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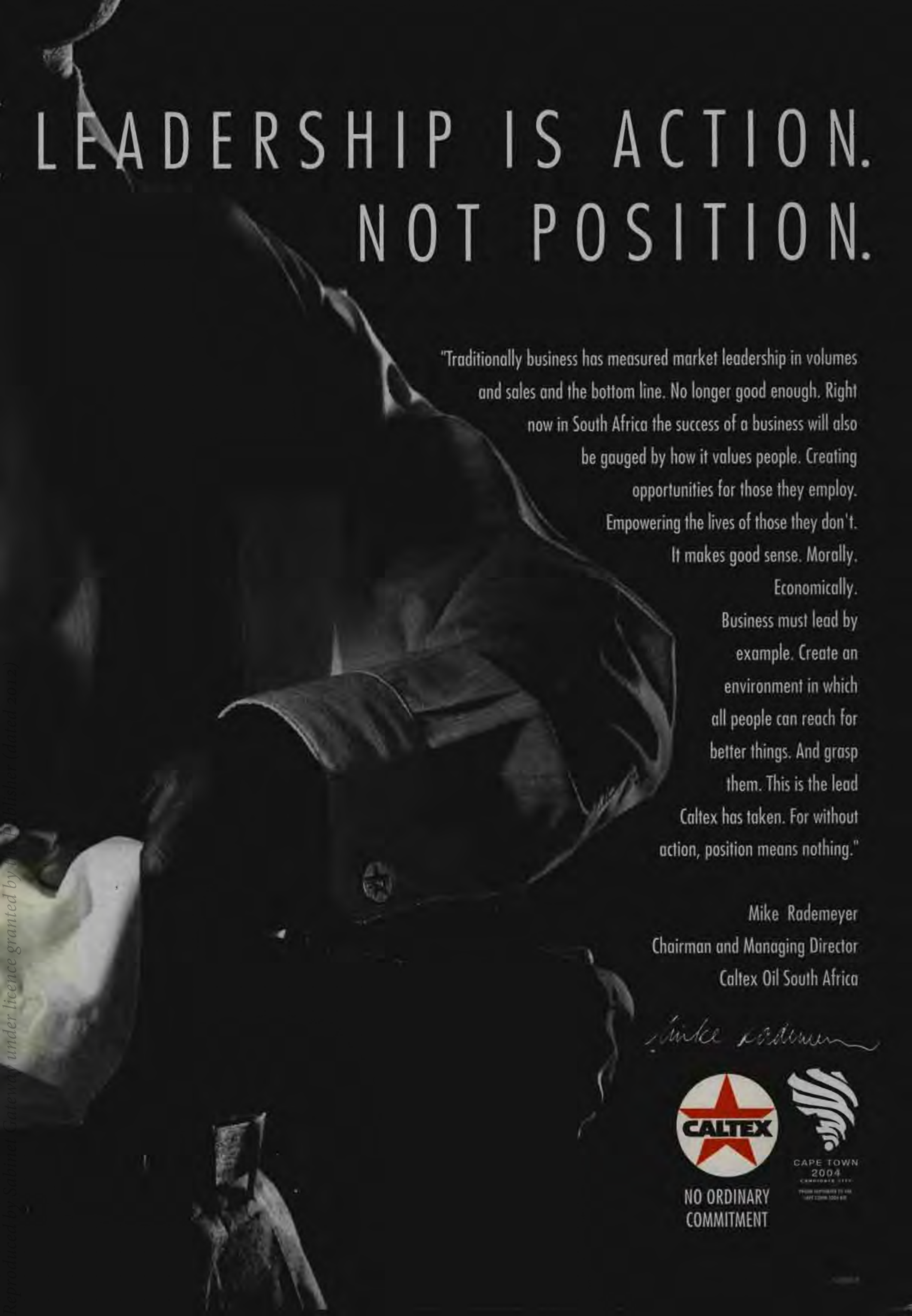
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Mike Rademeyer
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Those wishing to submit contributions for publication should refer to the guidelines set out in *Information for Authors* on the inside back cover of the Journal. All papers are refereed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

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

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Profile: Pieter Cox

Managing Director Sasol Limited

Born in Smithfield in the Free State on 5 September 1943, Pieter Cox matriculated from Pretoria Boys High at the end of 1961. He attended the University of the Witwatersrand, Johannesburg, graduating in 1966 with a B.Sc. in metallurgical engineering and in 1968 with a B.Sc. in mining engineering.

After working for two-and-a-half years at Anglo American's President Steyn gold mine, Pieter Cox joined Sasol in July 1971 as a technical assistant at the Sigma mine, Sasolburg. Over the next fifteen years, Pieter rose steadily through the Sasol ranks. In 1974, he was appointed underground mine manager and a year later, project manager (mining), before assuming responsibilities as mine manager of Bosjesspruit Colliery at Secunda.

In 1979, Pieter was promoted to the position of assistant general manager (mining) and appointed to the Sasol group management committee. Two years later he was appointed general manager (mining) and in 1986 the general manager of Sasol Limited responsible for the portfolios of exploration, mining, explosives and human resources. He also attended the Stanford Executive Programme at Stanford University, California (U.S.A.) in 1990.

In 1993, Pieter was promoted to group general manager before being seconded in October of that year to spearhead the formation of Polifin Limited, Sasol's joint venture with AECI Limited. Pieter became Polifin's founding managing director and chief executive officer. In January 1996 he returned to Sasol to assume the position of executive director. A year later, he took over the reins of Sasol from Paul Kruger when he was appointed chief executive officer and managing director of the company.

Pieter Cox assumed this portfolio at a time when the entire Sasol group of companies is undergoing a period of notably pronounced challenges, dynamism and transformation and he is keen to steer Sasol through a period of continuing dynamic growth in chemicals.

Pieter enjoys sailing, hiking, golf and listening to music in his spare time, and is also an enthusiastic spectator of rugby and cricket.

The determination of emissions, efficiencies and the cost-effectiveness of various domestic appliances used for cooking and heating in South Africa

*** J A N GRAHAM**

Received 25 May 1997
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Pollution from domestic fuel burning depends both on appliance emission rates and appliance efficiencies, since a more efficient appliance will burn less fuel. A test cell was designed and built to measure the efficiencies and emissions of various fuel/appliance combinations during cooking and space heating tests representative of field operating conditions. A novel experimental procedure for the determination of cooking efficiencies, also suitable for fieldwork, was derived. Domestic appliances commonly used in South Africa, burning liquefied petroleum gas (LPG), paraffin, coal and wood, were tested. Emissions of gaseous pollutants (CO_2, CO, NO_x and HC) and particulate pollutants (total suspended particulates (TSP), and particles less than 2.5µm aerodynamic diameter (PM2.5)) were measured.

The LPG ring burner was found to have the highest cooking efficiency and the lowest emissions. Traditional methods of burning wood and coal (three-stone stove and coal brazier) had higher cooking efficiencies than modern stoves but vented emissions directly into the living area. The low efficiencies of the modern stoves were attributed to the thermal inertia of the stove body. Heat losses from cooking appliances to the surrounding air, significant from solid fuel burning appliances, provide useful space heating energy in winter and were accounted for in the determination of appliance overall efficiencies. Steady state space heating tests were performed on a liquefied petroleum gas (LPG) fuelled appliance, a paraffin heater, an open wood fire, a wood stove and a coal stove. The wood stove had a similar efficiency to that of the open fire and had significantly lower emissions. The coal stove had the poorest space heating efficiency but had lower hydrocarbon (HC) and particulate emissions than the wood fire. Based on the results of the tests and the prices of the various fuels in the townships, the running costs of cooking and space heating appliances, including electrical appliances, were calculated. Electricity was found to be the most cost-effective fuel for cooking during the summer months, but wood and coal were cheaper in winter, when space heating output was considered useful energy.

Keywords: domestic energy; emissions; household appliances; energy efficiency; cost-effectiveness; traditional fuels; transitional fuels; South Africa

Pollution from domestic fuel burning

Assessments of pollution from domestic fuel burning in South Africa have, in the main, based their conclusions on measured ambient pollutant concentrations. One of the advantages of this method is that it allows the estimation of human exposures (and hence health impacts) associated with domestic fuel burning. However, ambient concentrations depend on a range of factors, including prevailing meteorological conditions and the contributions of other pollution sources. Thus measured pollutant levels cannot be attributed solely to domestic fuel burning, and studies that assume this run the risk of obtaining incorrect results. Alternatively, laboratory measurement of absolute emissions provides a better basis for comparison between the pollution effects of a range of fuel/appliance combinations.

Since different fuels have different energy contents, a household will use smaller amounts of, for example, LPG than wood to provide the same energy requirements. Therefore comparing the emission rates of domestic fuels in terms of grams of pollutant per kilogram of fuel burnt is unhelpful. A better comparison can be made by expressing the emission rates of fuel/appliance combinations as emissions per task or per useful joule of energy output. To determine such values it is necessary to measure simultaneously emissions and useful energy output. The emissions and efficiencies of a range of fuel/appliance combinations were measured during cooking and space heating tests representative of typical field operating conditions.

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Experimental methodology

Inadequacy of common stove efficiency determination methodology

The Standard Water Boiling Tests (SWBTs) outlined by Volunteers in Technical Assistance[1] have been widely applied to estimate stove efficiencies. Instead of calculating efficiencies based on actual cooking procedures, such as making maize porridge, SWBTs represent cooking tasks by boiling water for a certain length of time. The tests involve a high power phase, during which a pot of water is brought to the boil and boiled vigorously for fifteen minutes, followed by a lower power phase, during which the water is simmered for an hour. SWBTs define the useful energy output from a stove as being the specific heat required to boil the water plus the latent heat of the steam evaporated during the test. However, during an actual cooking task, steam generation is, in fact, an energy loss. When a pot containing food and water is heated on a stove the contents of the pot absorb heat until the water boils. Having boiled, heat is no longer absorbed by the water or food (unless it is cooked in large pieces) but dissipated through steam generation. Therefore to regard steam generation as useful energy in the cooking process is incorrect. In effect, SWBTs measure stove efficiency, indicating the fraction of energy in the fuel delivered to the pot, rather than cooking efficiency.

Defining useful cooking energy

Cooking efficiency can be defined as the heat required to raise the contents of a pot to the cooking temperature, plus the heat absorbed by the contents of the pot, divided by the energy potential in the fuel. During cooking operations a small amount of heat is required as useful energy to replace heat losses from the pot to its surroundings, hence maintaining the contents of the pot at the cooking temperature. The base of the pot receives heat from the stove while the lid loses heat. The pot's sides may be heated near the base by hot gases from the combustion zone but will lose heat further up. Additional useful cooking energy is absorbed by the endothermic chemical process of converting raw food to cooked food. This is generally small but varies with the foodstuff in question. For example, rice requires 172 kJ/kg but fresh vegetables require 0 kJ/kg [(2)].

Deriving a test to measure cooking efficiency

Although SWBTs provide ***stove*** efficiencies and not ***cooking*** efficiencies, the concept of using water to simulate actual cooking operations can be used to determine cooking efficiency. Water is the principal cooking medium used in the world. Boiling water is commonly used to cook starchy foods, such as rice and porridge, which form the basis of the diets of millions of people in the developing world. To raise 1 kg of rice from 20°C to 100°C and cook it takes 316 kJ[(2)]. By comparison, it takes 335 kJ to raise 1 kg water from 20°C to 100°C with no energy absorbed in the cooking process. Since water, as the cooking medium, is normally present in excess in most cooking procedures and in some procedures (such as, making tea) where water exclusively is boiled, a cooking task involving water only can be used to determine the cooking efficiency of an appliance.

The cooking task required that each appliance be lit from a cold start and consisted of two sequential phases. During the first high power phase, 3 kg of water were brought to the boil as quickly as possible. During the second low power phase, the appliance was operated at the lowest power output level needed to maintain the water at that temperature for an hour.

The useful cooking energy (MJ) and cooking efficiency of the appliance were expressed as:

$$N_c = \{M_w . C_w .(T_f - T_i) + (H_l . t)\} / F \times Cv$$

where

N_c	=	measured cooking efficiency (%)
M_w	=	mass of water boiled (kg)
C_w	=	specific heat of water (MJ/kg/°C)
T_f	=	boiling temperature of water (°C)
T_i	=	initial ambient temperature of water (°C)
H_l	=	heat loss from the pot (W)
t	=	time of simmering (s)
F	=	mass of fuel burnt (kg)
Cv	=	fuel calorific value (MJ/kg)

The heat losses from the pot were determined in advance using an immersion heater. The pot was filled with oil (to the same depth as that of the water during the test) and placed on an electric ring. Once the oil had been heated to the required temperature, the pot was removed from the electric ring and placed on an insulated tile. The heat loss from the pot was then measured as the power output of an immersion heater mounted inside the pot necessary to maintain the temperature of the oil. The heat losses were measured at a number of different ambient and oil temperatures (Figure 1). Knowing the ambient and pot temperatures, the heat loss during each test was determined from the plot.

Since steam generation is a heat loss in the cooking process, the most efficient appliances have a low steam output while simmering. Minimum steam production requires fine control of power output from the appliance. Most cooking appliances have rudimentary power output controls, resulting in varying amounts of steam being produced during simmering. To account for the small differences in power output that cause an increase in steam production during the simmering phase of the test, cooking efficiencies were expressed as adjusted cooking efficiencies[(3)]. The adjusted cooking efficiency is a measure of the efficiency of an appliance if it were operated at the optimum level and as such, provides a basis for comparison across a range of appliances. The adjusted efficiency was calculated by subtracting the energy expended in steam generation from the energy value of the fuel burned.

This novel method of cooking efficiency determination lends itself well to fieldwork since the heat losses from the test pot can be measured in advance in a laboratory. Assuming a water boiling temperature of 100°C, all that needs to be measured to know the pot losses is the ambient air temperature. The other parameters in the efficiency equation are already measured in the SWBTs.

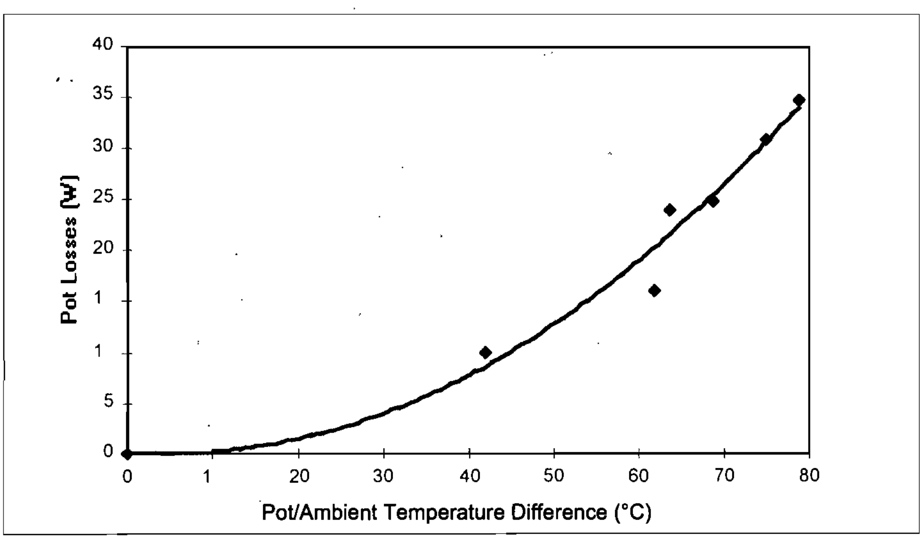

Figure 1: Experimentally determined pot losses

Overall efficiency during cooking test

Knowing the space heating output of an appliance while cooking is useful energy during the winter months. Although the space heating output of the LPG and paraffin stoves was small, that of the solid fuel burning appliances was significant. The overall efficiency determination of appliances regarded both cooking output and space heating output as useful energy during the cooking test.

Space heating efficiency determination

The space heating efficiency of appliances was determined by a method similar to that used by Allison and Dutkiewicz[(4)]. Appliances were placed inside an insulated test cell and operated at steady state burn conditions. The space heating output of each appliance was measured by drawing outside ambient air through the cell at a constant rate and measuring the temperature difference between air entering and leaving the cell. Heat losses from the cell walls were also measured as useful energy. Knowing the fuel burn rate and calorific value, the space heating efficiency of the appliance was then calculated.

	Cooking Efficiency		Overall Efficiency
	Measured	Adjusted	
LPG Ring Burner	27.0	38.6	82.6
Paraffin Primus Stove	33.0	34.3	67.6
Paraffin Wick Stove	27.6	31.4	72.6
Three-Stone Wood Stove	7.4	7.6	64.1
Coal Brazier	5.4	5.8	–
Wood Stove	3.8	3.9	38.5
Coal Stove	2.0	2.0	27.8

Table 1: Appliance efficiencies (%) achieved during the cooking test

Expressing emission rates

Emissions during the cooking test were expressed in two forms. Firstly, as grams per task, indicating the emissions from each appliance accompanying completion of the same task. (This emission rate was adjusted, as with the cooking efficiency, to resolve emissions if appliances were operated at the optimum power output level.) Emission rates were expressed, secondly, as grams per useful MJ energy, incorporating the cooking and space heating energy outputs of the appliances, representative of a winter scenario. Emissions during the space heating test were measured as grams per hour but expressed as grams per useful MJ energy delivered, to allow the comparison of emissions from appliances of varying power outputs.

	Gases				Particulates	
	CO_2	CO	NO_2	HC	PM2.5	TSP
LPG Ring Burner	155.1	0.73	0.05	0.19	0.0018	0.0019
Paraffin Primus Stove	195.0	0.78	0.06	0.64	0.0038	0.0025
Paraffin Wick Stove	215.6	2.83	0.00	1.11	0.0059	0.0076
Three-Stone Wood Stove	1131.2	53.40	0.75	30.17	3.55	4.52
Coal Brazier	1025.9	63.05	1.30	22.19	3.99	7.26
Wood Stove	1993.3	57.09	2.05	13.03	1.16	1.63
Coal Stove	2310.6	150.35	3.45	31.65	3.86	7.88

Table 2: Adjusted emissions of appliances during the cooking test (g/task)

Results and discussion

Cooking tests

Appliance efficiencies during the cooking test

The experimentally determined efficiencies of appliances during the cooking test are given in Table 1. The cooking efficiency values are not comparable to those commonly reported in the literature, reflecting differences in the experimental methodologies outlined above.

The cooking efficiencies of the LPG and paraffin burning appliances were significantly higher than those of the solid fuel burning appliances (Table 1). The lower combustion efficiencies of solid fuel burning appliances, resulting in higher emissions, do not fully account for these differences. The most significant energy losses of the three-stone wood stove and coal brazier were as heat to the surroundings. This is indicated by the improved overall efficiency of the three-stone wood stove as shown in Table 1. However, the overall efficiency of the coal brazier was not measured because high CO emissions require room ventilation, dissipating an unquantified amount of space heating energy. Further inefficiency resulted from the fact that the cooking test had a cold start. After lighting a wood fire or coal brazier, there is an initial period during which the fire establishes itself before the pot is placed on the fire. Only after the pot has been placed on the fire does any of the heat emitted from the fuel combustion become useful cooking energy

The cooking efficiencies of the wood and coal stoves shown in Table 1 were even poorer than those of the three-stone wood stove and the coal brazier. In addition to sensible heat loss in the flue gases, the thermal inertia of the two stoves represented a large heat loss in the cooking test. This was especially significant for the coal stove, which weighed 220 kg and required about 7,5 MJ to overcome its thermal inertia. This inertia is considerable when compared to the task cooking energy of 1,05 MJ. One of the consequences of this was that it took about 60 minutes to boil the water using the coal stove compared to 25-35 minutes for the other solid fuel burning appliances.

