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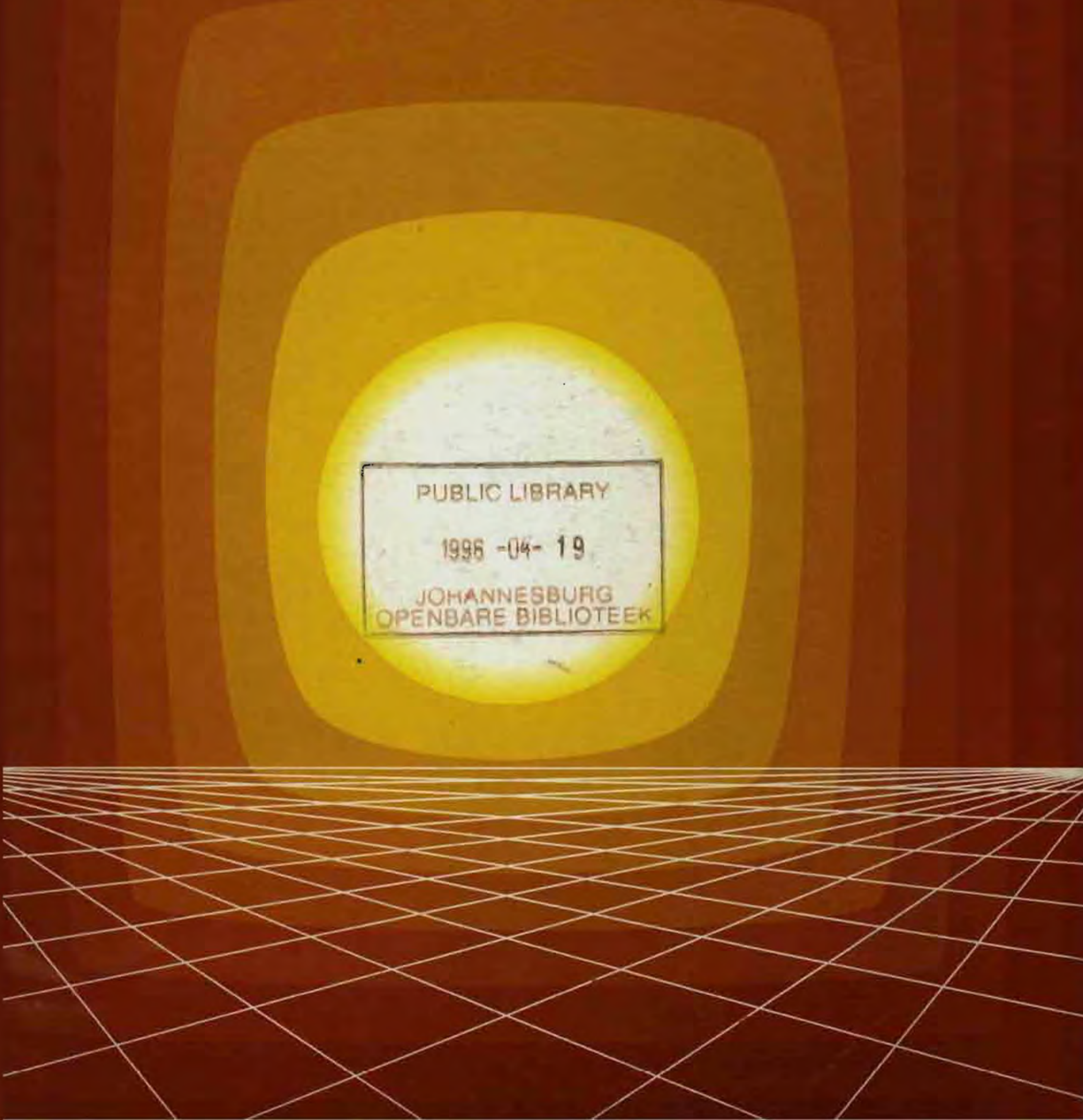


LEADERSHIP IS ACTION
NOT POSITION
"Traditionally business has measured market leadership in volume
and sales and the bottom line. No longer good enough. Righ
now in South Africa the success of a business will als
be gauged by how it values people. Creating
opportunities for those they employ
Empowering the lives of those they
don't. It makes good sense
Morally. Economically
Business must lead by
example. Create an
environment in which
all people can reach fo
better things. And grasp
them. This is the lead
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It is the policy of the Journal to publish, as far as possible, papers covering the technical, economic, political, environmental and social aspects of energy research and development carried out in or applicable to Southern Africa, and of general interest to Africa. Only previously unpublished work will be accepted. However, conference papers delivered but not published elsewhere are also welcomed. Short discussions, not exceeding 500 words, on articles published in the Journal are also invited. Items of general interest, news, technical notes, reviews and research results will also be included. Announcements of relevant publications, reviews, conferences, seminars and meetings will be included.

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.

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Profile: Ron Shires

Managing Director, ADE.

Ron Shires knows his way around the highly technical field of manufacturing engines and components for heavy vehicles and machinery - and is just as proficient when it comes to employing the human touch. Easy-going, with an open management style, Ron has taken charge of Atlantis Diesel Engines (ADE) at a time when the company is facing one of the biggest challenges in its history, namely, the lowering of import tariffs on automotive engines in South Africa.

Since his appointment as Managing Director in June 1995, Ron has repeatedly emphasised ADE's new vision, that is, to become a world player in the market for diesel engine components, whilst at the same time, continuing to better the Company's service to its loyal local customers. During 1995, ADE signed various lucrative export deals with companies in Korea, Europe and the Americas. Export sales worth R250 million/ year is ADE's aim. With his vast experience at ADE and in the engine business as a whole, this is not an impossible achievement for Ron.

