research tours to Europe, Scandinavia, Israel and the U.K. Since 1975 his interest in energy-effective design of buildings and the use of solar energy came to the fore.

Students of architecture at the University of Pretoria would have benefited enormously from his experiences through his teaching in the Department of design, building science, climatic design and history of the environment. He was appointed lecturer in the Department in 1967 and Professor and Head of Department in 1985. He is presently Professor and Director of Postgraduate Study and Research at the University of Pretoria's Division of Environmental Design and Management.

Between 1973 and 1980, Professor Holm was on the SABS' Committee for modular coordination, specification of steel windows and doors. He was also on the Education Advisory Committee of the South African Council for Architects. He has been external examiner at several universities, such as, University of the Free State (Design) and University of the Witwatersrand (Design and History of Building Technology). In 1994 Professor Holm received an Eskom Energy Efficiency Design Award for his entry on the thermal upgrading through passive solar design of former squatter settlements.

Professor Holm has held prominent positions in several institutions. He was president of the Solar Energy Society of Southern Africa (SESSA), board member of the International Solar Energy Society (ISES) and recently, director of ISES Africa.

His main expertise lies in the teaching of and research into energy-effective buildings. He was recently featured in the SABC TV environment programme, 50/50, which covered thermal efficiency in low cost housing. Professor Holm also lectures extensively to specialist and the lay public in South Africa and abroad on the promotion of energy effectiveness, which also forms the main subject of his research. He has published widely, both locally and internationally. He received the Austin Whillier Award for his book, *Energy conservation in hot climates.* London: Architectural Press, 1983, and is the co-author of three other related books.

He lives in a self-designed energy-autonomous house. His hobbies include playing the violin and sketching. One of his five children is also an architect and an expert in his own right in solar passive design.

LENNON S J

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Steve Lennon completed a Ph.D. at the University of the Witwatersrand on research into turbine disc cracking. In 1986 he joined the Metallic Corrosion Group at Eskom's TRI, where he was appointed Head of the Corrosion and Non-metallic Group. In 1989 he was appointed Scientific Investigations Manager, making him responsible for the chemical, materials and environmental tests, investigations and research at Eskom. In 1991 Dr Lennon was appointed Eskom's Scientific Services Manager and in 1993, his present position of Research Manager, where he reports to the Executive Director (Technology). He is also involved in strategic research planning, research project management, the technology transfer of research outputs and international technical research liaison. More recently Dr Lennon has become involved with the Southern African Electricity Research Network, the provision of a Corporate Advisory

Service, and research development and incident investigation. He also serves on the Southern African Power Utility Research Advisory Board. He is very involved in the establishment of the Power Technology Institute where he is responsible for industry-wide research management and standardisation (technical).

Dr Lennon's interest in environmental matters is reflected further in some of the offices he has held in the past and currently holds. He was past president of the S A Corrosion Institute and past chairman of the S A Electrolytic Corrosion Committee. He is presently the chairman of the Energy Use Task Group of the Interdepartmental Coordinating Committee for Global Climate Change.

Dr Lennon is also 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.

He has also published widely, locally and internationally.

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Deon Stassen obtained a Ph.D. from the University of Pretoria for research undertaken in the renewable energy policy field. In 1986 he joined the Development Bank of Southern Africa as an energy project leader and is currently attached to the Policy Business Unit as a senior policy analyst.

Besides publishing and presenting numerous papers on energy research and development, mainly in the field of renewable energy, Dr Stassen has served on several national committees and has participated in a number of energy policy initiatives at the national level. He is also the current chairperson of the Solar Energy Society of Southern Africa.

Forthcoming energy and energy-related conferences: 1997/1998

1997

SEPTEMBER 1997

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1998

MAY 1998

24-26
EFFICIENT ENERGY UTILISATION AND MANAGEMENT: A SEMINAR Johannesburg, South Africa

Enquiries: Rhona Campbell/
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South Africa

Tel.: +27 (11) 28 1066

SEPTEMBER 1998

13-18
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

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16-19
SOUTH AFRICAN TRANSPORT CONFERENCE Johannesburg, South Africa

Theme: Transport policy: Vision to reality

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

Tel.: +27 (12) 63 1681 (Cilla Taylor)
Fax.: +27 (12) 63 1680
Email: confplan@iafrica.com