The low cooking efficiency of the commercial wood and coal stoves reflects their unsuitability for performing a standard cooking task. It is questionable whether such a task is representative of normal field operating conditions for these appliances. Common sense suggests that lighting a coal stove to boil one pot of water, especially in summer (i.e. when space heating output is not useful energy), is not prudent. It is more likely that a stove would be lit to perform a number of concurrent cooking tasks, employing its multiple pot facility and thereby increasing the cooking efficiency substantially. Although the overall efficiencies of the wood and coal stoves are significantly increased over their cooking efficiencies (Table 1), the thermal inertia of the stove bodies remains a considerable heat loss.

Appliance emissions during the cooking test

<u>(i) Grams per task (g/task)</u>

The standard cooking test was performed three times on the appliances and Table 2 contains the mean results of these tests. Carbon dioxide (CO_2) is the primary combustion product of any fuel burning process. Carbon dioxide emissions were indicative of the amount of fuel burned to complete the cooking task. Thus the appliance with the lowest cooking efficiency (coal stove) also has the highest

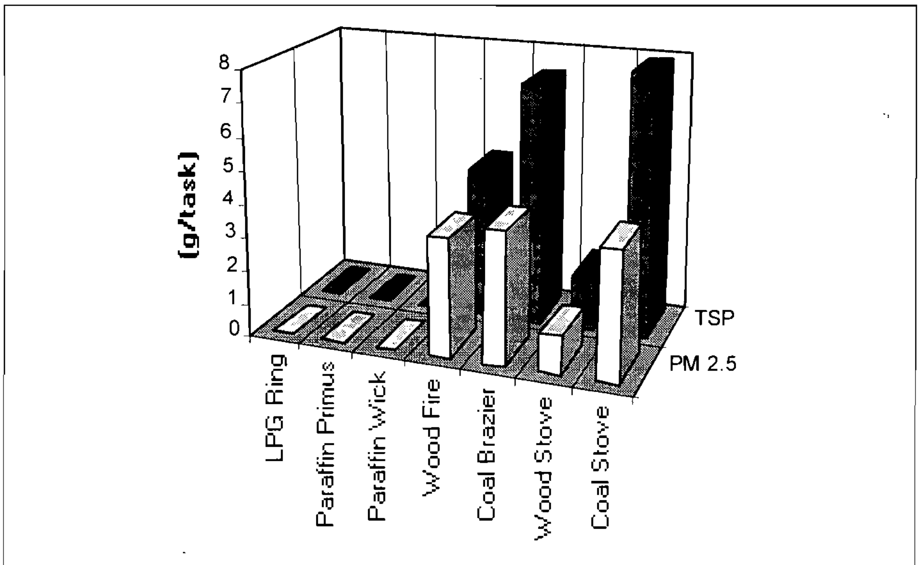

Figure 2: Particulate emissions from various appliances during the cooking test

carbon dioxide emissions (g/task). The measured CO_2 emissions per task of the LPG ring burner actually exceeded those of the paraffin Primus stove, reflecting the larger quantity of LPG burned[3]. However, the adjusted emissions from the LPG ring indicate a lower CO_2 emission rate per task than both paraffin stoves. This is expected since LPG emits less CO_2 per kilogram of fuel burned than paraffin[5]. Carbon dioxide emissions per kg fuel burnt were slightly greater for the Primus stove (2 776,7 g/kg) than for the wick stove (2 737,8 g/kg), indicating a higher combustion efficiency in the Primus stove. The CO_2 emissions of the LPG and paraffin burning appliances were of the order of one-fifth of those from the open fire and coal brazier and one-tenth of those of the wood and coal stoves (Table 2). This indicates the suitability of the smaller stoves for performing the cooking task and the inefficiency of the commercial stoves when lit from cold to boil one pot of water.

Carbon monoxide (CO) emissions were indicative of both the mass of fuel burned and combustion efficiency. Coal burning appliances had the highest CO emissions associated with the lowest combustion efficiency (Table 2). The combustion efficiency of the coal stove (CO_2/CO ratio 15,3) is not significantly better than that of the coal brazier (15,1) but would have been improved if the side vent had not been partially closed during the simmering phase. Despite slightly greater CO emissions (g/task), the wood stove had a much better combustion efficiency than the three-stone stove as indicated by their CO_2/CO ratios, namely 35,3 and 22,3 respectively. The combustion efficiency was improved in the wood stove by the design of the combustion chamber which allows better air circulation in the fuel bed.

"The LPG and paraffin burning appliances had consistently higher efficiencies and lower emissions than the solid fuel burning appliances. However, the high prices of transitional fuels make them, at best, more cost-effective than traditional fuels only during the summer months, when electricity is an even cheaper option. Traditional methods of burning wood and coal were more efficient than commercial stoves, having no flue gas heat losses and fractional appliance inertia losses. However, less complete combustion in the traditional appliances released large quantities of toxic emissions directly into the living space, posing serious health risks."

Under test conditions NO_2 was the only NO_x detected (Table 2). Trace amounts of NO_2 produced by the LPG ring burner and paraffin Primus stove were caused by the fixation of atmospheric nitrogen at high flame temperatures. Nitrogen dioxide (NO_2) was not detected in the wick stove tests as a result of insufficient flame temperatures. For the solid fuel burning appliances, NO_2 production results predominantly from the oxidation of chemically bound nitrogen. Nitrogen dioxide emissions therefore reflected the fuel nitrogen content and mass of fuel burned. Wood (<1%[6]) has a lower nitrogen content than coal (2% dry ash free basis[7]). Thus NO_2 emissions were greater for the coal brazier than the three-stone wood stove, and greater for the coal stove than for the wood stove. However, NO_2 emissions were greater for the wood stove than for the coal brazier, reflecting the larger mass of fuel burned in the wood stove during the cooking test.

Hydrocarbons (HC) are the products of incomplete fuel combustion and indicative of combustion efficiency. Thus the LPG ring burner had the lowest HC emissions, followed by the paraffin Primus and paraffin wick stoves (Table 2). The three-stone wood stove had higher HC emissions than the coal brazier because of the high volatile content in wood. These volatiles are vaporised from the wood during the preliminary stages of wood combustion and released directly into the living area. In the commercial wood stove the volatiles undergo secondary combustion at the high temperatures inside the stove, lowering the HC emissions (Table 2). The coal stove had higher HC emissions than the wood stove, both as a result of the increased time of the test, associated with the thermal inertia of the stove, and from the lower combustion temperature, limiting the degree of secondary combustion.

Figure 2 shows particulate emissions from various appliances during the cooking test. Particulate emissions are perhaps the most hazardous of all domestic combustion products. In addition to elemental carbon, particulates contain condensed and adsorbed organic matter, such as polyaromatic hydrocarbons (PAH), which are recognised carcinogens. Particulate size distribution is critical in determining the health effects of emissions. Smaller particles penetrate furthest into the respiratory system and pose the most serious health risks[8]. Furthermore, smaller particles have longer residence times in the atmosphere, magnifying their potential impact. Emissions of both total suspended particulates (TSP) and particulates of less than 2.5μm aerodynamic diameter (PM2.5) were measured during the cooking test.

The particulate emissions from the LPG ring burner and paraffin stoves were hard to resolve from background particulate levels. Almost all particulates from these sources were in the PM2.5 size fraction. Particulate emissions from the wick stove were greater than those from the Primus stove, reflecting the improved combustion efficiency of the latter. Maximum TSP levels inside the cell for a single wick stove test averaged $184\mu gm^{-3}$ but this was dependent on the flow rate of air through the room. If the test had been performed in a model Indian kitchen[9], a 16 m^3 hut with an average air exchange rate of 2,7 room volumes per hour, the average resultant TSP level for the wick stove would have been $214\mu gm^{-3}$. This is still lower than the U.S. 24-hour health standard of $260\mu gm^{-3}$, so it can be concluded that paraffin Primus and wick stoves do not pose a serious health risk in terms of particulate emissions.

Particulate emissions from solid fuel burning appliances were orders of magnitude greater than those from LPG and paraffin burning appliances (Figure 2). Although particulate emission rates (g/kg fuel) are greater for wood than for coal [10], TSP emissions (g/task) were greater for the coal burning appliances as a result of the increased mass of fuel burned. The PM2.5 size fraction was larger for the wood burning appliances for the coal burning appliances. The effect of this unequal distribution is that PM2.5 emissions from the three-stone stove, coal brazier and coal stove are very similar. Emissions from the wood stove were the lowest of all the solid fuel burning appliances, resulting from the secondary combustion of particulates and deposition of soot inside the stove. It is uncertain whether an older stove might have different deposition characteristics and hence different particulate emissions. Given that the coal stove vents its emissions outside the home and assuming that the coal brazier is left outside during the smoky light-up period, the three-stone stove can be regarded as the most hazardous appliance in terms of particulate emissions.

(ii) Grams per useful MJ (g/MJ)

In winter, heat losses to the surrounding space during the cooking test can be regarded as useful space heating energy. Now the emission rates of the appliances can be compared by expressing them as grams per useful MJ delivered, including cooking and space heating outputs. The main effect of expressing emissions as g/MJ instead of g/task is to reduce the emissions of the solid fuel burning appliances relative to those of the LPG and paraffin-burning appliances. However, the emissions of the latter appliances remain significantly smaller than those of the solid fuel burning appliances (Table 3).

	Gases				Particulates	
	CO_2	CO	NO_2	HC	PM2.5	TSP
LPG Ring Burner	67.8	0.33	0.02	0.08	0.0008	0.0008
Paraffin Primus Stove	94.6	0.38	0.03	0.31	0.0019	0.0012
Paraffin Wick Stove	86.5	1.17	0.00	1.44	0.0023	0.0030
Three-Stone Wood Stove	127.4	6.02	0.09	3.40	0.40	0.51
Wood Stove	177.8	5.13	0.18	1.17	0.10	0.14
Coal Stove	160.3	10.62	0.24	2.18	0.30	0.62

Table 3: Emissions of appliances during the cooking test (g/MJ)

It can be seen from Table 3 that although the LPG ring burner had the highest combustion efficiency, converting almost all the fuel to CO_2 (g/MJ) it has the lowest CO_2 emission rate. This is because in producing CO_2, the ring burner released the full energy potential of the fuel and the additional energy output lowered the CO_2 (g/MJ) emission rate. In the case of the other appliances, less complete combustion produces proportionally more products of incomplete combustion and less CO_2. The release of less energy increases the CO_2 g/MJ emission rate.

Appliance CO emissions (g/MJ) were indicative of the appliance overall efficiencies. For the solid fuel burning appliances, variations in the CO_2/CO ratio on different test runs (resulting from different fuel bed conditions) were correlated with changes in the measured overall efficiency. Stove inertia losses meant that despite a lower CO emission rate, the wood stove had a poorer overall efficiency than the three-stone stove.

Table 3 confirms that the release of chemically bound nitrogen in solid fuels is a more significant source of NO_x from domestic fuel burning than fixation of atmospheric nitrogen by LPG and paraffin burning appliances. The most striking result of expressing HC emission rates as (g/MJ) instead of (g/task) is the high emission rate of the three-stone fire (Table 3). Vaporisation of volatiles in the wood occurred, releasing them directly into the living area. This represents both increased emissions and loss of potential useful energy output in terms of incomplete combustion. Similarly, the PM2.5 particulate emission rate is even higher for the three-stone stove than it is for the coal stove, although, in terms of TSP emissions, these are higher in the coal stove (Table 3). The particulate emission rates (g/MJ) of the LPG and paraffin burning appliances remain smaller than the solid fuel burning appliances, by a factor of 200-300.

Space heating tests

Space heating efficiencies

The space heating test was carried out at steady state operating conditions, nullifying the effect of appliance inertia on the efficiency determination. A steady state burn rate was achieved by maintaining the LPG heater at a constant setting and by adding known charges of fuel to the wood and coal burning appliances at a predetermined rate. Changes in the fuel bed configuration during the tests caused slight variations in the burn rate and combustion efficiency which were reflected in the measured space heating efficiencies. Table 4 contains the mean results of the space heating tests, performed three times by each appliance.

In contrast to the results of a previous study[4] which tested a different LPG heater, the space heating efficiency of the open fire measured here was lower than that of the LPG heater (Table 4). The losses from the open fire were, however, almost entirely accounted for by incomplete fuel combustion. There was an additional small unaccounted for loss in terms of heat conducted through the cell floor. The space heating efficiency of the open fire is greater than the overall efficiency of the three-stone stove because, with regard to the stove, there are inefficiencies associated with the thermal inertia of the cell floor and the three stones themselves.

The high burn rate of the wood stove during the space heating test resulted in a considerable fuel consumption, although conversion to useful energy was at a high efficiency (72%). The wood stove was only marginally less efficient in terms of space heating than the open fire (Table 4). However, the predominant losses are different in each case. The wood stove combustion efficiency is higher than that of the open fire as a result of improved air access to the fuel bed. The main losses for the stove are therefore sensible heat in the flue gases and not a result of incomplete combustion. The proposed vent at the base of the flue would have improved the space heating efficiency of the stove further.

The space heating efficiency of the coal stove was significantly lower than that of any of the other appliances (Table 4). In an attempt to account for the losses associated with the coal stove, it is postulated that a substantial amount of energy is lost in coal char and ash which fell through the grate in the combustion chamber. While developing an improved method for the testing of solid fuel fired stoves, Clark[11] calculated the heat balance for a coal stove burn cycle lasting four hours. He found that 18%-36% of the energy in the fuel added to the stove was left in the char and ash at the end of a test. Additional losses occur as sensible heat in the flue gas.

	Output	Efficiency	Gases (g/MJ)				Particulates (g/MJ)	
	(kW)	(%)	CO_2	CO	NO_2	HC	PM2.5	TSP
LPG IR Heater	1.26	82.0	79.6	0.52	0.02	0.27	–	–
Paraffin Heater	1.97	84.7	85.1	0.13	0.14	0.17	0.02	0.01
Open Wood Fire	3.32	80.0	118.2	6.59	0.09	3.57	0.76	1.06
Wood Stove	3.85	72.0	122.0	2.67	0.07	0.73	0.04	0.06
Coal Stove	2.10	37.1	124.9	7.81	0.26	3.36	0.31	0.66

Table 4: Efficiencies and emissions during the space heating tests

Cooking					Summer	Winter
Fuel	Appliance	Fuel (kg/task)		Unit Price	Fuel Cost (R/task)	Fuel Cost (R/MJ)
Electricity	Single Ring		–	24.79c/kWh	0.07	0.069
LPG	Single Ring		0.087	3.21 R/kg	0.28	0.084
Paraffin	Primus		0.073	1.68 R/litre	0.15	0.072
Paraffin	Wick		0.090	1.68 R/litre	0.19	0.067
Wood	3-Stone Fire		0.847	0.45 R/kg	0.38	0.047
Wood	Stove		1.666	0.45 R/kg	0.75	0.065
Coal	Brazier	Coal	0.562	0.55 R/kg	0.45	–
		Wood	0.323	0.45 R/kg		
Coal	Stove	Coal	1.896	0.55 R/kg	1.23	0.084
		Wood	0.407	0.45 R/kg		
Space Heating						
Fuel	**Appliance**	**Fuel (kg/MJ)**		**Unit Price**		**Fuel Cost (R/MJ)**
Electricity	Heater	–		24.79c/kWh		0.069
LPG	IR Element	0.027		3.21 R/kg		0.087
Paraffin	Heater	0.027		1.68 R/litre		0.057
Wood	Open Fire	0.080		0.45 R/kg		0.036
Wood	Stove	0.084		0.45 R/kg		0.038
Coal	Stove	0.110		0.55 R/kg		0.061

Table 5: Coastal regions (Cape Town): Appliance running costs

Emissions during space heating tests

Table 4 contains the mean emission rates of appliances during space heating tests. The LPG and paraffin heaters had low CO, HC and particulate emissions compared to those of the solid fuel burning appliances associated with their significantly higher combustion efficiencies (Table 4). The paraffin heater actually had a higher combustion efficiency than the LPG heater and a slightly higher space heating efficiency. Given the flow rate of air necessary to maintain a temperature increase of no greater than 20°C across the cell, it was not possible to resolve the LPG heater particulate emissions from background particulate levels in the dilution air. A study of TSP levels in gas and paraffin burning homes in Cape Town confirmed that background particulate levels had a greater influence on indoor air quality than appliance emissions[12].

Less complete fuel combustion in the solid fuel burning appliances produced proportionally more products of incomplete combustion and less CO_2. Hydrocarbon emissions from the open fire were especially high (Table 4). Constant additions of wood to the fuel bed resulted in continuous vaporisation of volatiles in the wood to the surroundings which, along with high particulate emissions, pose a serious health risk.

In the absence of the stove inertia energy loss, the CO_2 (g/MJ) emission rates of the wood and coal stoves were reduced in the space heating test compared to those of the cooking test. The high burn rate in the wood stove during the space heating test improved its combustion efficiency over the cooking test by increasing the combustion temperature and promoting secondary combustion of volatiles and particulates. Particulate emissions from wood burning contain about 50% elemental carbon and 50% condensed hydrocarbons[8]. At the high combustion temperatures experienced in the wood stove during the space heating test, the condensed hydrocarbons are burnt in secondary combustion leaving formation of elemental carbon as the principal source of particulates. Some elemental carbon may also be converted to CO_2 during secondary combustion. The result was lower HC and particulate emissions during the space heating test than during the cooking test.

The thermal lag associated with the large thermal inertia of the coal stove means that CO_2/CO ratios could not always be correlated with variations in the measured efficiency. Nitrogen oxide (NO_x) emissions from the coal stove were higher during the space heating test than the cooking test, probably as a result of the higher average stove operating temperatures. Hydrocarbon emissions from the coal stove were varied but reflected the different burn characteristics of the tests. Particulate emissions from the coal stove were expected to drop relative to the cooking test given the absence of the smoky light-up period in the space heating test. However, regular addition of fresh charges to the fuel bed maintained a smoky burn throughout and actually slightly increased the PM2.5 and TSP emissions (g/MJ).

Despite increasing concern over the environmental and public health effects of domestic fuel use, appliance cost-effectiveness is, understandably, of paramount importance to most low-income households.

Cooking					Summer	Winter
Fuel	**Appliance**	**Fuel (kg/task)**		**Unit Price**	**Fuel Cost (R/task)**	**Fuel Cost (R/MJ)**
Electricity	Single Ring		–	19.49c/kWh	0.05	0.052
LPG	Single Ring		0.087	3.95 R/kg	0.34	0.104
Paraffin	Primus		0.073	2.20 R/litre	0.16	0.075
Paraffin	Wick		0.090	2.20 R/litre	0.20	0.070
Wood	3-Stone Fire		0.847	0.21 R/kg	0.18	0.022
Wood	Stove		1.666	0.21 R/kg	0.35	0.030
Coal	Brazier	Coal	0.562	0.26 R/kg	0.21	–
		Wood	0.323	0.21 R/kg		
Coal	Stove	Coal	1.896	0.26 R/kg	0.58	0.040
		Wood	0.407	0.21 R/kg		
Space Heating						
Fuel	**Appliance**	**Fuel (kg/MJ)**		**Unit Price**		**Fuel Cost (R/MJ)**
Electricity	Heater	–		19.49c/kWh		0.054
LPG	IR Element	0.027		3.95 R/kg		0.107
Paraffin	Heater	0.027		2.20 R/litre		0.060
Wood	Open Fire	0.080		0.21 R/kg		0.017
Wood	Stove	0.084		0.21 R/kg		0.018
Coal	Stove	0.110		0.26 R/kg		0.029

Table 6: Highveld regions: Appliance running costs

Appliance cost-effectiveness

The cost-effectiveness of domestic fuel/appliance combinations depend on both running costs and capital costs. The capital cost of an appliance is a one off investment which can be offset against its operating lifetime, which is variable. A previous study[4] found the capital costs of domestic appliances to be a small proportion of total operating costs. Running costs of appliances were calculated for both coastal and Highveld households because of marked regional fuel price differences.

