JOURNAL OF ENERGY IN SOUTHERN AFRICA

Vol.6 No.4 November 1995

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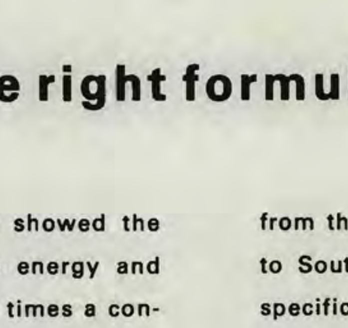

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It is the policy of the Journal to publish, as far as possible, papers covering the technical, economic, political, environmental and social aspects of energy research and development carried out in or applicable to Southern Africa, and of general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 Only previously unpublished work will be accepted.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

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10. Line drawings (not photocopies) and accompanying lettering should be of sufficient size to allow for reduction if necessary. Photographs of equipment must be glossy prints and should be used sparingly.
11. The body of the contribution should be preceded by an Abstract not exceeding 500 words, which should be a resumé of its essential contents, including the conclusions. Below the Abstract, a maximum of six Keywords should be included which reflect the entries the author(s) would like to see in an index. The Keywords may consist of more than one word, but the entire concept should not be more than 30 characters long, including spaces.
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Profile: Simbarashe Mangwengwende

Chief Executive, Zimbabwe Electricity Supply Authority

Mr Simbarashe Mangwengwende was born 37 years ago in the Buhera District of eastern Zimbabwe. After matriculating in 1976, he enrolled at the University of Zimbabwe and graduated with a First Class Honours B.Sc.(Electrical Engineering).

After working for a short while as a Research Assistant at the University of Zimbabwe, Mr Mangwengwende joined the then Harare Municipality Electricity Department (HMED) in 1981 as an Electrical Engineer (Mains). Due to the post-independence exodus of skilled staff, Mr Mangwengwende was thrown into the deep end. After a little over a year, he was promoted to Senior Engineer (Mains), but shortly thereafter was promoted to head the Operations Section.

In June 1984, Mr Mwangwengwende was appointed as Section Engineer (Design) and by the end of 1985, Acting Distribution Engineer, in charge of all distribution functions in Harare, including deputising for the City Electrical Engineer when required.

In order to further his management skills, Mr Mangwengwende studied for a Diploma in Management through the Polytechnic. He took study leave in August 1986 to read for a M.Sc. in the Management of Technology at Washington University in the U.S.A.

On his return to Zimbabwe in 1988, Mr Mangwengwende joined the Zimbabwe Electricity Supply Authority (ZESA) as head of the newly created Corporate Planning Unit. By this time, the electricity departments of the cities of Harare, Bulawayo, Gweru and Mutare had all been amalgamated into ZESA, together with the Electricity Supply Commission (ESC) (ZESA's predecessor).

As ZESA's first Corporate Planning Manager, Mr Mangwengwende developed the unit from its conceptual stage into a fully functional entity responsible for co-ordinating the preparation and implementation of corporate strategic plans.

In October 1991, Mr Mangwengwende was appointed Acting General Manager, and in December 1992 his appointment as Chief Executive was confirmed, making him, at the age of 35 years, the youngest Chief Executive ever to head the Authority. (He also has the distinction of being one of the youngest power utility Chief Executives in the SADC region.)

Simbarashe Mangwengwende took charge of ZESA at a time when the Zimbabwean government was implementing Phase One of its Economic Structural Adjustment programme, which required the profitable operation of parastatals. Under his direction, together with a new executive management team, ZESA was transformed into a more profitable and customer-oriented organisation. This included the implementation of a financial recovery plan which focused on efficient revenue collection, more cost-reflective pricing and cost-minimisation strategies, such as a Performance Improvement Programme which consisted of set targets for the various operations of the Authority. A multi-billion ZDollar programme was also instituted to upgrade and extend the available generation capacity to meet increasing power demand into the next century. Some of these projects include interconnections to South Africa and Mozambique which are expected to become operational in the 1996 and 1997 respectively.

Mr Mangwengwende has also implemented various information technology strategies in order to achieve maximum efficiency in the Authority's operations. ZESA has also played a leading role in the formation of the Southern African Power Pool.

In spite of his busy schedule, Mr Mangwengwende enjoys playing golf and the occasional game of squash and chess. He has authored and presented a number of papers at local, regional and international conferences.

He is married, with three children.

Profile: Howard Robin Whitehead

City Electrical Engineer, Durban Municipality

Howard Whitehead has been at the helm of South Africa's largest municipal electricity distributor since 1989, having joined Durban Electricity in 1966. His career in the municipal electricity field has covered the full spectrum of activities, including streetlighting, traffic signalling, radio communication, right through to electricity marketing, distribution and transmission. This broad background and his keen interest in the electricity supply industry (ESI) has caused him to become a leading light in the industry! His involvement in the various national bodies below bears testimony:

* immediate Past President of the Association of Municipal Undertakings (Southern Africa) (AMEU);
* founder member of the National Electrification Forum (NELF), having been a member of the Management Committee and convener of the Technology Working Group;
* AMEU representative on the National Electricity Regulator Working Group;
* member of the Electricity Working Group of the Department of Mineral and Energy Affairs and the Department of Constitutional Affairs
* member of Eskom's Electricity Council.

In addition, he is chairman of the council of the Durban Technical College and has a seat on the governing body of the George Campbell Technical High School in Durban.

Since completing his secondary education at Glenwood High School in Durban, Howard's life has been committed to the electricity industry. It was in the late 1980s, when Durban's electricity supply area was reconstituted on a uniform basis (embracing some 48 local authority areas, including all the major KwaZulu and other townships in and around Durban) that the opportunity was created to make the difference in the interests of the region but, more importantly, to improve the quality of life, create a bridge to address the education gap in South African society, and create small business opportunities through electrification. In 1991, Howard initiated Durban's self-funded electrification drive which has resulted to date in more the electrification of more than 80 000 homes, enabling about 600 000 people to enjoy the benefits of domestic electricity.

Howard was educated at the University of Natal where he obtained his B.Sc.(Eng.) degree, funded by a loan from the City Council. He went on to receive his government Certificate of Competence in 1980 and a Master's degree in Business Leadership from UNISA in 1985. During the 1980s he spent some 10 years on the Natal Centre Committee of the South African Institute of Electrical Engineers, resulting in him being elected Chairman of that body in 1985. In 1992, he was further honoured by the Institute when he was made honorary vice-president of the SAIEE.

His activities over the years have resulted in his having travelled fairly extensively. Initially this involved exploratory tours concerning traffic signalling to the U.S.A., the U.K. and Europe, as well as acceptance testing of the first computerised traffic signalling system for Durban which was acquired from Plessey in Poole, U.K. His travels also took him to Taiwan on a civic visit and, more recently, to Europe and the U.S.A. where he examined ESI structures, regulations and electricity pricing.

Howard shares the widely held vision of an electrified South Africa and regrets that the process was inhibited. "We now have a step function to overcome at a time when South Africa will find it more difficult to bear economically having other RDP (Reconstruction and Development Programme) commitments to contend with as well." He is of the view that the ESI industry is in need of an overhaul in various areas, not the least of which is in the electricity pricing arena.

Howard is a family man, married to Margaret, and has three sons. Most of his leisure time is spent in family-oriented pursuits, including swimming and do-it-yourself activities. In the 1970s, he was a Citizen Force pilot with 5 Squadron, Durban, where he flew Harvards and Impalas.

Energy used for transportation and electric vehicles: A global overview and a South African perspective

* C P SNYMAN

The forces driving the future of global transport energy are changing, mainly because of the uncertain supply of petroleum fuels and the adverse effects of combusting this fuel by a rapidly growing road vehicle population. This population is the largest consumer of energy in the transport sector. In California in the U.S.A., the biggest market for cars, legislation introduced to limit exhaust emissions is in effect creating a market for zero-emission vehicles. Currently, this refers mainly to electric vehicles. Electric vehicles are not new, but the renewed attention, money and muscle being invested into improving this technology could deliver viable and acceptable transport options.

The energy situation in South Africa, which is unique in the world, sets the scene where increased use of electricity in the transport sector offers various distinct advantages to the country and its people. South Africa has abundant supplies of cheap coal which is mainly used for electricity generation and synthetic fuel production. The cost of electricity supply in South Africa is one of the lowest in the world, while the cost of producing synthetic fuels is subsidised. All the crude oil used for the production of transport fuels has to be imported.

Improved electric motor and controller technology has enabled the electric vehicle to be significantly more energy-efficient than vehicles powered by an internal combustion engine. The introduction of electric vehicles into South Africa will reduce the need for crude oil imports and also reduce the energy consumed by the transport sector. This will in turn result in foreign exchange savings and reductions in transport costs, thereby increasing the amount of money available for other projects.

On a cost-per-km-travelled basis the electric vehicle saves the user money on energy costs. Electric vehicles also have a longer life and require less maintenance.

Although not yet a major factor in South African cities, the introduction of electric vehicles into the urban transport sector will reduce pollution levels. Because of the high efficiency of the electric vehicle system, there would also be a reduction in the total pollution load into the atmosphere.

The recharging of the batteries of electric vehicles, when the demand for electricity is very low, would improve the demand curve for electricity. This would lead to better utilisation of invested capital and more efficient electricity generation, thus assisting in the reduction of the price of electricity to domestic consumers and industry in South Africa.

It is believed that with international interaction and local co-operation between the key role-players in South Africa, the advantages of introducing electric vehicles, starting with shuttle buses and delivery vehicles in the automotive market, could be realised.

Keywords: electric vehicles; South Africa; transport sector; motor vehicle emissions; environmental legislation; United States

Introduction

In the late 1800s, there were more battery-powered cars on the road than internal combustion engine cars. The first electric car was built in 1837. The development of lead-acid batteries started in 1860. Battery-powered electric trolley cars were put into service in France in 1881[1] and a battery-powered car in 1886 in England[2]. In the U.S.A., the first production electric car was exhibited in 1892 in Chicago and by 1894 a variety of electric cars were available to the public[3]. Between 1903 and 1927 an English electric taxi covered more than 289 600 km. In 1912, 30 000 electric vehicles were registered for road use, and some 20 companies were manufacturing passenger and commercial electric vehicles in the U.S.A.. In the same year, the electric starter for internal combustion engines was developed, thus eliminating the need for cranking the internal combustion engine. This enhanced the acceptability of the internal combustion engine. Advances in the technology of the internal combustion engine were superior to the development of the electric vehicle, especially energy storage technology, which left electric road vehicle technology far behind. As a result, the production of electric vehicles was for specialised applications only[4].

It took a number of petroleum fuel supply disruptions and price shocks to initiate interest again in electric cars. These peaks of interest in electric cars corresponded well with the world oil crises. As soon as the oil crises became less important, so did the drive towards putting electric vehicles on the road. However, since the late 'sixties, increasing concern in the developed world over the emission of noxious gases from internal combustion engines increased momentum to research and develop electric vehicles. Also of concern to many countries has been their growing dependence on oil reserves controlled by the Middle East.

With the increasing awareness of environmental pollution up to the present, the ultimate solution in the minds of policy formulators is the development of a non-polluting vehicle which produces no emissions. The electric vehicle qualifies as such a vehicle. Legislation in southern California is demanding that by 1998, 2% of total vehicle sales must be of zero-emission vehicles. This percentage is to be increased to 10% by the year 2003, thus creating a market for electric vehicles. Recently various articles have heralded that the time for the electric vehicle has arrived[5,6].

Renewed investigation into the possible introduction of electric road vehicles into the South African transport market was initiated by the then National Energy Council, when the synfuels programme came to an end in 1989. This paper is intended to provide an overview of the international and South African transport energy situation, highlighting the motivation for this renewed interest in electric cars and the benefits of introducing more electric transport options into South Africa's transport sector.

* National Marketing Programmes, Eskom, P O Box 1091, Johannesburg 2000, South Africa

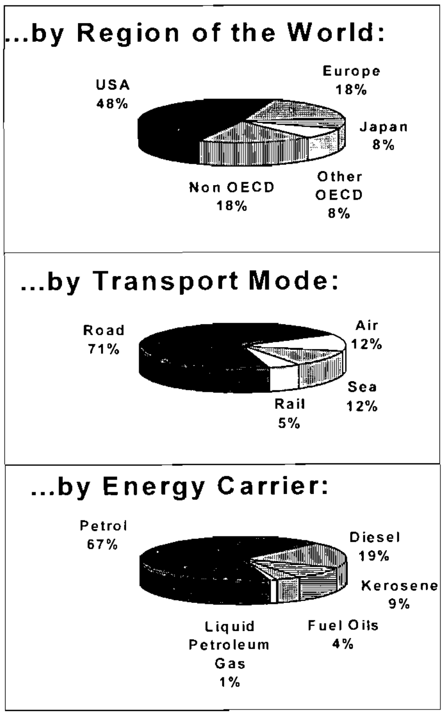

Figure 1: *Global transport energy consumption ...*

Transport energy: A global overview

The greatest portion of the world's transport energy is consumed in the U.S.A. as shown in Figure 1 (excluding the consumption of electricity for transport).

The energy used for the transportation of people and goods comes almost exclusively from crude oil as the primary energy source. This is converted at the refinery into liquefied petroleum gas (LPG), aviation fuel, petrol, diesel, and heavy fuel oils as secondary energy carriers. Most of the world's transport energy is utilised by the road transport sector. From Figure 1 it can be seen that petrol is the most preferred energy carrier.

Global driving forces

Currently various global driving forces which will shape the future of transport energy are at play. Characteristics of the 1970s were rising prices and supply disruptions of crude oil. Since the oil embargo of 1973, world energy trends have fluctuated widely, driven first by economic considerations and later by ecological constraints. This resulted in the world experiencing a sharp reversal of the oil consumption trend which had been, up until then, doubling each decade. World oil use actually dropped from 65 million barrels daily in 1979 to 59 million barrels in 1985. Consumption rebounded to about 64 million barrels a day in 1991. This was only 12% more than in 1973, compared to an increase in the world population of almost 40% during this same period[7].

During the 'eighties, the world experienced an over-supply of oil with falling oil prices and came to the realisation that the extensive use of crude oil was causing considerable environmental damage. This resulted in a renewed drive to investigate less polluting sources of transport energy.

A look at the trends and issues dictating the world's transport energy future reveals that proven world oil reserves could last up to 2054 at current consumption rates (Figure 2). The world's total petroleum resources could last up to 2350. It would, however, become more difficult to exploit the resources and be more costly to produce oil and its petroleum products.

Three main driving forces can be identified[8]:

(1) the geographical and political availability of crude oil;

(2) environmental pollution caused by fossil fuel combustion;

(3) political enforcement of global environmental legislation.

(1) *Geographical and political availability of crude oil*

Although oil is a depletable resource, its base is huge. Over the past 130 years, since the first oil-well was drilled, the world has produced and consumed 600 billion barrels of oil. Proven reserves in 1990 were 1 009 billion barrels, and it is expected that another 500 billion could be discovered and developed by conventional oil recovery processes[9,10]. As illustrated in Figure 2, these amounts portray a world with more than enough petroleum resources to last for many years to come.

However, more important than its large resource base and the increased cost of exploiting these resources is the fact that two-thirds of the remaining oil reserves are positioned in the Middle East, as is illustrated in Figure 3.

This means that presently the Persian Gulf controls two-thirds of the world's oil

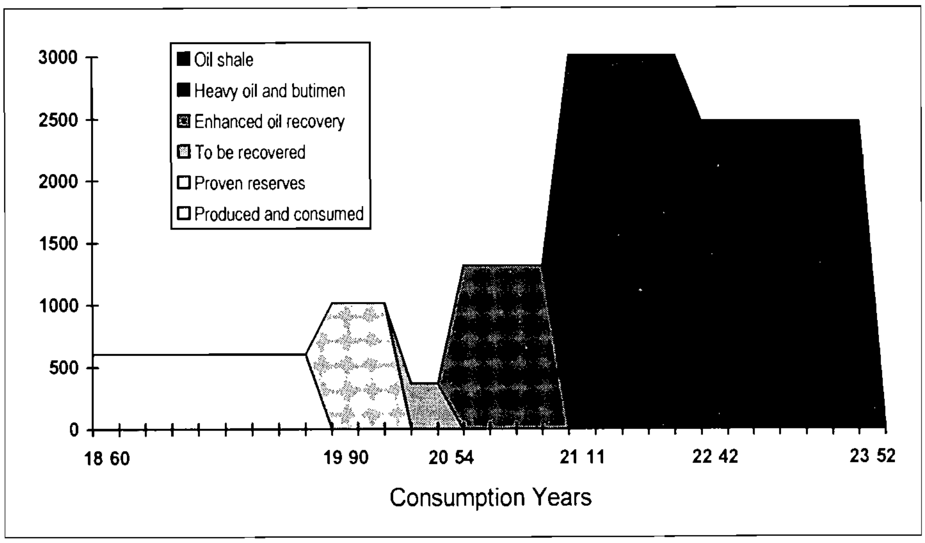

Figure 2: *The world's potential petroleum reserves (1 000 million barrels)*

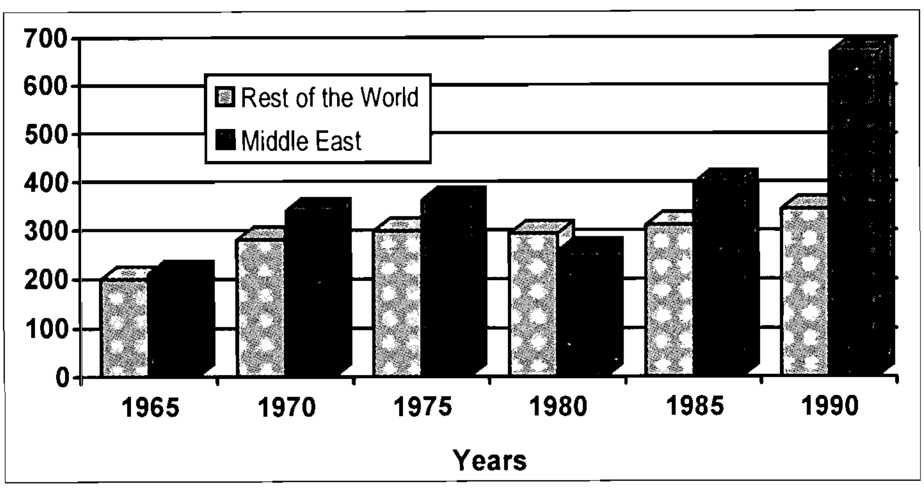

Figure 3: *The world's proven crude oil reserves (1 000 million barrels)*

reserves, with the rest of the world becoming very vulnerable to oil supply disruptions[11].

To make matters worse, a steady decline in oil production is forecast for the U.S.A. (Figure 4) and many other countries, including most of the OPEC countries. U.S. oil production is expected to decrease from almost 4 380 million barrels in 1970 to fewer than 2 920 million barrels in 2000 and 1 825 million barrels in 2010. During this period imports are likely to rise from 1 095 million barrels in 1970 to 3 650 million barrels in 2000 and 5 475 million barrels in 2010[12,13].

This trend is already having an impact on the security of U.S. oil supplies and various alternatives to conventional petroleum fuels are being developed.

(2) *Environmental pollution*

Motor cars are responsible for the major part of urban air pollution. Exhaust gas emissions include unburned hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NO_x). The major concerns of exhaust gas pollution are:

* emissions (CO, benzene, etc.) which are damaging to human health – especially to small children, the elderly and people suffering from respiratory problems, and
* reactive exhaust gases (NO_x, CH, etc) which, in the presence of U.V. light and high humidity, lead to the formation of photochemical smog.

Approximately 540 million vehicles now travel the world's roads, a figure that seems destined to continue to rise in the years ahead. In the Third World, car ownership has doubled since the late seventies. In the United States, where new car fuel consumption decreased from 15 litres/100 km in 1974 to 7,8 litres/100 km in 1990 and where average fleet efficiency has reached 10 litres/100 km, increased driving and traffic congestion has caused fuel consumption to rise[14]. This underlines the fact that pollution from internal combustion-engined cars is rising because of increased vehicle ownership and urban driving conditions, despite their lower fuel consumption and more efficient engines.