Ron Shires was born in 1944 in Kingston-upon-Hull, England. On finishing his schooling at Hull Technical Grammar School, he enrolled at Hull Technical College and began his career at Perkins Engines in 1966. In 1974 he was appointed Manager of Perkin's Product Design department, and three years later was appointed to Chief Engineer: Large Engines. His last three years with Perkins were spent as Chief Engineer: Product Engineering.

In 1983 Ron came to South Africa where he started working for ADE, which had begun manufacturing engines under licence from Perkins and Mercedes-Benz of Germany. He initially served as General Manager of ADE's Perkins Division before his appointment to Technical Director in 1991 and assuming responsibility for all manufacturing operations for both Mercedes-Benz and Perkins products at ADE. He then became Director of ADE's manufacturing operations, which included his responsibilities as Technical Director, as well as for supply and material planning.

Although a creative person, who likes to be actively involved in what goes on on the plant floor, Ron has adapted to the role of strategist and policy-maker with apparent ease. He has also set about increasing ADE's exposure - locally and internationally - through raising the profile of the Company's senior management team. This includes extending ADE's involvement in the Atlantis community, where it is recognised as the largest employer in the area.

Ron is confident that ADE will continue to grow, especially once the recent investments in expanding plant capacities have been implemented. Testimony to this is that ADE has increased its work-force by 200 employees to 2 100 at a time when other Atlantis-based companies have been forced to retrench employees.

Of these 2 100 employees, only 435 are office-workers, which reflects Ron's belief that in a manufacturing industry office administrative personnel should be kept to a minimum. Ron is also a firm believer in a flat organisational structure, with the minimum number of levels between workers and management. He strongly supports ADE's team centre concept which encourages open communication and transparency between all levels of employees within the company. He admits to not being the most organised of people, but that he attributes to his creative-mindedness. The organisation and much of the policy implementation is done by the people around him. He, however, generates the enthusiasm.

Not surprisingly, Ron's hobby is cars – preferable of the red, sporty type. He has two Lotuses, an Austin-Healey and a Mazda MX5. Contrary to any perceptions conjured up by his hobby, he is very much a family man. He is married to Shirley and they have two daughters, Lindsey and Karen. Karen is doing a Ph.D. in medical microbiology at UCT's Medical School and Lindsey works for Southern Life.

Peat and peatlands in South Africa: Characterisation and quantification

* W J SMUTS

Significant peat and other biofuel resources exist in various parts of Southern Africa, and the presence of these natural resources has to be recognised and considered to ensure that there is future sustainability and balance between conservation and utilisation.

Appropriate management and choice of utilisation methods, where applicable, are crucial in achieving sustainability for these natural assets as there is an increasing tendency towards diversified exploitation of the resources by an ever-increasing population.

Keywords: peat characterisation; Southern Africa; renewable energy; domestic energy; sustainable energy

Introduction

In an apparently arid country like South Africa, a very common reaction to the mention of peat is (1) what is peat, and (2) why even dwell on it here in Southern Africa, where it does not exist? Surely, it only occurs in Ireland or Northern Europe?

(1) In response to the first reaction and put very simply, peat is dead plant material that accumulates in still or slow-flowing permanent water. There is very little oxygen available in these layers and therefore the plants do not rot away as expected but are preserved as long as the above conditions prevail. Minute, slow-acting chemical changes then start to affect the appearance of the peat and over a very long period of time the dead plant material (peat or "baby coal"!) may eventually be transformed first to lignite and finally to coal.

(2) Peat can be formed anywhere where there is permanent water and plants growing in or near the water. Plants growing in warm temperate to tropical climates are usually physically big compared to those growing in colder conditions, and they also grow much faster, generating more dead plant material quicker. The result of this is that many so-called "warm, dry places", like South Africa, can support significant peatlands.

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The multi-million Rand South African mushroom industry is absolutely dependant on peat as a casing medium. By far the largest portion of this peat is sourced locally since the varieties of South African peat are more suitable as casing media and cheaper than the blends of imported Canadian moss peat or Dutch sugar beet sludge. A wide range of peat-based horticultural products are also available from most nurseries, farmers' co-operatives and large department stores. In the mid-1940s the town of Lichtenburg supplied peat in sod form to the townsfold at "a shilling a donkey cart load" and it was used widely in domestic cooking. Poor harvesting techniques and management resulted in a peat fire and that valuable resource was lost to the community. The traditional abundance of wood and coal in this country limited the use of peat as an energy source up to now to a few small occurrences. An example is the Bankplaats kieselguhr mine near Sheepmoore in Mpumalanga, where, until recently, the peat was hand-cut, dried, stacked in open clamps and burned to liberate the diatoms, producing a very high quality product.

In other countries, such as Ireland, parts of Scotland, Holland, Scandinavia, Canada, and many of the CIS republics, both the horticultural and energy applications of peat play a significant role in everyday life. The economy of the modern state of Ireland was largely built on peat. Today about 16% of the country's electricity needs are supplied by clean-burning peat-fired power plants. Peat still plays a dominant role in the energy supply of rural Ireland, to the extent that even city dwellers still own and exercise their inherited tribal rights to harvest energy peat annually. The city of St. Petersburg, Russia, (with a population of approximately 5 million) was built on the salt-marshes of the Neva River Delta, and most of the vegetables consumed are grown in greenhouses with peat as the growing medium.