Unit costs of fuels

Within a certain region fuel prices may vary significantly from one retail outlet to another. Seasonal and short-term price fluctuations further complicate the estimation of fuel unit prices. The unit costs of LPG and paraffin in Cape Town were taken from a survey in April 1997 by Mehlwana[13] in the Langa and Khayelitsha townships. Interestingly, the cost of LPG per kg was lower when bought in smaller cylinders. (The price quoted here was for a 19 kg cylinder.) The cost of wood and coal in Cape Town, purchased for this study from Cape Coal (Pty) Ltd, included delivery costs. The unit cost of fuels in the Highveld regions were taken from the February 1997 figures of a longitudinal study by the Palmer Development Group[14] in Kameelrivier B, an area about 160 km north-east of Pretoria. Wood purchased was assumed to have a moisture content of 9,9%.

Electricity prices in both regions were at February 1997 average rates for the domestic sector[15].

Running costs of appliances

Having determined the cooking and space heating efficiencies of various appliances, and knowing the unit cost of fuels, it is a trivial task to calculate the cost of useful energy as provided by each of the appliances (Tables 5 and 6). The cost-effectiveness of each appliance during the cooking test was expressed both as cost per task (summer) and cost per useful joule of energy delivered (winter). The calculation of costs of electrical appliances assumed 100% efficiencies and a cooking task requirement of 1,05 MJ. The calculations for wood burning appliances assumed a fuel moisture content of 9,9%.

Apart from self-collected wood at no cash cost, electricity appeared to be the most cost-effective energy source in terms of R/task in both regions. This is because the appliance has been assumed to be 100% efficient and all the energy supplied is utilised in the cooking process. The transitional fuel burning appliances are generally cheaper than the traditional fuels in terms of R/task, resulting from their higher cooking efficiencies. However, the situation is reversed when fuel costs are expressed as R/MJ, including space heating output in the cooking test. Electricity becomes more expensive than wood, and the transitional fuels become the most expensive of all. Tables 5 and 6 suggest that a coal burning stove is more cost-effective than electricity on the Highveld but not in the coastal regions. However, it is important to remember that the standard cooking task used to calculate cooking efficiencies neglected the multiple pot capacity of the coal stove.

Electricity and transitional fuels are less cost-effective than traditional fuels for space heating (Tables 5 and 6). Indeed, a coal stove is more cost-effective as a space heater than an electrical heater even in the coastal regions. The multiple fuel use patterns of many South African households reflect a recognition of the task-specific cost-effectiveness of appliances. Even after electrification, households have been found to rely on a variety of domestic fuels to provide their energy requirements[16].

Conclusion

The novel procedure for the determination of cooking efficiencies enabled the resolution of both the cooking energy output and total useful energy output of appliances. In order to compare the performance of a range of appliances, each appliance was tested using a standard cooking task. Some appliances were better suited to the task than others. The LPG and paraffin burning appliances had consistently higher efficiencies and lower emissions than the solid fuel burning appliances. However, the high prices of transitional fuels make them, at best, more cost-effective than traditional fuels only during the summer months, when electricity is an even cheaper option. Traditional methods of burning wood and coal were more efficient than commercial stoves, having no flue gas heat losses and fractional appliance inertia losses. However, less complete combustion in the traditional appliances released large quantities of toxic emissions directly into the living space, posing serious health risks. In addition to emissions benefits, transitional fuels are convenient and offer an improved standard of living. The multiple fuel use patterns of many South African households represent an attempt to achieve cost-efficiency whilst improving living standards.

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Critical success factors in commercialising renewable energy systems in developing countries

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Many renewable energy projects in developing countries have had success in bringing affordable and environmentally acceptable energy to people, especially in the rural areas. There have, however, been other projects and programmes that have been less successful. This paper, which describes some of the work of the U.K.-based Energy Technology Support Unit (ETSU) in developing countries around the world, sets out to identify the key factors which need to be in place to maximise the probability that future renewable energy projects and programmes will succeed. In this context, success is defined as the sustained and replicated introduction into a suitable market place.

The analysis was carried out by developing a wide range of case studies selected to illustrate the diversity of available technologies, markets and institutions. Lessons are drawn from the case study information and classified into specific critical success factors. The paper goes on to present some views concerning the relevance of these findings to Southern Africa, and the current plans for wider implementation of renewable energy programmes in the region.

Keywords: renewable energy; Southern Africa; developing countries; ESTU

Introduction

Renewable energy systems offer many advantages for developing countries, and interest in renewable energy as a means of supplying electricity has been growing steadily over the past twenty years. Nowadays, few people in the energy sector would perceive a future (at least within the next twenty to thirty years) which excludes renewable energy as a valuable source of world energy. Indeed, many observers believe that renewable energy will make a substantial contribution to world energy supplies in the longer term.

This interest in renewable energy has been heightened by concerns over the use of conventional fossil fuel energy supply technologies and their environmental impacts. This is particularly the case in North America and Western Europe where renewable energy technology may offer one means of achieving environmental improvements in terms of both local and global pollution, compared with the fossil fuel alternatives.

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In developing countries, the emphasis is focused more on the scope which renewable energy technologies can give in terms of expanding the supply of electricity to remote rural areas, where conventional grid connections may not be cost-effective. Environmental considerations are probably less important in developing countries, where wood is used as a fuel for cooking and heating in the vast majority of rural homes. This scenario does not support a significant achievement in environmental improvement with the introduction of renewable energy systems.

The motivations and interests of national governments, utilities and energy sector organisations in the development of renewables can differ according to the region of the world under consideration. However, it is universally true that, if renewable energy technologies are to achieve the potential which has been suggested for them, it will be necessary for power sector markets to develop and mature in such a way that renewables provide cost-effective, as well as socially and environmentally acceptable, alternatives to conventional power generation.

A key issue that must be recognised is that conventional power supplies have the advantage of being well-established, with a significant sunk investment in plant and equipment. They are also familiar to policy makers, utility companies and end-users. Regulatory and legislative frameworks in the power sector have evolved with the characteristics of conventional power supply systems as the only major consideration. Meanwhile, renewables require some differences in treatment due to their technical features, the economics involved and the commercial incentives to exploit renewable resources. This is not to say that renewables necessarily merit special treatment, but it is important to ensure that they are not unfairly penalised by market factors which do not take into account the particular characteristics of renewable energy systems.

This paper presents the findings of a recent research study[1] to identify the key factors which need to be in place to maximise the chances that future renewable energy projects and programmes will succeed. In this context, success is defined as the sustained and replicated introduction into an energy supply market by means of suitable market enablement mechanisms.

The study was based on examining previous and ongoing renewable energy projects and programmes in several developing countries, including Asia and Africa. These projects have utilised different approaches to improving the delivery and uptake of renewable energy in the energy services market within developing countries. It was based on a two-fold approach: (1) an analysis of the critical success factors involved in the utilisation of aid programmes to stimulate renewable energy investments, and (2) an examination of the market integration steps needed to ensure cost-effective and socially acceptable systems.

Renewable energy in developing countries

Renewable energy systems cover a wide range of technologies, including solar/photovoltaic systems, solar/thermal power plant, solar water heating, biomass technologies, wind, small hydro and geothermal power generation. Considered as a group, renewables have a number of important features that distinguish them from conventional energy technologies, and many of these features offer advantages for developing countries. For instance, they are available in a wide range of energy production size capacity, are capable of modular design, and are relatively easy to construct and commission.

The range of sizes allows renewables to be tailored to meet the characteristics of particular resources and markets at a very local level. The time taken to develop a renewable energy system can be considerably shorter than the time taken to bring on stream conventional (typically much larger) power systems. These features make renewable technologies attractive in areas where there is a need for power with only a limited existing infrastructure. They also offer the means of achieving environmental improvements in terms of both local and global pollution compared with fossil fuel alternatives.

There are two broad areas in which renewable energy has a role to play in developing countries. Grid-connected applications are of greatest interest to those countries where there is a significant capacity shortage of electricity supply. One of the best known examples of the large-scale uptake of grid-connected renewable energy is in India, with some 600 MW of installed wind energy capacity. Other countries where a rapid rate of growth is possible include China, Egypt and a number of Central American states.

Despite this widespread potential and the successes that have been achieved, there are barriers to the further uptake of renewables. For example, not all electricity supply sectors are open to private industry participation. Renewables remain more costly than the alternatives, and comparisons with conventional generating plant are not easy because of the decentralised and intermittent generation characteristics of the technologies. The variable and energy-limited nature of renewables is sometimes cited as an important impediment to their integration within a conventional energy supply system. Furthermore, most renewables, in their modern form, are relatively new technologies for energy provision and have to become more technically mature and commercially accepted.

On the other hand, the decentralised applications of renewables could play a major role in the provision of modern energy services to those people, predominantly in rural areas, who do not presently have access to these services. In general, developing countries have high population growth, yet inadequate energy supplies and infrastructure to satisfy basic needs and aspirations. Many developing countries have limited or very little indigenous fossil fuel reserves, and those that do have reserves often rely on the revenues from exports to help finance their development efforts. The use of renewables would help to avoid costly oil imports and protect the fossil fuel reserves of those countries which have them.

Multilateral development agencies

Given the potential advantages of renewables, it is not surprising that multilateral and bilateral aid donors have included renewable energy projects in their portfolios of aid programmes during the last 10-15 years. Attractive low rate loans and grants provided by these donors have become available for energy schemes which are, in principle, environmentally attractive, and which offer social and economic benefits in the longer term.

Over the last few years, renewable projects have begun to feature more highly in these programmes. For example, the World Bank's Solar Initiative has its emphasis on identifying and financing renewable energy projects by targetting commercial and near-commercial applications. These include large-scale, grid-connected renewables, as well as rural-based systems at a local level. The stated priority of the Solar Initiative will be large-scale, grid-connected and industrial projects that are already considered economic, but for various reasons are not yet in the Bank's lending portfolio.

The second target will be technologies and applications in this category that are still marginally more expensive than alternatives, but which could be made to meet Bank investment criteria through intervention from the Global Environment Facility. This Facility finances the incremental cost on projects with global environmental benefits, and renewable energy projects feature in this activity. It is jointly administered by the World Bank and the United Nations Development Programme, which are committing increased resources, in terms of staff and financing, to the renewable energy sector.

A pipeline of renewable energy projects is thus starting to emerge for aid funding and for other public or private investments. With this level of interest and the opportunity it presents for exploiting renewable technologies on a more substantial scale than hitherto, it is important for international and national organisations to plan and prepare for these investments with a high level of confidence that they will be successful and achieve the desired results.

Experiences of renewable energy projects

It is clear from an analysis of the literature that many of the early renewable energy projects in developing countries have been successful, whilst other projects have achieved less success and have not met the objectives of the funding agencies or aid organisations involved.

In the work for the U.K. Overseas Development Administration[(1)] ETSU conducted a series of interviews with key decision-makers and project managers in renewable energy programmes in Asia and Africa. Comparisons with renewable energy projects in Europe and the United States were also undertaken. The key factors involved in each case study were assessed and discussed with the relevant organisations responsible for the projects, and the critical success factors were identified from this analysis. In total, nearly thirty case studies were carried out. The case studies included the following technologies and countries:

- hydro, wind, forestry residues (UK)
- hydro, wind (Spain)
- biomass (Greece)
- biogas, hydro (Thailand)
- biomass (ASEAN)
- PV, solar home systems, wind, biomass, hydro (India)
- wind (China)
- PV (Zimbabwe)
- solar systems (Botswana)
- PV (Kenya).

Critical success factors

Over fifty success factors were identified as a result of the work. Clearly, such a large number of diverse factors would be impractical to apply in any single renewable energy project and difficult to apply across a renewable energy investment programme. The most important success factors comprise the following:

- a national medium-term energy strategy needs to be in place;
- proven or reliable technologies need to be used in the design of renewable energy systems;
- the investment must have acceptable economics so that an appropriate financing package can be put together;
- there must be provision for a market support structure, including marketing, sales, delivery, guarantees, maintenance, spares, etc.;
- a target market must actually exist in which commercial decisions can be made regarding purchase and supply;
- a chain of necessary actors from fuel suppliers to financial intermediaries to end-users must exist;
- site-specific factors must have been considered and a full assessment must have been made of the costs and benefits involved;
- a favourable legislative, political and regulatory framework must be in place which is understood and accepted by all parties in the energy industry;
- there must be an acceptable tariff structure so that user costs can be recovered;
- there must be mechanisms to disseminate and publicise the programme and its results;
- a system of project review, including provision of feedback to the relevant authorities, and suitable record keeping must have been established;
- the programme must have built into it the ability to cater for future changes in demand, including growth.

Commercialisation

The very early stages of introducing energy services present particular problems, especially when social need or poverty alleviation are the driving forces for the provision of very basic services, or when attempting to establish energy markets, such as in rural electrification.

The following three key strands have been identified in recent years:

- the importance of market economics;
- the nature of financing mechanisms;
- the role of institutions.

In terms of market economics, the basic standpoint is that the establishment and nurturing of energy services markets should be the primary goal of all investment in renewable energy. To be most effective, renewables should be used only when they represent the optimum technical and economic solution to energy supply in developing countries. Ensuring that this is the case will require close attention by the promoters of renewable energy systems to the critical success factors outlined above, together with a rigorous technical and economic analysis of the costs and benefits from renewables projects in comparison with other energy supply options.

Unless projects are sustainable, they cannot contribute to the long-term economic development of the countries in which they are implemented. Projects should also aim at being replicable on a significant scale within the local area or region, with decreasing reliance on assistance from aid programmes.

The ability to obtain an appropriate financial package is one of the most important stages in developing the potential of renewables. It is probably more important than the underlying economic case because of the often constrained availability and high cost of finance. For example, one of the reasons why wind power has proved so successful in India is because financial institutions view such investment as mainstream and do not add risk premiums to the financing charges.

The nature and role of institutions in developing renewable energy have also emerged as paramount issues. This is because it is often the unstated roles and duties of the public and private sector institutions that govern the success or failures of investment programmes.

Implications for Southern Africa

There is every reason to believe that renewable energy systems have the potential to contribute to the diversity of supply and the sustainable development of energy services in developing countries. The technologies and markets for renewable energy are being nurtured through the supportive policies of many international and national organisations. The critical success factors already identified will need to be included in the planning and implementation of support programmes in order to give renewable energy the best chance to become fully commercial in the energy markets.

Although the potential supply of renewable energy in Southern Africa is significant, the pace and magnitude of its commercialisation has been slow. Renewable energy technologies require a large capital investment in exchange for very low or zero fuel costs and low operational and maintenance costs. The lack of access by renewable energy developers or users to appropriate financing mechanisms has been a constraint to their adoption. Project and programme proposals must be designed to stimulate the creation of a wider market base for renewable energy systems among both business and domestic users by providing consumer-oriented financing mechanisms, with technical support services and authoritative and independent information dissemination.

Successful renewable energy deployment in energy supply markets needs a stable commercial framework. As renewable energy systems are capital-intensive, a predictable, long-term revenue stream is needed to ensure adequate capital return to investors. This, in turn, gives confidence to manufacturers and suppliers to develop markets for their products. The challenge in Southern Africa is to translate the undoubted technical potential for renewable energy systems into commercial reality.

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Strengthening energy cooperation between the European Union and Southern Africa: Conclusions for future EU activity in Southern Africa

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The paper provides an overview of current activities in the energy sector undertaken by the European Union (EU) relevant to the Southern Africa region. In addition to presenting a description in broad terms of the specific actions comprising this current cooperation, the lessons learned to date from the experience of energy sector development in the region are also outlined. The ultimate aim is to define how best the EU and Southern Africa can work together in the energy sector to achieve mutual benefits. Some of the conclusions drawn to date are described.

The ongoing action supported by DGXVII, the Directorate General for Energy of the European Commission, can be divided into five elements. Having determined the potential for effective EU intervention, one of the key goals was to specify a range of actions that could be supported in the future. This, in fact, covered all non-nuclear sectors. However, the renewable energy sector was selected as the focus for initial investigation, primarily due to the clear access of the entire region to appropriate resources. The ways in which the renewable energy sector is being considered are discussed.

Since the start of the current work, many issues have been identified that need to be addressed during the development of any future EU/Southern African activity. Some the issues that seem to appear consistently are (i) the need for integration with Southern African Development Community (SADC) objectives, (ii) a clear knowledge of ongoing policy development, (iii) understanding of the issues surrounding technology implementation, (iv) identification of all relevant role players in the region, and (v) effective coordination of the international financiers. These points have provided the framework for some of the conclusions drawn.

The similarity between the structure of the EU and SADC provides a common awareness of the needs and processes required for effective regional cooperation. The historical links established through many EU Member States and Southern Africa also provide a firm basis for future action, although the need for coordination with other financiers is also recognised to ensure the efficient use of increasingly limited international resources.

Finally, it is clear that an effective contribution from the EU to sustainable energy development in Southern Africa is dependent upon the engagement of long-term cooperation. Appreciation of this requirement has been a basis for all specific conclusions from the current initiative and can hopefully form the foundation for any action agreed on in the future.

Keywords: EU; SADC; Southern Africa; energy cooperation; renewable energy; energy information networks; finance; sustainable energy development; energy policy; regional cooperation

Introduction

Since June 1996, the EU has been engaged in carefully targetted activity to investigate the potential for closer cooperation with the Southern African energy sector. This initiative has been taken in parallel to the EU's primary assistance to the region which is offered through Delegations established in all SADC countries, each with clearly defined National Indicative Programmes to address the priorities for development. A Regional Indicative Programme for SADC is also in place, coordinated through the Delegation in Gaborone, Botswana.

The ongoing action directed towards the Southern African region and supported by DGXVII can be divided into five elements. Firstly, the intention is to identify what should be the nature of future energy sector cooperation between the EU and Southern Africa. In the field of international cooperation, this is really the first time that DGXVII has attempted to investigate the potential for concerted action in the region. It was therefore necessary to establish whether Southern Africa should be a priority target when compared to other regions of the world, such as Central and Eastern Europe, South-East Asia or Latin America.

In fact, it became apparent very soon after this work commenced that the region has considerable potential for future collaboration which could offer mutual benefits. The question is to determine exactly how this potential can be realised. Due to this early positive conclusion, a small number of more specific actions aimed at certain SADC Member States (such as, the investigation of non-solar renewable resources in South Africa and the identification of sites for mini hydro in Mozambique) have already been introduced to initiate closer cooperation.

Secondly, having determined the potential for effective EU intervention, one of the key goals is to specify a range of actions that could be supported in the future. This, in fact, covers all non-nuclear sectors. However, the renewable energy sector was selected as the focus for initial investigation, primarily due to the clear access of the entire region to appropriate resources.

Therefore the renewable energy sector is being considered in three ways. The first is to assess the current policy-related issues throughout the region, and thereby to determine what exactly is the existing status of renewable energy policy and how such a policy is presently being implemented or is likely to be implemented in the future. Then, in order to show how more targetted cooperation from the EU can lead to effective results

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for all concerned, rural electrification has been selected for specific attention. An assessment of how relevant technology can be implemented to extend access to electricity across the region is now nearing completion.