(3) *Political enforcement of global environmental legislation*

The American situation is an example of how events evolved towards decisive efforts to stop environmental degradation. In the U.S.A., the federal role in environmental policymaking has expanded dramatically over the past years[15]. Examples are:

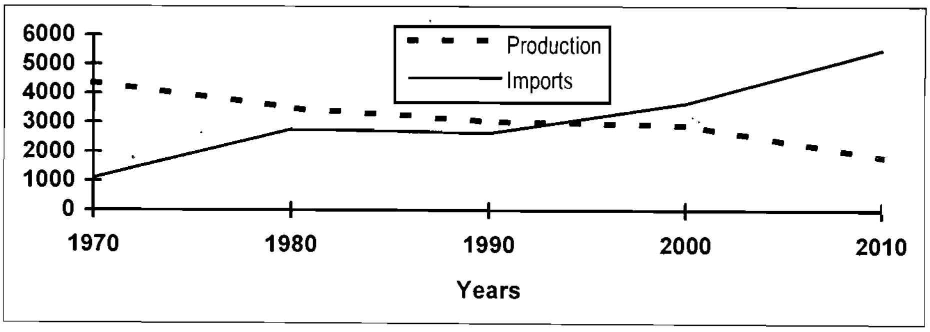

Figure 4: U.S. oil production vs. imports (million barrels of oil per year)

- the Air Quality Act that became law in 1967;
- the National Environmental Policy Act that was passed in 1969;
- the formation of the U.S. Environmental Protection Agency (EPA) in 1970;
- the passage of the Clean Air Act Amendments which followed in 1970, 1977 and 1990.

"The current performance characteristics of electric vehicles limit their use to niche markets such as, urban deliveries and passenger transport, site transport, game-viewing, etc. . ."

The environmental movement gained momentum, and numerous environmental interest groups emerged and began to lobby Congress for action. In many cases, the technologies called upon to control pollution were not yet fully developed and despite overall reductions in pollutant emissions, many of the targets still have not been met. In 1990 about 100 areas in the U.S. did not comply with the ozone (O_3) standards, more than 40 with carbon monoxide (CO) standards, and nearly 60 with particulate matter standards. The main purpose of the 1990 legislation was to address the non-attainment of the National Ambient Air Quality standards for O_3, CO and particulates, to tighten regulation of toxic and hazardous emissions, and to control the precursors of acid rain (primarily SO_2 and NO_x)[16].

The first step in the move towards "cleaner" exhaust emissions was the removal of lead from petrol specifications. Lead is a heavy metal which is damaging to health and which remains in the atmosphere for many years. It is believed that lead impacts negatively on the learning ability of small children. The next step was the introduction of catalytic converters to the exhaust systems of new petrol-powered cars to convert the reactive combustion products to less reactive exhaust emissions. Lead inactivates the catalyst and therefore catalysts can only be installed in cars using unleaded petrol. Changing the fuel specification by removing components which are highly

Type of fuel	ROG (reactive organic gases)	NO_x	CO
Gasoline	0,16	0,25	2,13
Methanol	0,13	0,17	0,88
Liquefied petroleum gas (LPG)	0,21	0,28	0,63
Compressed natural gas (CNG)	0,12	0,28	0,06
Electric vehicles	0,004	0,04	0,005

Table 1: Comparisons of emissions for various fuels (g/km)

Vehicle emission type definitions	ROG	CO	NO_x
CA passenger car standard (1987)	0,26	2,13	0,25
CA passenger car standard (1995)	0,16	2,13	0,25
Transitional low-emission vehicles	0,08	2,13	0,25
Low-emission vehicles	0,05	2,13	0,13
Ultra-low-emission vehicles	0,03	1,06	0,13
Zero-emission vehicles	0,0	0,0	0,0

Table 2: CARB vehicle emission definitions (g/km)

reactive in the atmosphere and lowering the vapour pressure of the fuel also reduces pollution. However, it also makes the fuel more expensive and could result in changes in the combustion characteristics of the fuel.

Research is also well under way into alternative transport energy carriers, such as alcohols (methanol and ethanol), hydrocarbon gases and hydrogen. These can be used with minor modifications and adaptations in "conventional" combustion engines, but, whilst being less polluting with regard to unburned hydrocarbons, the alcohols increase the level of acetaldehydes in the atmosphere, which contribute to the formation of photochemical smog. Vehicles running on these energy carriers are regarded as transitional low-emission vehicles (those burning alcohols) or low-emission vehicles (those burning natural gas) or ultra-low-emission vehicles (hydrogen), compared to conventional petrol- and diesel-fuelled vehicles. Table 1 presents a comparison of emissions from the use of various fuels.

The implications of the introduced legislation for road transport in the U.S.A. are[17]:

(1) beginning in 1992, oxygenated fuels, petrol blended with alcohol, will be sold in winter in those cities having the worst carbon monoxide problems;

(2) under the new law, new cars sold in 1994 and later will emit about 30% less hydrocarbon and 60% less NO_x pollutants than at present;

(3) the law also extends the durability requirements of emission control equipment from 50 000 miles to 100 000 miles;

(4) in 1995 reformulated petrol will have fewer aromatics, and will be introduced in the nine cities with the worst ozone problems;

(5) in 1996 a pilot programme will introduce 150 000 cars into California that meet the tighter emission limits through a combination of vehicle technology and "clean" fuel substitutes for gasoline, or blends of substitutes with gasoline;

(6) beginning in 1996, automobile companies must sell 150 000 cars in California that have emission levels of half that allowed for other new cars. The number of cars is expected to increase to 300 000 per year in 1999. In 2001 emission levels are expected to be reduced again by half;

(7) as early as 1998, a percentage of new vehicles purchased in centrally fuelled fleets in 22 polluted cities must meet exhaust emission standards that are about one-third of those in place for general passenger cars;

(8) from 1998, 2% of all new vehicles sold must be zero-emission vehicles;

(9) the California Air Resources Board (CARB)'s "Low-Emission Vehicle" programme creates four new categories of vehicles to meet increasingly stringent emission standards to be introduced over the next ten years.

With regard to emission levels, the categories compared are shown in Table 2.

Ultimately, the only true ultra-low-emission or zero-emission vehicles would be electric vehicles. Electric vehicles could already serve some transport markets with performances comparable to their petrol or diesel counterparts.

Environmental legislation in California is effectively creating a market for electric vehicles, thus accelerating the development and commercialisation of these prototypes. A schedule for the introduction of vehicles with less (down to zero) emissions has been mandated in California and is presented in Table 3.

The 2% shown for 1998 for zero-emission vehicles translates into 40 000 vehicles. This figure increases to 200 000 vehicles in 2003 when a percentage of 10% zero-emission vehicles is mandated. Twelve other states in the U.S.A. have indicated that they would adopt the same legislation. An estimate of this market is a total of 602 000 vehicles by 2003.

What has started in California is expected to expand to the rest of the world in different ways, but with the same effect. Ultimately, the drive system for vehicles will be electric because of the high efficiency, low noise and the non-polluting characteristics of the electric motor.

Year	Conventional vehicles (%)	TLEVs (%)	LEVs (%)	ULEVs (%)	ZEVs (%)
1990	100				
1994	90	10			
1995	85	15			
1996	80	20			
1997	73		25	2	
1998	53		45	2	2
1999	23		73	2	2
2000			96	2	2
2001			90	5	5
2002			85	10	5
2003			75	15	10

TLEVs = Transitional low-emission vehicles
LEVs = Low-emission vehicles
ULEVs = Ultra-low-emission vehicles
ZEVs = Zero-emission vehicles

Table 3: California mandated vehicle sales schedule

The advantages of using electric vehicles in South Africa

South Africa is uniquely positioned to benefit more than many other countries in the world from the use of electric vehicles.

This statement is based mainly on the transport energy supply situation and the low cost of electricity supply in South Africa. As already mentioned, all the crude oil (10% of primary energy) for the production of liquid fuels has to be imported. About 40% of the liquid fuels consumed in this country comes from coal. The price of electricity in South Africa at present is the second lowest in the world. The largest primary energy source used in South Africa is coal (82% of South Africa's primary energy). About 30% of the total net energy consumption by the South African economy is used for transportation. Petrol is the main energy carrier used.

In 5-10 years from now, South Africa could be facing the same environmental pollution problems that the rest of the world is presently experiencing. However, this is not the major motivation for the introduction of electric vehicles into the South African automotive market. With increased activity and the sustained realisation of electric vehicle development, electric transport options to serve various niche markets are fast becoming an energy efficient and cost-effective reality. Existing technology could be put to use in transport applications where it would be more effective and efficient than current transport options.

Improved energy efficiency

The efficiency of converting crude oil to tractive work is only 10% for the operation of a petrol-fuelled car in an urban environment. The most inefficient conversion takes place at the point of vehicle usage (Figure 5).

Coal is converted to liquid fuels in South Africa and the efficiency of this process is assumed to be 36%. Together with the 12% efficiency of the internal combustion engine, about 96% of the energy contained in coal is wasted. The total conversion chain efficiency for an electric car using coal as its primary energy source, under the same conditions, is 22%. With the current average conversion efficiency of coal to electricity at 34%, this process makes available more than twice the useful energy at the wheel than the petrol chain conversion. This is achieved through the electric vehicle's high efficiency (70%), using current technology. Should hydro generation be used, the total energy chain efficiency increases to about 60%!

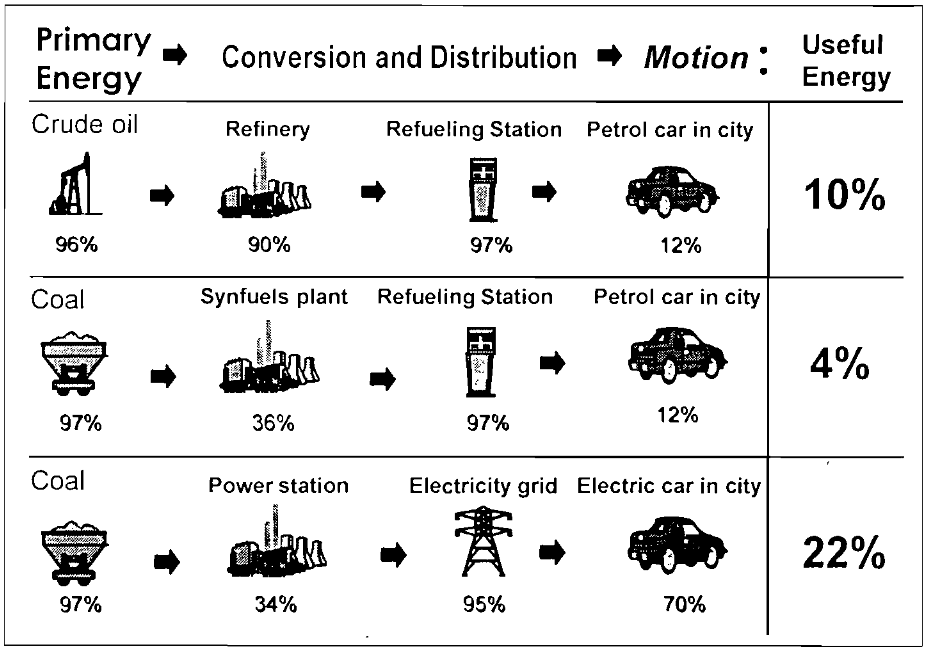

Figure 5: The total process efficiency for converting primary energy into motion for a car in city traffic

	Petrol	Peak electricity	Off-peak electricity
Unit price	R1,82	15c	7c
Units/100 km	8 litre	14 kWh	14 kWh
Energy/100 km	272 MJ	50,4 MJ	50,4 MJ
Cost/100 km	R14,56	R2,10	98c

Table 4: The energy use and cost comparison between a petrol-fuelled and an electric car

Reduced transportation costs

An electric car about the size of a conventional small car (1 300 cc), consumes about 10 kWh of battery power for every 100 km travelled (Table 4). Due to recharging inefficiencies, the user pays for the 14 kWh that the battery charger takes off the supply grid to recharge the the car's battery pack. At 15c per kWh this amounts to R2,10 of energy costs for every 100 km travelled in an electric car (2c/km). At an off-peak price of 7c per kWh, the energy cost is only 98c per 100 km (1c/km).

With the price of petrol at R1,82/litre, it costs the user R13,00-R20,00 for 100 km, depending on the consumption rate (13c/km-20c/km). Lower maintenance costs for the electric car would further reduce costs to the user. Benefits to the user of an electric vehicle would also include reduced running costs (higher energy efficiency), reduced life cycle costs (less maintenance required), longer life of the vehicle (less moving parts, less wear and tear), no harmful emissions (no combustion) and less noise.

Decreased vulnerability to oil shocks

Electric transport would not be affected by any oil supply disruptions or price instabilities. The coal used for generating electricity comes from local mines in South Africa while, as already mentioned, all the crude oil used for petrol and diesel production needs to be imported. Even with synthetic fuel production from coal in South Africa, motorists had to pay the higher price for petrol during the oil crises of the past. This was not due to unreasonable profit gain by the synthetic

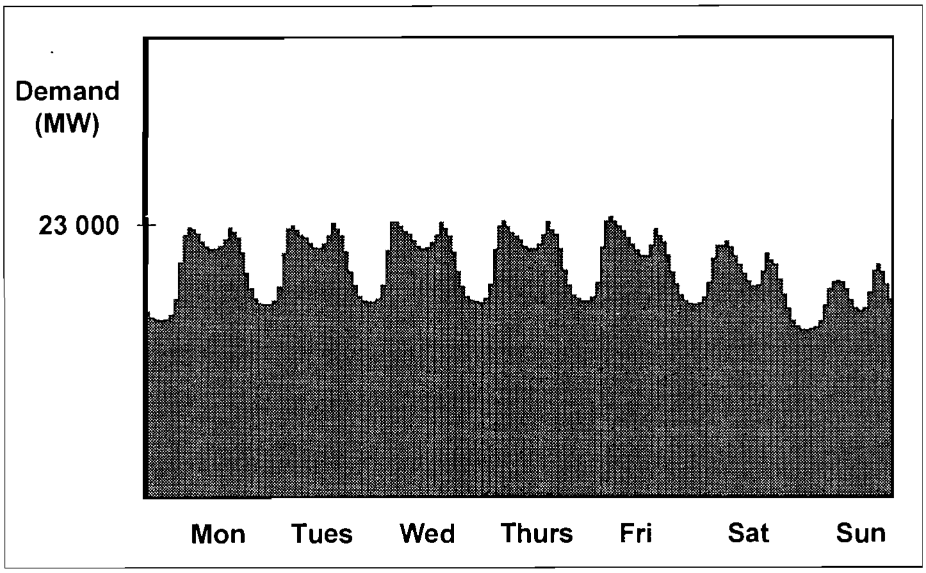

Figure 6: *An average weekday load profile for Eskom*

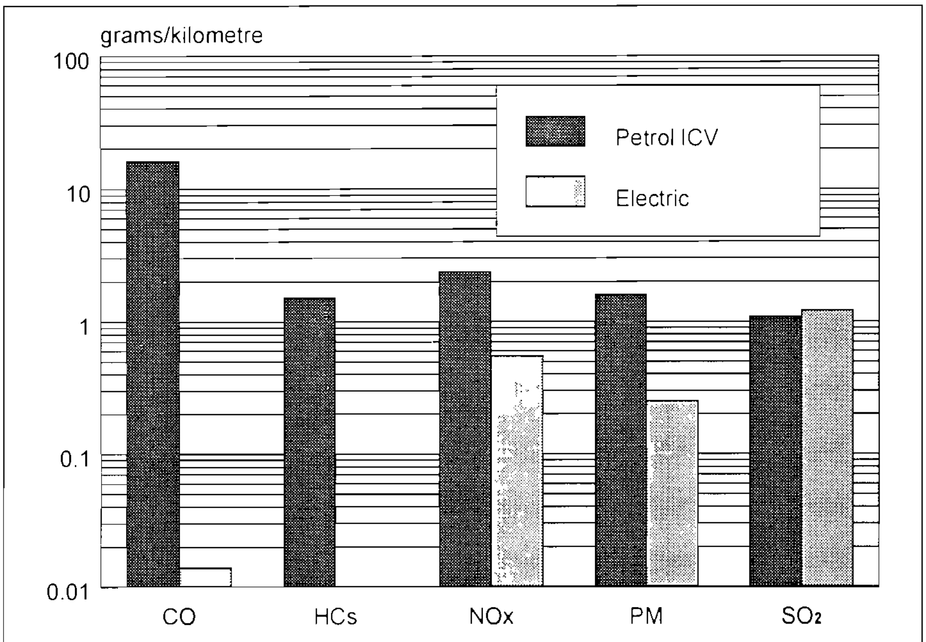

Figure 7: *Total emissions from operating a petrol-fuelled or an electric vehicle*

Emission component	Power station emission factors (g/kWh)	Emissions with 100% EVs (tonnes)	Potential change	
			(tonnes thousands)	(%)
CO	0,098	1 150	-1 369	-99,9
HCs	–	–	-129	-100
NO_x	4,0	47 100	-156	-76,8
PM**	1,8	21 200	-115	-84,6
SO_2	8,8	104 000	+111	+11,9

** particulate matter

Table 5: *Power station emission factors, estimated emissions for electric vehicles in the place of the current petrol vehicle fleet and the resultant emission changes*

fuel industry but because of the high production cost of the synthetic fuel.

Savings on crude oil imports

Should more electricity be used for transport, less crude oil would need to be imported, thus resulting in foreign exchange savings. It should be noted that this trade off is not exactly equal. The higher energy efficiency of the electric motor in comparison with the combustion engine further improves this trade off. Less energy would be required to do the same work. The funds saved in reduced oil imports and higher energy efficiency could then be used for development within South Africa.

Better utilisation of electricity generation investment capital

South Africa uses a single time zone and it is therefore not possible to reduce peaks by selling electricity into a different time zone, as is practised by utilities in the U.S.A. and Europe. Recharging batteries for electric vehicles overnight, when the demand for electricity in South Africa is very low and the investment poorly utilised, would be an ideal way of improving Eskom's electricity load profile. Figure 6 presents a typical load profile for an average weekday.

About 38 GWh of electric energy is currently available for batteries being recharged after the evening peak (10 p.m.) and before the morning peak (7 a.m.). (This relates to the period between 22:00 and 8:00 in Figure 6.) With an average daily distance of 50 km and an average consumption of 14 kWh per 100 km, a theoretical (uniform) population of about 6 million electric cars could be accommodated with no increase in capacity needed. The current vehicle population is about 5 million vehicles. Intelligent battery recharging systems could switch on at different times to ensure a levelling of Eskom's load profile. As an incentive for users to recharge batteries in the above way, low off-peak tariffs could be made available. Savings in electricity costs could pay for the installation costs of these "smart rechargers".

The investment to generate the required electric power has already been made. With the existing electricity supply capacity in South Africa the load curve will improve and the generating investment would be better utilised. This would further contribute to increased generating efficiency and reduced electricity prices.

Reduced pollution levels

Conventional petrol and diesel vehicles are major contributors to air pollution in urban areas. Electric vehicles as such have no exhaust emissions. However, the electricity to recharge the batteries is generated at a power station where emissions are produced and released into the atmosphere. The comparison therefore between the emissions produced by a petrol-fuelled vehicle and an electric vehicle respectively, has to take into consideration the emissions produced by all the processes, from primary energy conversion to the energy used to drive the wheels. The results of such an investigation for the South African situation are presented in Figure 7.

The total power station emissions for a scenario where all petrol-fuelled vehicles are replaced by electric vehicles have also been calculated. These results and the changes in total emissions released to the atmosphere are presented in Table 5.

Dramatic reductions in urban air pollution levels could be obtained by introducing electric vehicles into the South African automotive market.

Conclusion

This paper set out to put into perspective the advantages for South Africa, from a national energy viewpoint, of introducing electric vehicles. It would be impracticable to even suggest that all petrol vehicles should be replaced by electric vehicles. The current performance characteristics of electric vehicles limit their use to niche markets such as, urban deliveries and passenger transport, site transport, game-viewing, etc. The long recharging times for batteries (lead-acid and nickel-cadmium) at present contribute to the inconvenience of operating an electric vehicle. However, increased pressure from the global driving forces discussed in the first part of this paper would advance the development of improved electric vehicle technologies. Increased volumes of electric vehicles and financial support for energy storage development would soon enable the electric transport option to be a viable proposition.

In niche markets, where electric vehicles can be successfully applied today, the use of these vehicles would not only benefit South Africa in general, but also save the owner operating costs through more efficient energy consumption and lower maintenance requirements. It is felt that this is the right time for the electric transport option to fill its logical niche and find application in the market-place.

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A vision and strategy for electricity pricing in South Africa

*** B R A MOUNTAIN and * * C E DINGLEY**

This paper attempts to develop a long-term vision for the electricity supply and distribution industry in South Africa. The focus is on a pricing vision, but since the pricing practices are closely linked to the structure of the industry, it thus also describes a vision for the structure of the industry. A possible three phase development process is discussed which is aimed at transforming the industry based on this vision.

Keywords: electricity pricing; South Africa; electricity supply industry

Introduction

Electricity in South Africa has consistently been amongst the cheapest in the world. There are perhaps two main reasons for this. Firstly, South Africa's abundant reserves of cheap coal have resulted in the development of large coal-fired stations which produce electricity very economically. Secondly, largely as a result of the policies of a previous political dispensation, the industry has largely ignored the electrification of millions of potential customers whose limited ability to pay would have placed a financial burden on the electricity industry.