Both peat and papyrus briquettes are produced and sold in Bujumbura (Burundi) and a lucrative business has sprung up on the side supplying simple stoves, made from empty oil tins, to peat users. Similar peat-burning tests are also underway in Senegal and Benin in West Africa. All over Africa one can find market gardens on or flanking peatlands. A few examples are the Niyaes in Senegal, Brazzaville (Congo), Cotonou (Benin), Maputo (Mozambique), and widely in Uganda. Locally, they can be found in Witbank (Mpumalanga), the KwaZulu/Natal south coast, Maputaland, etc.

Peat is a renewable natural resource, like wood or other biomass (grass, reeds, cow dung etc.), and it should be considered in the energy context as a biofuel. Global peat formation is estimated at not less than 200-250 million tonnes (Mt) dry matter per annum. This exceeds by 4-5 times the 50 Mt dry matter that is extracted annually by the peat industry primarily in the Northern Hemisphere. Wetlands (including peatlands) cover approximately 495 million hectares (ha.) (3%) of the earth's total land area. African wetlands cover about 34 million ha. of the continent[1].

As a fuel, peat can be characterised to be somewhere between wood and lignite, although closer to wood in terms of chemical and physical properties (Figure 1). Peat has higher nitrogen, oxygen and volatile contents than wood but contains less sulphur than older fossil fuels. The higher moisture content results in lower combustion temperatures and insignificant nitrogen oxide emissions.

Peat genesis is influenced by drainage, climate, hydrology, geomorphology, basement geology and nutrient status. Peat deposits form in localities of impeded drainage and/or high rainfall. Any freshwater wetland ecosystem in which autochthonous peat accumulates is termed a **mire**. This is a general term that

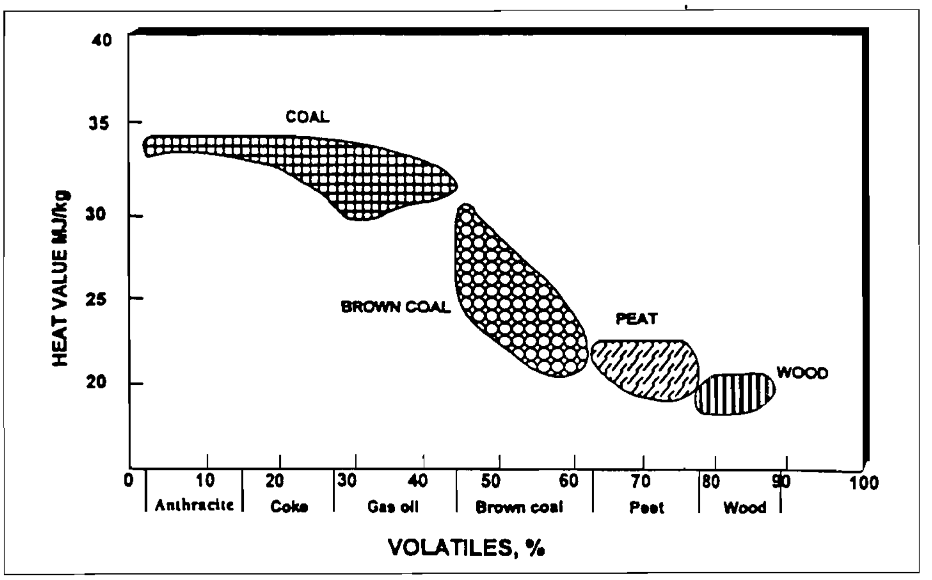

Figure 1: *Peat relative to wood and other fossil fuels in terms of its heat value and volatile content*