Finally, at the outset of this investigation the need to demonstrate a concrete result from collaboration was recognised, even though there was no guarantee of any follow-up to the action selected. For this reason, it was decided to establish an energy information network as a foundation for all future activity. Again, the initial focus was on the renewable energy sector, and a pilot network has been set up for full-scale operation and expansion as required, providing that future EU energy cooperation in the region will be pursued.

EU energy sector cooperation in Southern Africa

In general terms, the EU engages in cooperation with Southern African countries within a framework known as the Lomé Convention. In fact, the Convention covers cooperation with seventy countries in Africa, the Caribbean and the Pacific (ACP). It is subject to periodical renegotiation and represents, to date, the broadest (with regard to scope) North-South cooperation agreement in existence. Lomé IV, which covers the period 1990-2000, amounts to 50% of the overall aid provided by the European Commission (EC).

The Lomé Convention signifies global cooperation and has a diverse remit. It includes the whole range of assistance and development instruments, and covers the totality of socio-economic sectors in ACP countries. However, it should also be noted that South Africa represents an exception to ACP-EU cooperation since, due to the country's unique circumstances, it has only recently become associated with the Lomé Convention. Now that South Africa has joined as a qualified member, efforts are being made to establish a comprehensive bilateral agreement to deal with all subjects not covered by this membership.

Activities undertaken within the framework of the Lomé Convention are financed by means of loans and subsidies provided by the European Development Fund (EDF). The EDF drafts five-year financial protocols on the basis of voluntary contributions from the EU Member States. The 7th EDF (1990-1994) amounted to 12 billion ECU* and the 8th EDF (1995-1999) allocated over 13 billion ECU. Grants represented 75% of the 6th EDF's total funds and increased to 92% in the 7th EDF. However, no specific ACP-EU cooperation document exists which is directly related to energy sector development. The resources allocated directly to the energy sector are therefore limited in comparison with total funding. In most cases, energy provision is viewed as a component of other programmes, such as rural development, natural resource utilisation or regional development, rather than as a specific target.

Cooperation in the energy sector, within the framework of the Lomé Convention, is under the management of DGXVII in the EC in the case of non-reimbursable aid, and the European Investment Bank (EIB) in the case of loans. EIB financing is based on its own resources or else on EDF risk capital intended to finance schemes considered as sound long-term investments.

Regarding its relation to energy, the development of this sector was mentioned for the first time in the Lomé II Convention (1980-1985) and now has a definite place in the areas of ACP/EU cooperation of Lomé IV. It provides for further economic and social development through the balanced exploitation of natural energy resources, with an emphasis on the use of renewable energy. The Convention encourages alternative solutions for energy resource development in remote rural areas.

In order to specifically target the issues related to energy sector development in Southern African countries, the work of DGVIII within the EC is supplemented by DGXVII. In broad terms, the energy cooperation programme in Southern Africa is viewed in the context of EU assistance to the developing world, whereby all EU programmes emphasise the concept of mutual benefit. Cooperation activities are aimed at reinforcing the efforts of individual governments to restructure and liberalise their economies, while at the same time providing for effective interaction between those countries and the EU.

With regard to international cooperation, the following themes govern the approach of DGXVII to Southern Africa:

- to foster the development of electricity generation, transmission and distribution in the region;
- supplying electricity to rural areas and townships by an increased use of renewable energies;
- introduction of clean coal technologies;
- the enhancement of regional industrial competitiveness through the promotion of EU collaboration with the main energy producing and consuming industries in Southern Africa;
- the promotion of technology transfer and sustainable institution building;
- improving the rational use of energy, reducing distribution losses, managing efficient use in energy-intensive industries, introducing cost-effective saving schemes in the residential sector;
- to protect and preserve the global environment.

Collaboration in the energy sector at the policy level, including regard for the necessary institution building, is pursued through the programme, SYNERGY. SYNERGY is a bilateral programme implemented by the Directorate General for Energy since the early 1980s, the fundamental objective of which is to improve the long-term world energy situation, and hence the energy security of the EU, by helping other countries take well-founded energy policy decisions.

Besides the policy issues, a fundamental focus for EU energy sector cooperation in general, concerns the introduction of appropriate technology. Technological developments can have a decisive impact on the future shape of energy patterns. New technologies will be required to ensure the development of the energy sector in Southern Africa, particularly with regard to the effective use of renewable energies and new ways of using fossil fuels to maximise efficiency of use and minimise environmental impacts. However, the rate of penetration is heavily dependent on the level of public policy supporting science and technology activities.

In the light of the important barriers to the market penetration of innovative technologies, the EU established in 1994 the Fourth Framework Programme of Research and Technological Development (RTD). This lasts for four years and comprises nineteen specific programmes dealing with various technology areas, such as telecommunications, industry, transport and energy.

Inside the Framework programme, THERMIE is the specific programme for non-nuclear energy (demonstration and dissemination) with an overall budget of over 550 million ECU (approximately US$700 million). THERMIE aims to

* 1ECU = approximately US$1,1

encourage a greater use of innovative technologies across all major energy fields, including rational use in the energy industry, renewable energy sources (solar photovoltaics, solar thermal applications, biomass and waste, wind, geothermal, small hydro) and fossil fuels (clean coal, hydrocarbons). The programme operates through the provision of support to demonstration projects and to promotion activities designed to stimulate the market uptake of those technologies, both within and outside Europe (e.g. Southern Africa).

Outside DGXVII, there are also other initiatives within the Commission that involve provision for cooperation in the energy sector. For example, the Directorate General (DG) dealing with policy research is currently implementing a programme which targets the effective utilisation of natural resources worldwide. There is specific provision for energy-related issues in Southern Africa. In addition, the DG for the Environment has expressed some interest in the energy activities of the region, and the DGs for Industry and Transport may also be active.

In general terms, the energy sector in Southern Africa is covered by the European Commission through those DGs responsible for the geographical location and the sectoral interest. However, there are many other parts of the Commission which may be associated. In order to facilitate the interaction with countries in the ACP region, including Southern Africa, local Delegations of the European Commission have been established. These offices represent the first point of contact to the EU for any role player in the region, and provide a convenient channel between the region and Commission decision-makers for all issues involving possible cooperation. In addition to these national points of focus, an office has also been created to deal specifically with the Southern African region. This is located in Gaborone, Botswana, close to the SADC Secretariat.

Priority considerations before further action

Since the start of the current work in Southern Africa, supported by DGXVII, many issues have been identified that must be addressed during the development of any future EU activity. Some of those that seem to appear consistently are:

- integration with SADC objectives;
- clear knowledge of ongoing policy development;
- understanding of the issues surrounding technology implementation;
- identification of all relevant role players in the region;
- coordination of the international financiers.

The close coordination with SADC is clearly an essential requirement. It has become increasingly evident that any activity in one of the countries in the region may have a significant impact on neighbouring countries and on the region as a whole. The Southern Africa Power Pool (SAPP) is perhaps the most high-profile example, though other key issues, such as access to oil and gas reserves, environmental concerns and rural electrification, all have clear regional significance. Any EU cooperation under consideration is likely to incorporate regional issues. Some, such as the information network mentioned, already have clear regional implication. It is therefore important to work closely together with the SADC organisation.

In fact, the SADC Energy Unit based in Luanda, Angola, is currently undergoing a fundamental restructuring. This will be performed on the basis of energy sector action plans which will represent the basis for energy activity in the region. It will be important for the EU to have a clear understanding of these plans and to ensure that any future action is complementary.

SADC also clearly has many years of experience in the region with regard to the energy sector. With the exception of South Africa, which is only a recent member, the regional structure has been in place for many years. Much energy sector experience has been developed in this time which will certainly help to orient future initiatives. Of course, there are also ongoing activities which must be accounted for when deciding exactly where to target EU support. This again means that a close association with SADC will be both necessary and mutually beneficial before the precise details of EU cooperation are finalised.

The development and implementation of energy policy is where the EU has considerable experience. Only recently, a new White Paper for Energy was published by the Commission, and at the end of last year a Green Paper for renewable energy was also prepared for discussion. In Southern Africa, the establishment of energy policy is very much an ongoing process, with different countries at different stages. Perhaps there are useful lessons to be learned from each other with regard to the most effective means of policy production and the best way to turn policy into practice.

It is, of course, essential to be familiar with a nation's policy before trying to establish the direction for future cooperation. In Botswana, the Energy Master Plan has been under preparation for several years but there is still no clear decision on how it might be used. A clear policy framework is also required for the energy sector in Lesotho. An energy White Paper is under preparation in Namibia where detailed consideration is given to how best to focus on the energy priorities, many of which are already being addressed by Government. A similar process has recently been undertaken in South Africa, with the resulting draft White Paper soon to be under Cabinet consideration. Swaziland is also engaged in the development of a clear policy - with specific attention to renewables - which is now reaching the final stages. Zimbabwe has recently developed Energy and Biomass Policy papers which are also at the stage of Cabinet approval and further consultation.

However, across the region as a whole, most nations still have no clear energy policy in force. This situation presents the opportunity for targetted policy development and implementation, with consideration of the lessons already learned elsewhere. The final definition of policy and the transition from policy to application could be assisted through closer regional and international collaboration.

When it comes to technology and technical reliability, it is the implementation of the technology which must be carefully considered and the large number of associated issues which much be understood, before any successful impact can be achieved. Highly successful technology operated in Europe will not necessarily have the same success in Southern Africa, unless the local conditions are taken into account and appropriate modifications made.

This is particularly apparent in the rural areas where, for many years, international support has been used to carry out technology demonstrations and pilot schemes, only for those projects to fail due to local circumstances that were not envisaged. How the introduction of energy technology will affect the economic and social conditions of the community in which it is located must be understood. Adequate capacity must exist to enable the necessary supply, maintenance and service of any system implemented. It also has been realised that cultural factors must be taken into consideration when an energy technology is introduced into a community. This invariably requires the education of potential end-users, based on their energy options and the associated systems required.

Those actors in the region who influence the development of the energy sector clearly have to be identified and effective communication channels established. In most Southern African countries, the principal energy sector role players are the government and the utility. The capacity within these organisations and the attitude towards future energy options will often be the determining factors in how effectively the sector develops. In addition, there may be other institutions, centres of expertise and non-governmental organisations (NGOs) which can have an important influence on key national decisions. The international actors in any particular country are often represented by local offices which have a certain degree of autonomy from their head offices. They are therefore also important contacts when trying to develop future cooperation to complement an ongoing activity.

Perhaps one of the messages heard most often from the actors in the region is the request for more effective coordination of international financiers. There are a considerable number of such organisations which are likely to be involved in the energy sector. Apart from the EU, these include the World Bank, United Nations, European Investment Bank, African Development Bank, International Energy Agency and, of course, a wide range of bilaterals. Any future initiatives considered by the EU will certainly need to take into account how best to complement and avoid duplication with the plans of other international financiers.

Early conclusions from the current EU activity

After an investigative period now extending over more than twelve months, some important conclusions have been drawn with regard to how best the EU might be involved in the Southern African energy sector in the future. In fact, some of these impressions - again primarily in the renewable energy sector - were presented at a recent conference for the region, entitled *Sustainable energy development for Southern Africa*, and are supported by DGXVII. This conference actually provided a significant focal point for ongoing EU initiatives since local reaction to the ideas generated could be expressed.

During the conference, clear presentations were made regarding the Southern African energy objectives and of EU experience and capability. This enabled a clear understanding of the situation from both perspectives. Overall, the results from the conference were very encouraging, with broad agreement on exactly what should be targetted by the EU when trying to formulate future action that will be of mutual benefit in the region.

In the energy sector as a whole (excluding nuclear energy), the following fundamental conclusions were reached:

(1) In the renewables sector, there is experience in the utilisation of the solar energy resource which is, of course, widespread. Outside of this, the data in existence and the potential for other renewables subsectors are generally not clear and require further attention. This applies to the mini hydro, biomass and wind resources which, other than solar energy, are the priority areas of interest. The dissemination of information regarding renewables, both within the region and outside, is an activity which requires greater priority. Much useful experience can be gained from neighbouring countries and the EU. The Renewable Energy Information Network, supported by the EU, could provide an effective foundation for such efforts, though clear integration with SADC plans is required.

(2) The rational use of energy, or energy efficiency, is at a very early stage throughout the region. The relatively low cost of energy supplies - particularly electricity - means that historically, there has been little attention given to efficient energy use. This is now beginning to be addressed, though the requirements at present are the foundations for future development of this theme, including institution-building, improving awareness and encouragement for no- or low-cost actions. The one main SADC initiative for energy efficiency involves capacity-building through training, and this has been very successful. Support should be considered to develop a clear strategy for improved energy efficiency which could be put into practice through the capacity developed.

(3) In the coal sector, the resource distribution is limited, being heavily dominated by that in South Africa. Other countries, such as Zimbabwe, Botswana, Swaziland and Zambia, also have significant supplies which are utilised. However, the truly regional concerns are based rather on electricity generated and potential environmental degradation. An investigation into the utility of regional resources and the potential for the effective use of discard coal from South Africa, is required before detailed future plans can be developed.

(4) Consideration of hydrocarbons is again limited by the specific location of resources. Despite the reserves very recently exploited off the coast of South Africa, it is Angola which is the only regional oil supplier. For gas, again exploitation of significant fields has not yet been effectively achieved, although generation from the Kudu and Pande fields in Namibia and Mozambique respectively could play an important role in the future.

Given the truly regional potential for energy efficiency and the increased utilisation of renewable resources, and considering the extensive European experience with these issues, it seems that these could represent the priorities for future EU cooperation.

The nature of future cooperation

To provide a context for these indications from the different subsectors, a number of broader issues have been investigated. Again, there are certain themes that are regularly encountered and therefore are likely to provide a framework for future cooperation. The application of these requirements to the energy sector priorities will be essential when formulating specific plans for the future.

For example, it has become increasingly apparent when speaking to other international financiers that energy does not necessarily have to be a direct priority to be accepted as an essential issue. In fact, when dealing with the requirements of Southern Africa, energy is very rarely specified as a target. This classification is usually reserved for issues such as poverty alleviation, good governance, economic growth through small- and medium-sized enterprises, health, education, agriculture and housing. However, it is accepted that energy is a fundamental component of all these priorities and therefore support is required. In this case, future energy cooperation between the EU and Southern Africa will generally be most easily complemented by other activity supported by international financiers when the broader perspective is considered.

Any regional activity in the sector will certainly need to take into account the SADC position. Close cooperation with SADC can, in fact, benefit both sides, since the regional experience of SADC and the ongoing actions coordinated by SADC can help the EU to focus its own support on those areas most in need of attention. Collaborative activity may also be possible which will help to supplement the resources available on both sides.

The issues with which the EU has extensive experience are likely to be those most effectively targetted. The needs in Southern Africa may be addressed with support from a range of international organisations, including bilaterals from around the world. The EU is a world leader in many fields of the energy sector and therefore Southern Africa will benefit most from cooperation with the EU in these fields.

A past tendency for international cooperation has been to help provide the required energy supplies with little regard for the real needs of end-users. It is becoming increasingly clear that any collaboration from the EU in the future should focus primarily on the demand-side requirements in order to have long-term sustainability. Leading directly on from this is the need to develop a clear understanding of end-user issues that relate to energy needs. As mentioned previously, the particular energy form to be employed in the rural areas will be dependent upon many factors, which include the social and economic impacts on the members of the community for which it is intended.

In order to make effective progress with such an activity, it will be essential for a clear channel of communication to be established from the finance provider in the EU, through to the end-user in whichever urban establishment or rural community is targetted. This must pass through the EU contractor, the relevant SADC contact, the national decision-maker and the local authority responsible. A clear understanding of the objectives and requirements at all levels will be essential to the success of the proposed initiative.

Finally, coordination of EU support with that from other financiers will be necessary in order to achieve the ultimate goals that may be outside the aims of the specific EU action envisaged. In general terms, a need will be identified which involves supporting a transition from the existing situation to a sustainable improvement. A number of steps are normally required for this transition involving, for example, an investigation or market study to confirm that the potential for improvement exists, demonstration of the new systems or processes to be implemented, information and education to raise awareness of the likely benefits, capacity-building through training or the creation of institutions to ensure sustainability, the identification of a financing mechanism to allow the broadest accessibility to the new means, and finally, significant funds to initiate the intended scheme before market forces ensure sustainability.

It is clear that no single financier has the capability to support the necessary action at every stage. To reach the ultimate goal it is therefore necessary for several financiers to be involved. Each step will have clear objectives associated with it and these will be the aim of the financing organisation providing support at that stage.

This form of coordination will help to avoid duplication or conflict between internationally supported activities. In Southern Africa, the process is still at an early stage, so a carefully planned approach could produce effective channelling of international resources towards the agreed aims. Of course, to target these resources effectively, it will be necessary to clearly recognise the national priorities in the region and therefore close association with the SADC organisation will be required.

If the local priorities can be clearly established and accepted by the international financing community, then the organisations concerned can work together to resolve the key problems. Agreement to carry out complementary activity will not only help to address the local issues effectively, but can meet the individual aims of the financiers through their specific activity, and recognition of their contribution to the successfully achieved ultimate goal.

Future cooperation between the EU and Southern Africa

DGXVII activity to date has helped to understand those issues which will need to be carefully addressed when any future EU/Southern Africa cooperation is planned. This dramatically improved appreciation of the energy sector needs in Southern Africa could provide a foundation for follow-up action with clear benefits on both sides. The similarity between the structure of the EU with its fifteen Member States and SADC with its twelve Member States provides a common awareness of the needs and processes required for effective regional cooperation.

The historical links established through many EU Member States and Southern Africa also provide a firm basis for future action, since there is extensive knowledge of current issues and the background to their development. The range and extent of bilateral support, which in many cases has clear impact on the energy sector, is a further indication of the positive relationships established which offer a basis for further effective energy sector cooperation.

A clear message that has been regularly encountered during the current investigation is the need to consider the practical energy requirements at the user level. It seems that an approach to simply offer increased supply options is unlikely to address the real problems faced by potential users with no access to the supply. A demand-driven approach should therefore form the focus of future cooperation. Also related to this theme is the clear link between energy and development throughout the region. The effect of improved access and utilisation of energy can certainly facilitate the development goals targetted by many organisations, such as improvement in health care, education, transport and agriculture.

Coordination with other financiers has been identified as the only real mechanism to achieve the ultimate energy requirement of Southern Africa and to ensure the effective use of increasingly limited international resources.

Finally, potential collaboration between the EU and Southern Africa in the future should not be a one-way transfer of experience, technology or services. The mutual benefit of any cooperation is recognised since coordinated activity can bring positive outcomes for both sides. In general terms, the only restriction on the benefits likely to be achieved is the duration for which clear commitment to cooperation is engaged. It is quite evident that a quick attempt to address the energy sector issues prioritised in Southern Africa is unlikely to result in sustainable results. An effective contribution from the EU to sustainable energy development in Southern Africa is clearly dependent on the engagement of long-term cooperation. This need has been recognised and can hopefully form the foundation for any future action.