One of the consequences of the low cost of producing electricity is that there has been relatively little incentive for the development of economically efficient tariffs. This problem is further exacerbated by an inefficient and fragmented distribution industry in which the structure and level of tariffs has generally been influenced to a greater extent by political rather than economic considerations.

However, political changes in South Africa are forcing the industry to face up to some of the realities that have so far been swept under the carpet. The success of the industry in future will depend on a workable solution being found to the problem of serving the needs of the industry's existing customers, as well as providing electricity for many millions of currently unelectrified homes. The way electricity is priced is at the heart of this issue. This paper, which is based on an M.Sc. thesis[1], seeks to develop a vision for pricing in the South African electricity supply and distribution industry. The focus is on a pricing vision but, since the pricing practices in the electricity industry are inevitably closely linked to the structure of the industry, in reality it also describes a vision for the structure of the industry.

This paper begins with a discussion of the long-term vision for pricing in the industry. It then proceeds to explain a possible three phase development process aimed at transforming the industry in accordance with this vision. Finally, the conclusion attempts to capture the essence of the vision and proposed strategy.

The vision

The heart of the vision proposed here is that in the long term, fair competition should be the prime criterion for determining the price for electricity sold between suppliers, distributors and end-users. Fair competition is frequently promoted by economists and theoreticians because it will encourage what is rather amorphously termed the "optimal allocation of resources"[2]. In the context of the electricity industry, to date no decisive empirical proof exists to suggest that fair competition encourages "economic efficiency" to any greater or lesser extent than would a monopoly or even a regulated monopoly. The vision put forward here in favour of fair competition is thus based on faith in the system of economic behaviour established in competitive market economies.

Perhaps some may infer that faith in competition means faith in private capital, and that what is indirectly being advocated here is that ownership of the South African electricity industry should become private as opposed to public. Indeed, in the past it has almost invariably been the case that the profit motive in privately owned companies has rendered them intrinsically more competitive than publicly owned companies. However, today many public companies worldwide have successfully copied the competition-induced motivating factors of private companies such as, strong performance-related pay-scales and high degrees of managerial autonomy, and consequently, are now in many cases as competitive as their privately-owned competitors. If a company is as efficient and competitive under public ownership as it is under private ownership, to the public who purchases the company's products it is immaterial who the owners are. The essence is thus competition and not ownership. Indeed, provided that the correct competitive industry structures were to be established, it is entirely reasonable to argue that a truly competitive electricity industry in South Africa may just as efficiently function under a regime of public ownership as it may under a regime of private ownership. Ultimately, perhaps the best solution may lie in a combination of private and public ownership, as is the case in many significant electricity industries world-wide.

Internationally, the idea of full competition in the electricity industry is still relatively new. The electricity industry in Chile was the first to have developed a system of competition in the supply as well as the distribution industry in the late 1980s***. This was followed shortly after by the momentous changes in the electricity industry in the U.K. in 1990. Variations on the competitive theme have since been applied in the electricity industry in Norway[3], Finland, Sweden, Holland and New Zealand. Indeed, in the countries forming the European Union (EU), the development of truly open and competitive electricity industries in each member state is now

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*** An illuminating discussion on competition in the electricity industry is to be found in *Power supply in developing countries: Will reform work?*, the Proceedings of a Round Table discussion co-sponsored by the World Bank and Electricité de France, November 1993.

being vigorously debated****. Even the American electricity industry, which has hitherto developed an enormously complex system of regulations based on monopoly supply and distribution rights is, in parts, starting to implement a system of third-party access, thereby facilitating unrestricted competition*****.

South Africa has both a very substantial developed economy as well as a sizeable undeveloped economy. The electricity industry has a common responsibility to both to provide the best service at the lowest cost. However, the enormous disparity in the distribution of resources between South Africa's developed and undeveloped economies means that if the South African electricity industry were to be restructured to achieve competition in the shortly foreseeable future, millions of currently unelectrified homes would remain unelectrified. This is because the electrification of most domestic dwellings in South Africa is financially viable only in the very long term and would thus, in the short term, not deliver an adequate rate of return to motivate competing organisations to invest in such electrification projects. Before fair competition in the distribution industry can be established, it will be necessary that the unelectrified market be considerably developed in order to attempt to rectify the current imbalance in the allocation of resources. Furthermore, until the many existing customers who are presently unable to pay the full cost of supply, are able to pay a price in excess of this cost, an effective competitive industry can simply not exist. With the existing wealth distribution, it is clear that a competitive industry created now would only be effective in serving the needs of the developed market. This was recognised within the National Electrification Forum (NELF) (a non-statutory body representative of industry stakeholders and interest groups) which did not see the introduction of competition as a priority at present. It is accepted that at this time a doctrinaire adherence to the principles of competition will not achieve the far-reaching structural transformation which is necessary before fair competition can be created. For this reason a phased progression, directed towards an increasing degree of competition, is envisioned.

**** Perhaps one of the most significant developments in this regard is a recent proposal by the German federal government to introduce third-party access in the German electricity distribution industry.

***** On 20 April 1994, the Public Utilities Commission in the state of California in the U.S.A. proposed a system of third-party access in the supply of all customers greater than 50 kVA by 1996 and complete third-party access to all customers by the year 2002.

A three phase development process

Reconciling the long-term vision of competitive pricing with the short-term reality of the need for pricing to facilitate massive electrification, the envisioned strategy is to develop pricing in the industry in three distinct phases, during which transformations in pricing practice should coincide with transformations in the industry structure. During the first phase the industry should be centralised. There should be one national distributor. It is immaterial whether this national distributor is unified with generation and transmission into a single industry, à la Electricité de France, or whether it separates from the generation and transmission industry. During the second phase the industry should be gradually decentralised through the creation of a number of autonomous regional electricity distributors and perhaps a number of different electricity generating companies. In the final phase the industry should be open to full competition with a power pool, in which a number of competing distributors and generators buy and sell respectively from the pool. The rest of this section expands upon this three phase process.

Phase 1: Centralisation of the distribution and supply industry

The currently fragmented distribution industry should be rationalised under one single organisation. Existing distributors should be placed under central control as agents with a franchise over all customers in their existing area of supply, acting for a single principal. The principal should thus be the joint governing body and should hence represent the interests of all the distributors to which it has granted an agency. Municipal distributors and Eskom distributors should therefore continue their distribution operation but as agents acting for a central principal. The distributors should also be free to merge and, indeed, should be encouraged to do so, thereby progressively rationalising the number of distributors in the industry.

The centralisation of the industry under a principal should very quickly facilitate a solution to the current problem of fragmented and politically-induced pricing structures. More importantly, however, the immense electrification task, which is seen as the industry's most important task at present, would most effectively be addressed in a centralised and homogeneous industry. It is only once the industry has been extensively electrified that control of the industry should be decentralised.

The supply industry in South Africa, which is already effectively under the control of one organisation, should remain as such during the first phase. Those other small power stations which are not currently under central control should be integrated into the existing monopoly, although it is expected that most would be decommissioned on account of their relatively uneconomic operation. Similarly, the existing centrally controlled high-voltage transmission network should remain unchanged.

Phase 1: Pricing in the supply industry

The supply industry in South Africa at present uses generation and transmission tariffs to account for sales from the generation and transmission businesses. These tariffs should continue to operate.

Phase 1: Pricing in the distribution industry

Through the establishment of the agency/principal relationship between the principal and the existing distributors, it should be possible to change the control structure of the industry overnight without disrupting the physical operation of the industry. From the perspective of control over tariffing in the industry, the agency/principal relationship instantaneously remedies the current regulatory tangle by placing all existing distributors under one common principal. At the same time, however, existing distributors should still maintain a degree of autonomy in their relationship with the future principal. In the beginning, the agents should be instructed to maintain their existing tariffs until such time as a detailed national pricing policy has been developed. In developing such a policy, electricity pricing during the first period should be focused on remedying many of the current deficiencies. In particular, the following is proposed:

(1) A single national pricing policy should apply to the whole distribution industry. To this end the existing plethora of different tariffs should be rationalised into a set of generic marginal cost-based tariff structures for different types of customers, to be applied nationally.

(2) The calculation, allocation and apportionment of the costs of supplying electricity to different types of customers should be accurately established so that a rational basis is used to determine the price level to different customers.

(3) The accounting principles used to determine the revenue requirements of individual distributors must be common throughout the industry.

(4) The principle of transparency should be established as a key principle in pricing. This has wide implications: (i) the profitability or otherwise of each distributor must be clearly established and widely publicised; (ii) the allocation of distributable profits, if any, should be widely publicised; (iii) the determination of strictly cost-based tariffs should be a transparent process. Deviations from tariffs based on the cost of supply in the case of very poor customers, for example, is a significant issue and one which must be solved jointly by the industry, its customers and the government. However, most importantly, the consideration of cross-subsidies must take place after the true costs of supply have been established, thereby allowing the exact extent of the subsidy (or cross-subsidy) to be accurately determined and transparently communicated.

(5) The degree of tariff choice which a customer is offered should be proportional to the size of the customer.

(6) Non-tariff agreements should continue to play a role in the industry, particularly for large and nationally significant customers. Such agreements should be open to public inspection.

(7) End-customer tariffs should be taxed. There should possibly be local taxes to compensate those municipalities that would lose the considerable net income which they currently derive from their electricity service. There should also be a national tax to contribute to a national electrification fund.

Phase 2: Regionalisation

It is intended that the rationalisation of the distribution industry under a single organisation, as proposed in Phase 1, would have facilitated the electrification of much of South Africa's underdeveloped areas. Having progressed to achieving this critical objective, it should be possible to move to the second phase, that is, regional autonomy in the distribution industry. This phase in the development of the industry is primarily an interim step between a centralised industry and a competitive industry.

The generation and transmission industry, should remain in one single organisation. However, the creation of some sort of generation power pool in which conceptually autonomous generating companies compete to sell power, should be developed as a precursor to the actual working of a similar structure in the proposed third and final phase.

In the distribution industry, a number of regional electricity distributors should be created by merging the operations of small neighbouring distributors. There is no justification for the boundaries of regional distributors corresponding to the provincial boundaries. On the contrary, if the regional distributors' boundaries do not correspond to the provincial boundaries, they would be less likely to fall under the control of provincial government. This would prevent an unnecessary counter-competitive political dynamic from being introduced.

During this second phase, the regional distributors should have a franchise over all customers in their particular area. The regional distributors should bid to purchase electricity from a power pool managed by a national transmission company. As in the case of the U.K. power pool, the regional distributors should be free to enter into direct contracts with the conceptually autonomous generating companies[4].

Phase 2: Pricing in the supply industry

The main pricing aim in the supply industry during this phase should be to establish a power pool to bring about competition. During this phase, however, all competing generation companies should remain part of a single organisation and they should not be totally separated until the final stage. A key criterion in the structuring of the competing generation companies is that no single company has an unfair competitive advantage over any other company. Furthermore, to recall the experience of the restructuring of the U.K. industry, it is vital that competing companies are not in a position to be able to collude in anti-competitive behaviour[5].

Phase 2: Pricing in the distribution industry

During this phase the regional distributors should have a franchise over all customers inside their area of supply. Three aspects of pricing in this sector of the industry need to be considered: (1) the pool pricing mechanism between the distribution and generation-transmission side of the industry; (2) pricing between the distributors and their end-customers; (3) price regulation of the regional distributors to ensure that they do not exploit their monopoly status.

With regard to the first aspect, it is envisioned that the regional distributors should bid to purchase electricity from the pool or, via the pool, directly from the generation companies. The power pool currently used in the U.K. seems to provide a workable example of how this could be done[6].

With regard to the second aspect, the costing systems developed during the first phase of the industry should form the basis of the tariffs applied by the distributors. The urge of the regional distributors to abuse their monopoly distribution rights will be tempered by the threat that in the third and final phase, it is intended that they should no longer have a franchise and hence, in order to ensure that they remain in business, they will be forced to develop competitive tariffs. The tariff principles described in the first phase, that is, economic costing, transparency, choice, should play an important role in this phase. However, distributors should have discretion over the extent to which their tariffs reflect these objectives. Ultimately, towards the end of this phase, pricing policies should be driven by the threat of competition in the final phase.

The third aspect in pricing in distribution during this period relates to the regulation of the prices charged by the regional distributors to their customers. As long as the regional distributors have a franchise over their customers, it shall be necessary to regulate the tariffs charged. The objective of such regulation should be to provide an incentive to distributors to minimise their costs so as to make a profit. This can be achieved by regulating the maximum prices to be charged by distributors. These maximum prices may be linked to the annual change in indices, such as the retail price index, to determine the allowable price increases from one year to the next. This methodology of indexed-linked price regulation is becoming widely practised internationally.

The challenge in distributor price regulation is to reconcile the disparities in wealth distribution with the need to create an equitably competitive system. It is envisioned that the electrification efforts, particularly in the first phase, would have contributed towards lessening the highly uneven wealth distribution in South Africa. However, it will take a considerable period of time, if ever, for the geographic distribution of wealth in South Africa to reach the degree of homogeneity evident in the U.K., for example. This is obviously an obstacle, although not an insurmountable one. One possible solution to the problem is for the State to reimburse competitive distributors for the difference between the cost of supply (plus a reasonable return on assets) and the revenue recovered, in respect of electricity sales to sub-economic customers. The income for this State subsidy could, say, be generated through a levy on all electricity sales.

Phase 3: Competition

It is intended that a state of fair competition in generation and distribution should take shape in the third and final phase. The experimental power pool and competitive structures developed as part of the second phase should form the basis of the structure in this final phase. The Government, having guided the allocation of resources up to this point, should now leave this to the market. From this phase onwards the Government's only role should be to ensure that the market remains equitably competitive and to ensure that, if applicable, the competitive industry has incentives to undertake electrification projects which may otherwise not be financially viable.

Phase 3: Pricing in the supply industry

In a truly competitive industry, there is no need for a regulated pricing policy. Competitive suppliers should frame their pricing policy in terms of their specific competitive strategies relating to price, quantity and quality. In theory, such competition should always be free and fair with the most competitive supplier winning the best advantage both for itself and its customers. In practice, competing suppliers may collude in an attempt to manipulate the market through anti-competitive strategies in order to achieve an unfair competitive advantage. A current example of this is the alleged duopolistic behaviour between National Power and PowerGen in the U.K.[7].

In the triangular relationship between customers, suppliers and the State, the role of the State is thus to ensure that the market remains fair. Hence, while pricing-related decisions in the supply industry during the competitive phase will be decentralised and largely left to the market, there should still be a strong regulatory framework to ensure that competition remains fair.

Phase 3: Pricing in the distribution industry

Although the essence of the third phase is that competition should be the principal determinant of the price of electricity, there is a fundamental difference in the supply industry and the distribution industry in the operation of this competition. In the supply industry there are a number of existing and possible future power stations which may be grouped in different ways to form different supply companies. New power stations should be built on condition that the present value of future earnings exceeds the present value of the investment.

In the distribution industry there is an existing network of lines and cables, switch-gear and transformers which are used to distribute electricity from a central network to the end-user. It would be a gross misallocation of resources if prospective distributors were to build their own distribution networks in order to supply the same customers. Instead, prospective distributors must compete to provide a distribution service to customers, using the existing distribution network. This service entails firstly, the purchase of electricity from a central pool and secondly, the sale of this electricity, via established distribution networks to the distributor's customers. The extent to which a particular distributor is able to meet different customers' specific service requirements will determine the success of that distributor. As such, distributors do not have a franchise over the distribution of electricity in any specific area. Rather, they compete with other distributors for the business of existing or new customers.

In this situation, ownership of the distribution networks is immaterial: the only condition is that distributors who use the distribution networks pay the owner(s) of these networks an amount to cover the costs incurred by usage of the network plus a reasonable return on assets. In the competitive U.K. structure, in forming the Regional Electricity Companies (RECs), the former Area Boards took ownership of the distribution networks inside their area of jurisdiction. These RECs are compelled to charge an amount for the use of their networks which represents the cost of using the network, plus a specified rate of return on the network assets. This means that RECs are unable to profiteer from other distributors who wish to use their networks. Ownership of the distribution network could, however, just as easily rest with a public corporation which would then charge competing distributors for the use of the network.

With carefully controlled costing and pricing of the use of the distribution infrastructure, the competition created in the distribution industry, it is envisioned, will maximise the operational efficiency of competing distributors and in so doing, will result in a distribution service to the end-customers of the highest quality but at the lowest price.

Conclusion

Like open political competition, competition in many sectors of the highly protected South African economy has, for a long time, been excluded. The recent change to democratic government has brought with it the prospect of achieving an open and competitive economy in the long term. In the short term, however, the need to develop skills and economic self-sufficiency in South Africa's substantial underdeveloped economy is of primary importance. The electricity industry has a substantial role to play in this process, specifically in terms of the electrification of an estimated 4 million homes. This will obviously mitigate against the development of a competitive electricity industry in the short term. However, after some progress has been made towards electrifying the large sub-economic sector, it is proposed in this paper that the electricity industry should evolve towards a competitive structure, the end result of which will be a situation where the force of fair competition will be the sole determinant of the price of electricity.

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The innovative African kilowatt-hour

* A C CALITZ

There is a world-wide resurgence of interest in pricing electricity. Whether motivated by deregulation and the threat of competition (as in England and New Zealand), or by the restructuring of regulatory goals to encourage competition or conservation (as in the United States), electricity suppliers and distributors are seeing pricing as a means of safeguarding, maintaining and increasing sales. South Africa is no exception in this regard, and this paper describes current developments in electricity pricing in the South African electricity supply industry (ESI) in response to pressures across several fronts. These pressures come from (1) customers to reduce electricity prices to facilitate growth and survival in the South African economy; (2) the National Electrification Programme; (3) the appointment of the National Electricity Regulator; and (4) moves by Southern African electricity utilities to establish a Southern African grid.

The paper reviews the current status of electricity pricing, metering, demand profile research and demand-side management in South Africa.

Keywords: South Africa; Eskom; electricity supply industry; electricity prices; demand-side management

The South African Electricity Supply Industry

Salient features

The South African electricity supply industry comprises

* Eskom, the national electricity supply utility, which generates 96% (159 TWh) of the electricity in South Africa and transmits 57% of that energy directly to large industrial and mining customers, and 900 000 residential customers;
* 200 non-Eskom redistributors of electricity, who supply electricity to residential, commercial and small industrial customers.

Five pricing interfaces

From a tariff perspective, the present structure of the electricity supply industry contains five pricing interfaces:

At the **first** interface, electricity is "sold" by the majority of Eskom's power stations on an internal generation tariff, to the main transmission system which, at the **second** interface "sells" to Eskom's distribution business at another internal tariff known as the transmission tariff.

At the **third** interface, the Eskom distribution business supplies electricity on a bulk supply tariff to approximately 200 redistributors, and at the **fourth** interface, these redistributors sell to their customers at redistributor tariffs. At the **fifth** interface, the Eskom distribution business also sells directly to mining, industrial, rural, agricultural, traction, commercial and residential customers on a variety of tariffs.

Developments in the South African electricity supply industry

It is important to note several important developments in the South African ESI. Some of these are:

* a high degree of politicisation of electricity pricing and attendant issues;
* customer calls for reduced electricity prices to facilitate growth and survival in the South African economy;
* renewed growth in the South African economy following the recent political transition in the country;
* the National Electrification Programme for 3 million houses, and the resulting focus on residential electricity tariffs;
* the appointment of the South African National Electricity Regulator, and the investigations into restructuring the electricity supply industry;
* the attempts by Southern African electricity utilities to establish a Southern African electricity grid, and the requirements to engage in energy trading.

These developments have given strong impetus to new developments in the field of electricity pricing in South Africa.