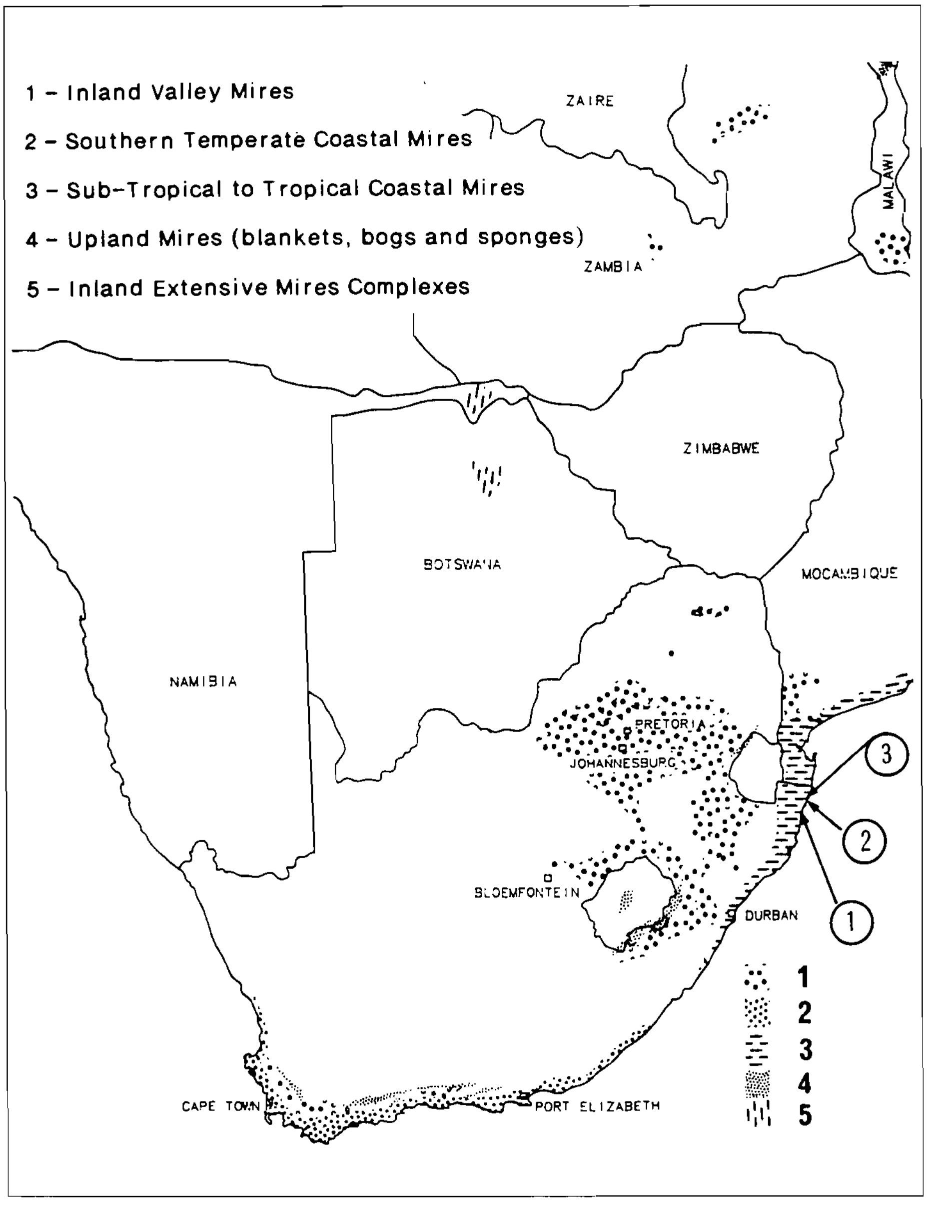

Figure 2: *Distribution of major peatland types in Southern Africa*

includes all the following ecosystems, namely, bog, fen and swamp. These terms are defined as follows:

Bog is confined to ombrotrophic peat-forming ecosystems ("nutrition from rainwater" synonym for ombrogenous[2,3]. Precipitation is essentially the only input of water to the system and thus also the source of nutrition entering the system).

Bog forest is the same as above but the dominant vegetation is trees[4].

Fen refers to rheotrophic peat-forming systems in which the dry season water-table may be below the peat surface (a rheotrophic system is one in which both precipitation and groundwater/surface run-off plays a role in affecting that system hydrologically. (Synonym for topogenous[2,3].)

Swamp is a rheotrophic wetland in which the water-table is almost always above the surface of the substrate.

Floating swamp often develops around the fringes of lakes and is especially common in tropical and sub-tropical African lakes where these platforms can be thick and extensive[5].

Swamp forest is a specific swamp type (also rheotrophic in nature) in which trees are the dominant plant constituent in sub-tropical and tropical climates[6], while temperate swamp forests are usually termed "carr" [7].

Mire types can be found in all except the most hot and arid climatic areas of the world.

> The principle prerequisite for the formation of peat is that the rate of production and accumulation of organic material must be greater than its decay.

Peat consists predominantly of loosely compacted, partially decayed, semi-carbonised plant material in a water-saturated environment. It is generally fibrous (structures of the vegetal matter can be recognised) and contains between 75% and 97% water in the natural state.

Organic material falling onto a mire's surface may decompose completely in the acrotelm (aerobic peat layer) or it may pass down into the sulphide zone (catotelm) where decomposition rates are extremely low[8,9,10]. Once inside this anaerobic reducing environment of the catotelm, plant and animal remains will remain virtually unchanged for a long time. The only notable change is vertical compaction under the weight of the further accumulation of organic matter. Two types of material are dominantly preserved in peat, namely, (i) those parts of plants and animals made up of materials resistant to microbial breakdown (suberin, lignin and chitin) and (ii) those plant organs that penetrate the peat to be closer to the sulphide zone on death (roots and rhizomes).

The following peat components are recognised:

Organic matter
- identifiable by its organised state of preservation
- cell structure still visible but much decomposition has taken place
- decomposed to below cellular level, forming humus or peat matrix.

Inorganic matter
- either blown or washed into the mire, or from plant cells, e.g. silica phytoliths from reeds and grasses or diatomaceous tests.

Mires are fundamentally classified into bog and fen. More elaborate classifications have been devised, their nature largely dependent on the origin and purpose of the particular system. The criteria used in such systems have to be easily accessible, hence shape, chemistry, plant species composition and vegetative structure are all common criteria used in various parts of the world[11]. Two mechanisms are recognised as being responsible for mire formation[11]:

(i) Terrestrialisation – formation of a mire by infilling of a shallow water body by organic matter. This is usually caused by the progressive extension of peat-forming communities from the shoreline into a lake.

(ii) Paludification – also known as swamping, i.e. formation of a mire over previously forested land, grassland, bare rock or river flood plains. This can be caused by climatic, autogenic (processes internal to the mire) or tectonic processes.

Modifications by man to the natural environment may also activate either of these mechanisms into mire formation.

South African mire types

Under favourable conditions mires occur in South Africa in widely different climatic systems, from the Antarctic blanket bogs of Marion Island to the tropical palm and hardwood forest swamps of Maputaland (Figure 2). However, those of economic consequence tend to be located in certain broad geomorphological settings in the higher rainfall, eastern half of the country. Geology *per se* has very little to do with peat formation. However, the geomorphological expression of the geology of an area is extremely important to peat accumulation as it provides the template required for mire development. The local geomorphology is therefore considered to be a primary classification parameter. However, climate (and hence, vegetation) may have a strong modifying influence on mire development.

Vegetation

As far as vegetation is concerned, four main mire types can be distinguished, *viz.* sedge/reed, hardwood forest, *Raphia* palm and mangrove mires. However, different hydroseral assemblages under different climatic conditions result in a number of transitional types.