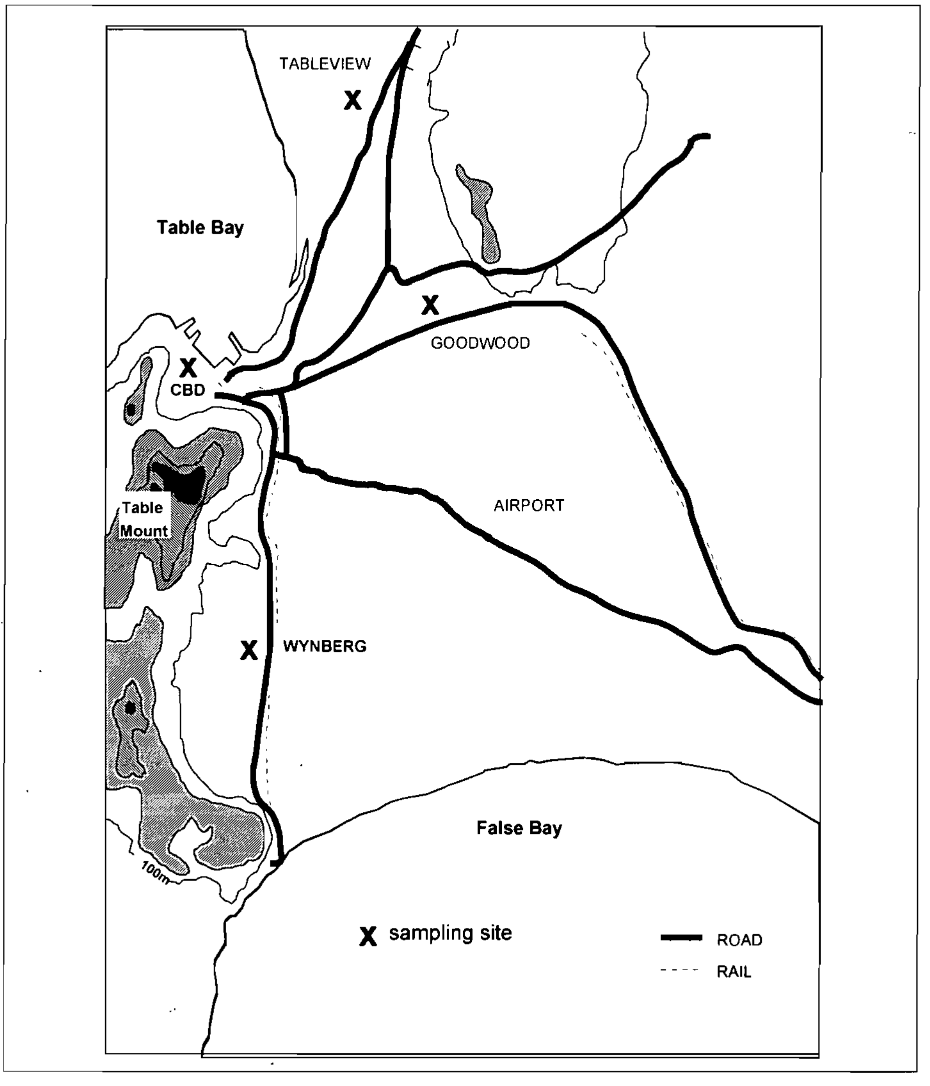

Figure 1. Location of the brown haze sampling sites in Cape Town

Comparison of air pollution levels in Cape Town with international health standards

During the one-year sampling period, the health standards of the United States Environmental Protection Agency[10] and/or of the World Health Organisation[11] for nitrogen dioxide (NO_2) were exceeded during most brown haze episodes, while those for sulphur dioxide (SO_2) were very seldom exceeded, and those for PM10 were never exceeded. The United States PM2.5 daily standard was not exceeded on the days that the brown haze episodes were measured, but it is likely to be exceeded on the worst brown haze days. Despite being a relatively small city, Cape Town can experience strong temperature inversions in winter which trap pollutants at a low level. The entrapment of air pollution is further enhanced by the shielding effect of the mountains in the area. In general, it can be said that, due to Cape Town's unique meteorology, the city experiences strong pollution episodes for only a few hours per day on some days of the year. Pollution levels and visibility during these occasions are comparable with some of the worst polluted cities in the world, but they are not sustained. For this reason, daily and annual air pollution standards are seldom exceeded.

> "Primary PM2.5 emissions are the most important cause of the brown haze, and in the business-as-usual scenario they are estimated to increase by 48% over the next decade. It is therefore likely that the intensity of the brown haze will increase by a similar amount."

Emission inventory for Cape Town

The geographical coverage of the emission inventory is the Cape Metropolitan Area, comprising the six newly formed municipalities. Emissions were mostly determined by multiplying fuel consumption by emission factors, although large industries did supply their own emission data. There is generally a high degree of uncertainty with the inventory data because of the many assumptions that had to made in order to derive the data. It should also be noted that source emissions given by the inventory will not be proportional to their contribution to visibility impairment or health risks for the following reasons:

(i) emissions will have differing dispersion mechanisms from each source since they are released at different heights, times, and positions;

(ii) primary emissions may undergo phase changes and/or chemical transformations, the rate of which depends on factors such as humidity, temperature, light, and the presence of other chemical species and catalysts. Examples of transformations are SO_2 converting to sulphates and NO_x converting to nitrates;

(iii) differing chemical species have differing effects on visibility impairment and health. For instance, carbon particles have a far greater visibility impairment effect than silica particles;

(iv) visibility impairment and health risk depend on particle size distribution, which is not indicated in the inventory;

(v) certain emissions are seasonal in nature and therefore may only contribute significantly to the haze during certain periods of the year, for instance, veld and forest fires rarely occur in winter in Cape Town.

Table 1 shows the emissions inventory in physical units. The PM2.5 emissions have the largest influence on the brown haze.

The Cape Town Brown Haze Study[2]

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A study was recently carried out by the Energy Research Institute to quantify the contribution of all significant sources of the brown haze in Cape Town, which has been growing in intensity over recent years. The study used a receptor modelling approach, which requires the chemical characterisation of both the haze and all possible significant sources of the haze. The most important sources to be characterised were selected based on an emissions inventory which was compiled during the initial stages of the study. The study focused on small particulates (PM2.5), although gaseous air pollutant data was also used. Brown haze episodes were sampled at a number of sites in Cape Town over a one-year period. Following the chemical analysis of all samples, the Chemical Mass Balance Model was used to apportion the haze to all sources considered.

The study indicates that, on average, diesel vehicles cause most of the visible brown haze (48%), followed by petrol vehicles (17%), industrial boilers (13%), wood burning (11%), industrial process emissions (9%), wind blown dust (1%), and sea salt (1%). Prominent industrial point sources, including the Athlone Power Station, the Caltex Refinery and the Kynoch Fertiliser Factory, were not significant in terms of the brown haze. Localised air pollution problems were not investigated.

The most important component of the brown haze was identified as primary PM2.5 emissions, and in a business-as-usual scenario they were estimated to increase by 48% over the next decade. It is therefore likely that the intensity of the brown haze will increase by a similar amount. It is also likely, under the business-as-usual scenario, that PM2.5 health standards will be exceeded with increasing frequency over the next decade.

If Cape Town is serious about improving air quality and reducing the intensity of the brown haze, then both immediate action and longer-term planning is required. Immediate attention should be focused primarily on enforcing diesel black smoke legislation, introducing measures to reduce the number of smoking petrol vehicles, enforcing industrial black smoke legislation, and upgrading the air pollution control capacity of local authorities. Discussions should be initiated with the oil companies regarding fuel reformulation. An air quality management system should be developed for Cape Town, with realistic and measurable targets, and air pollution planning should be integrated with other metropolitan activities, such as urban and transport planning.

Keywords: brown haze; source apportionment; PM2.5; Cape Town; air pollution management; air pollution modelling; visibility

Introduction

The Cape Town brown haze occurs mostly from April to September due to strong temperature inversions and the windless conditions that can occur during these months, which leads to the build-up of pollutants emitted into the atmosphere. The haze extends over most of the Cape Metropolitan area and is normally most intense in the morning, after which it lifts and disperses.

The haze has a strong degrading effect on visibility, which is immediately apparent to the general public and to tourists. Capetonians are especially proud of the natural beauty of their city, and the haze is increasingly eroding this pride. Also of concern is the effect on the tourist industry, which is projected to be Cape Town's most important economic growth area. Concern has been expressed about the increasing incidence and intensity of the haze.

The main objective of the Cape Town Brown Haze Study was to determine the contribution of all major sources to the brown haze and to obtain a better understanding of the mechanism of haze formation. The focus of the study was therefore on visibility, rather than health, although the two are closely related. It should be noted that localised air pollution problems were not addressed in the study.

Methodology of the study

Generally, in urban areas, particles less than 2.5 microns in size (PM2.5) are the single largest cause of visibility impairment. They are also the most harmful size range of particles to human health. Because of the importance of PM2.5 in the haze, the main focus of the study was a source apportionment of PM2.5, although gaseous air pollutants were also taken into account. The apportionment used a receptor modelling approach that required chemical data about the main sources and the brown haze itself.

The brown haze was sampled over a one-year period, from July 1995 to June 1996, using PM2.5 samplers situated at four sites (City Hall, Goodwood, Table View, Wynberg) in the Cape Metropolitan Area as shown in Figure 1. This network was geared for optimum sampling during brown haze episodes. A single sample was also taken at Guguletu, located near the township, and at Cape Point, a remote location 40 km south of central Cape Town.

In addition to the PM2.5 sampling there was ongoing continuous measurement of a number of air pollutants and meteorological parameters at the four sites. The Chemical Mass Balance Model[1], an accepted source apportionment tool of the United States Environmental Protection Agency (EPA), was used to determine the contribution of various sources to the brown haze

Important sources of air pollutants were identified through an emissions inventory of the Cape Metropolitan area. Sources that were included in the modelling were various soils, road dust, sea salt, coal-fired boilers, oil-fired boilers, emissions from the Caltex Refinery, emissions from the Kynoch Fertiliser Factory, diesel combustion, petrol combustion, wood fires, grass fires and tyre burning. Secondary sources for sulphates, nitrates and carbon were also used in the modelling. In some instances the model could not distinguish between the different types of sources, which meant that those sources had to be combined.

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Results

Ambient sampling was carried out on twenty-nine brown haze episodes at each of the monitoring sites. In order to satisfy a number of data quality criteria for modelling, only four to six brown haze episodes were modelled for each monitoring site. The following factors are important for interpreting the results:

(a) The crustal group represents the contributions of all geological dust sources, including paved road dust.

(b) The petrol vehicle source group is represented by the contribution of well-maintained and badly-maintained petrol vehicles.

(c) The wood burning group represents the contribution of all the wood- and grass-burning sources.

(d) No unique chemical characteristic was given by tyre burning. Tyre burning was indicated by the model to be insignificant, but with a high degree of uncertainty.

(e) Emissions from the Kynoch Fertiliser Factory were indicated to be insignificant.

(f) The boiler source group represents the contributions of both oil- and coal-fired boilers. This includes emissions from the Caltex Refinery and from the Athlone Power Station. It was not possible to model these sources individually as they did not have unique characteristics.

(g) The carbon source group represents the residual organic and elemental carbon species from modelling. Also significant to the apportionment is the carbon group. Some of the carbon may be secondary in nature, but typical reaction rates of organic carbon indicate that it is unlikely that most of the carbon is secondary carbon. It is likely that a significant portion of the organic carbon is derived from industrial process emissions.

Average PM2.5 source apportionment of the brown haze episodes modelled is shown in Figure 2.

PM2.5 apportionment was converted to visibility apportionment, that is, contribution to the visual impact of the brown haze. Average visibility apportionment of the brown haze episodes modelled is shown in Figure 3.

The results show that the major source of the brown haze in Cape Town is diesel vehicles, with petrol vehicles, wood burning, and industrial boilers also being significant. A significant unknown source also exists, which comprises mostly organic carbon. It is likely that a significant portion of this organic carbon is derived from industrial process emissions. The Caltex Refinery and the Athlone Power Station are included under boilers, together with other oil- and coal-fired boilers. Due to the emissions of the Caltex Refinery and the Athlone Power Station being above the inversion layer during the worst period of the brown haze, in the early morning, they are not expected to form a significant portion of the industrial contribution during brown haze episodes. The model indicated tyre burning and the Kynoch Fertiliser Factory emissions to be insignificant. It must be emphasised that these results do not reflect on possible localised air pollution problems that may exist.

	Emission Rate (tons/year)				
	SO_2	NO_x	VOCs	PM10	PM2.5
Residential					
Coal	185	15	49	40	16
Paraffin	344	61	4	8	8
LPG	0	31	11	2	2
Wood	1	542	2387	1877	1314
Transport					
Petrol vehicles	1591	16848	33696	562	472
Diesel vehicles	2716	1781	460	1927	1773
Brake and tyre wear				86	0
Paved roads				2129	213
Unpaved roads				1391	139
Aviation fuel	46	576	470	33	30
Ship diesel	69	739	31	52	47
Ship bunker oil	1145	582	109	67	60
Industry and Commerce					
Coal	4750	1875	6	975	390
HFO	7686	695	4	451	406
FFS fuels	146	154	1	100	90
Diesel	84	900	38	64	59
Power paraffin	39	7	0	1	1
Caltex	10880	1643	1700	432	302
Kynoch		888		135	122
Athlone Power Station	2261	893	3	464	186
Other					
Tyre burning	241	13	107	335	168
Medical incineration	1	2	0	3	3
Veld fires	40	107	647	460	322
Other VOCs			15618		
Total	32225	28352	55341	11594	6123

Table 1 Summary of primary atmospheric emissions in Cape Town[2]

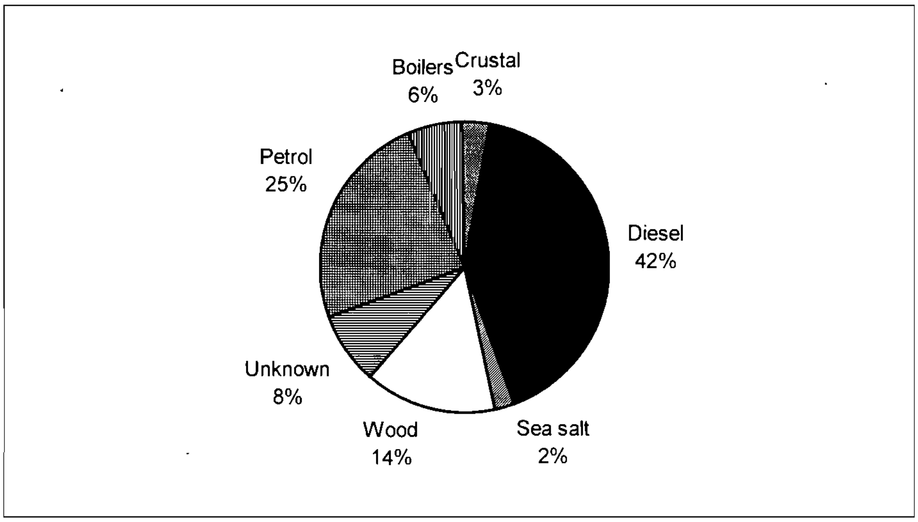

Figure 2: *Average PM2.5 apportionment of the brown haze in Cape Town*

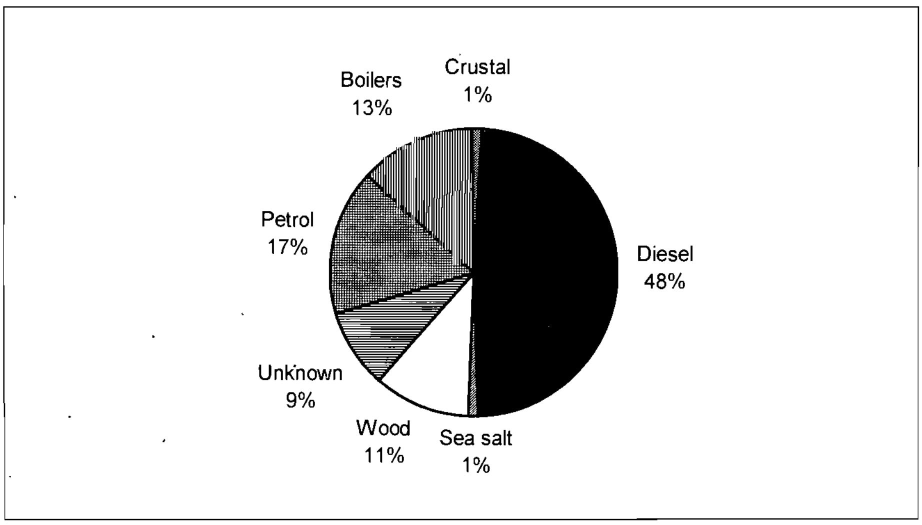

Figure 3: *Average visibility apportionment of the brown haze in Cape Town*

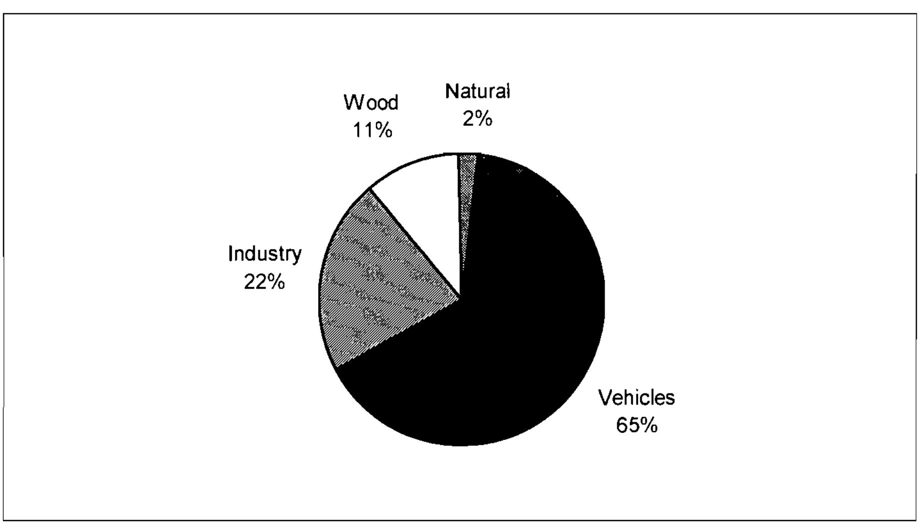

Figure 4: *Average visibility apportionment of the brown haze in Cape Town (aggregated)*

Assuming the unknown portion is attributed to industry, contributions to the brown haze can be further aggregated as shown in Figure 4.

The results shown represent the average situation for Cape Town. Although all monitoring sites showed a similar trend to the average situation, there were some significant differences:

(1) The central City area had an even greater contribution from vehicles (72%).

(2) Table View had a larger contribution from industry (35%).

(3) Guguletu had a larger contribution from wood burning (20%).

In general, haze-related pollution levels were worst in Guguletu and Goodwood, closely followed by central Cape Town. Table View and Wynberg indicated significantly lower haze-related pollution levels.

Business-as-usual scenario for the brown haze in Cape Town

Over the next decade the following trends are expected in the Cape Metropolitan Area:

(a) A 1,5% per annum growth in population, mostly in the low-income bracket[3]. Due to the opposing forces of electrification and population growth, domestic fuel burning levels are expected to remain the same.

(b) A 5 % per annum growth in use of transport fuels[4], with a similar growth in vehicle emissions. Vehicle emissions are becoming increasingly concentrated in certain congested areas, such as the Waterfront.

(c) A 1% per annum growth in harbour activity[5] and a 10%-15% per annum growth in airport activity[6].

(d) A 2% per annum growth in combustion of coal and fuel oil by industry, with a similar growth in emissions.

(e) A 4% per annum growth in economic activity, with a corresponding growth in emissions of VOCs[7].

(f) A decline in emissions from the Caltex Refinery[8], Kynoch[9] and Athlone Power Station.

Taking into account the relative contribution of the above sources to the brown haze, the following trends in emissions are likely over the next decade:

(a) PM2.5 emissions will rise, with increasing diesel and petrol combustion and growing industrial activity. An increase of about 4% per annum is estimated.