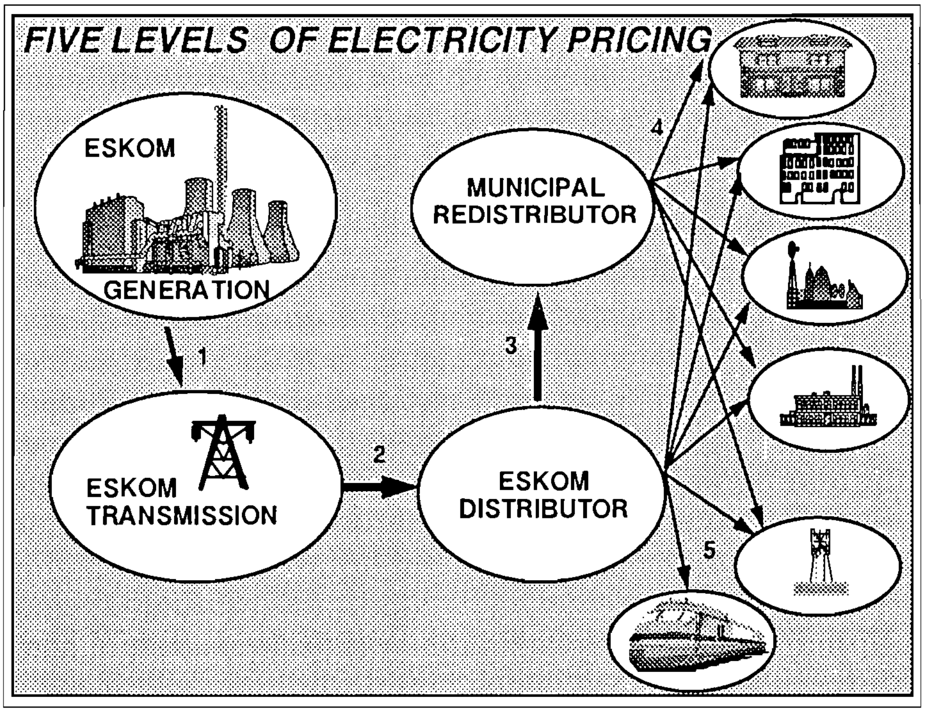

Figure 1: Five levels of electricity pricing

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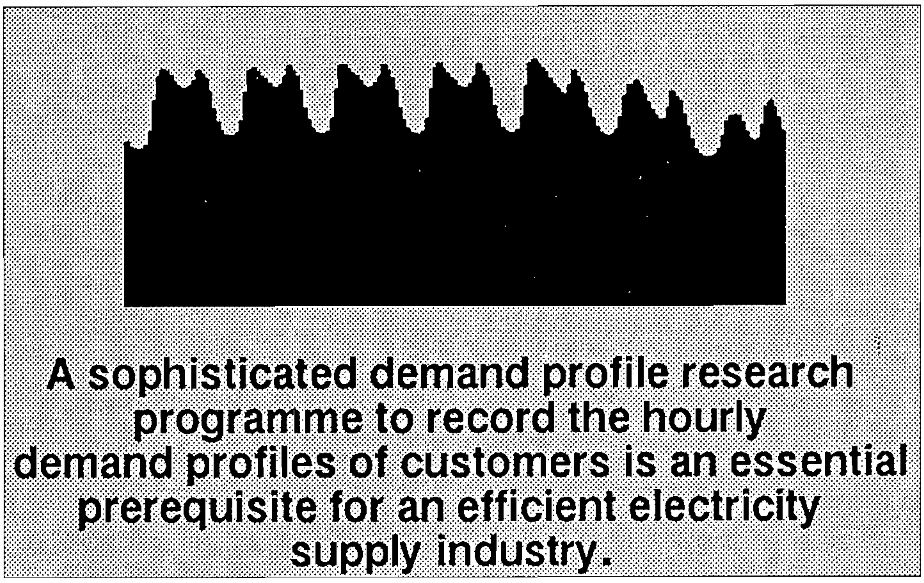

Figure 2: Demand profile research

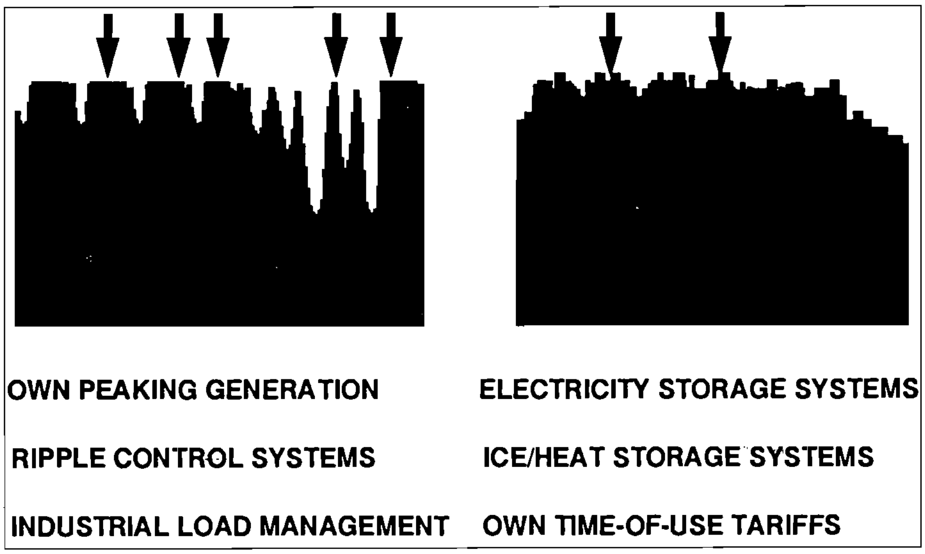

Figure 3: Customer demand-side management

Eskom tariff developments in the past five years

Pricing compact

The current average electricity price for a large high voltage industrial customer of Eskom is 2,7 USc/kWh (exclusive of 14% VAT). Eskom in 1991 entered into a pricing compact with its customers and the South African government in which it has pledged to reduce the real price of electricity by 20% during the period 1992 to 1996. This compact has now been extended to also reduce the real price of electricity by 15% during the period 1995-2000.

Prices and tariffs

During the past five years Eskom has introduced:

* a tariff for off-peak consumption of electricity
* tariffs for prepaid electricity
* non-tariff pricing - growth incentives for industry, and self-generation displacement agreements for municipal customers with their own generation
* time-of-use options with time-variant energy rates for customers
* linking the price of electricity to the price of a commodity produced by the customer
* internal pricing mechanisms between its power stations and transmission, and between transmission and its distribution business
* names - like Nightsave, Maxiflex, Homepower and Homelight - for its prices to customers
* lifeline tariffs for needy customers
* interruption clauses, in exchange for price reductions, in supply contracts
* quality of supply commitments for Eskom and requirements from customers in supply contracts.

To achieve this, extensive work had to be done in

* analysing the time-differentiated short- and long-run marginal costs of generation
* developing cost-of-supply methodologies
* tariff design
* demand analysis.

Demand profile research

* Eskom, at the beginning of 1989, embarked on an extensive profile research program to measure customers' active and reactive demand profiles. At present the demand profiles of 30% of Eskom's customer demand are captured on a routine basis. Other pioneering work has been done, or is presently being undertaken.
* Municipalities are disaggregating their system demand profiles.
* The South African hourly system electricity supply profile (Eskom, municipalities, and industrial self- and cogeneration summated) has been measured and disaggregated into its constituent components of customer demand.
* Eskom has investigated the demand profiles of developing communities and calculated the likely impact on the system demand profile of the National Electrification Programme.

A sophisticated demand profile research program to record the (half) hourly demand profiles of customers is an essential prerequisite for an efficient electricity supply industry. Eskom has benefited greatly from inputs received from the Electricity Association in Britain and Electricité de France. Demand profile research in South and Southern Africa is now being conducted at six levels: an international level between countries on the subcontinent, a national level, an Eskom level, a customer level, a municipal level and an end-use level.

Demand-side management

During the past 20 years Eskom's customers have invested some R1 500 million in demand-side management equipment (own generation, ripple control systems, industrial load management, power factor correction, electricity storage systems, hot-water and ice storage systems) to manage their maximum demands.

Redistributors of electricity and end-use customers are discovering that they have at least six mechanisms at their disposal to shape their demand.

Eskom repeatedly investigates and analyses its own cost behaviour and tariff structure to ensure that the correct price signals go to customers for their decision-making with regard to demand-side management.

Metering developments

Innovative developments in electricity tariffs usually stimulate metering developments. During the past five years the South African ESI has seen

* the local development of prepayment meters using disposable cards, encrypted numerical tokens, and "smart" cards
* the local development of meters with a time-of-use capability
* Eskom installing 1 000 meters with a time-of-use capability for its large customers
* Eskom and municipalities beginning to move towards remote interrogation of metering
* Eskom upgrading the metering on its main transmission system for transactions between its transmission and distribution businesses
* the development of a universal metering-billing interface by Eskom to interface between the meters of a number of local and overseas manufacturers and Eskom's billing systems.

The interest of commercial customers, municipalities, consultants and Eskom in recording the demand profiles of customers (not necessarily for immediate tariffing purposes) has also created an additional demand for meters with a demand profiling facility.

The size of the South African electricity supply industry warrants the continued local development of electricity meters to fulfil the needs of customers (for information and control signals from the meter) and electricity suppliers alike.

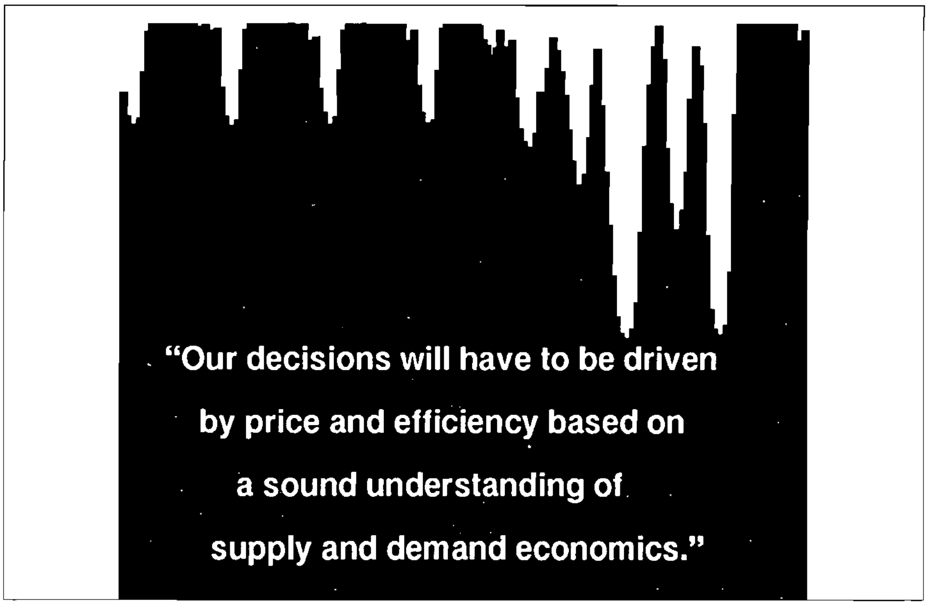

Figure 4: The future of demand-side management

Training and education

A training and education programme in power system economics and electricity pricing is a vital prerequisite for tariff reforms in a developing country. To this end Eskom has made maximum use of international and local training courses in supply-side economics, demand-side economics, electricity tariffs, and energy economics. The considerable number of publications in these fields by the staff of the South African ESI also bears testimony to these developments in the industry.

International knowledge transfer

In endeavouring to catch up on the South African backlog in tariffing innovation, Eskom deliberately sought to effect an international knowledge transfer,

France	Rigorous cost analysis Tariff theory Load research Time-of-use tariffs Peak-day-withdrawal tariffs
Britain	Hourly pricing in a power pool Load research Interruptible tariffs Bulk supply tariffs Regulation
U.S.A.	Demand-side management Hourly integrated purchase pricing Spot pricing Cost-of-service studies Theory of public utility pricing
New Zealand	Unbundling costs Treatment of transmission costs Price as a "P" in the marketing mix

Table 1: International knowledge transfer

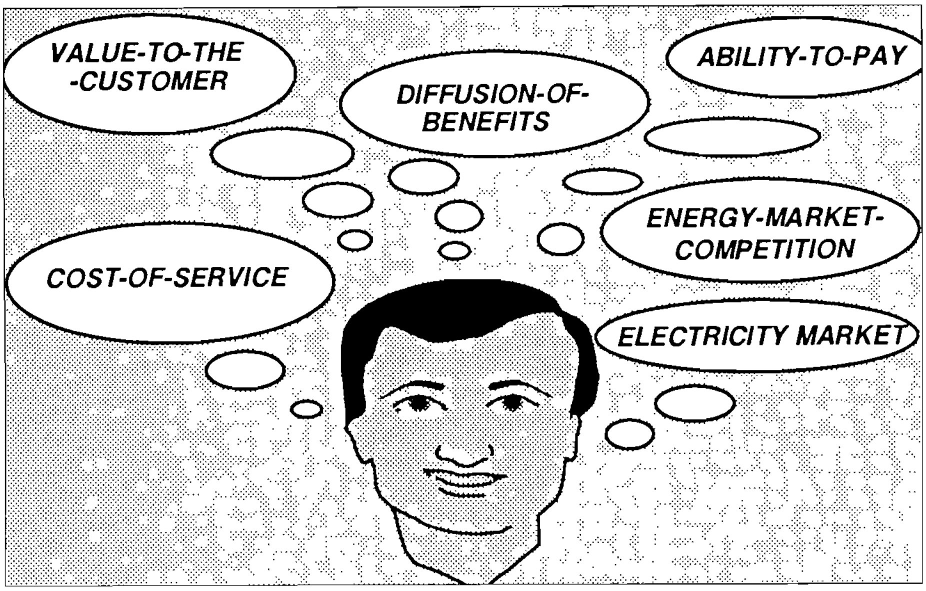

Figure 5: Pricing philosophy

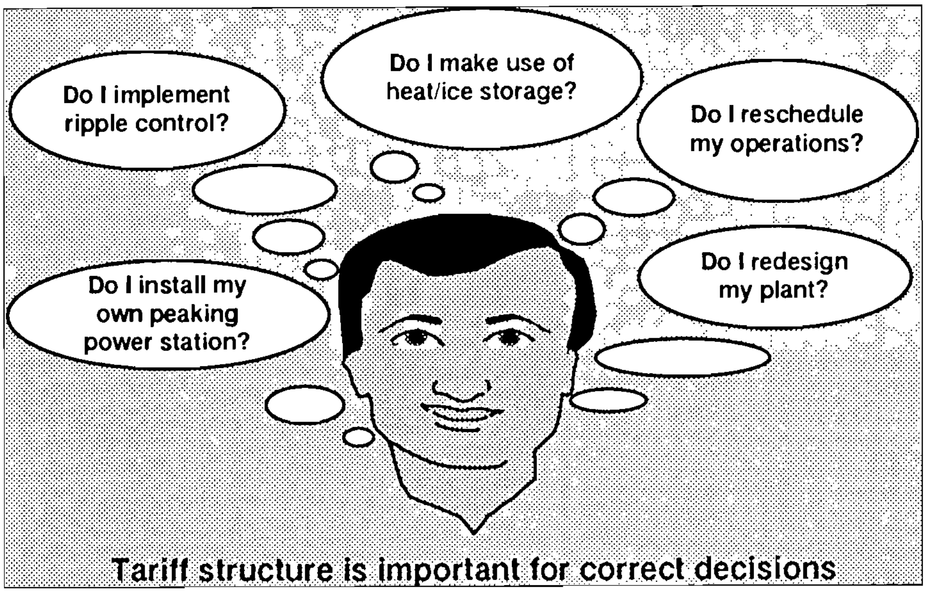

Figure 6: Customers take decisions based on electricity tariff structure ...

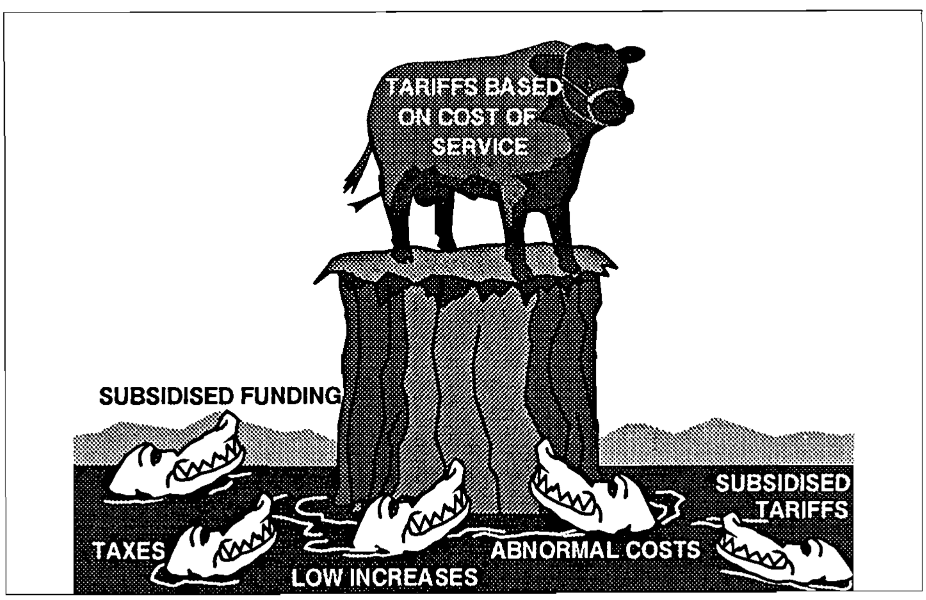

Figure 7: Political intervention in electricity tariffs

learning from the cutting edges in France, Britain, the U.S.A. and New Zealand. South Africa sourced expertise as follows:

A framework for development

When a developing country emerges from political isolation and embarks on a process of tariff reform it is vital that it has a framework for tariff development covering the schools of thought on electricity pricing, customer requirements and expectations, the aims and scope of electricity pricing policy, the effect of subsidies on decision-making and efficiency, and political intervention in electricity tariffs.

Schools of thought: Several schools of thought may guide the direction of electricity pricing policy. Some of the important ones are cost-of-service, value-of-service, competitive pricing and social pricing. In a developing country it is important to define, describe and communicate these to a wide audience.

The effect of subsidies - Uneconomic customer decisions: In an attempt to demonstrate the effects of subsidies and tariff distortions in terms of uneconomic customer decisions, the following two models were developed. **Distorted electricity tariff levels**, as a result of premiums or subsidies, cause customers to install their own base load generation plant, switch to alternative energy forms, or take bad decisions on electricity intensive projects. **Distorted or inappropriate electricity tariff structures** result in uneconomic customer decisions related to the supply of peaking power: peak power plant, ripple control, heat and ice storage, operations scheduling and power factor correction.

Political intervention in electricity tariffs: Political intervention in electricity tariffs is the norm rather than the exception in developing countries. To frame the debate, the following framework for political intervention in electricity tariffs was developed.

Given that electricity tariffs are designed to be cost-based, intervention with regard to either the costs or tariffs of an electricity supplier constitutes intervention in its tariffs. There are five areas of possible political intervention in electricity tariffs:

(1) **subsidised funding** through prescribed investments or low-cost loans for the electricity supplier or fiscal subsidies;

(2) imposing **abnormal costs** for subsidised fuels, employment targets, purchasing cogeneration;

(3) **low increases** through price capping;

(4) taxes;

(5) pressure for **subsidised tariffs** for specific customer classes (agricultural, residential, industrial) or for customers in specific geographic areas.

Political intervention invariably results in cross-subsidisation; subsdies between generations of customers, between customers in different classes, and between the people and customers through taxes. The political objectives of intervention are fourfold:

(i) to favour certain customer categories for political, social or developmental reasons;

(ii) to achieve an income redistribution;

(iii) to achieve economic development; to protect the environment; and

(iv) to cap the price of a monopoly product. Practical objections to political intervention relate to issues of efficiency in the economy, to price elasticities of demand, and to intervention in the management of the electricity supplier.

The current view in the South African electricity supply industry must transparently quantify the cost of such intervention.

The innovative African kilowatt-hour has been hard at work to ensure that the South African economy and public is served by an efficient electricity supplier.

Acknowledgments

Thanks to Eskom and a terrific team of colleagues in Electricity Pricing, Power System Planning, Electricity Demand, Generation and Finance for their enthusiasm.

Rural electrification case-study in northern Botswana

* M DAVIS, *M L BORCHERS and *A A EBERHARD

The article describes an evaluation of the electrification, in 1987, of the Kasane/Kazungula area in northern Botswana. This project has been largely funded by donor grants. Although electricity supply has had significant beneficial impacts on the development of the local economy, almost all of the low-income households (over 60% of the population) do not have access to the network. Proposals are made describing an alternative connection and tariff policy for these households, and the financial and economic implications of these proposals are tested. Conclusions are made concerning the planning and identification of rural electrification projects and the need to ensure, (1) that the economic base in the area is sufficient to support and benefit from the investment and, (2) that adequate interventions are made to maximise the benefits to low-income households.

Keywords: rural electrification; Botswana; Kasane; Kazungula; energy consumption; scenarios; electricity prices; case-studies

Introduction

In most rural areas of Southern Africa, levels of access to electricity are low. However, in countries such as, Namibia, Botswana and South Africa, there has been a recent increase in rural electrification activities and a growing interest in developing plans to extend the grid network into the rural areas. There are examples in Namibia where there has been a fairly extensive electrification programme in the rural areas of Ovamboland and in South Africa where the national utility, Eskom, has embarked on a major electrification programme, much of which will be aimed at the rural areas of the country.

At this early stage in the development of these countries' rural electrification programmes, it is important to take stock of experiences to date. The two important questions that need to be addressed relate to the links between energy and equity, and between energy and the local economy. If equity considerations are driving a rural electrification programme, then it is important that some attempt be made to monitor and evaluate the effects of access to electricity on low-income households. On the other hand, if a rural electrification programme is to be sustainable, it is necessary that efforts be made to ensure that the economic benefits of individual projects are maximised.