(i) Sedge/reed (grass) mires are the most common in Southern Africa and most likely in Africa as a whole. These mires display a hydroseral zonation which has important implications for the eventual peat types preserved in the wetland. Plants that are particularly widespread throughout the continent are *Cyperus papyrus, Phragmites australis* and *Typha capensis.*

(ii) Hardwood mires (swamp forests) include all dicotyledonous, woody peat-forming communities in freshwater environments, e.g. Mgoboseleni (27°32'S/32°39'E) and Siyadla (27°03'S/32°48'E) (Nos.1 and 2 on Figure 2). It is the next most important mire type after sedge/reed mires in the Natal Mire Complex (NMC). Approximately 3 986 ha. of swamp forest occur in Maputaland[12]. Swamp forest represents the final mire stage in the natural hydroseral succession from open water to dry ground (first characterised by *Nympheae* in open water, then by sedges and reeds, and finally by hardwood trees). Relict clumps of swamp forest or large dead/burnt trees, along with woody layers in the peat, are found in some sedge/reed mires in the NMC, indicating a reactivation in the mire succession due to a sudden change in water-level. Such water-level changes are most often related to fires where the vegetation is burnt off along with the upper peat layers[13].

(iii) *Raphia* palm wetlands in Southern Africa today only occur on the western shore of Lake aManzamnyama (27°01'S/32°49'E) (part of the Kosi system) (No.3 on Figure 2). The vegetation of this mire type is virtually monotypic. *Raphia australis* with some climbing ferns *(Stenoclaena tenuifolia)* is present where more light is available. Exploratory drilling near Lake aManzamnyama has shown that this mire type used to have a much wider distribution.

(iv) Mangrove mires occur at 14 important localities from Kosi Bay in the north, to Kabonqaba north of East London[14]. Mangroves only occur in the intertidal zone along the coast. The most common of the South African mangrove trees are *Avicennia marina* and *Brugueira gymnorrhiza* compared to *Rizophora* and *Avicennia spp.* in other mangrove mires in Africa and tropical America[15,16,17]. Mangrove swamps represent the most seaward (and topographically lowest) component of coastal unbound mires, such as the Greater Mhlatuze wetland and Mfolozi Swamp.

Mire classification based on geomorphology

Extensive mires are only limited by macro-scale topography and thus occur over extended areas, often with an undulating character with respect to the land surface. This results in expansive wetlands of varying depth. The thickness of the peat is to a large extent governed by the covered topography at any particular locality. Because of their extensive nature (usually 10 000 ha.) these mires typically have a complex hydrology, resulting in rather intricate mosaics of plant communities and corollary peat types. Extensive mires are further subdivided into coastal and inland mires.

Extensive coastal mires only occur from northern Natal northwards and within 30 km from the coastline (Figure 2). Mires that answer the above description are the Greater Mhlatuze, Mfolozi Swamp, Greater Mkuze Swamp, Muzi Swamp and the Southern Maputo Bay Swamps in Mozambique. All but the Muzi Swamp drain directly into the sea, so that conditions range from saline to fresh water with the resultant spectrum of mangrove, to fresh water forest swamp, to reed/sedge swamp, to meadow communities.

Coastal mires also occur along the southern Cape coast. However, due to the very different climate, these mires are characterised by plant communities that differ from those in northern Natal. Two tropical mire types (mangrove and swamp forest) are absent from the southern temperate coastal mires. In the reed/sedge peatlands *Phragmites spp.* and *Typha capensis* are still co-dominant as peat formers, but the other peat formers are replaced by different species. At Groen-