(b) NO_x and VOC emissions will grow with increased petrol and diesel combustion, and the greater use of industrial solvents and paints. An increase of about 4% per annum is estimated.

(c) SO_2 emissions from the Caltex Refinery are not expected to increase. However, SO_2 emissions from fuel use by other industries and diesel use will result in rising SO_2 emissions. A 2% per annum growth in SO_2 emissions is expected.

Primary PM2.5 emissions are the most important cause of the brown haze, and in the business-as-usual scenario they are estimated to increase by 48% over the next decade. It is therefore likely that the intensity of the brown haze will increase by a similar amount.

Recommendations

If Cape Town is serious about improving air quality and reducing the intensity of the brown haze, then both immediate action and longer-term planning is required. Immediate attention should be focused primarily on diesel vehicles, the largest single contributor to the brown haze. The following recommendations have been made to the authorities:

- Enforce the diesel black smoke legislation.
- Introduce measures to reduce the number of smoking petrol vehicles.
- Enforce the industrial black smoke legislation.
- Initiate discussions with the oil industry about the potential benefits from fuel reformulation.
- Initiate the upgrading of air pollution control capacity in the Cape Metropolitan Council.
- Initiate the development of an air quality management system for Cape Town.
- Reassess existing national air pollution legislation, as much of it is outdated.

Responsibility for managing Cape Town's air quality lies primarily with the Health Department of the Cape Metropolitan Council. Presently this Department does not have the manpower, resources, or influence to adequately enforce current legislation, to adequately examine air quality data, or to ensure that air quality is optimally integrated within metropolitan planning. It is therefore recommended that:

- Manpower of the Air Pollution Division be increased.
- Adequately qualified and experienced manpower be taken on.
- The necessary budget for facilities to test and monitor emissions be allocated.
- The Air Pollution Division be given sufficient power to be able to enforce standards and have a say in metropolitan planning.

Immediate action should be complemented with the development of an integrated air quality management system for Cape Town. At the heart of the system will be an ongoing process of planning, implementing, and assessing emission reduction measures. Medium- and long-term air quality targets should be set and periodically revised. The system should include setting of relevant ambient air quality standards, development and updating of an accurate emissions inventory, improving the air quality monitoring system, as well as a public awareness component.

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*The 1997 Eskom eta Awards

Received 21 October 1997

Keywords: eta Awards; energy efficiency; South Africa

Introduction

The Greek letter η (eta) is used as the symbol for efficiency in the scientific world and as such underpins the objectives of the eta Awards. Like its predecessor, the Eskom Energy Effective Design Awards (EEEDA), the aim of the eta Awards (also sponsored by Eskom) is to promote the more efficient use of electricity, as well as improving business competitiveness - all in all, an effort to prove that "There always is a better way".

If South Africa is to avoid the extensive investment required for the construction of another power station, it needs to promote the more efficient use of energy and electricity. To this end the electricity industry annually rewards those companies and individuals who have made a contribution to the more efficient use of electricity by designing, manufacturing or installing products which bring about energy savings.

The awards are presented in five categories (related to the various Eskom services): Industrelek, Agrelek, ElektroServe, ElektroWise and Supplier Development, with a maximum of one winner and three runners-up being chosen per category. In addition to a prize (valued at R20 000), the winner in each category receives a trophy, while runners-up are awarded certificates.

Background

For ten years EEEDA paid tribute to excellence in energy design, recognising the achievements of South African industrial and engineering designers, and encouraging the promotion of the more effective use of electrical energy. In 1995 Eskom "branded" EEEDA, making awards in four different categories which reflect its services, and targetted the different market sectors i.e. Industrelek (Industrial Sector), ElektroServe (Commercial Services Sector), Agrelek (Agricultural Sector) and ElektroWise (Residential Sector). In 1996 the awards were extended to include a fifth category, Supplier Development, in an effort to reward the *developers* of energy effective designs, not only the *implementers* thereof.

Many changes have taken place in the electricity supply industry, and 1996, the tenth anniversary of these awards, also marked the last year that they were presented under the EEEDA banner. The rationale was that these awards should be seen, not as Eskom awards, but rather as industry awards. They were thus renamed and relaunched as the eta Awards.

The format of the awards scheme has remained the same as far as timing, entry criteria and judging are concerned. As with the EEEDA, the eta Awards are administered by the SABS Design Institute and enquiries should be directed to Joop Dullaar/Adrienne Viljoen**.

Summary of 1997 eta Award finalists

AGRELEK Category

Winner of the Agricultural Award

Hein Schoeman of Kandelaarsrivier Farm, Oudtshoorn, for the unique ostrich bone-drying and processing operation.

Runner-up

Ampie de Swardt of Boplaas Farm, Plettenberg Bay, for the multi-stage pump system, coupled to Eskom's NightSave tariff.

Runner-up

Paul and Michelle Lindsay of Mon Songe Estate, Umtentweni, for the modern egg-laying poultry operation at Lindsay Poultry.

SUPPLIER DEVELOPMENT Category

Winner of the Supplier Development Award

Compact Digital Meters (Pty) Ltd, Benoni, for the mains-borne energy dispenser.

Runner-up

Circuit Breaker Industries (Pty) Ltd in Germiston for the flat-rate electricity meter.

INDUSTRELEK Category

Winner of the Industrial Award

Otokon Systems (Pty) Ltd, Potchefstroom, for their energy monitoring and management system comprising the ecWIN SQL load data acquisition and display software and ecLOG datalogger.

Runner-up

Beka (Pty) Ltd, Olifantsfontein, for the Bekanova wall-mounted HID bulkhead luminaire.

ELEKTROSERVE Category

Winner of the Commercial Services Award

Spoormaker & Partners Inc., consulting engineers in Pretoria, for the cooling and heating systems developed for the Frans Indongo office and shopping complex in Windhoek, Namibia.

Runner-up

Nico Janse van Rensburg of CA du Toit, consulting engineers in Cape Town, for the air-conditioning installation at Foschini head office in Parow, Cape.

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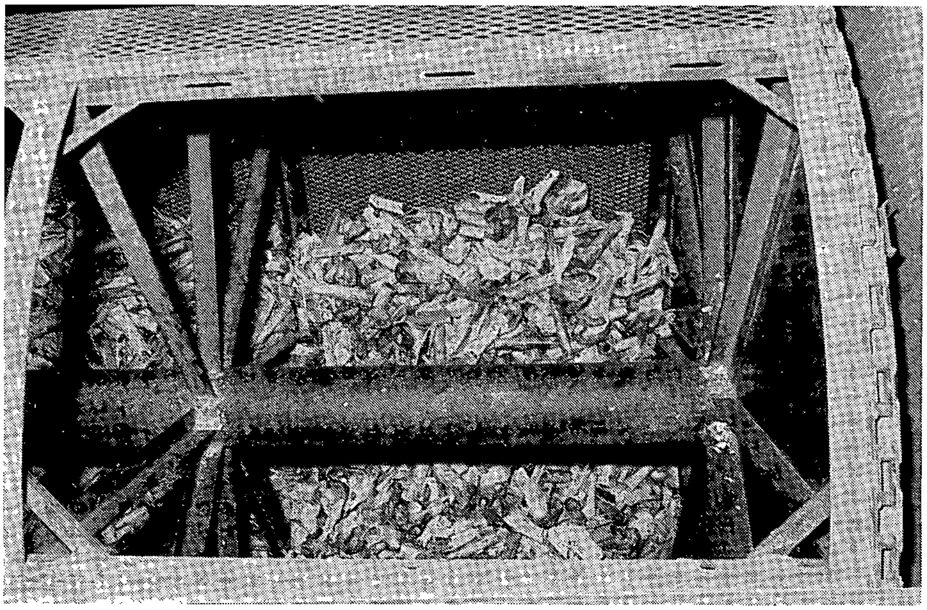

Figure 1: The electrical drying oven used on Kandelaarsrivier Farm for drying ostrich bones

Eskom 1997 eta Award Winners

AGRELEK Category: Agricultural award

Hein Schoeman, Kandelaarsrivier, Oudtshoorn

Hein Schoeman of Kandelaarsrivier Farm, near Oudtshoorn in the Klein Karoo, employed entrepreneurial skill and good business sense to create for himself a niche market locally and internationally.

A project that started out as a means to produce bonemeal as feed for his ostriches has grown into a full-blown operation that distributes poultry feed throughout the country, with the potential to tap the lucrative export market.

Ostrich bones contain many essential minerals which, if properly utilised, can be valuable in poultry feed. After struggling to find good quality bonemeal, Mr Schoeman decided to buy ostrich bones, which he dried and milled to make bonemeal for his own stock. This was a labour-intensive and lengthy process, which resulted in the bones having finally to be dried out in the sun for at least two days.

Mr Schoeman also started selling his product to neighbouring farmers. As production grew he identified the need to streamline the process to make it more profitable.

The biggest problem was drying the bones thoroughly in order to produce the best quality feed. Although the Karoo enjoys mostly dry, sunny weather, this drying process could be at times delayed by as much as a week in adverse weather.

His first attempt at solving this problem was to install a diesel-driven drying device. However, the dryer at times burnt the bones or covered them in a black residue, making them unsuitable for processing.

He then investigated several other alternatives, all of which were unsuccessful, before approaching Eskom's Agrelek advisory service. Eskom suggested that Mr Schoeman use an electrical drying oven. He installed a test unit, which he intended to run over a period of 4-5 months to determine its effectiveness. Within a few days, he realised that the electrical dryer had solved his problem.

Similar in construction and principle to a tumble-dryer, the dryer consists of a drum that spins on its own axis, fitted with electrical elements and a fan to circulate the warm air. The bones are dried over a period of four hours. In order to utilise Eskom's low-rate tariffs, this part of the operation is performed in off-peak periods.

Savings realised through the automation of the process has seen costs reduced from 20 cents/kilogram to 5 cents/ kilogram, while production has been boosted from 20 tons/month to 80 tons/month. Also, the improved quality of the product has enabled Mr Schoeman to register with the South African Stock Feed Association. The stringent regulations and standards set by this body require that bones be dried within a stipulated period, with which Mr Schoeman can now easily comply. He also believes that the bonemeal is of export quality.

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SUPPLIER DEVELOPMENT
Category: Supplier Development award

Compact Digital Meters (Pty) Ltd.
CDM 110 Energy Dispenser

The electricity metering industry has seen a surge of innovations and the development of new technologies to facilitate prepayment metering, one of which is the CDM 110 Energy Dispenser.

Compact Digital Meters (Pty) Ltd (CDM) recognised that while this industry is presently overtraded and highly competitive, their product has unique features and benefits to offer electricity supply authorities.

The most striking feature of the CDM 110 Energy Dispenser is its low installation cost - less than half that of its nearest competitor - and the ease and speed of installation. Tests carried out in the KwaZulu-Natal Midlands showed that the CDM 110 could be installed in 22 minutes, including the removal of an existing meter, all associated drilling, fitment, cleaning and switching.

These dramatic cost savings are possible largely due to the ease of installation that circumvents additional labour and material, such as Special Airdac cable (a special pilot wire), the need to dig a trench, lay the cable and backfill the trench.

CDM identified one inherent problem with existing meters: the need for pilot wires to supply power to the passive unit inside a consumer's dwelling once the 230 V mains power has been disconnected. The company therefore adopted the use of mains-borne communication, not an innovation in itself, but certainly in the application of this technology to prepayment metering. In conjunction with CDM's patented means of transferring power to the electricity dispenser while the contactor is in the open position, the company has established a means of communication that works entirely on the live and neutral cable - eliminating the need for a costly pilot wire cable.

The CDM 110 is produced in two models - for indoor and outdoor installation. The indoor unit is suitable for mounting in meter boxes, kiosks or minisubs, either as a new installation or as a direct replacement of an older meter. The outdoor meter is suitable for pole-mounting.

Unique built-in security features include split metering, which removes the switching and metering function away from the consumer's dwelling, thereby reducing the risk of tampering and bypassing. This threat is totally negated since it is impossible to obtain credit from the dispenser once credit has been exhausted, even if the enclosure is completely destroyed and the wiring "shorted" or reversed. Also, the enclosure itself is factory-sealed.

Additional features of the CDM 110 include:

- a consumption rate indicator;
- a low credit indicator;
- ex-factory calibration and Class 2 accuracy;
- a 16-character LED display;
- four language options;
- a robust IP54 enclosure;
- non-volatile memory;
- one metre of shielded three-core surface wiring cable.

A five-option menu allows for the following:

- opening the contactor;
- closing the contactor (if sufficient credit is available);
- displaying information such as total kWh used to date, instantaneous power load in kW, time remaining, and the unit's serial number;
- displaying all messages in English;
- a "second" language option - Afrikaans, Zulu or Xhosa.

The unit has been subjected to stringent testing by the South Africa Bureau of Standards (SABS), Gerotek and Circuit Breaker Industries. Results have shown the CDM 110 to be capable of withstanding the vigorous electrical tests required by SABS 1524-1 and SABS 1036. In most cases it surpasses these requirements by more than 100%. In addition to these tests, the CDM 110 is already STS-approved.

The reduced costs associated with the meter, together with the accelerated rate at which new connections can be made, make the CDM 110 particularly attractive to supply authorities.

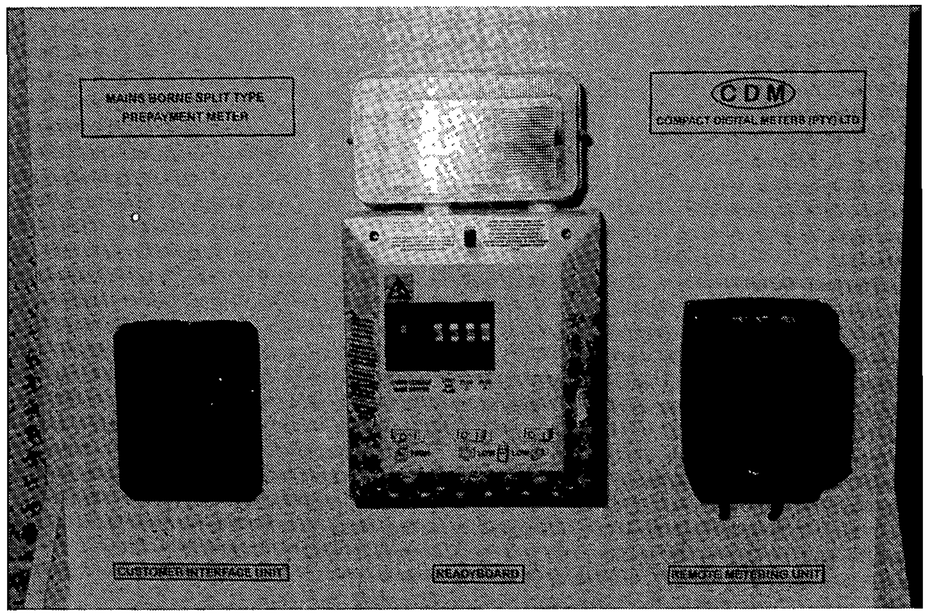

Figure 2: The CDM 110 Energy Dispenser

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INDUSTRELEK Category: Industrial Award

Otokon Systems - ecWIN SQL Load Data Acquisition and Display Software and ecLOG Datalogger

The success Otokon Systems has achieved in establishing a culture of energy efficiency through a dedicated energy monitoring and management system epitomises the aim of the Eskom eta Awards.

Following the installation of Otokon System's software and datalogging systems at the Sasol Chemical Industries plant in 1994, the chemicals manufacturer was able to optimise energy costs by R6,48 million for the 1995/1996 financial year - the equivalent of a reduction of 6,78 MW in the total load. These dramatic savings meant that the payback period for the system was achieved in 4-5 months.

Otokon Systems has developed the ecWIN SQL Load Data Acquisition and Display Software and ecLOG Datalogger, a family of software and hardware modules for utility and demand-side management. The software package was developed for the energy end-user to manage the entire electricity bill, with energy reallocation models for internal electricity energy accounting.

The software package consists of a graphical man-machine interface that provides daily, weekly and monthly load patterns, and load data analysis and viewing tools. The software system features six tools, namely: a configuration editor; data collector module; information processor; display viewer; utility manager; and a cost/tariff module.

This product was developed over a six-year period, with its key feature being the ability to customise the software to meet the needs of the customer's load data analysis and cost allocation. All software is designed for client/server use on a LAN or WAN.

The ecLOG Datalogger is an intelligent RTU for energy and process historical trend logging. Its multi-port and modular communications configuration supports Modbus, RS-232 and Ethernet. The unit can be programmed with PC5 Soft Function Modules to perform a specific control task in real-time.

Sasol Chemical Industries' core business is chemical manufacturing, with a present load of approximately 120 MW, which is distributed to 60 internal end-use consumers.

When specific, internal questions relating to the plant's energy wastage were asked in 1994, it was not believed possible that R1 million per annum could be saved through the implementation of a dedicated energy management system.

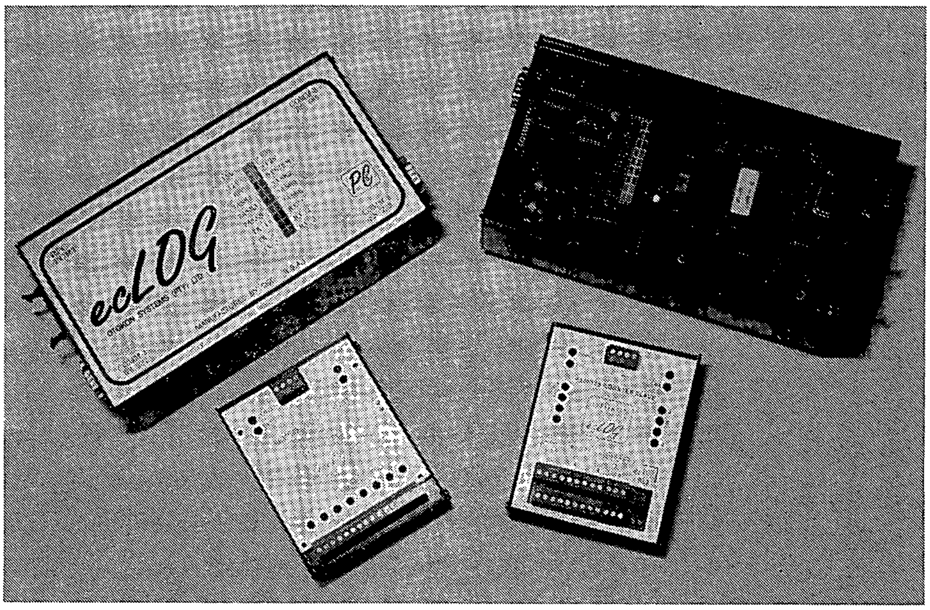

Figure 3: Otokon Systems has developed the ecWIN SQL Load Data Acquisitionand Display Software and the ecLOG Datalogger, a family of software and hardware modules for utility and demand-side management

Sasol's objectives were to reduce the cost and consumption of its electrical energy, and the proposed solution included the installation of a real-time energy monitoring and management system.

When the Otokon Systems' products were introduced, certain cost-control measures were initially implemented to monitor the energy usage of each end-use consumer, which included billing each consumer separately. These consumers were then provided with load data information, hourly load patterns and usage per day, week and month, with the message to optimise energy consumption.

Following the installation of the Otokon Systems products, Sasol was able to immediately make their customers aware of their present consumption - which was higher than expected - and to institute an energy awareness and training process.

Through the application of the ecWIN SQL Load Data Acquisition and Display Software and the ecLOG Datalogger, Sasol Chemical Industries was now able to manage its energy consumption properly. Through the combination of the awareness and education programme, and the data provided on the energy efficiency performance of each business process, the company was able to achieve a dramatic improvement in energy performance.