> "... in the development of ... rural electrification programmes ... two important questions that need to be addressed relate to the links between energy and equity, and between energy and the local economy."

This case-study attempts to examine the use of electricity in a small rural town in northern Botswana, six years after the town was electrified. The significance of the study is that it represents an ideal opportunity to assess in some detail the experience in one specific locality. Not only are there lessons concerning the methodological aspects of this type of assessment, but it is hoped that the experience will provide insights of relevance to similar projects in other rural areas in the region.

Assessment objectives and methodologies

An assessment was commissioned by the Energy Affairs Division (EAD) of the Botswana Ministry and the Canadian International Development Agency (CIDA), who were the main funders of the electrification project. CIDA was interested in an assessment of the value and impact of the original grant, whereas EAD was interested in the development of policies concerning rural electrification in Botswana.

A baseline study[3] was undertaken in 1987 to determine the pre-electrification characteristics of the area. In early 1994, a second study was undertaken to examine the effects of the electrification project[4]. For the second study, information was gathered using a number of techniques. Household energy use information was gathered mainly by means of an extensive questionnaire survey. Over 20% of all households were surveyed. Participatory rural appraisal techniques were also used to obtain information concerning energy consumption patterns, focusing on wood use and the history of development in the area. Detailed interviews were undertaken to collect information on business and government departments. A total of 76 interviews were conducted, which covered almost all businesses and government offices in the area.

Description of the area

The Kasane/Kazungula area in northern Botswana was electrified in late 1987, with power being supplied from the Zambian grid. Much of the costs of the new transmission and distribution system was grant-funded and much of the subsequent extension to the reticulation system was funded through the Botswana Government's Accelerated Land Servicing Programme (ALSP).

The town of Kasane is the administrative centre for the northern district of Botswana and is located on the Chobe river in the extreme north-eastern corner of the country. The village of Kazungula, also on the Chobe river, is located 30 km to the east of Kasane. The economy of the

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area revolves around four main functions: (1) the area's role as the regional district administration centre (the State is the largest employer in the area); (2) the tourism trade, which is the second largest employment category; (3) business related to the transport route to Zambia and Victoria Falls and; (4) its function as a supply depot for surrounding rural settlements in Botswana, Zambia, Zimbabwe and Namibia.

The town of Kasane has a population of around 8 000 and four main residential areas: State-owned houses "White City", the private river front (high income residents), the Self-Help Housing Agency (SHHA) area where plot owners build their own houses, and the Plateau, where the ALSP has financed the construction and servicing of 215 houses and laid out a further 200 SHHA sites (currently unoccupied). Other residents in the area live in the village of Kazungula and there are a few other houses at the border posts, prison, and the defence force camp.

The main businesses in the area are tourist lodges (five in the vicinity), wholesale and retail outlets, and a reasonably large irrigation farm run by the Botswana Development Corporation. There is also a significant informal business sector. The area is relatively well serviced with an adequate road system, an airport, an extensive water distribution network, a hospital, a bank and three junior schools. As part of the Government's ALSP, serviced industrial and commercial sites were established. The majority of these remain unoccupied.

Access to electricity

The Botswana Power Corporation (BPC) does not generally finance new connections. However, there are two financing schemes available: the Rural Collective Scheme (RCS) and the Line Service Charge scheme (LSC). The RCS, operated by the BPC and the Botswana government, is designed to facilitate domestic access to electricity. New users pay 40% of the total cost upfront, and the State pays the remaining 60%. This amount must then be repaid by the users over the next ten years (at a 9% nominal interest rate). The LSC scheme is designed to promote a community-wide initiative to gain access to electricity. Each user must pay an initial amount equal to the total cost of the project, divided by the potential number of users (estimated as 70% of the population). Connected users must also pay, on a monthly basis, the interest on the loan covering the outstanding costs. When 70% of the population has been connected, repayments cease. Unless either of these schemes is applied (neither of which have been applied in Kasane), new consumers must pay the full costs of connection and line extension. Both the RCS and the LSC schemes require users to make a large upfront payment. This represents a major hurdle to most households and neither of these schemes have been widely applied (access to electricity in the rural areas of Botswana remains below 5%).

	White City	SHHA	Plateau houses	Plateau SHHA	River front	Kazungula	Other
Households	145	484	215	0	16	123	8

Table 1: Residential areas in Kasane/Kazungula

	Median household monthly income (US$)	No. of electricity users	No. of houses/ offices, businesses	Percentage electrified (%)
DOMESTIC				
Kazungula	220	6	123	5
Plateau -houses	520	215	215	100
SHHA	270	14	484	3
White City	590	140	145	97
River front	1 650	15	16	94
Other		43	43	100
Total domestic	390	433	1 026	42
BUSINESS & GOVERNMENT OFFICES				
Large business		42	46	91
Small business		3	33	9
Government offices		42	45	93

Table 2: Take-up rates of different end-users

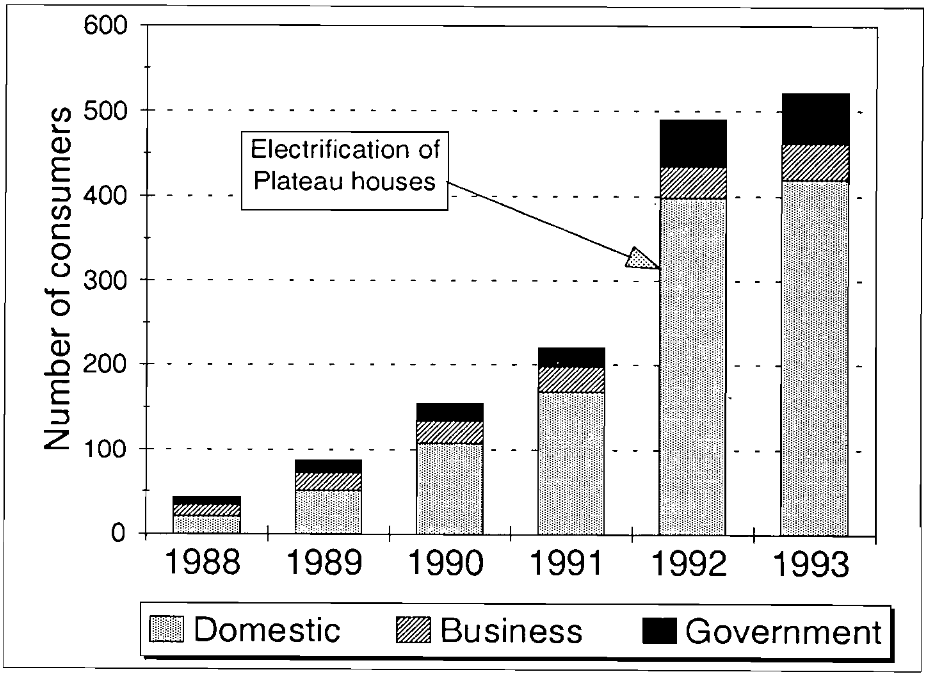

Figure 1: Growth in the number of consumers

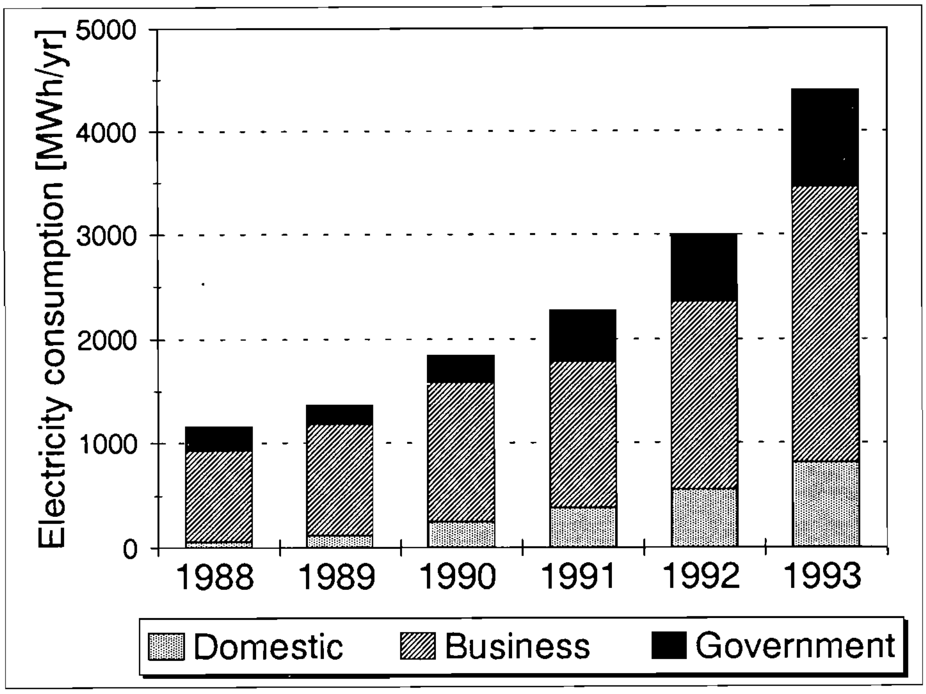

Figure 2: Growth in electricity consumption

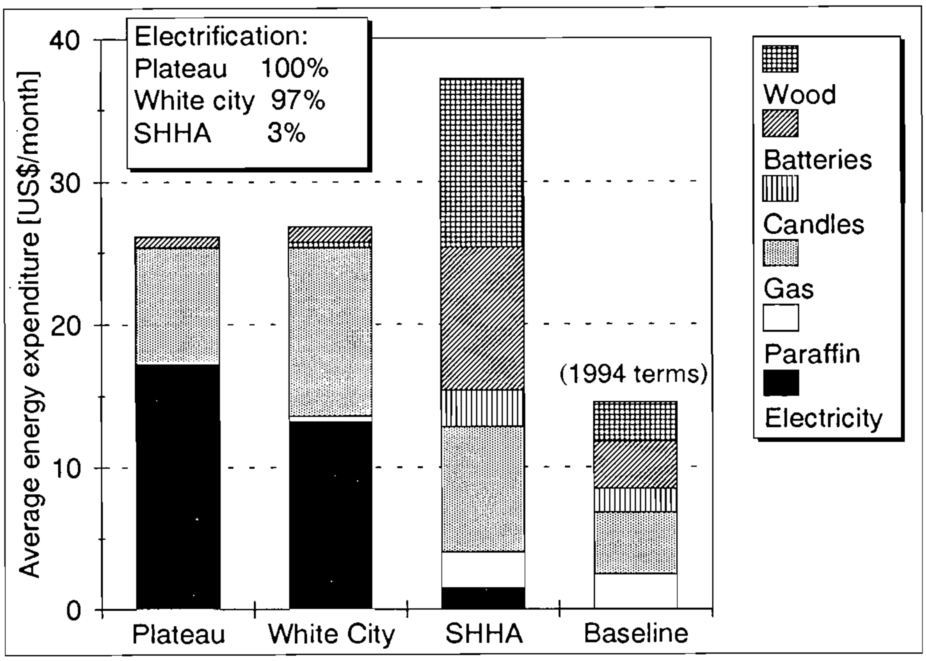

Figure 3: Current energy expenditure

As a result of the high upfront costs involved, very few domestic households in the Kasane/Kazungula area have paid for connections. The level of electrification in Kazungula and the SHHA area is around 4%. However, the Botswana Government paid for connections to State-owned houses in Kasane and has paid for the cost of reticulation in the new housing area on the Plateau (through the ALSP). The majority of larger businesses and government departments have been connected, although only 9% of small and informal businesses have access to electricity.

Energy use patterns

The growth in the number of consumers and the growth in electricity demand is shown in Figure 1. It can be seen that the bulk of electricity consumed is by consumers on commercial tariffs. Average consumption of households connected to electricity is low (160 kWh/month in 1993).

The baseline study conducted in 1987 made estimates of future peak demand and consumption. These predictions have not been met to date: current consumption and demand is still less than 25% of the predicted values. However, recent growth rates in consumption (from 1990 onwards) are far greater than those originally estimated and if this continues, the actual consumption rates will soon exceed the predicted values.

Domestic energy consumption and expenditure

Wood, candles, paraffin and batteries are widely used in the areas without wide access to electricity – Kazungula and SHHA. Gas is extensively used for cooking, even in electrified households.

It is difficult to compare the energy expenditure of electrified and non-electrified households, mainly due to the fact that average incomes in electrified areas tend to be much higher than in non-electrified areas. However, there is some evidence to suggest that households without access to electricity pay more for energy. In particular, residents in Kazungula and SHHA spend, on average, 25%-30% of energy expenditure on batteries, which are hardly used in electrified areas.

Energy consumption by businesses and Government

All the larger business enterprises are heavily dependent on electricity, although gas is still used for cooking in lodges and restaurants. Before electrification in 1987, most businesses used diesel generators as an electricity supply and the switch to grid electricity has, by and large, meant considerable savings in energy expenditure. Tourist lodges tend to be penalised by the structure of the business tariff, where the demand charge is based on the greater of the actual demand and 90% of the maximum demand over the past twelve months. Since the tourist industry is largely seasonal, the lodges have large electricity bills even during the off-peak season.

Most small businesses have not been able to afford the connection fee, in spite of the advantages offered by access to electricity.

Almost all State departments have connected to the grid and use a wide range of appliances. The main benefits for government offices are the use of office appliances, cooling equipment and lights. Some departments used diesel generators before electricity was available and have benefited from the reduced cost, greater convenience and increased capacity of grid electricity.

Energy consumption by community facilities and agriculture

Energy consumption by community facilities is mostly restricted to electricity use. The junior secondary school is fully electrified, while the staff houses at the other two schools have access to electricity. The hospital uses a wide range of electrical appliances which used to be powered by two diesel generators. One generator has been kept as a back-up generator. Prior to 1987, the hospital ran the generators for 12-14 hours per day and at night used hurricane lamps for lighting.

The importance of streetlights was raised by many of the residents during the surveys and interviews. They are expected to be an effective measure against crime, and to allow safe movement at night (since the area is adjacent to the Chobe Game Reserve and many wild animals roam the area at night).

One of the major benefits of access to electricity has been the ability to operate electric pumps for water supply. A few years after electricity was brought to the area, the water supply for the Kasane area was extensively upgraded and large electric pumps were installed. As a result of this upgrading exercise the pumping capacity has almost tripled, but the actual expenditure on pumping has decreased by approximately 15% in real terms.

There is only one large agricultural enterprise in the area – Chobe Farms. Prior to 1987 the farm used a small diesel generator to supply electricity to the farm workshop and houses, and a large 120 kW diesel pumpset was used to irrigate the land. Before connecting to electricity, the farm conducted a financial study to investigate the feasibility of doing so. The results showed a small cost advantage for electricity and so a connection was made. Additional benefits have been that the electric pumps are more easily controlled and a cold-room has been installed which allows for harvested products to be stored with minimal waste.

A new domestic connection policy

It is clear that the benefits of electricity in the Kasane area have been restricted to government offices, commercial enterprises and those families in government houses. Over 60% of the population do not have access to electricity. More importantly, unless new policies are implemented to promote improved access, very few additional households will be able to afford the connection fees and the level of access is likely to decrease (as the population grows) rather than increase.

New electrification projects in South Africa have used prepayment meters and a straight-line tariff. Connection fees are nominal, which effectively overcomes the main hurdle to low-income households obtaining access to electricity. The tariff is necessarily comprised of an energy component, which includes a capital redemption surcharge to cover the costs of connection(4). In spite of this surcharge, recent experience indicates that revenues are inadequate to recover costs and cross-subsidisation is required to cover the costs of electrification(2).

> “Where large investments are to be made to extend a bulk supply to a rural area, it is imperative that efforts be made to ensure that the benefits of that service are maximised. In particular, it is necessary to ensure that special financing arrangements be made to allow low-income households the opportunity to connect up.”

The situation in Kasane represents an opportunity to utilise similar policies. The bulk supply infrastructure exists and the medium-voltage reticulation system is close to most of the unelectrified residential areas. The costs of extending reticulation would be relatively small in comparison with the investment to date. To connect all non-electrified households in Kasane, Kazungula and future houses in the new Plateau housing development scheme would cost approximately US$1 m, less than 15% of current investment to date.

Financial and economic analysis

A financial analysis attempts to examine the financial viability of the project from the utility's viewpoint. Only those costs and receipts seen by the utility are accounted for and the results show the financial returns to the utility. The economic analysis attempts to take a broader perspective and includes all the real economic costs and benefits directly attributable to the project. It is the economic analysis which can help to evaluate the economic viability of the project and assess the justification for grant funding or subsidies.

Both the financial and economic evaluations of the project require a long time frame (twenty years was used here). This makes it necessary to estimate future consumption growth and cost increases.

Consumption growth scenarios

The most important assumptions concern the expected increase in the number of consumers and the increase in average domestic consumption. For non-domestic consumers, long-term growth trends (of the number of consumers) of around 5% per annum were assumed. This is less than has been experienced in the past few years. Consumption estimates for these consumers were based on the experience to date.

For domestic consumers, two scenarios were proposed. The first scenario assumed that there would be no changes to the connection policies and that as a result, the increase in the take-up rate would remain low. Connection rates in the currently unelectrified areas of Kazungula and SHHA were assumed to slowly increase access to a level of around 7%. In the new housing development scheme on the plateau (a new SHHA area), where fairly extensive reticulation already exists, it was assumed that the sites would be occupied over the course of the next twenty-four months and that take-up rates would gradually increase to 30%. Average domestic consumption was assumed to be similar to that experi-

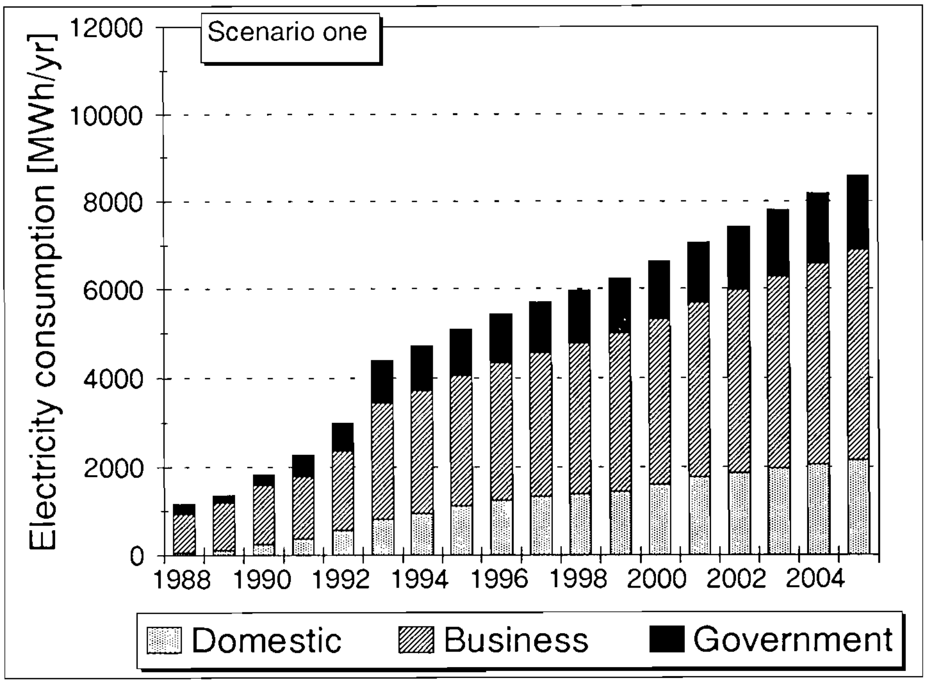

Figure 4: Estimated consumption growth: Scenario One

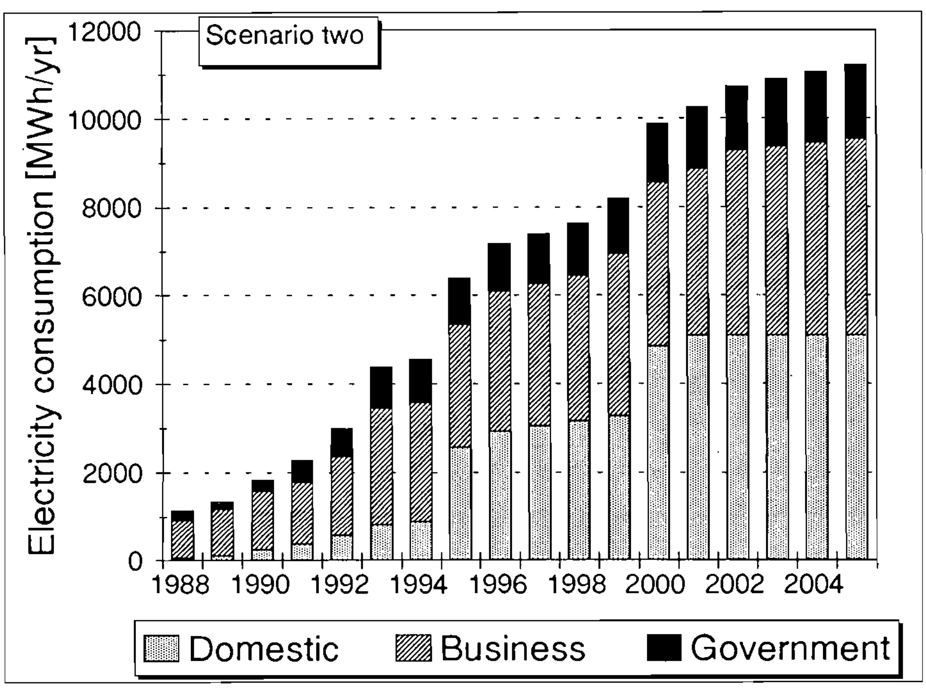

Figure 5: Estimated consumption growth: Scenario Two

enced in the past few years - in the region of 150-200 kWh/month.