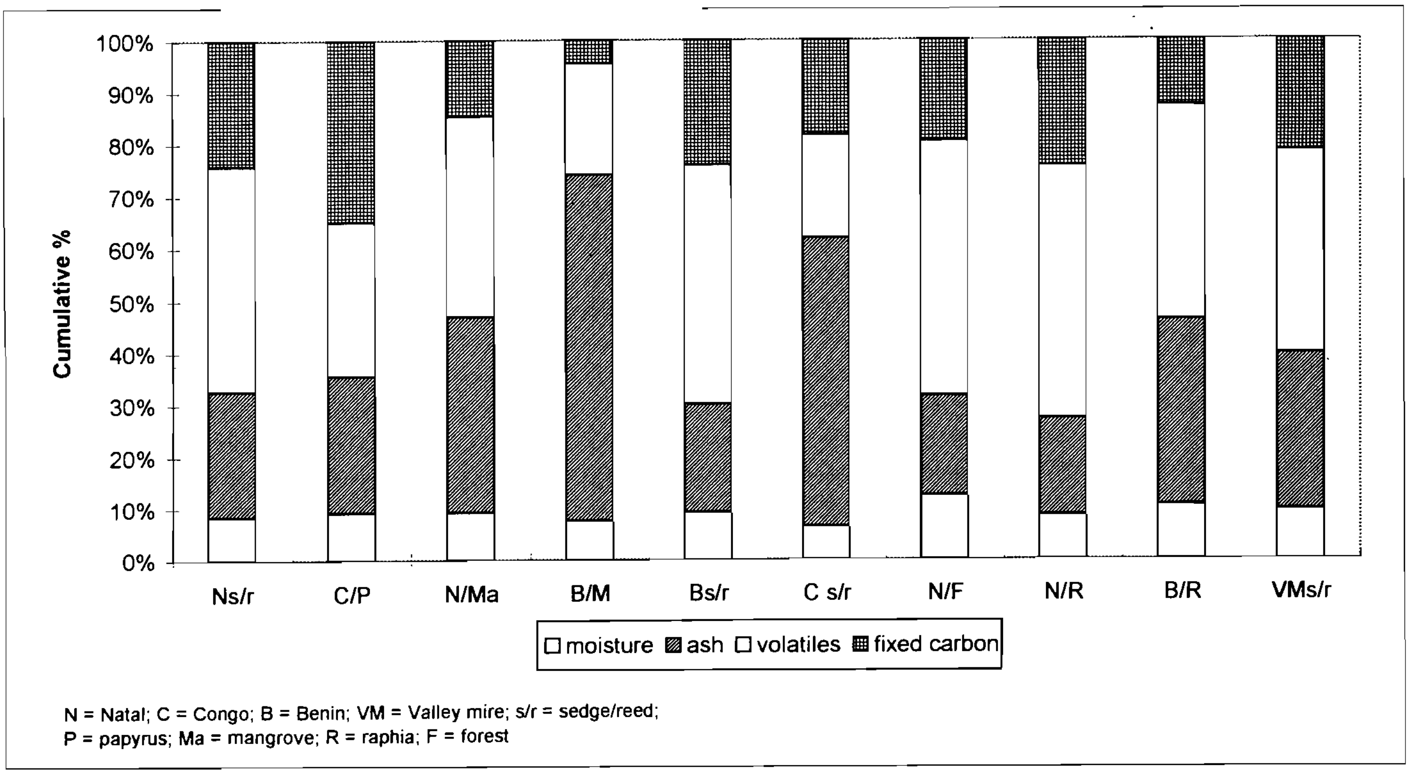

Figure 3: Proximate analyses of African peats

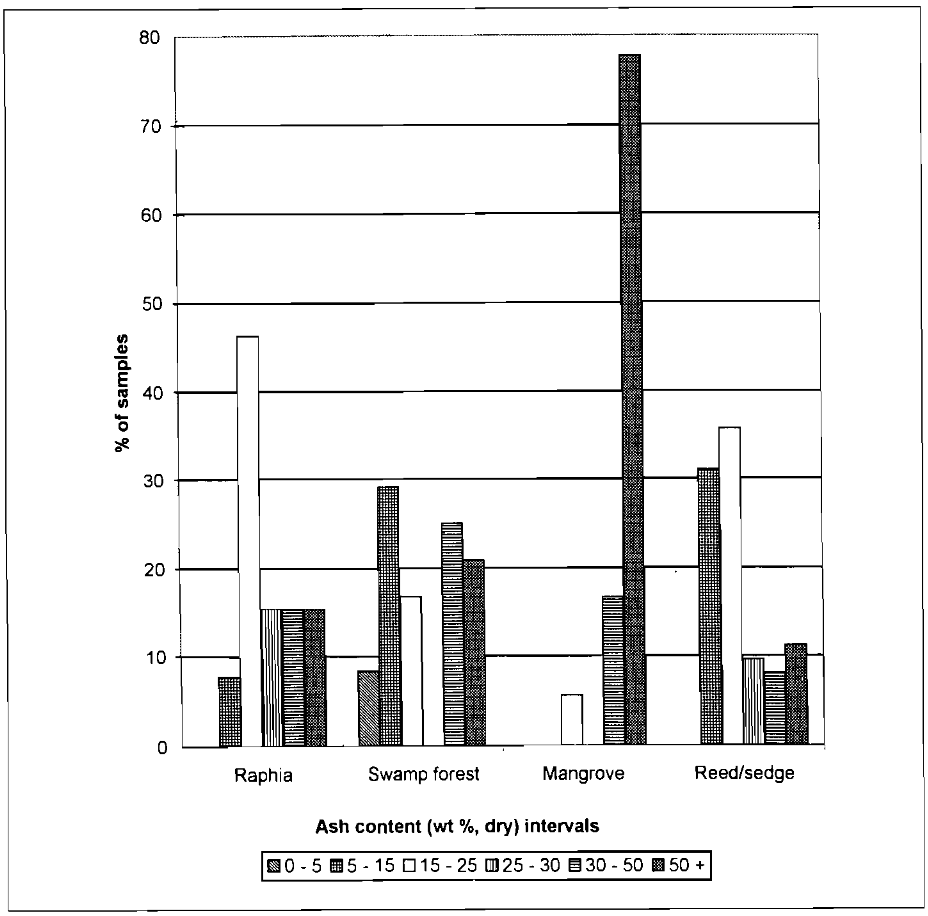

Figure 4: Ash content (wt.%, dry) intervals

vlei in the southern Cape the hydroseral succession end member (fen carr) comprises shrubs and small soft wood trees such as *Rhus spp.*, *Rhamnus spp.* and *Myrica spp.*[7].

Inland mire. The Okavango Swamp complex is the largest example of an extensive inland mire in Southern Africa. This vast mire is situated in the semi-arid Kalahari Desert of Botswana. The swamp complex occurs in an active north-easterly striking half graben and is fed by the Okavango River draining the highlands of central Angola[18]. The system consists of permanently inundated (6 000 km^2) and seasonal (7 000 to 12 000 km^2) swamps. The dominant peat forming species in the swamps is *Cyperus papyrus*, a plant which under tropical conditions exhibits high rates of primary production[19,20], with the consequent potential of producing large volumes of peat annually. Peat volumes in these vast mires are, however, kept in check by regular drought/fire cycles which are a common aspect of African ecosystems. The Kwando-Linyanti-Chobe wetland system in the eastern Caprivi (Namibia) is similar to the Okavango in many respects except that its water-supply is less stable, with the result that Lake Liambesi has dried up twice this century resulting in spontaneous extensive peat-fires that burn for years until the next good rains eventually extinguish the burning fronts.