21-25
CODATU VIII Cape Town, South Africa

Theme: Urban transportation policy: A sustainable development tool

Enquiries: CODATU VIII – Scientific Committee,
9/11 Av. de Villars 75007
Paris, France

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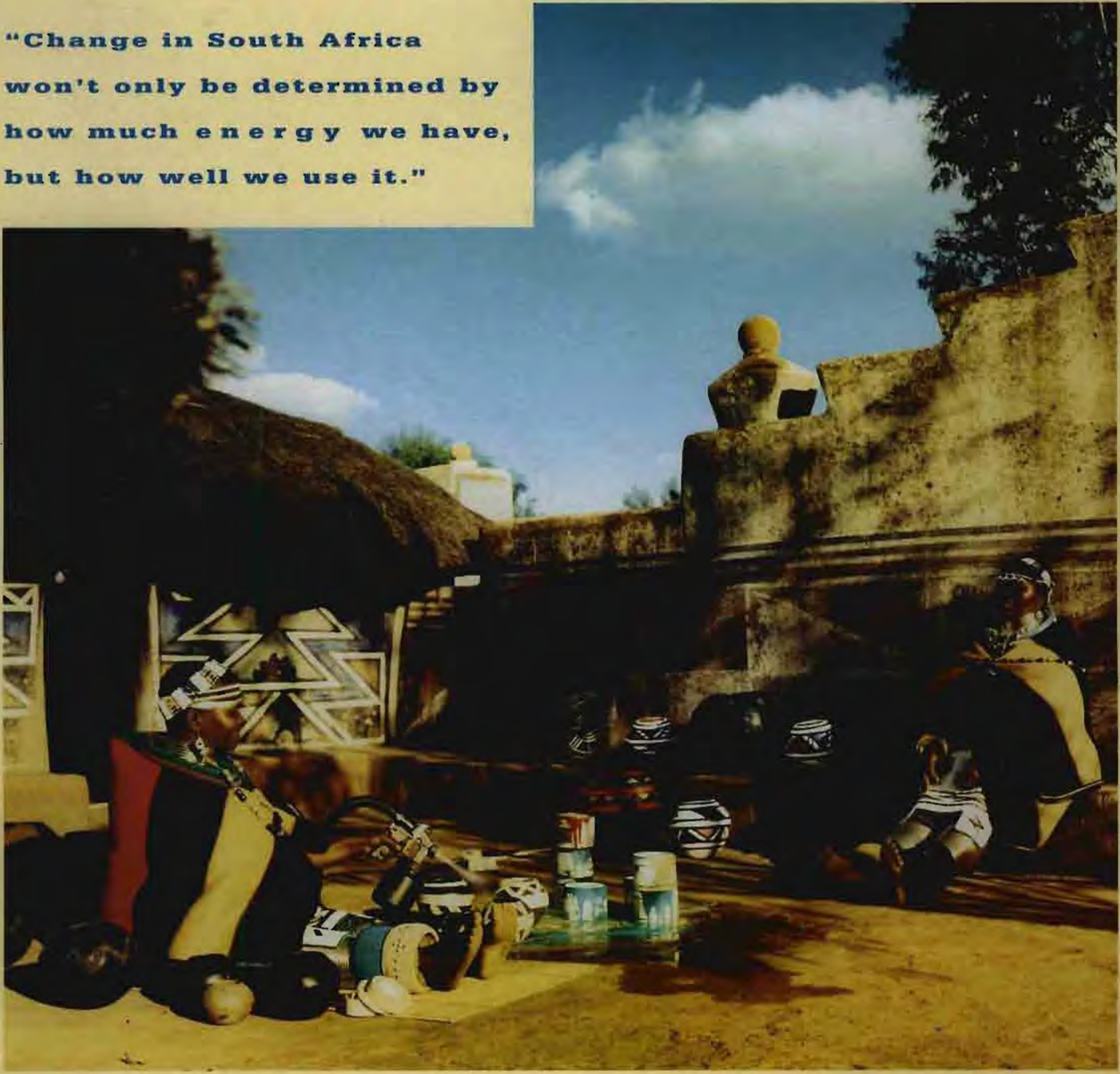

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