Scenario Two attempted to test the proposed new policy concerning the electrification of domestic dwellings. It was assumed that prepayment meter systems would be installed and that consumers would pay a nominal connection fee, but a higher tariff. As a consequence of this policy, it was assumed that the take-up rates in the unelectrified areas would be high - in the region of 90% of all households. Non-domestic consumers would be connected and billed using the same techniques as before.

The prepayment meter tariff was structured to completely recover connection costs. The tariff consists of a single energy charge which is made up of the standard domestic energy charge, a surcharge to cover the fixed costs (currently billed at US$2,60 per month), and a capital redemption surcharge to cover the original connection costs. Assuming a connection cost of US$1 100 per site, a payback period of twenty years, a real rate of return requirement of 2,5% and an average consumption of 200 kWh/month, the tariff is made up as follows:

Standard energy charge:	9,8 USc/kWh(70%)
Fixed cost surcharge	1,3 USc/kWh(9%)
Capital repayment surcharge:	2,9 USc/kWh(21%)
TOTAL	14 USc/kWh(100%)

Although this tariff may appear high in comparison with the Eskom S1 tariff for prepayment meter systems (currently at 7 USc/kWh), the bulk of the cost is made up of BPC's current domestic energy charge, which is high in comparison with other utilities in the Southern African region.

Since the capital repayment surcharge is calculated at a low interest rate over a long period, this tariff policy is in effect a concessionary financed tool to promote increased domestic access to electricity. It should be noted that the Rural Collective Scheme financed by the Botswana Government charges negative real interest rates on loans.

Capital and operating costs

The original grant, made in 1986, totalled US$3 m (US$5 m in 1994 terms) and paid for the 66 kV line from Zambia, the Kasane substation, 30 km of medium-voltage reticulation and a contribution towards the cost of an underground line inside the Chobe Game Reserve (BPC, the Chobe Lodge and the Botswana Government also contributed in equal shares to the cost of this line).

Connections to the distribution system commenced in 1988 and, over the past five years, a total of US$0,8 m (1994 terms) in connection costs has been paid to the BPC by private and Government customers.

In 1992, the ALSP paid for electricity reticulation to newly developed industrial sites near Kazungula and the newly developed commercial sites in Kasane. In addition, reticulation in the Plateau area was installed and the new houses constructed there were connected. The total investment in electricity infrastructure came to about US$0,4 m in 1994 terms.

Under Scenario One, a further US$0,5 m (1994 terms) in connection fees is paid by private and Government customers. Under Scenario Two, an amount of US$1 m is invested by the BPC to establish new connections in unserviced residential areas.

Operating costs include bulk electricity purchases from ZESCO and support costs in the area. The ZESCO tariff currently consists of a basic charge of US$386 per month, an energy charge of 1,2 USc/kWh and a demand charge of US$3,3/kVA per month. It is assumed that this tariff will increase with inflation. The support costs include maintenance, billing and service costs, salaries and overheads. These were estimated on the experience of past trends in the Kasane area (in the region of US$150 per customer per year).

		IRR[a] (%)	NPV[b] (US$ m)
Financial analysis	1986 to 1993	43	0,6
	Scenario 1: to 2005	50	2,5
	Scenario 2: to 2005	48	2,5
Financial analysis (assuming no grants were made)	1986 to 1993	-25	-4,4
	Scenario 1: to 2005	-0,2	-2,6
	Scenario 2: to 2005	0,3	-2,6
Economic analysis	1986 to 1993	-20	-4
	Scenario 1: to 2005	3,4	-1,3
	Scenario 2: to 2005	3,3	-1,4

(a) Internal rate of return.

(b) Net present valus (in 1994 terms). A real discount rate of 6% was used.

Table 4: Results of financial and economic analysis

Revenue and benefits

	Basic Energy Demand		
	(US$/mth)	(USc/kWh)	(US$/kW)
Domestic	2,57	9,8	n/a
Business 1	6,25	10,0	n/a
Business 2	6,25	5,2	12,50
Business 3	6,25	4,7	8,45
Government	6,25	12,5	n/a

Table 3: Tariffs in Kasane (1993)

The two main sources of revenue to the BPC are customer contributions towards capital costs (described above) and revenue from electricity sales. Tariffs in the area include a domestic tariff, three business tariffs and a special tariff for government departments. Tariffs have decreased in real terms over the past few years (by approximately 5% per year) and it is expected that similar decreases will continue for at least a few years. After a further five years, tariffs are assumed to remain constant in real terms.

In Scenario Two, new domestic consumers are charged at the proposed new tariff. The energy component of this tariff follows the same price trend as the other tariffs.

The additional economic benefits which arise from access to electricity include the consumers' surplus, defined as the difference between consumers' willingness to pay for electricity and what they actually pay. The data from the questionnaire survey was analysed to examine the savings due to access to electricity. Based on the quantity and cost of fuels displaced by electricity, a willingness to pay for electricity was calculated for different consumer categories. For domestic and small commercial consumers, the willingness to pay was 30% higher than the actual tariff, and for large commercial consumers, the willingness to pay was 10% higher than the actual tariff. For new domestic consumers on the prepayment meter tariff, no consumer surplus was included since the proposed tariff is relatively high.

Other observed benefits are harder to quantify and value. Electricity has certainly been a stimulant to the development of the local economy and a number of businesses indicated that they would not have been established had electricity not been available. The number of jobs thus created was counted and 10% of the annual salary bill of these newly created jobs was taken as an estimate of the benefit associated with the provision of electricity. This was a crude but conservative way to account for the growth stimulus created by the project.

Financial and economic analysis results

A real discount rate of 6% was used to discount costs to their present value. All costs are reported in 1994 terms.

Since the capital investment by the utility was small and most of the initial costs were paid for by a grant, it can be expected that financial returns will be high. To date the internal rate of return has been in the region of 45% and is projected to remain high over the course of the analysis time frame. Even under Scenario Two, which requires the utility to invest in domestic reticulation, the internal rate of return after twenty years is close to 50%. Had grants been restricted to 50% of the initial costs, then the real financial returns would have been in the region of 6%.

However, had the initial grants not been available, and if the utility had paid for the full costs of installing the bulk supply, then the financial results would have been poor. The net present value of the project would be negative after twenty years (-US$2,6 m) and the internal rate of return would be close to zero.

When the additional economic benefits are included in the analysis, the results improve considerably. Although the net present value remains negative, the internal rates of return are in the region of 3%-4%. It must be stressed that the quantification of economic benefits tended to be conservative, and this result shows that the project is marginally economically viable.

Discussion

A comparison between the two scenarios shows that the proposed new connection policy will have little impact on the economic and financial viability of the project. The capital costs of connecting these households are designed to be recovered over twenty years, assuming an average consumption of 200 kWh/month during this period. The most important impacts of this policy on the utility are the exposure to a risk of US$1 m and the concessionary terms of the capital repayment portion of the tariff. If average consumption rates are below the estimated 200 kWh/month, then returns on the investment will be lower, thereby threatening the replication of the exercise in other areas. However, a sensitivity analysis on average domestic consumption rates showed that rates of return are only reduced by approximately 2% if the average consumption falls to 150 kWh/month.

Given the current situation in Kasane, there is the potential to make very real equity gains with a comparatively small investment and only limited exposure to risk. Given both the BPC's and the Botswana Ministry's interest in promoting domestic access to electricity, there are clear opportunities to explore appropriate policies and financing tools designed to achieve this objective. The Kasane area represents an ideal opportunity to apply proposals, such as those contained in this document, on a pilot project basis.

Conclusions

Perhaps the most important conclusion arising from this study concerns the planning of rural electrification projects. Where large investments are to be made to extend a bulk supply to a rural area, it is imperative that efforts be made to ensure that the benefits of that service are maximised. In particular, it is necessary to ensure that special financing arrangements be made to allow low-income households the opportunity to connect up. Such special arrangements allow important equity gains to be made through the benefits, financial and otherwise, that accrue to households.

At first glance it would appear that an area such as Kasane would be an ideal target for rural electrification. The area has a relatively large commercial sector (with a strong tourist industry), some agricultural and small-scale workshop activities, a large number of government offices and a reasonably dense residential area. In fact, even if all households were connected, domestic consumption would still only account for less than 50% of all electricity consumption. However, the economic analysis revealed that the project was only marginally economically viable (at very low social discount rates). This suggests two things: firstly, that it is necessary to look more closely at benefit measurement techniques (particularly with regard to the role that electricity can play in promoting economic growth in a small rural town); and secondly, that particular attention must be paid to the identification and selection of rural electrification sites.

In South Africa, Eskom has committed itself to a large-scale electrification programme and fairly ambitious annual domestic electrification targets have been set. However, most urban unelectrified sites, particularly the metropolitan areas, do not fall in Eskom's right of supply area. Consequently, it is likely that there will be a premature focus on the electrification of rural areas. Although experience is still limited, indications to date are that electricity consumption in rural households is very low. Consequently, if the electrification programme is to prove itself to be sustainable, it is necessary that careful attention be given to the links between electricity supply and commercial, productive and agricultural activity. Methods need to be developed to identify and select areas where a strong potential exists for electricity to make a significant impact on economic growth (at the local level), and strategies need to be implemented to promote the synergistic effects of electricity supply in conjunction with other economic activities and development projects.

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Electrification planning in Eskom

* D P THERON

The key factors in a successful, sustainable electrification programme are (i) understanding and managing within a dynamic, changing environment, (ii) actively pursuing community involvement and acceptance, (iii) the availability of accurate planning information, (iv) integrating with other development initiatives, and (v) a constant drive towards improving efficiencies and cost-effectiveness.

This paper focuses on electrification planning in Eskom and covers a range of important aspects considered to be essential for successful implementation, such as, the planning process, specific issues, tools and principles.

Keywords: electrification; planning; development; Eskom; non-grid electrification

Introduction

Eskom's electrification programme commenced towards the end of 1990. In 1991, some 31 000 connections were made. The 1995 target of 300 000 represents a tenfold increase over the four year period.

At the end of 1994, 44% of the estimated 8,4 million houses in South Africa were electrified and, provided that the electricity supply industry can meet the Reconstruction and Development Programme (RDP) electrification targets, 65% of the households in South Africa will have electricity by the year 2000.

Given the substantial increase in the number of connections over time, as well as the drive to reduce the costs of electrification, thorough upfront planning has become essential to ensure that the programme is implemented in an effective and efficient manner.

The electrification planning process

The long-term (20 year) national electrification connection targets have been derived from the National Electrification Economic Study (NEES) Phase 1 which was conducted under the auspices of the Finance and Tariffs Group for the National Electrification Forum (NELF). The aim of this study was to provide quantifiable inputs with regard to the financial impact of possible electrification programmes. This study covered an electrification programme up to the year 2012 and the medium-term scenario for the period 1994 to 1999 matches the RDP electrification requirements as illustrated in Figure 2. Based upon its supply areas, Eskom's national electrification targets have been extracted from this study.

Eskom re-evaluates the long-term targets of the electrification programme annually, taking into account current realities such as, the regulatory influence, electricity supply industry dynamics, supply areas, Government policy, housing and demographic dynamics, technologies and costs.

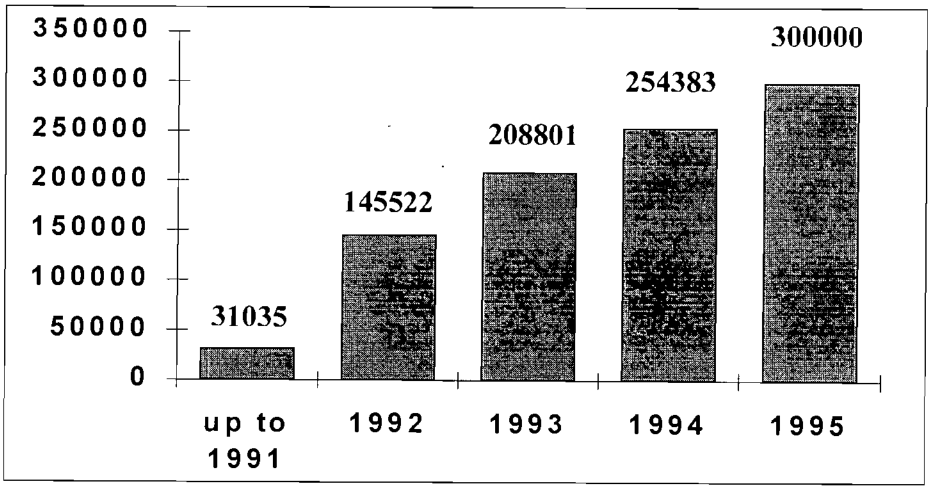

Figure 1: Eskom's annual electrification progress

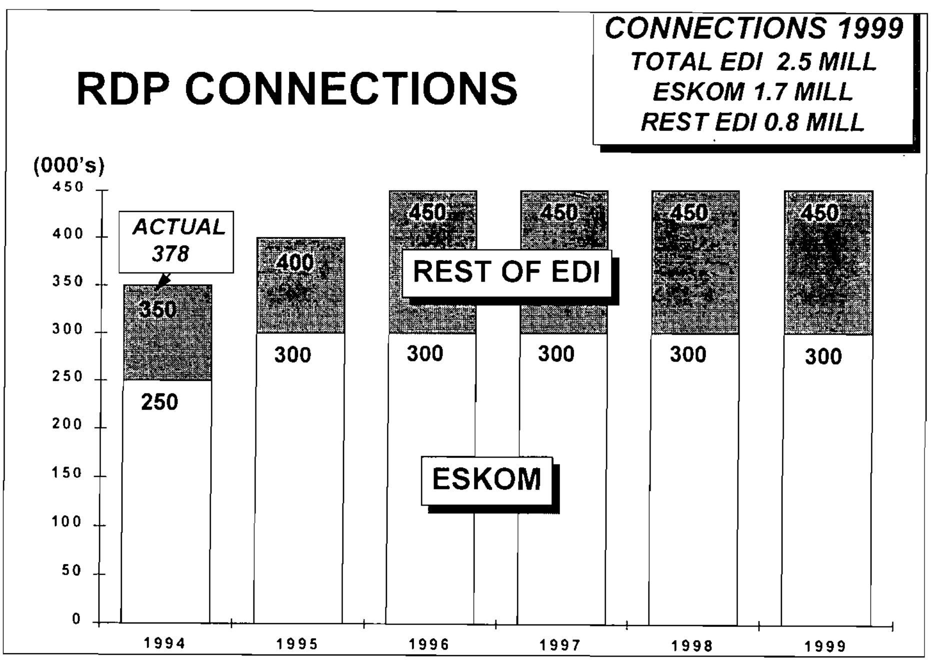

Figure 2: RDP electrification requirements

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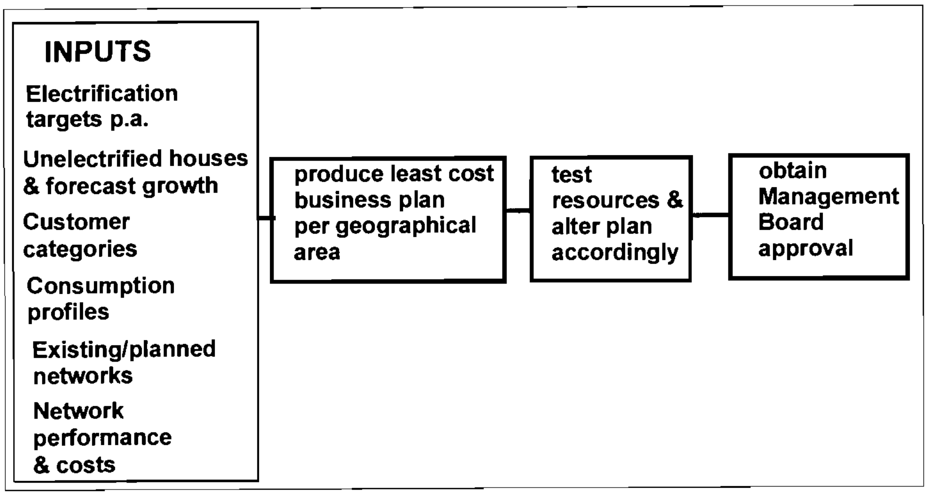

Figure 3: *Electrification business planning process*

	1996	1997	1998	1999	2000
Connections (No.)	300 000	300 000	300 000	300 000	300 000
Capital expenditure (Rm)	945	828	719	690	621

Table 1: *Eskom's electrification business plan*

* electrification planning is performed within a **public policy framework**, in accordance with RDP objectives, Government policy, and in a consultative and transparent manner
* electrification projects are selected so as to ensure **sustainability** of the electrification programme and, wherever possible, are planned in conjunction with other service-, energy- and infrastructure providers to ensure integrated development
* electrification is performed within the broader framework of **integrated energy planning**
* projects which are **not economically justified** are not performed unless a capital contribution equal to the uneconomic portion is received from an external source
* **maximum electrification capital expenditure and operating loss limits** for the electrification programme are set to ensure that Eskom's public commitment to reducing the real price of electricity can be honoured and that long-term financial health can be maintained
* **demand-side management** is encouraged to reduce the cost of delivering electricity and to improve the natural environment

Figure 4: *Eskom's electrification planning principles*

In line with its annual business planning process (Figure 3), Eskom produces a high-level 5-year electrification business plan. The first stage of the process entails the production of a least-cost network expansion plan to meet the national residential targets over time. Thereafter, this plan is adjusted according to the available resources, external influences and stringent cost reduction targets. Approval is gained from the Eskom Management Board to implement the plan, which is then shared with the stakeholders. The connections and capital expenditure electrification business plan for 1996 to the year 2000 is shown in Table 1. Stringent capital expenditure reduction targets have been set to ensure the long-term sustainability of the electrification programme.

The electrification planning process on the project identification and selection level falls in line with Eskom's distribution business capital investment process. Some R2 billion is annually invested in Eskom's distribution business for the creation of capital assets to service the existing customer base, new commercial ventures, and the increasing residential customer base. A 24-month rolling capital investment process has been adopted to ensure Eskom's capital programme is optimally managed. The capital investment plan consists of a 12-month fixed, as well as a 12-month semi-fixed plan. The fixed plan consists of projects which have already been approved through the internal Capital Investment Committees (CIC), and the semi-fixed plan consists of projects regarded as fairly definite.

On a two-year rolling basis, projects are identified for electrification which will meet the business plan connection targets and capital budgets, and which are in accordance with Eskom's electrification planning principles (Figure 4). Accurate planning information such as, the number and physical positioning of the houses to be electrified, terrain, income levels and access to water, form the essential inputs necessary to accurately determine the demand for electricity over time, the suitability of different technologies and the associated capital costs. Inputs and acceptance for the plan are obtained from the various community representative forums. To ensure more accurate upfront planning, a certain percentage of the forecast project cost is used for pre-engineering work.

Issues impacting on electrification planning

Electrification planning operates in an ever-changing, diverse environment. There are a number of issues which have a daily impact on the quality of the plans produced. A few of these are discussed below.

National housing programmes

The Eskom electrification plans include new housing developments in accordance with the RDP target of building one million houses by the year 2000. (The original electrification scenario studies were based upon a growth rate of new planned housing stock of some 180 000 per annum). A certain portion of the original electrification plans catered for new housing development.

The slow pick-up of this programme has had a negative impact on the electrification programme to date. New projects have needed to be tabled at a late stage in order to meet the annual electrification connection targets and this has, in turn, led to inefficiencies in the implementation of the projects. In addition, these planned projects have had to be replaced with more costly rural projects, resulting in an additional financial burden.

It is essential that Eskom keeps constant contact with the National/Regional Housing Boards and other bodies associated with the planning and managing of housing projects in order to improve planning in this area. Ideally, a detailed two-year housing plan from Government would be required to ensure optimisation of the planning process. To facilitate the smooth and efficient electrification of townships, Eskom has produced a policy on the financing of the electrification of townships developments.