Bound mires, as opposed to extensive mires, are strictly controlled (and bound) by local topography and geomorphological features. Bound mires are by far the most common in Southern Africa. Bound mires, because of their smaller size and confined nature, tend to be much more sensitive to climatic changes than unbound mires. The unbound mires of Natal exist successfully through a much wider climatic and topographic range than the bound mires which are confined to a narrow topographic and rainfall band along the coast.

Characterisation

Proximate analysis

Proximate analyses (moisture, fixed carbon, volatile matter and ash content) and calorific value determinations were done on both peat and organic-rich sediment samples (ash content 50%) (Figure 3).

However, for certain analytical calculations and discussions that follow, only peat samples were considered (Table 1).

	Average (%)	Range (%)
Fixed carbon	25	10-29
Volatile matter	48	35-68
Ash	27	1-47
Calorific value (MJ/kg)	16,5	11-22

Table 1: Characteristics of all Natal mire complex peats[6] (Ash <50% irrespective of type - moisture-free basis)

Ash contents

The ash contents of mangrove peats are significantly higher than those of any other peats. This is probably because these peats formed at the edges of brackish river channels or in the lower reaches of estuaries. All freshwater peats have very similar ash contents with swamp forest peats, exhibiting the lowest average value (Figure 4). Two likely reasons for this are that the vegetation that produces swamp forest peat contains less authigenic silica (intracellular phytoliths) than other types of peat forming plants (notably grasses and sedges) and swamp forest peatlands are better protected against the incursion of mineral material in the form of water- or wind-carried sediments.

There was a general decrease in ash content from shallow to deeper peats. Thin proximal peats (shallow dipping bottom topography) also exhibit a much higher ash content than thick proximal peats (steep bottom topography)[21].