The ease-of-use and access to information by all end-users contributed greatly to the acceptance and implementation of the management system to curb costs and consumption. If the same controls and measures are applied to other manufacturers, this would enhance South Africa's standing in world competition.

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ELEKTROSERVE Category: Commercial Services Award

Spoormaker & Partners Inc. - Frans Indongo Gardens, Windhoek, Namibia

Spoormaker & Partners Inc. have successfully "exported" their engineering expertise to Windhoek, Namibia, as consultants in the design of the cooling and heating systems of the Frans Indongo Gardens office and shopping complex.

They have managed to effect savings of R202 000 per annum on energy consumption. Considering the extra costs over capital expenditure of R340 400 for double glazing and air-conditioning, it is anticipated that these costs will be offset within a period of 19 months.

The original intention for the 7 110 m^2 building was to install a conventional commercial air-conditioning system, although this would have meant the installation of up to 300 console units.

Spoormaker & Partners looked at the provision of a state-of-the-art building that would take climatic conditions into consideration. Additional considerations were the skills and technology available in Namibia, as it was a requirement that the project provide employment opportunities for the local workforce.

A stated objective was also to produce a cost-effective design that would minimise initial and operating costs, while reducing energy consumption and conserving natural resources.

A key factor that needed to be addressed was the thermal design of the building. Working closely with the architect, the thermal design of the building was optimised to minimise cooling and heating loads. This was successfully achieved through providing full external shading on the north and south elevations, eliminating glass on the east facade and minimising glass on the west. Double glazing was then installed for the "cold" south-facing offices, while high performance double glazing was installed on the west elevation. To minimise daytime lighting, clear glazing was used on the north and south facades.

In addition, all exposed roofs were insulated to achieve a U-value better than 0,5 W/m^2 degrees Celsius.

These additions and installations allowed for major reductions in energy consumption. As a comparison, the same size building situated in South Africa's milder climatic conditions would have consumed 1 113 MJ/m^2 per annum and drawn 91 VA/m^2. On the other hand, the Frans Indongo Gardens complex consumes only 539 MJ/m^2 (53% lower than the South African building) and draws 39 VA/m^2 per annum - 58% less than the South African equivalent.

An innovation that contributed to these reductions was the extraction of 50% of the lighting heat load during summer through ducts that discharge this heat at roof level. During winter, 80% of the lighting load is recovered by the comfort system to minimise heating requirements.

Making use of the dry climatic conditions in Windhoek, the air-conditioning system was designed in such a way that it provides cooling through the evaporation of water. By relaxing the maximum internal comfort design temperature of 27 degrees Celsius, it was possible to eliminate mechanical cooling completely for the office block and the anchor shop tenant, PEP Stores.

Taking the expertise of the local manufacturers into consideration, a two-stage evaporative cooling, variable volume system was designed. This means that during summer, full outside air, cooled by the evaporation of water, is used, while the stale air is extracted through the light fittings and relieved at roof level through a purpose-designed shaft.

Although the cooling system is based on the use of water, every effort has been made to conserve water. Some waste water from the cooling system is used as grey water in the toilet system, while the balance is used to water plants on the balconies - the latter being a unique aesthetic feature in the dry Windhoek climate.

Spoormaker & Partners Inc. has clearly shown that by integrating the design of the building and all services, it is possible to conserve energy and reduce operating costs.

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Figure 4: The Frans Indongo Gardens Development, Windhoek, Namibia

SHORT COMMUNICATION

Power Institute for East and Southern Africa (PIESA)

*J MADZONGWE

Received 1 September 1997

Keywords: PIESA; Southern Africa; East Africa; electric utilities; regional cooperation

Introduction

After two years of brainstorming in meetings and workshops, the power utilities in East and Southern Africa launched the Power Institute for East and Southern Africa (PIESA) on 18 August 1997 as a first step to integrate research activities related to the electricity industry in the region. The utilities have agreed to an interim period of six months in which to formally establish the PIESA. The six founding member utilities are:

- Electricity Supply Commission of Malawi (ESCOM)
- Eskom of South Africa (also representing the Association of Municipal Electricity Undertakings (AMEU)) for the interim period only
- Swaziland Electricity Board (SEB)
- Societe Nationale d' Electricite (SNEL) of the Democratic Republic of the Congo (formerly Zaire)
- Uganda Electricity Board (UEB)
- Zimbabwe Electricity Supply Authority (ZESA).

The objectives of the PIESA are to form a utility association that will enable the regional power utilities to coordinate and share technology and experience in the common areas of:

- technology and engineering support
- applied research
- standardisation
- incident investigation and technical auditing
- quality of supply
- technological skills and resource development.

* SAD-ELEC, P O Box 1049, Rivonia 2128, South Africa

The need and benefits of pooling resources

The electricity supply industry (ESI) in most countries in the East and Southern African region has undergone numerous structural changes. In order to meet the rapidly increasing challenges faced by the power generation, transmission, distribution and end-use industries, there is a drive to reduce costs. The cross-cutting strategic needs of the industry, coupled with financial and skills constraints, are additional factors to ensure the rationalisation of research and resource development activities.

The challenges and resource constraints faced by the ESI, and the reality of reduced access by the region to concessionary donor funding, places urgency on the adoption of measures that will ensure adequate self-sufficiency for the region to support the power industry.

The potential key benefits of cooperation in the above-stated areas to the East and Southern African electricity supply and end-use industries will be:

- cost reduction and optimisation of resources
- enhanced overall industry performance
- joint research planning, increased research capacity, and technology transfer
- independent technical opinions
- standardised purchasing specifications
- industry-wide representation and increased negotiating strength
- strategic technical skills development and retention
- long-term focus on technological development of the power industry
- increased regional and national liaison.

The consultative process and outputs

The South African electricity supply and end-use industries began a process in 1996 towards the creation of a pooled resource, formulated as the South African Power Technology Institute (SAPTI) which was conceptualised along lines similar to that of the Electric Power Research Institute (EPRI)** in the United States. Recognising that such a collaborative initiative could be extended to the East and Southern African region, SAD-ELEC was asked by the SAPTI initiators to solicit the views of the top and senior management of the power utilities in the region.

Most utilities in the region were consulted to assess their requirements in the context of initiatives for privatisation and increased competition related to the structural changes in the ESI. A positive response from utility management resulted in a further process of consultation in the form of a workshop which was held on 21-22 November 1996 at the ZESA Performance Improvement Centre in Harare, Zimbabwe. Representatives from nine power utilities participated in the workshop, which was supported by the South African Power Utilities' Advisory Board (SAPURAB) and facilitated by SAD-ELEC. The aim of the workshop was to discuss and agree on the scope, structure, governance, financing mechanisms, modus operandi and implementation responsibilities of the PIESA. The workshop resulted in a unanimous decision to establish the PIESA and to retain membership exclusively for electric power utilities.

** Based in Palo Alto, California, U.S.A. EPRI's mission is to "discover, develop and deliver high value technological advances through networking and partnership with the electricity industry. Funded through annual membership dues from some 700 utilities, EPRI's work covers a wide range of technologies related to the generation, delivery and use of electricity, with special attention paid to cost-effectiveness and environmental concerns".

Other major elements recognised and recommended by the workshop included:

- the functions of a PIESA Board made up of senior electric utility representatives,
- the appointment and functions of a Secretariat to serve the PIESA,
- the establishment of inter-utility Working Groups to address technical priority areas,
- drafting of terms of reference (TOR) for the Working Groups' activities,
- financial contributions based on a cost-sharing formula related to sales of electricity,
- financial support for the Working Groups,
- the legal framework.

Following the workshop, an Inter-Utility Task Group which was comprised of four electric utilities, namely, the Botswana Power Corporation (BPC), Eskom, UEB and ZESA, was formed and mandated to discuss and recommend the options for the formalisation of the PIESA. The Task Group recommended the following:

- the PIESA be formed as a legal entity,
- investigations for registration be conducted in South Africa and Zimbabwe,
- a six month "interim period" be established to investigate the requirements to formalise the PIESA,
- SAD-ELEC be contracted to provide secretariat services for the "interim period".

The "interim period"

The Task Group concluded that the PIESA should be launched after a minimum of five power utilities had given formal indication of their agreement that such an Institute be formed and to the cost-sharing principle. A six-month "interim period" would commence under the guidance of an Interim Board.

During this period, the Board would provide strategy and direction. At the end of this period it was expected that there would be:

(1) a legally registered utility association,
(2) final terms of reference (TOR) and progress made on the activities of five technical Working Groups,
(3) TOR and proposals prepared for a permanent secretariat function.

It is expected that other utilities in the region will formally participate in the PIESA by the time it is legally established and registered.

Operationalising the PIESA: Priority activities

Five areas were identified by the workshop participants as priority focus areas for common research and development, namely:

- standardisation;
- incident investigations;
- reduction of non-technical losses;
- low-cost electrification;
- power system analysis.

Individual utilities took up the responsibility to formulate draft TOR for each of the above activities. These were then circulated and reviewed by all interested utilities.

PIESA structures

At the workshop in Harare, the utility participants chose that the PIESA be fully independent organisation with its own Board (integrating the interested regional utilities), with a functional relationship with the SAPTI but with no formal legal integration or relationship.

It was also recommended that the Institute should establish functional and cooperative links with the SAPTI, which could be formalised, for example, through an 'associate' status.

The costs of participation: The cost-sharing principle

At the Harare workshop it was decided that some form of cost-sharing should form the basis of the running costs of the PIESA. The participants agreed that a formula for members' contributions based on bulk sales of electricity would be the most appropriate and equitable way of calculating these contributions. SAD-ELEC was requested to prepare a proposal for a schedule of suggested contributions from the power utilities for their comment.

It was further agreed at the time that costs related to utility participation in the Working Groups would be met by the utilities involved and that external financial support may also be solicited. However, outputs would be available to non-participating utilities at a cost. Encouraging each utility with a vested interest in the activities of the PIESA would thereby ensure its sustainability.

The way forward

The PIESA's founding members are determined to move forward into operational mode through the Working Groups, so that the advantages of sharing technology in these important technical areas will be made visible and soon translate into tangible benefits for their utilities and the region's economies. It is hoped that this will encourage non-participating utilities in the region to join the PIESA. The top management of member utilities have appointed senior staff to represent their utilities on the PIESA Board, thereby indicating their support for the establishment of the Institute. The PIESA initiative should not be seen as a replication of, or competition with, other groupings in the regional power sector, nor will it divert financial and technical resources from developments elsewhere in the power sector. Instead, it is intended to compliment the efforts of others and to work in consultation with them. For instance, the PIESA would be available as a technology support agency for the Southern African Power Pool (SAPP) if required. The challenge for the PIESA is to demonstrate tangible results in meeting the needs of member utilities in the areas of technology and engineering support, research, standardisation and quality of power supply to enhance the development of the regional power sector.

SANEA Leadership and Innovation Awards, 27 November 1997

Introduction

On the 27 November 1997 it was the first time that the South African National Energy Association (SANEA) presented their Leadership and Innovation Awards to three outstanding individuals who have made their mark on the South African energy industry.

The main objectives of the awards are:

- to recognise and honour persons who have made a very significant contribution to the South African energy scene, by means of major contributions to the energy industry in general; and exceptional services or outstanding individual contributions to SANEA.
- to influence SANEA's position and relevance in the South African energy environment, to enhance its image in accordance with the objectives it strives to achieve, forming part of its marketing campaign and promotion, including
  - attracting new members;
  - encouraging young players to make their contribution to the energy industry.

The main criteria for consideration of the award are that the individual must have demonstrated any one or more exceptional abilities related to the energy industry in:

- leadership
- innovation
- exceptional service
- initiative
- gaining international recognition
- being a role model.

The recipients of the 1997 awards are:

Professor R K Dutkiewicz
Dr I C McRae
Dr R L Straszacker

PROFESSOR RYSZARD KAROL DUTKIEWICZ

Professor Dick Dutkiewicz, as he is known to colleagues and friends, obtained his B.Sc.(Eng.) and M.Sc.(Eng.) degrees in 1956 and 1958 respectively from the University of the Witwatersrand. He obtained his Ph.D. degree from Cambridge University in the UK in 1964 for work on heat transfer in nuclear engineering.

He started his engineering career at Eskom on the construction of the Taaibos Power Station. He then joined the General Electric Company in the UK as a nuclear engineer and worked on the design of the Hunterston Nuclear Power Station in Scotland and the Tokai Mura Nuclear Power Station in Japan. On his return to Eskom he was put in charge of the then newly formed Research Laboratory. Promotion saw him in the position of deputy chief mechanical engineer (construction) and subsequently manager of system planning.

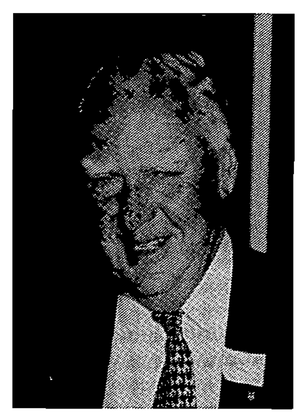
In 1975 he joined the University of Cape Town as Professor of Mechanical Engineering during which time he started the Energy Research Institute, now a separate entity within the Faculty of Engineering. His current position at UCT is Professor of Applied Energy and director of the Energy Research Institute. He is also managing director of Engineering Research (Pty) Ltd (a company formed to provide an infrastructure for industrial development).

Professor Dutkiewicz is well known and highly respected in the national and international energy arena. He has published widely over the years and has served on numerous committees, both locally and internationally – Chairman of the International Alcohol Fuels Committee and Project Leader for the Rural Energy Project of the World Energy Council, to name but few. He is also a past-president of the South African Institution of Mechanical Engineers.

Professor Dutkiewicz has been a valuable contributor to the World Energy Council (WEC) and SANEA. He has attended WEC Executive Assemblies, Congresses, Regional Forums in all parts of the world. He has also travelled extensively in Africa – obtaining a depth of understanding and insight into the energy issues requiring research and attention.

In 1994 he chaired the organising committee of the WEC Executive Assembly and Regional Energy Forum for Southern and East African Countries which were held in Cape Town, South Africa. His dedication to the success of these events was an inspiration to those who worked with him, and the results were evident in the positive, overwhelming response received from those who attended.

Professor Dutkiewicz and his wife, Debbie, have four children.



DR IAN CAMPBELL McRAE

Dr Ian McRae has had an illustrious career in both Eskom and the South African section of the World Energy Council. He is the first to have been given Honorary Vice-Presidency of SANEA in recognition of his major contribution over the years.

Ian McRae first obtained an NTC(V) (ATCII) and subsequently a B.Sc (Mech. Eng.) at the University of the Witwatersrand in 1953.

He joined Eskom in 1947 as an apprentice fitter, rising to the position of Chief

Executive and Chairman of the Management Board in 1985. He was appointed Chairman of SANEA at the same time.

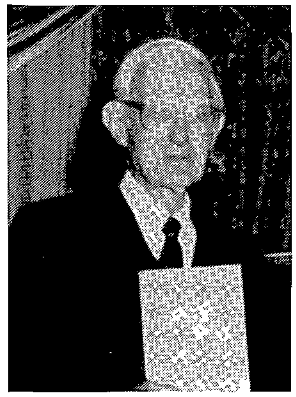
He received many awards during his service to Eskom, amongst these the Engineering Newsmaker of the Year Award in 1988, an Honorary Doctorate in Engineering from the University of the Witwatersrand in 1989, the Business Statesman of the Year Award from the Harvard Business School Club of South Africa in 1991 and in 1993, the coveted Order for Meritorious Service – Gold (OMSG), from the State President.

The recognition and accolades were granted for the major role that he has played in the development of improved living standards and upliftment of the people of South and Southern Africa. Whilst at Eskom, he made important breakthroughs in various parts of the continent, and created opportunities for the exchange of information, knowledge and fundamental understanding of the needs in other countries and cultures. He took advantage of the "open doors" provided by the World Energy Council to influence positively and to integrate with the WEC, the many Eskom initiatives during a time when South Africa was largely unaccepted in parts of the world.

When Ian McRae retired from Eskom in 1994, he became Chairman of the National Electricity Regulator (NER), Chairman of the Southern African Development through Electricity (SADELEC), Chairman of Rotek Industries and Honorary Vice-President of the SANEA. Ian McRae is also Vice-Chairman of the WEC's Administrative Committee.

He retired from the NER in October 1997.

Ian McRae and his wife, Jess, have two children.



DR REINHART LUDWIG STRASZACKER

In 1929 Reinhart Ludwig Straszacker graduated with a B.Sc. (Eng.) *cum laude* from the University of the Witwatersrand, and was also awarded the Vice Chancellor's Medal. In 1930 he received the Union's postgraduate scholarship for study overseas and after obtaining his M.Sc (Eng) in 1931, he continued his studies in Germany where he obtained a Dipl. Eng *cum laude* and a D.Eng *summa cum laude*.

Between 1935 and 1941 he lectured in Mechanical Engineering at the University of the Witwatersrand, whereafter he accepted a senior lectureship at Stellenbosch University. He played an important role in the establishment of the Engineering Faculty at Stellenbosch and pioneered an engineering terminology in Afrikaans. In 1944 he was appointed as Professor within the Engineering Faculty. The twenty-one years spent at Stellenbosch was a most important period in his life – his intellect and personality allowing him to venture into broader fields of exploration – as evidenced by his appointment to the boards of several companies.

His most significant contribution was made as a member of various government and public bodies, such as Eskom (then known as Escom), the S A Bureau of Standards, the CSIR, the Atomic Energy Board, and others. Dr Straszacker took over the Chairmanship of Escom when the electricity industry in South Africa was entering a new phase of its development – requiring decisions which were to have a far-reaching effect on the entire pattern of electricity supply in Southern Africa. Some of these major initiatives were:

- opening the annual congress of the AMEU in Margate – which resulted in close cooperation between the municipalities and Escom;
- the decision to establish a national power grid using 400kV lines (a decision accelerated by the Orange River Project);
- in 1966, under his guidance, negotiations were entered into with the Portuguese regarding the importation of electricity from the Cahora Bassa hydro project in Mozambique (resulting in an agreement three years later between South Africa and Portugal);
- the announcement of the Camden Power Station (followed by Hendrina, Arnot and Kriel);
- the decision to establish a nuclear division to prepare for the erection of South Africa's first nuclear power station;
- the establishment of the Central Generating Undertaking (CGU) in 1972;
- the construction of the largest dry-cooling tower in the western world at Grootvlei;
- the establishment of a capital development fund in 1972, thus reducing Escom's dependence on local and foreign capital;
- the decision to construct a head office north of Johannesburg – Megawatt Park.

Dr Straszacker revived South Africa's interest in the World Energy Council (WEC) in the 1960s and actively participated in WEC activities – leading a delegation to Abidjan at a time when most South Africans were nervous to venture beyond the border.

He has positively influenced many engineers, several of whom hold high positions in Eskom and in other energy-related organisations. He is regarded fondly and with great respect by those in the energy field. His passion for golf particularly raises interest – if not *envy* at his handicap! A razor-sharp, critical mind, resolute determination, unostentatious self-assurance are some of the qualities which earn "Strassie", as he is affectionately known, the recognition he deserves.

SANEA Youth in Energy Certificate of Recognition

At the same ceremony, SANEA also awarded the Youth in Energy Certificate of Recognition. This will become an annual award, and, it is hoped, will be the beginning of an awareness of energy in all its forms among young people in South Africa.The first recipient of this certificate was Yogi Pillay.