Demographic movements

Eskom needs to take care to only connect customers in areas where their long-term presence is ensured. Since the electrification infrastructure cannot be simply and cheaply moved to another area, the electrification of areas which soon afterwards experience movement and in some instances become "ghost towns", could lead to significant irrecoverable costs. The national housing, land reform and public works programmes could have a significant impact on demographic movements in the next decade, the extent of which is difficult to forecast.

Representative community forums

To ensure acceptance and the successful implementation of the electrification programme, the electrification planning process needs to be demand- or customer-driven, as far as possible within the given technical and financial parameters. Where it concerns the selection and prioritisation of projects, Eskom's preference is to liaise with communities via the sub-regional forum's representative of a number of communities and local governments in a geographic area. Eskom shares the least-cost plan with representatives of the forums. Potential projects are evaluated from a social, political, economic and technical perspective.

Where no legal or elected committees exist, Eskom establishes Electrification Committees, representing civics, political, traditional and other community leaders. Eskom is hoping that future community involvement will be improved through the process of democratically elected local governments.

Once a project has been selected and approved by Eskom's CICs, liaison takes place directly with the communities concerned. Discussions typically revolve around the timing of implementation, the plan to do the work, the phasing-in of the electrification, the availability of local contractors, the use of local labour, revenue collection, service quality, customer satisfaction, education in the safe use of electricity, and the technology used.

A major issue facing Eskom is that in certain areas, the forums which were originally involved in the selection of electrification projects are no longer recognised by the communities as being representative and past decisions made by these forums are regarded as null and void, thus putting the entire plan in jeopardy. The reasons often given are that these forums represent the old regime and are therefore not representative of all stakeholders.

This situation has not improved as infrastructure planning forums have still not been put in place by the Government. Eskom is liaising closely with the RDP office to encourage the formation of representative sub-regional infrastructural planning forums.

Electricity supply industry (ESI) dynamics

The National Electricity Regulator (NER), established by an Act of Parliament, requested the ESI to re-apply for licences to generate, transmit and distribute electricity. Upon receiving the applications the NER decided not to issue permanent licences for electricity distribution due to a number of reasons relating to the performance of the industry in its present state. Interim licences have thus been issued until the end of May 1996. An Electricity Working Group (EWG), comprising of government department and key ESI representatives, was formed, the task of which was to develop proposals for the most efficient and effective ESI structure for South Africa, and the process by which such a structure can be implemented. Various proposals are currently being debated and the outcome of such a process could have a signifi-cant impact on Eskom's future role in the ESI, supply areas and accountabilities. This will in turn, impact on electrification planning and implementation. (It is not the intention of this paper to evaluate the potential impact of various scenarios.)

Financing requirements of electrification

In order to meet its commitment to reduce the real price of electricity by 23,5% over the period 1992 to 1999 and to retain its financial health in the future, Eskom can only invest a certain amount in capital expenditure on electrification projects and absorb a certain amount of the operating losses. Many factors impact on the long-term viability of electrification projects. These factors include the density of the areas to be electrified, the distances from the existing electricity grid, the technologies used, electricity consumption, the revenue received, the cost of capital, as well as operating-, maintenance- and customer service costs. All these factors need to be taken into account and optimised as far as possible to reduce the financial burden of electrification projects.

Whereas the original NEES studies indicated that the electrification operating cash flows, although initially negative, would be positive in the later years of the programme, the latest financial studies indicate that the electrification programme will not break even over time. This is due to lower consumption rates than originally expected, more costly rural areas being electrified, and higher than expected revenue losses, i.e. meter failures, meter tampering, and meter by-passing.

Figure 5 illustrates the income statement of an average Eskom electrification customer. This shows that Eskom experiences a net operating loss per customer of some R65 per month. This loss includes a revenue loss component of R7 per customer per month.

Since the electrification programme is financially non-viable, it is essential that strict cost control with respect to capital and operating expenditure be put in place. There is a constant drive to improve the efficiency of the process and to reduce costs wherever possible. An accurate 24-month electrification plan which fulfils the capital expenditure and long-term sustainability criteria is regarded as crucial to ensure optimal infrastructure planning and implementation.

Reducing the costs of the electrification infrastructure

Eskom's electrification programme is moving increasingly into the rural areas which are remote from the electricity grid, as illustrated in Figure 6. A substantial portion of Eskom's plans are for the former self-governing and independent states where, in many cases, no electrical

Assumptions

- 90 kWh average consumption per household per month
- Homelight tariff applicable
- technical losses (i.e. losses needed to operate network, e.g. transformer, lines and meters) = 10%
- operating expenditure per customer per month (market research, customer service, operation & maintenance) = R25
- revenue losses = 34% of electricity delivered in bulk to the project

Revenue	R13
less cost of sales	R 3
Gross profit	R10
less operating expenditure	R25
less depreciation	R11
	(R26)
less interest	R39
Net operating income	***(R65)***

Figure 5: Monthly income statement per electrification per month

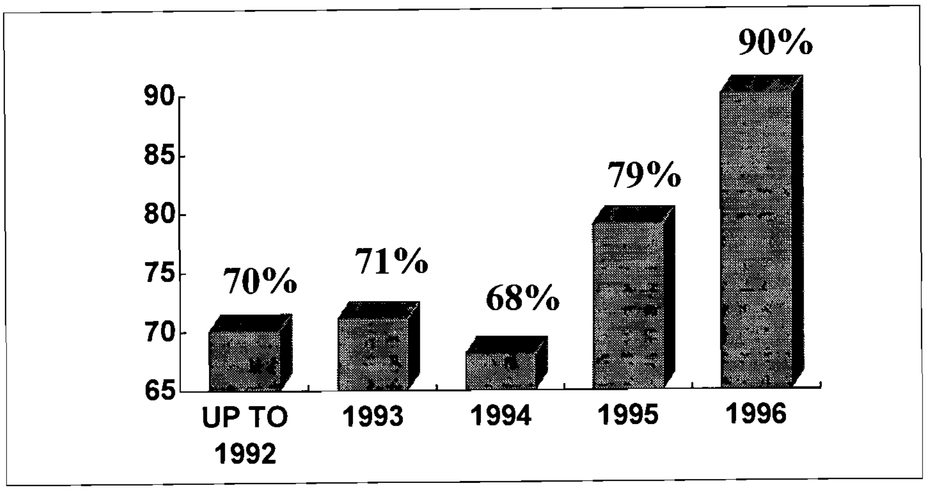

Figure 6: Percentage of connections in rural areas

	1996	1997	1998	1999	2000
Meter	2%	4%	6%	6%	6%
Distrib. line	20%	25%	30%	35%	35%
Reticul. line	20%	25%	32%	32%	35%
Improved planning	5%	10%	15%	15%	15%

Table 2: Cost savings which need to be achieved[11]

infrastructure exists. Costly bulk infrastructures in the form of high-voltage lines and substations are needed to bring the electricity grid to the communities in these areas. In addition, since the housing densities are lower than those in urban areas, a more expensive reticulation network is required.

In order to meet the stringent business plan capital reduction targets, many innovative technology changes are needed. Table 2 illustrates the percentage cost reduction required in the various areas of electrification infrastructure provision to achieve the cost targets.

Many pilot studies are taking place to test new ways of reducing the cost of rural electrification by using appropriate innovative technologies and methodologies. Examples of these include small rural HV/MV substations, small 5 kVA 22 kV transformers, various 22 kV single-phase systems, single-wire-earth-return (SWER), 3,3 kV intermediate-voltage underground and overhead systems, combined prepayment meters and readyboards, and current limited supplies. The applicability of all new technologies are tested. Pilot studies which prove to be successful from a technical, social and financial perspective will be incorporated as part of the electrification standard.

The move towards current limited supplies in the future is critical in order to achieve savings in two important areas, namely, meter costs and reticulation networks. Savings can be realised by a lower after diversity maximum demand (ADMD) due to the maximum demand per connection being limited to the limit of the breaker. Smaller cable sizes and intermediate voltages or SWER systems can be used.

Distribution line savings can be realised by using new conductors, loading criteria, tower utilisation, probabilistic planning and design techniques.

Extending the present legal limit of voltage limits from 6% to 10% should save an estimated 3,5% on reticulation networks. The reason being that a transformer can cover an increased distance of 50 metres in all directions.

Integrated development

Eskom acknowledges the importance of a sound economic base to support electrification and to ensure long-term sustainability. One method of attaining this goal is through integrated development programmes. Wherever possible, Eskom liaises closely with other service and infrastructure development agencies to perform integrated planning, thus reducing the costs of infrastructure and service provision, as well as bringing about broad economic development.

An example of such a liaison is in the telecommunications arena. A Code of Practice[9] was signed by Eskom and Telkom in 1993 which outlined the agreements on the joint use of a pole route for power and telecommunications lines. This was compiled in order to rationalise the supply of power and telecommunication systems in a developing area by using common structures, thereby ensuring cost savings and visual environmental improvements.

With respect to new housing developments, Eskom liaises closely with the developers and Government to ensure that electricity supply is planned as part of the new housing developments. These "green field" electrification projects can be efficiently designed thus resulting in cost savings.

Electrification planning tools

Efficient electrification planning depends upon the availability of a number of information systems and computer-based models. Some of the tools which Eskom uses are described below.

Housing and demographic database

Eskom uses a housing and demographic database for electrification macro- and micro-planning purposes. This database includes the total number of houses categorised into housing types, population figures, services (electricity, water and sanitation) and income profiles, down to enumerator area for 1993, as well as forecasts for 20 years. The 1991 census was used as the main source of information. Other sources of information included are from the Development Bank of Southern Africa (DBSA), Human Sciences Research Council (HSRC), Council for Scientific and Industrial Research (CSIR), Eskom, the Urban Foundation and various market research houses.

This database was recently accepted as the base for the core data set which forms part of the RDP's National Information Project. It is currently being updated in two phases in co-operation with the Department of Housing, Central Statistical Services and Telkom. It has also been renamed as the Housing and Electrification Database (HELP). Phase 1 of the update process will entail taking aerial photographs of the whole country, digitising where feasible, and capturing the information per housing type per place as defined in the database. The data is then linked to a Geographic Information System. Phase 2 will involve the collation of detailed demographic information to satisfy the needs of the parties concerned.

The information stored in this database is the core set of data used for modelling least-cost network expansion options.

Electrification Management System (EMS)

The EMS was developed as a mainframe system to facilitate electrification planning and project management. It is used for recording project details on a monthly basis up to a maximum of 60 months. This readily available information provides present and planned electrification information on a local, regional or national level. This information is used for the tracking of projects, performing scenario planning, pinpointing high-risk areas and for contingency planning.

Schools and clinics database

In order to facilitate the planning of the electrification of schools and clinics, Eskom has developed in-house education and health databases. The main sources of information used in compiling the schools database are the Department of Education and Training and the Research Institute for Education Planning. The accuracy of the information is, however, questionable and cannot be used for planning purposes. The government's RDP office is presently reviewing ways of improving this situation.

The source of the clinics database information is primarily the Rehmis database received from MEDUNSA, as well as information from the Department of National Health and Population Development. The information contained in this database is based upon data gathered via questionnaires sent out annually to all clinics and hospitals in South Africa. During the next update the electrification information will be gathered.

National network electrification planning model

This network planning model, which takes as input macro-electrification plans, demographic data from the HELP database, existing networks and approved master plans, is used to develop a supply-side 20-year electrification planning scenario based on the least-cost option around which the impacts of various connection rates and locality prioritisation can be modelled. This model determines the number of bulk MV/LV transformers required, the distances of bulk HV and MV lines to be built, capital expenditure for substations, HV and MV lines, infrastructure and service connections, and the expected cost per electrification connection.

This model is used to determine the cost and technology impact of various electrification scenarios, to provide input to the transmission expansion plan, for locating areas suitable for non-grid electrification, and to help determine the distribution network master plan.

Cost-benefit analysis model

This model is used to provide the financial and economic evaluation of projects. It was developed to be used as a tool by Eskom, the Department of Mineral and Energy Affairs (DMEA) and the DBSA. The economic evaluation is required to identify projects on the basis of economic efficiency, to look at wider benefits in the case where the project is not financially viable, to justify and motivate for subsidies and grants, and to ensure that the selection of the project contributes to economic growth. The financial internal rate of return (IRR) and net present value (NPV), as well as the economic internal rate of return (EIRR), economic NPV and benefit to the cost ratio are calculated. Eskom regards this model as an essential means to determine whether a project adds economic value to the country and uses it to prioritise projects for electrification.

The electrification of schools and clinics

The RDP calls for all schools and clinics to be electrified as soon as possible. It is estimated that some 19 300 schools (86%) and 2 200 clinics (47%) are unelectrified. These figures, based upon existing database information, are, however, not very accurate.

Eskom's responsibility with respect to the electrification of schools and clinics is for the connection of the premises and the metering of electricity consumption. The internal wiring is the responsibility of the Ministry of Education or Health.

Eskom connects all schools and clinics within its electrification projects to the electricity grid provided that the customer agrees to pay the recurrent costs. Thus schools and clinics are planned in conjunction with residential electrification projects. Eskom's grid electrification programme will unfortunately not reduce the backlog which is mainly due to most of the schools being located in remote areas far from the grid.

Where grant money or money from Eskom's social investment fund is available, the money is allocated firstly, to the internal wiring of schools and clinics inside Eskom's project areas, and secondly, to funding the electrification of

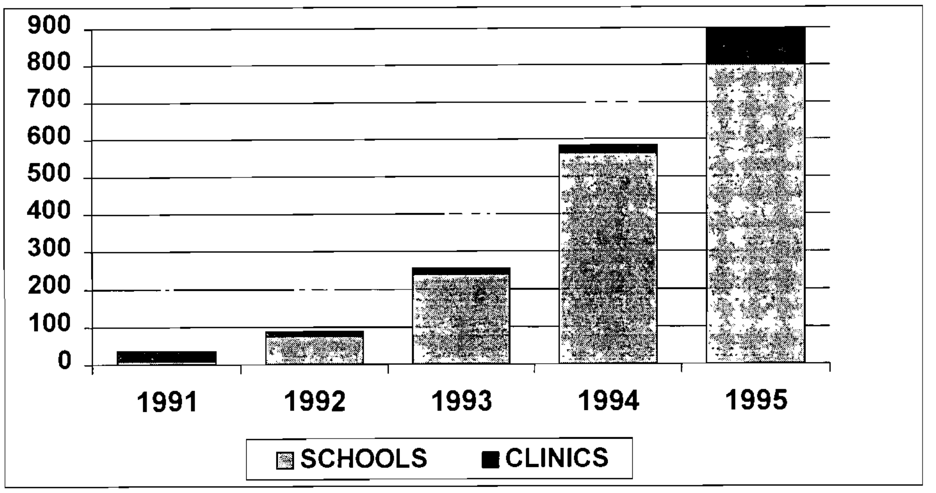

Figure 7: Number of schools and clinics electrified using Eskom's social investment fund and external grants

schools outside Eskom's project areas (i.e. costs not covered by the tariff).

The Independent Development Trust (IDT) has taken on the responsibility to electrify all clinics outside Eskom's current project areas. The IDT has also indicated that they have sufficient funds for the electrification of 85% of the clinics over a two-year period.

A major inroad into the electrification of schools will require a government-driven and government-funded programme. Government has taken cognizance of this and has assessed the financing and information requirements for launching such a programme. The RDP office has recently made money available to Eskom towards the electrification of schools.

Figure 7 illustrates the progress on schools and clinics electrified using Eskom's social investment funds and external grants.

Non-grid electrification

Eskom recognises the important role that non-grid systems can play in providing electricity to areas where grid electricity is neither technically, financially nor economically viable, or will only reach those areas after a long period of time.

Due to its already substantial human and financial commitment to the grid electrification programme, Eskom is presently not in a position to drive a non-grid electrification programme to the same extent. Thus the stance adopted by Eskom is to concentrate its non-grid effort on schools and clinics where the need is certainly the greatest. With regard to residential non-grid projects, wherever possible, Eskom participates in projects planned and financed by bodies external to Eskom.

Eskom has thus established a non-grid implementation arm to meet the challenge of performing the non-grid electrification of schools and clinics. This is done on a full cost-recovery basis and is subject to the customer (e.g. principal, Ministry office) agreeing that the schools and clinics are priorities in terms of electrification and have budgets in place for the recurrent costs.

Eskom plays a project management role regarding the implementation of these systems and upon successful fulfilment of this role, the system is handed over to the customer who is then responsible for the future maintenance and operation of the system.

The selection of schools and clinics for non-grid electrification is demand-driven and done through provincial liaison forums involving the provincial Departments of Education and Health.

Conclusions

(1) Thorough upfront planning is essential to ensure the sustainability and efficiency of the electrification programme.

(2) The acceptance of the electrification programme is dependent upon the extent of the involvement of the communities in the planning and implementation thereof.

(3) Electrification performed in conjunction with other develop-mental initiatives improves the overall economic benefits to the community.

(4) The impact of a constantly changing external environment needs to be soundly managed.

(5) A consistent, focused drive towards reducing the costs of electrification is necessary to maximise the extent of electrification in South Africa.

(6) Electrification must be performed in a manner which is economically efficient for the country.

(7) Accurate planning data is central to a successful electrification plan.

(8) Non-grid electrification systems have an important role to play in providing access to electricity to as many people as possible in South Africa.

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Phambili Nombane (Pty) Ltd: A joint venture between Eskom, EdF and EME

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Keywords: Phambile Nombane; electrification; Khayelitsha; Eskom; South Africa; townships

Phambile Nombane (Pty) Ltd (which means in Xhosa "Forward with electricity") was formed on 1 January 1994, with the major aim of electrifying the whole of Khayelitsha. Khayelitsha is a township with approximately 500 000 inhabitants, located 30 km south-east of Cape Town, South Africa. It is an area which has experienced rapid growth due to the influx of rural people in search of jobs to the urban centre of Cape Town. The township has approximately 70 000 dwellings, with the following approximate breakdown:

* 5 000 permanent houses with electricity, and characterised by a relatively high unit consumption (about 250 kWh/month)
* 7 000 permanent houses without electricity
* 58 000 informal dwellings made from various materials (corrugated iron, hardboard, plastic) without electricity

Most of the energy requirements in Cape Town's townships are met by means of candles, paraffin and gas, all of which are expensive. A small percentage of township residents use batteries to power television sets or radios.

The task undertaken by Phambile Nombane (Pty) Ltd involves the electrification of approximately 50 000 dwellings over a two-year period. It includes the construction of networks, connections, the installation of prepayment meters, and the technical and financial management of the Khayelitsha power system.

The management team was drawn from the three shareholders, namely Eskom, Electricité de France (EdF) and East Midlands Electricity (EME). EdF and EME provided the General Manager and Operations Manager respectively whilst the four Functional Managers were provided by Eskom.

The supply rights for Khayelitsha had been transferred to Eskom from the Lingelethu West City Council. Phambili Nombane has taken some of this Council's electrical staff to form its own maintenance department. These maintenance staff were a mixture of operators and general workers but all are being trained to become multi-functional. On completion of the training all the maintenance staff will be operators in their own right and no general worker post will exist.

The other staff in the Company have been drawn mainly from employment agencies and are being developed and trained appropriately. Wherever possible staff have been drawn from the recipient community of Khayelitsha.

The training given to the staff is aimed at empowering them to take their own decisions within guidelines set by the management team. This approach gives the Company operational flexibility and gives the staff increased job satisfaction.

The reticulation agreement Phambili Nombane has with Eskom specifies the remuneration per connection. There is also a maintenance fee per customer per month which is also indexed to consumption levels to give a marketing incentive.

These figures were set to represent a saving on Eskom's historic costs. Eskom in fact makes further savings as it receives one-third of the Company's profits. Break even, in terms of maintenance costs, is expected to occur when the total customer base reaches around 34 000. Until break even is reached the construction income is subsidising the operation of the Company, which is in effect a further saving to Eskom.

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Community liaison

Liaison with the community is very important and SANCO (South African National Civics Association) has emerged as the leading stakeholder in this respect. The local zone of SANCO was instrumental in obtaining the supply rights for Eskom and they continue to play a positive part in the project. Regular progress reports are issued to other civic and political bodies in the community and the management of Phambili Nombane attend meetings with these bodies on request.

This communication process enables the Company to respond flexibly to changes in the community structures within Khayelitsha. Recently RDP (Reconstruction and Development Programme) committees have been set up and these have been included in the Company's communication network.

Although Phambili Nombane is using established electrical contractors to carry out the project management and materials management aspects of the contract, they, in turn, are obliged to make extensive use of local labour. The SANCO structures have assisted in the recruitment of this labour so as to ensure an even spread of work throughout the community.

The original intention had been to make use of labour-based sub-contractors who again would be drawn from the local community. Whilst it was believed that this would be popular with the community, the converse was true. As a result of pressure from workers and their trade union, it was decided to temporarily abandon the use of labour-based sub-contractors. It is probable, however, that this method of sub-contracting will again be used in the future.

Network description

The technology chosen for the network is basically an overhead system with bare 11 kV conductors and LV ABC. All poles are on the street front and the service connections are made underground in order to avoid having any poles in gardens. This will facilitate any extentions or rebuilding of customers' houses in time.

The target of 22 000 connections in 1994 was achieved. Eskom's Cape Distributor has carried out a quality audit and is satisfied with the Company's quality control systems and the standard of construction.

The design for the first batch of contracts was done in-house using a professional engineer seconded from a local firm of consultants. This approach was adopted in order that the Company could have a strong influence on the design. The most recent contract went out to tender on a design-and-construct basis. This approach was used in consultation with the local branch of the Association of Consulting Engineers. Each tendering contractor formed an association with a consulting firm and the tender was awarded to the partnership which put in the lowest bid consistent with the performance specification that had been issued. By this method it was possible to involve the traditional role-players in the project but to also maintain the element of competition which is so important in terms of reducing prices.

Customer service

The network is designed to give a high level of reliability of supply. The design philosophy was to build a robust system, omitting any components which may pose a failure risk without adding to the value of the supply.

Prepayment metering is being used for all new connections and vending agents have been identified in the local community. It is of course important to recognise that theft of electricity is a major problem. The vending system will enable the identification of customers with low sales or no sales so that it can be ascertained whether any meter tampering has taken place. Such visits will always be made in the spirit of customer care and will be made by a sales advisor who will be offering assistance to the customer in the economic use of electricity.

A door-to-door sweep of the area electrified six years ago by the local authority is being made to identify any tampering. This sweep started after a long and careful negotiation process to ensure that it has community support. As cases are found, meters are replaced but no reconnection fee is imposed at present. However, community leaders accept that in future a reconnection fee will have to be imposed on people who have tampered with their meter. Eskom is funding this initial sweep to give Phambili Nombane a clean start in managing losses. The Company will be accountable for any future action taken.

As part of the customer care programme, extensive customer training is given in the areas where new connections are being made. This is being done on a street-by-street basis using a training programme devised by the Company. This modular programme has been adopted by the local Cape Distributor for use in other areas.

Customer satisfaction in Khayelitsha is measured by Eskom as part of its normal survey. The three surveys carried out since Phambili Nombane started have shown a rise in the customer satisfaction index from 3,2 to 7,7.

Client liaison

There is close liaison with the client, Eskom Cape Distributor. The Company's Senior Managers meet regularly with Eskom's SACS Manager and colleagues to provide feedback and to resolve problems.

There is working-level co-operation on public relations issues to ensure that Eskom's important role is recognised by the community. Also on the construction side, there is detailed liaison to verify the number of connections billed and to resolve any technical queries.

From time to time Phambili Nombane staff give presentations to Eskom management meetings. These help to inform those Eskom managers who are not closely involved in the project.

Conclusion

Phambili Nombane has demonstrated that it can deliver a large number of connections within a tight time-scale whilst at the same time maintaining high standards of quality and customer service. This has been achieved at costs below the Eskom historic norms. Eskom has thus gained firstly, by a reduced fee per connection compared with its own costs and secondly, by sharing in the profits which flow from Phambili Nombane's cost savings.

Unlike a conventional consultant/ contractor team, Phambili Nombane is able to offer a complete turnkey delivery leaving Eskom to perform only routine audit functions. Phambili Nombane has demonstrated that their design and quality control standards are consistent with what would be expected from a major utility. By using Phambili Nombane for a portion of its work, Eskom is able to increase its number of connections without having to increase the level of human resources, stocks or vehicles.

COMPARATIVE ENERGY COSTS IN SOUTH AFRICAN CITIES RELATED TO HEATING VALUE

NOVEMBER 1995											
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)	274,17	83,22	R/Ton	0,98	0,30	0,64	3,29	1,00	2,15	28,0	MJ/Kg
Elect.	21,47	24,43	c/kWh	5,96	6,79	5,68	20,07	22,84	19,11	3,6	MJ/kWh
Heavy Furnace Oil	63,06	78,96	c/litre	1,54	1,93	1,54	5,17	6,48	5,17	41,0	MJ/litre
Illum. Paraffin	91,63	103,53	c/litre	2,48	2,80	2,48	8,33	9,41	8,33	37,0	MJ/litre
Petrol (Premium)	177,00	187,00	c/litre	5,10	5,39	5,10	17,16	18,13	17,16	34,7	MJ/litre
Diesel	145,90	155,90	c/litre	3,76	4,02	3,76	12,65	13,52	12,65	38,8	MJ/litre
Power Paraffin	90,00	102,30	c/litre	2,40	2,73	2,40	8,07	9,18	8,07	37,5	MJ/litre
LPG	108,80	123,10	c/litre	3,97	4,49	3,97	13,36	15,12	13,36	27,4	MJ/litre
Gas											
Cape Gas	45,60	–	R/GJ	4,56	–	–	15,34	–	–	–	–
Gaskor	–	17,16	R/GJ	–	1,72	–	–	5,77	–	–	–

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

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

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

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

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

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

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

(Source: *Selected Energy Statistics: South Africa*, No. 35, November 1995)

Energy news in Africa

Coal

Mozambique's Moatize coal mine, where production fell to only 100 000 t/year during the civil war, is to resume operation soon with the backing of a new Australian company, Austral Coal NL. (Production stopped almost completely when the mine was flooded in 1993.) Full-scale development, including a railway to the coast, will be undertaken over a 10-year period with Soviet, French and South African partners. The company signed an agreement with Mozambique's government to jointly develop proven reserves of more than 250 Mt of high-grade coking coal located along the Zambezi river. Austral will hold a 51% stake and the government 49%, and they will be targeting customers in the Indian and Brazilian steel industries. Austral is planning to develop an open cut operation at Moatize with an initial output of 1 Mt/year and a potential production of 5 Mt/year.

The coal will be carried by barge down the Zambezi river to a new offshore loading terminal on the coast. The coal, which is low in ash and impurities, did well on the Japanese market before the mine's closure. Because the resource lies in one shallow seam of about 30 m in depth and the first 100 Mt will have a low over-burden ratio, mining costs are expected to be low.

(Source: African Energy & Mining, 20 September 1995)

Electricity

Kenya

The Kenyan government and the Kenya Power & Lighting Corporation (KPLC) recently unveiled their energy projects. Private industry will be involved in two projects which are to be financed by a BOT-type arrangement. These are Kipevu II (75 MW) and Olkaria III (64 MW), diesel-powered and geothermal power stations.

(Source: African Energy & Mining, 20 September 1995)

Madagascar

Madagascar is planning to privatise its electricity sector in the near future. This is high on the agenda of an "outline document for economic policy" for 1996-98. According to the document, the legal framework for the electricity sector has to be modified and restructured to make way for private projects. Electricity rates also need to be completely revised on the basis of marginal cost and set by an independent body.

(Source: Africa Energy & Mining, 18 October 1995)

Hydro-electricity

The private sector in the Congo is to build their first power station prior to the privatisation of the national electric utility, Societé Nationale d'Electricité (SNE). The scheme involves a hydro-electric power station on the Kouilou river, north of Koulilou province. The first section of the project will have a 50 MW capacity. A BOT-type formula was chosen for the project, with SNE pledging to take production and practice indexed rates, with the facility becoming the property of the State after a specified time. Future users of the power station will raise part of the money needed for the scheme.

A second section with the same capacity, is expected to be built in a few years time.

(Source: Africa Energy & Mining, 18 October 1995)

General

A Round Table conference on Angola was held in Brussels on 25-26 September 1995. Some of the points made were that oil production in Angola was expected to reach 775 000 barrels/day by 1998.

Changes were also expected in the electricity sector, although only minor projects were discussed. These include the rehabilitation of local networks, replacement or repairs of small diesel generators, and the training of personnel in low-voltage and diesel maintenance. Funding was requested for the repair of several dams, such as, the Kunje dam, Matubas dam and the Quininha dam. There are also plans to boost the capacity of the Luachimo power station.

(Source: African Energy & Mining, 4 October 1995)

Natural gas

The Ghana National Petroleum Corporation recently recommended that a mechanism be set in place to force industrial users to pay the economic price for liquefied petroleum gas (LPG). Budgeted supplies of LPG from the Tema refinery had been increased from 650 t/week to 880 t/week for local consumption and export.

The use of LPG as an automotive fuel had taken place in an unregulated environment. However, the real problem was identified as the small businesses that used LPG because it was cheaper than other oil products. The import price of LPG is about $300/ton, while the pump price was $200/ton.

(Source: Africa Energy & Mining, 4 October 1995)

Oil

A 6 Mt/year oil refinery is to be built in Bizerte in Tunisia. Up to 80% of its output is expected to be exported. A memorandum of understanding on the project has been signed with a group of private Libyan investors. All the money for the project, estimated at $570 m, will come from private or institutional sources. There is the possibility that an oil pipeline could be run to the refinery from Libya or one could be extended to the refinery.

Tunisian oil output has been dropping for want of any major discoveries. It was less than 4,4 Mt in 1994, compared with 4,65 Mt and 5,2 Mt in 1993 and 1992 respectively. The Bizerte refinery has been expanded to produce 3 Mt/year of refined products. Tunisia's consumption is rising at a rate of 3%/year since the early 1980s and is presently about 3 Mt/year.

(Source: Africa Energy & Mining, 20 September 1995)

The International Finance Corporation (IFC) is to back most of Engen's share in the investment to develop the N'Kossa oil field in the Congo. This IFC loan will total about $91,4 m. Engen's share of the field is 4% as opposed to a possible 10% contemplated before it ran into funding problems because of certain South African regulations.

(Source: Africa Energy & Mining, 4 October 1995)

The message delivered to African countries by the major oil companies at this year's Africa Oil conference held in Johannesburg on 11-13 October was to "stay in line with global market realities or face a squeeze on investment and technology both up- and downstream". However, there were strong commitments by companies to pump more money into major development projects. However, Exxon, Mobil, Chevron, Texaco and Amoco stressed criteria for prioritising upstream opportunities across the globe, forcing West African oil and gas projects to be compatible with other major exploration areas and to compete for scarce capital.

The strategies of the major players in the African upstream market appear to be to focus on fewer countries and prospects. However, Texaco is concentrating its efforts on just two countries, Nigeria and Angola, in order to build on its existing infrastructure and to go for what it describes as "high impact" projects. Elf has concentrated mainly on Chad, Nigeria and Angola, where it sees the best growth prospects.

(Source: Africa Energy & Mining, 18 October 1995)

The closing down of existing refineries in Southern Africa, with the exception of those in South Africa, remains as high a priority as ever for the World Bank and international oil companies. These uncompetitive and often badly managed facilities are regarded as a burden rather than an asset for the countries in question. However, the increased demand (4%/year to the year 2005) for oil coming from the SADC countries points to the need for increased refining capacity in the medium term. This increased oil demand is based on the increase in the use of kerosene (replacing fuelwood) and increased demand for gasoline.

All the major oil companies believe that "obsolete" refineries such as the Indeni plant in Zambia, Solima in Madagascar and Tiper in Tanzania, as well as certain facilities in Mombasa (Kenya) and Luanda (Angola) should close because of their inability to compete with highly efficient, export-oriented refineries.

BP Southern Africa projects that refining capacity will increase by 150 000 barrels/day by the year 2000 in the SADC countries.

Caltex has also started pulling out of distribution in countries other than South Africa, selling its service stations in Uganda, Tanzania, Malawi and Zambia.

(Source: African Energy & Mining, 18 October 1995)

MBendi Information Services provides a variety of consultancy services ranging from oil industry consulting to assisting companies leverage their investments in information technology. The most important of these services is to assist companies to get added value from the Internet. The MBendi (a composite African word meaning "the knowledge that brings wisdom") is an electronic encyclopaedia of commercial information on Africa. It contains a profile of each of the countries of Africa, providing demographic, economic and fiscal information, as well as easy-to-use maps of each country. There are also profiles on each of the stock exchanges.

There is also a comprehensive encyclopaedia of the African oil industry. This includes profiles of each country's oil industry, details of refinery configurations, biographies of key individuals in the industry, and profiles of oil-related companies. The system is to be expanded in the near future to include profiles of other African business sectors, as well as a facility to assist companies in Africa to source chemicals efficiently.

The information is updated regularly.

For those users who are new to the oil industry, a glossary and table are available to allow the conversion of the various measuring units used in the industry, and they are accessible from every page.

The information in the MBendi system can be accessed free of charge via the Internet. However, because the Internet is not accessible everywhere in Africa, MBendi has designed a stand-alone version of the encyclopaedia which can be run under Windows on individual PCs (including the notebook PCs) which will be available at a nominal subscription fee.

For further information on MBendi, contact:

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(Source: MBendi Information Services, 1995)

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Ian has been employed by East Midlands Electricity (EME), one of the regional electricity distribution companies in the U.K., since 1971. He has held numerous engineering posts and was Engineering Manager at Coventry from 1985 to 1992. In 1992 he was part of a team which devised a new organisational structure for East Midlands Electricity District Offices.

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While undergoing military training (1982-84) he was seconded to the Institute for Maritime Technology for research in underwater magnetics and acoustics. His career with Eskom began in 1984, and since then he has held the portfolios of Chief Engineer (Production Planning), Electricity Pricing Manager, and now Senior General Manager (Marketing).

His work during this time and to date includes:

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* **in-depth knowledge of and contact with the key players in the S.A. electricity industry**, the Electricity Control Board, the majority of City Electrical Engineers of the AMEU, the Eskom Electricity Council, the National Electrification Forum;
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* **interaction with neighbouring electricity industries** in Namibia, Botswana, Zimbabwe, Lesotho and Swaziland.

He has authored several articles and papers for publications and seminars, as well as being a keen public speaker on the electricity industry.

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On his return in 1995, he has been employed as an Electricity Economics Consultant at Kennedy and Donkin (Africa) (Pty) Ltd. His main areas of interest are electricity economics, utility price regulation, and energy costing.

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With the disbandment of the NEC, Carel joined Eskom Technology in 1992 and Eskom Marketing in 1993, where he is presently responsible for the Electric Vehicle Programme. Nominated by the Department of Mineral and Energy Affairs, he represents Eskom and South Africa on the Executive Committee of the International Energy Agency Implementing Agreement for Electric Vehicle Programmes and Technologies.

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Diana Theron is currently Eskom's National Electrification Planning Manager. She is accountable for the timeous production and risk management of a five-year high-level and two-year detailed electrification project plan to meet Eskom's electrification target of 300 000 connections per annum. Prior to this role, she was involved in the design of Eskom's time-of-use tariffs and the establishment of the demand-side management function in Eskom where she developed and implemented the processes necessary to evaluate demand-side management programmes.

Forthcoming energy and energy-related conferences: 1996/1998

1996

MARCH 1996

6-8

FRIGAIR '96 Kempton Park, Johannesburg, South Africa

Enquiries: Melanie Campbell

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

APRIL 1996

14-17

ELEVENTH INTERNATIONAL SYMPOSIUM ON ALCOHOL FUELS (ISAF XI) Sun City, South Africa

Enquiries: ISAF XI, P O Box 207, Plumstead, South Africa

Tel.: (021) 705 0120
Fax.: (021) 705 6266

OCTOBER 1996

7-8

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

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

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

1998

SEPTEMBER 1998

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

Theme: Interface between developing and developed countries

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

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

Recent energy publications

ELEFTHERERIADES C M

Characteristics and requirements for a low-smoke coal. Jun-1995. 33p.

A synthesis of current research on low-smoke coal uses was carried out in order to identify the characteristics and requirements for a low-smoke coal which may be acceptable to users while reducing pollution and health risks. The physical characteristics and chemical analysis of low-smoke coals were identified and their ash content, volatile content, heating value and other characteristics were discussed in terms of the fuel's performance, comparing the performance of sub-bituminous coals currently being used in households. A list of low-smoke performance criteria applicable to braziers and domestic heaters is presented in the report. International health requirements on pollutants were applied when testing the low-smoke coals.

LAGESSE R B and GELDENHUYS H J

Lightning performance of aerial bundle conductor lines 1990-1993: Lightning seasons (Part 1). Aug-1995. 36p.
Report No. EL9009

The objectives of this study were to evaluate the sensitivity of ABC systems to lightning damage and to make recommendations on the correct method of installation to reduce the risk of damage. A literature search was first conducted to obtain information on the insulation coordination of ABC lines. Computer simulation was used to simulate lightning strikes in order to provide information about back flashovers. It was concluded that direct strikes did not affect an insulated line and that strikes hitting the ground nearby would also not affect the line.

LAGESSE R B and GELDENHUYS H J

Lightning damage to woodpoles: Nature and minimisation of the problem (Part 2). Aug-1995. 67p.

The aim of the project was to find out how lightning splits woodpoles and what can be done to solve the problem. A survey was undertaken to assess supply, demand, treatment and wood damage in South Africa. A literature survey was undertaken of local and international publications. A laboratory experiment was undertaken where the effects of different wood preservatives were tested under conditions simulating realistic lightning strikes. No reliable figures of lightning woodpole damage in South Africa were found. Woodpole damage was found to be dependent primarily on the path of an arc through the wood and on the arc's energy.

RAND AFRIKAANS UNIVERSITY (INSTITUTE FOR ENERGY STUDIES) and COOPER C J

South African Energy Database 1993: Consumption summary. 1995. 1V. (various pagings)

Contains the 1993 sectoral energy breakdown for South Africa. Energy consumption data is analysed into 38 end-use sectors. For 1993 the focus was on the mining sector and the larger manufacturing end-users.

SMUTS W J and KIRSTEIN L S

Peat and related biofuels as a potential renewable alternative energy option in part of KwaZulu/Natal. Jul-1995. 52p.
Report No. EO9417

The prime objectives of this project were to (1) determine whether any of the wetlands in the study area contain significant peat deposits; (2) quantify the natural resource; (3) select one or more peatlands for detailed characterisation; (4) characterise and analyse the resource in terms of its potential as an alternative domestic energy source; (5) present proposals for the development of a sustainable exploitation programme for certain of the peatlands in the study area.

SMUTS W J, BARCLAY J and KIRSTEIN LS

''Peat and related biofuels as a potential renewable alternative energy option in developing rural areas'': A workshop. Nov-1995. 1V. (various pagings)
Report No. EO9503

The results of an evaluation of three areas containing extensive peatland in KwaZulu/Natal were presented at this workshop. It was shown that peat, together with the sedge and reed growth on the mire, can be utilised as a substainable and renewable source of domestic and multipurpose fuel, as well as an important agricultural resource. Recommends further investigations of the peatlands and the development of a pilot project in co-operation with the local community. The publication includes a report on an official visit to Benin by Marlett Wentzel of the DMEA.

TERBLANCHE A P S

Evaluation of the use of coal in Evaton. Jun-1995. 14p.
Report No. ES9417

The main aim of this project was to investigate the effects of the following factors on the risk for humans to develop respiratory tract illnesses: condition of coal stoves, type of cooking appliance, level of ventilation in housing structure, use of conventional versus smokeless coal, and exposure to coal emissions. The ultimate aim is to introduce practical and easy-to-implement interventions such as community education programmes, to reduce indoor air pollution levels in coal-burning households.

VAN HOREN C, DICKSON B and SIMMONDS G

Market interventions to promote low-smoke fuels. Sep-1995. 61p.
Report No. ES9413

The primary objective of the report is to present a set of workable market interventions that will enable low-smoke fuels to penetrate the existing household bituminous coal market and ultimately replace the household use of bituminous coal in South Africa. Other aspects covered include the theoretical issues surrounding market-based policy options for low smoke fuels.

VAN VUUREN M C J

Guidelines for the prevention of spontaneous combustion of coal during storage and transport. Jun-1995. 55p.
Report No. ES9307

Briefly describes the mechanisms of the oxidation phenomenon of South African coal, including its properties. Briefly summarises the sampling and analyses of coal and how the results of the analyses were interpreted. The reactive and non-reactive components are related to different analytical parameters and described in some detail. Summarises the main factors contributing to the self-heating of coal, emphasising the storage of coal. Stockpiling procedures are described in some detail, as well as the management and guidelines for monitoring these stockpiles and dumps. The guidelines are given in a "Code of safe practice on the prevention of spontaneous combustion of coal during storage and transport".

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

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

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"Electrical energy is the common factor that binds us in our quest for a better quality of life for all our peoples. By concentrating on the positives, on common development factors, we are building bridges for tomorrow. I believe that electricity could be a catalyst not only for illustrating the interdependence of all Southern African states, but also for stimulating a new development in our subcontinent."

Dr. John Maree, Chairman,
Eskom Electricity Council.

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