YOGESVERI PILLAY

In 1990 Yogesveri (known as Yogi) Pillay obtained a B.Soc.Sc. from the University of Natal and in 1991, received B.Soc.Sc. Honours *cum laude* in Geographic and Environmental Sciences. In 1992, she was awarded a CSD Post-Graduate Scholarship and a Graduate Assistanceship. In 1993, she obtained a Masters in Geographic and Environmental Sciences. In the same year she was also awarded a Graduate Assistanceship and the received the Best Presentation by a Young Scientist Award at the SASAS conference. She received merit awards for outstanding achievement in Geography for three consecutive years. She is currently involved in research for her doctoral thesis on *Ultraviolet Radiation Forecast & Reporting Procedure for South Africa.*

Yogi entered and won a competition run by SANCWEC for young professionals, which saw her and two other South Africans represent the country at the 1995 WEC Youth Energy Symposium held in Tokyo. The three returned to South Africa with the commitment to hold an African Youth Energy Symposium (AYES). As only Egypt and South Africa were represented in Tokyo, it was felt that an African perspective was lacking. The SANEA committee agreed to support this idea and a successful AYES was held in Johannesburg in late September/early October 1997. Yogi was appointed Chairperson of the AYES.

Yogi has always shown leadership qualities – having been a school prefect in high school for five years. These qualities were very much in evidence during the organisation of the AYES and during the week of the symposium.

She went to great lengths to achieve quality and variety in the technical programme, to the benefit of all concerned. She personally approached several members of the South African energy industry for sponsorship, and wrote to close to a hundred international organisations for assistance – ensuring that Eskom would not bear the brunt of the debt.

The AYES was an exceptional experience – bringing young African energy professionals to South Africa for the first time – thus starting a "networking" in Africa at a new and exciting level.

Energy news in Africa

Electricity

Chad

The government has officially launched a privatisation project that will go along with the oil and electricity project based on the Sedigi project. The sell-off will involve the existing installations of the Societe Tchadienne d'Electricite et d'Eau (STEE), management of the company and construction of a new 16 MW power station supplied by Sedigi.

One of the targets of the privatisation project, which involves the extension of a small network based on the capital, will be to generate electricity at a cheaper rate. Funds for the project have been put up by the World Bank and other donors.

(Source: Africa Energy & Mining, 1 October 1997)

Ethiopia

Drought has severely hit Ethiopia's electricity supply, reducing the reserves of the country's three hydroelectric dams to extremely low levels. The government has therefore announced random power shedding, calling on consumers in the industrial and commercial sectors (who normally account for 80% of demand) to accept the need for their decision. The production capacity linked to the Electric Light & Power Network is expected to increase in the end when ongoing projects are completed. The most recent scheme involves investment in production and in the modernisation of Addis Abba's grid, funded largely by the World Bank.

The new hydroelectric power station which is to be built at Abbay on the Nile, known as Tiss Abbay II will be carried out by Chinese and Yugoslav firms.

(Source: Africa Energy & Mining, 15 October 1997)

Morocco

ABB and CMS Energy have put a financial package together for the second section of the coal-fuelled Jorf Lasfar power station. The capacity of its two units will add up to 700 MW. The European and American subsidiaries of ABB will provide the production units, including the turbines, coal furnaces, control and command system, and related equipment for a a total of $620 million. The project aims to install the first of the two units by June 2000, and the second by the end of the same year.

(Source: Africa Energy & Mining, 17 September 1997)

Hydroelectricity

A consortium of Danish and Norwegian agencies and companies, including Norconsult and Denconsult, will carry out part of a hydrographic and hydrological study on the Zambezi river basin. The project, which aims to assess the basin's hydroelectric potential, is being conducted under the auspices of SADC.

(Source: Africa Energy & Mining, 17 September 1997)

Oil and gas

Angola's oil, diamond and other natural resources have ensured the country's development in the future, provided it remains politically stable. The country has allies in the form of the Democratic Republic of the Congo and Congo-Brazzaville.

Angola's deep offshore resources from the Dalia oil field are expected to boost the country's production to nearly 1,2 billion barrels per day (bpd) in 2002, according to new projections from Wood Mackenzie. However, there are other potential finds from, for example, Elf's Rosa and Dalia-2 wells which, including production from Girasol and Dalia-2, could total 3-4 billion bpd.

(Source: Africa Energy & Mining, 15 October 1997)

Sasol is considering a new extension to the Natref refinery, the aim of which will be to increase the facility's capacity by a third.

The refinery's capacity has already been increased in several stages - to 95 000 bpd in 1996-97, representing an 11% increase from the previous financial year. The new capacity will enable the refinery to process 130 000 bpd.

With regard to natural gas, 1996-97 saw Sasol Gas and Petronet put a R85 million gas pipeline into service to supply industrial customers north of Durban. The pipeline is expected to be extended to the south of Durban.

Money was also invested in the Secunda site to boost gas production by about 5%.

(Source: Africa Energy & Mining, 17 September 1997)

Algeria has wasted no time in asserting its determination to maintain and even accentuate its main options concerning gas. Algeria is planning to boost gas exports from 60 billion m³ to between 90-100 billion m³/year.

The second phase of the North Africa-Europe gas pipeline, which may be carried out soon, could boost the pipeline's capacity to 15 billion m³/year, only if the market can justify the extension.

(Source: Africa Energy & Mining, 17 September 1997)

The Observatoire Meditarraneen de l'Energie (OME) has projected that Morocco has a natural gas potential of 3,8 Mtoe in 2010 (covering 24% of primary commercial energy demand and 49% of electricity generation). The Tahaddart private power station near Tangiers and the GME, a combined cycle 2 x 350 to 2 x 470 MW facility will be coming on line in 2003 (first section). It will use 1,1 billion m³/year of gas, although industrial users close to the GME could boost this to between 1,6-1,8 billion m³.

(Source: Africa Energy & Mining, 1 October 1997)

A study of the costs of developing and producing methane gas under Lake Kivu in the Democratic Republic of the Congo (DRC) is to be undertaken to reassess the feasibility of such an operation. An assessment of resources was originally undertaken in 1972 but needs to be updated. At the time, methane reserves were estimated at 60 billion m³, of which 50 billion m³ were regarded as recoverable. Regeneration of the reserves was estimated at 250 million m³/year. A Memorandum of Understanding between the DRC and Rwanda was signed early in September.

(Source: Africa Energy & Mining, 1 October 1997)

Sudan's oil exporting prospects are looking very promising at present. Bids for the construction of a pipeline for the export of oil, and financing arrangements for field developments and the pipeline, are being undertaken. Sudan's proven oil reserves are estimated to total 262 million barrels.

The Canadian firm Arakis is targetting the completion of the 1 500 km pipeline linking the fields to the Red Sea coast by 2000. Planned capacity of the pipeline has been set at 250 000 barrels/day. If this capacity is utilised, it will sharply improve the economics of the project.

(Source: African Review of Business and Technology, September 1997)

General

South Africa's Department of Minerals and Energy (DME) recently adopted a new logo as shown above. The logo's symbolism is explained as follows:

The cogwheel (above) symbolises commitment to occupational health and safety in the mining industry.

- The crystal (centre) symbolises commitment to mineral development, leading to wealth and thus economic stability.
- The flash (right) symbolises the ensuring of affordable, appropriate and sustainable energy to all citizens of this country.
- The outer circle symbolises the Department's continuous striving to achieve its objectives in these three areas.

The logo appears in the colours of the South African national flag, reflecting the alignment of the Department's mission and vision to that of the Government of National Unity.

(Source: Department of Minerals and Energy)

SANEA/DME/JETRO Energy Efficiency Seminar, 11 March 1998, Pretoria, South Africa

The Japan External Trade Organisation (JETRO) is a non-profit, governmental organisation promoting, *inter alia;* industrial cooperation between Japan and other countries, trade and industry in developing nations, and transfer of energy-related technology.

Recently JETRO approached South Africa's Department of Minerals and Energy (DME) with an offer to bring Japanese experts to Africa to participate in an Energy Efficiency Seminar. This event will contribute towards fulfilling a need which has been identified in South Africa for more information on energy efficiency projects in Africa, investment opportunities, and information on energy efficiency-related activities in general. It will also be an ideal opportunity for information-sharing and enhancing communication channels with Japan on energy efficiency.

Energy efficiency specialists from South Africa, Japan, as well as other countries, will debate the technical details of energy efficiency issues. In particular, the important matter of the establishment of an Energy Efficiency Infrastructure for South Africa will be discussed. Other related topics to be included are, *inter alia*, energy efficiency information systems, and the synergy between renewable energies and energy efficiency.

An invitation to participate in this very important event is extended to all parties with an interest in energy efficiency.

For more information contact:
Wendy Izgorsek, South African National Energy Association (SANEA)/World Energy Council, P O Box 785673, SANDTON 2146, South Africa

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Dean Cooper graduated in 1988 with a B.Sc. (Hons.) in Mathematics and Physics from the University of York in the UK. His association with AEA Technology began in 1989 when as Staff Development Officer in the Personnel Policy Branch, he was responsible for special projects in training.

From 1991-1992, as Project Manager in the Energy Efficiency Technical Department of ETSU (Energy Technology Support Unit), he was mainly concerned with technology transfer under the UK government's Best Practice programme in the fields of management techniques and advanced computer methods. Since 1992, he has undertaken many overseas assignments. These include Head of Section, International Cooperation, and later Deputy Manager OPET-CS, DGXVII, European Commission in Brussels. As such, he was responsible for the coordination and support of all THERMIE activities in countries outside the European Union (EU).

In his present capacity, Dean is responsible for coordinating the Southern African elements of three EU actions aimed at strengthening energy cooperation between the EU and the region. This included establishing an EU contact point for the energy sector in South Africa, maintaining regular communication with all Southern African stakeholders and general project management of local partners.

Dean has also authored many papers, strategies, brochures, conference presentations relating to energy cooperation with developing countries and energy training.

DE VILLIERS M G

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Following his undergraduate studies, Mark de Villiers worked initially as a water treatment engineer. He joined the Energy Research Institute in April 1992 after completing a Master's programme at the Institute. His half-thesis was on energy management in industry, and included a case study on the brewing industry.

He is currently working on energy and environmental research projects. Major projects include a study of the brown haze in Cape Town, development of an industrial energy efficiency collaboration with countries in the region, energy audits in industry, and sustainable energy in South Africa.

DUTKIEWICZ R K

B.Sc. (Eng.)(Wits), M.Sc. (Eng.)(Wits), Ph.D.(Cambridge), Pr.Eng., FIMechE, Hon.F(SA)IMechE, MIEE (U.K.), FInstE, C.Eng.
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Professor Dutkiewicz was born in Poland and obtained his schooling in the United Kingdom and South Africa. He obtained his B.Sc. and M.Sc. degrees from the University of the Witwatersrand in South Africa, and his Ph.D. degree, which was on heat transfer in nuclear engineering, from Cambridge University in the UK. He joined the General Electric Company in the UK as a nuclear engineer and worked on the design of the Hunterston Nuclear Power Station in Scotland and the Tokai Mura Nuclear Power Station in Japan.

He returned to South Africa to work for what was then the Electricity Supply Commission (now Eskom), and was appointed head of the newly formed Research Laboratory.

Promotion saw him in the position of deputy chief mechanical engineer (construction), and later as manager of system planning.

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

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

GRAHAM J A N

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After completing his studies at Eton College, Berkshire, in the UK in 1991, and with an interest in environmental and humanitarian matters, Jimmy Graham undertook work in Africa, mainly as a volunteer. In Uganda, he was camp leader for the Society for Environmental Exploration Expeditions which involved biodiversity studies in Uganda's game reserves. This incorporated project organisation from Kampala, flora and fauna data collection, running a self-sufficient scientific bush camp, responsible for the health, safety, supplies, day-to-day duties and morale of 12 scientists. As a volunteer, he undertook a personal study of crocodiles and navigation of River Wasa.

In Ethiopia, Jimmy performed an environmental and agricultural assessment of Dimma Refugee Camp for UNHCR, and made recommendations to the Ethiopian Government. In Rwanda he was involved with the administration of international aid to Rwanda. He assisted ODA at Kigali airport, marshalling the stockyard for 200 NGOs, and organised water and pharmaceutical supplies at an AMERICARES field hospital.

In 1996/97, Jimmy studied at the Energy Research Institute, University of Cape Town. As part of his Master's project, he designed an experimental test rig and ran a research programme measuring efficiencies and emissions of various domestic fuel/appliance combinations commonly used in developing countries. The project was sponsored by BP Southern Africa (Pty) Ltd. His research was nominated to represent Southern Africa in the Annual BP Chairman's Awards.

Jimmy has a wide range of interests and hobbies, from farming and gamekeeping in Scotland, hill walking and hiking in various parts of the world, to his interest in Third World development. He is also interested in Scottish history and Gaelic culture.

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Jean Madzongwe is a Zimbabwean who has been working in the Southern African energy sector for more than 13 years. She is presently a Project Manager with SAD-ELEC.

WICKING-BAIRD M C

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Mark Wicking-Baird was working on the Cape Town Brown Haze project at the Energy Research Institute while undertaking his Master's studies. His thesis topic was "Fine particulate matter source apportionment".

ERRATUM

Journal of Energy in Southern Africa, Vol. 8 No. 3 August 1997, p. 90.

The incorrect figure was provided for South Africa in Table 1, column 3.
The figure should read 153 547 Gwh and not 53 547 Gwh.

Forthcoming energy and energy-related conferences: 1998

FEBRUARY 1998

23-24

RENEWABLE ENERGY SYSTEM DESIGN AND SIZING: A SHORT COURSE Stellenbosch, South Africa

Enquiries: Elsabé Enslin, Short Courses, P O Box 12570, Stellenbosch 7613, South Africa

Tel: +27 (21) 808 4979
Cell: +27 082 854 0269
Fax: +27 (21) 808 4979/886 4783
Email: ecenslin@firga.sun.ac.za

MARCH 1998

11

SANEA/DME/JETRO ENERGY EFFICIENCY SEMINAR Silverton, Pretoria, South Africa

Enquiries: Ms W A Izgorsek, SANEA, P O Box 785673, Sandton 2146, South Africa

Tel.: +27 (11) 883 8883
Fax.: +27(11) 883 8885

APRIL 1998

6-8

5TH DOMESTIC USE OF ELECTRICAL ENERGY CONFERENCE Cape Town, South Africa

Enquiries: Heidi Neves, Domestic Use of Electrical Energy Secretariat, Cape Technikon, P O Box 652, Cape Town, South Africa

Tel.: +27 (21) 460 3657
Fax.: +27 (21) 45 4940
Email: nbeute@norton.ctech.ac.za

MAY 1998

24-26

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

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

Tel.: +27 (11) 28 1066

SEPTEMBER 1998

13-18

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

Theme: Interface between developing and developed countries

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

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

21-25

CODATU VIII Cape Town, South Africa

Theme: Urban transportation policy: A sustainable development tool

Enquiries: CODATU VIII - Scientific Committee, Christian Jamet, President, 9/11 Av. de Villars 75007, Paris, France

Fax.: +33 (1) 44 18 78 04

Recent energy publications

WICKING-BAIRD M C, DE VILLIERS M G and DUTKIEWICZ R K

Cape Town Brown Haze Study.
Sep-1997. 118p.
ERI Report No. GEN 182
R85,00

The main objective of the study was to determine the contribution of all major sources to the brown haze and to obtain a better understanding of the mechanism of haze formation. The focus was therefore on visibility, rather than on health. Localised air pollution problems were not addressed. Contains a literature review, meteorology of Cape Town, methodology used, emissions inventory, source profile, ambient conditions, results of the apportionment of the brown haze, projected emissions for Cape Town, options for reducing emissions, and recommendations.

This publication can be ordered from: Information Officer, Energy Research Institute, P O Box 207, Plumstead 7801, South Africa, at the price indicated.

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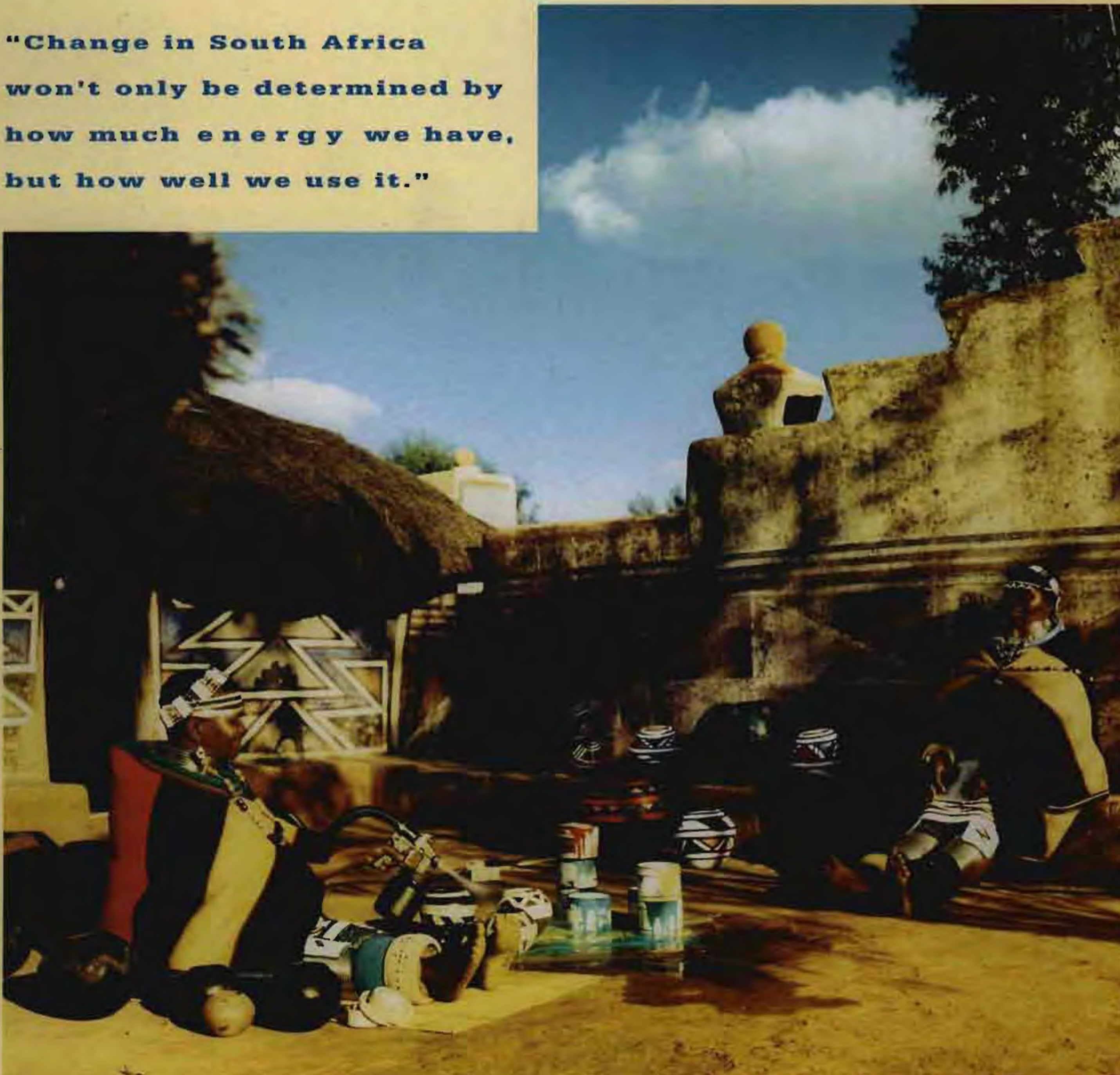

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