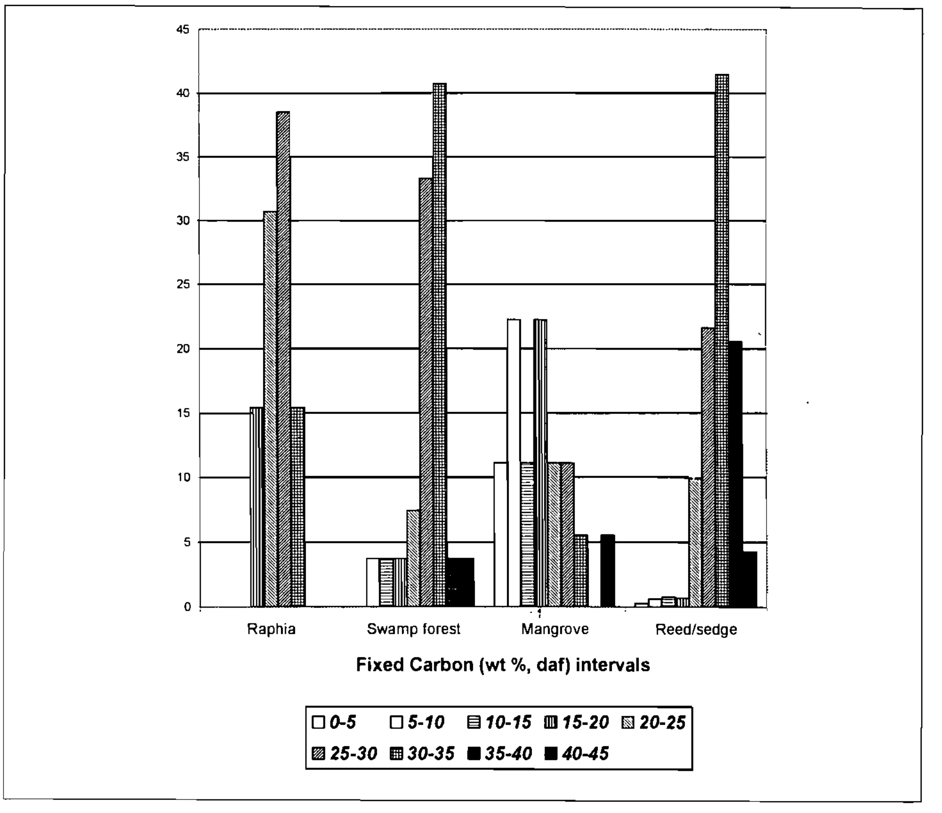

Figure 5: Fixed carbon (% daf) for the major South African peat types

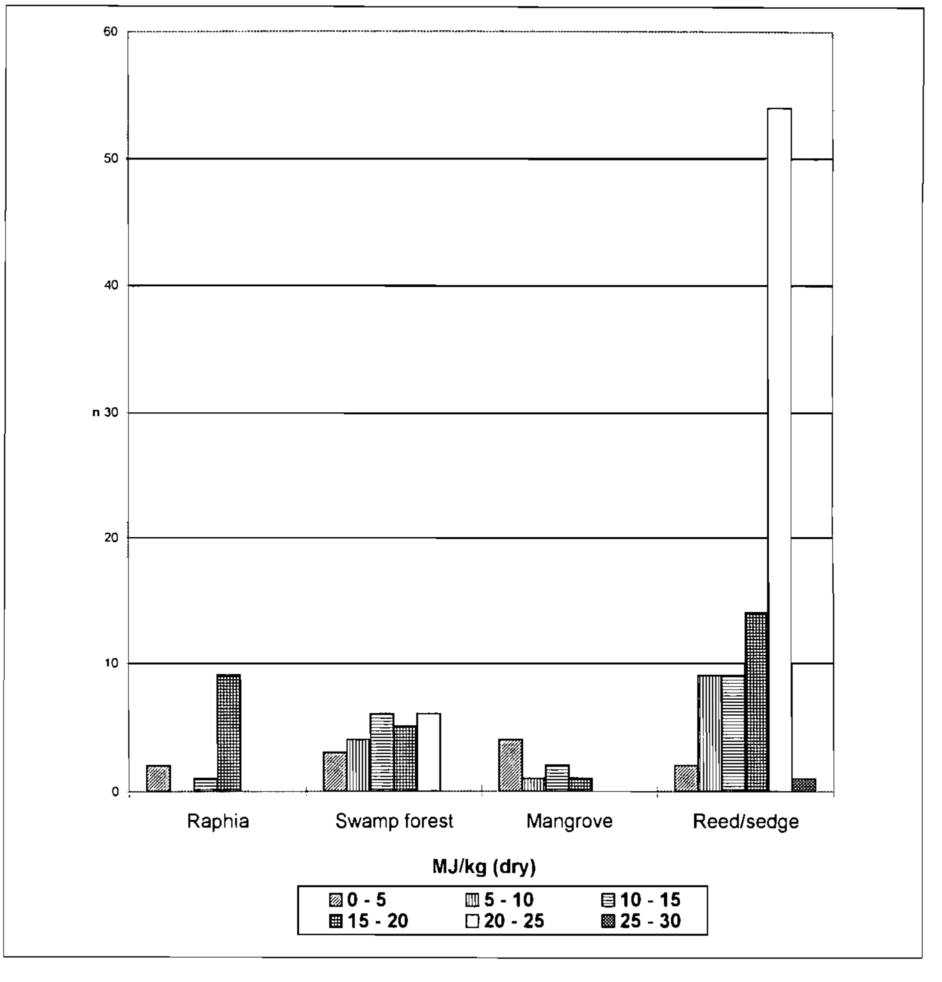

Figure 6: Calorific value (MJ/kg, dry)

There appears to be two reasons for this, (i) thick proximal peats are influenced to a much lesser extent by the mineral base, and (ii) steep edges to a peatland tend to be associated with smaller run-off areas, thus feeding less mineral material into the peatland. This trend can be observed in all sedge/reed mires.

The general zigzag nature of the ash contents in sedge/reed mires can be ascribed to oscillating climatic conditions. Most peats, however, present a pattern that moves between 10% ash and 40% ash throughout any particular profile. For example, during dry periods ash may be increased by the prevalence of fires, larger volumes of dust being blown into the mires and more sediment being washed in from barren high ground during flash-floods. Conversely, during wetter periods fires will be less frequent and less widespread, dust will be largely absent, and less erosion will occur from the surrounding high ground. At the same time the rate of primary production in the mire will also be higher and larger volumes of peat will accumulate. Channel switching (particularly in a valley mire) may also cause similar ash content variations in the peat profile. The majority of valley mire peats have a tendency of decreasing ash content with an increase in depth. This is probably due to a general decrease in moisture (from older to younger peat) over an extended period with a resulting increase in surface run-off as vegetation cover becomes sparse.

Fixed carbon and volatile matter

In the case of *Raphia* palm peat fixed carbon (FC) clearly increases with depth. In the case of swamp forest and reed/sedge peat, there is a very gentle increase in fixed carbon with depth. This is in keeping with the findings of Cohen[22] on the peats of Costa Rica. The strong drop in fixed carbon with depth demonstrated by mangrove peat is most likely as a result of the high ash contents encountered in these peats. Inorganic volatiles would report with the organic volatiles, thus leading to a lower FC where these are more abundant. The dissociation of the likes of carbonates, pyrite and gypsum may explain the observed drop in FC with depth in mangrove peats.

Wide ranges in fixed carbon were observed between different peat types (Figure 5). Reed/sedge peat has the highest average fixed carbon content at 33% and mangrove peat the lowest at 16%. Fixed carbon tended to generally increase with depth. At shallow levels valley mire peats exhibit a very wide range in fixed carbon contents, ranging from 4% to 50% (dry ash free). With increasing depth (± 350 cm) this range is narrowed to about 25% to 40%. The few very low fixed carbon values (daf) (implying >90% volatiles) are most probably an indication of high inorganic volatiles.

Calorific value (CV)

Increasing depth leads to a slight increase in calorific value (MJ/kg) for all peats. There was only a small difference in calorific value among the various peat types. Swamp forest peats had the highest average values with the widest range and mangrove peat had the lowest average calorific value (Figure 6). All peat types demonstrated a general trend of increasing calorific value with increasing fixed carbon content. Sedge/reed peats exhibit a strong tendency towards being perhydrous (rich in combustible hydrocarbons). Swamp forest and mangrove peats plot close to the normal trend, while *Raphia* peats have a tendency towards subhydrousness (rich in incombustible volatiles).

Raphia peat and forest peat have a very narrow calorific value band (21-25 MJ/kg) with a wide (20-38%) fixed carbon band, while for sedge/reed peat, a wide band is shown for both CV (4-28 MJ/kg) and FC (18-42%). This is most likely due to the fact that *Raphia* and forest mires tend to have a much smaller variety of contributing peat formers than a typical sedge/reed mire. *Raphia* and forest mires are also less likely to be influenced by inorganic inputs from external sources and furthermore, fires are less frequent than in sedge/reed mires. Increasing depth appears to have little effect on calorific value for most valley mire peats. All deposits analysed demonstrated a general trend of increasing calorific value with increasing fixed carbon content. Ash content, on the other hand, affects the calorific value inversely, low-ash peats (<15%) range 18,4-22,0 MJ/kg, medium-ash peats (15-30%) have a range of 12,7 MJ/kg to 19,7 MJ/kg and high-ash peats (30-50%) range between 10,4 MJ/kg and 14,9 MJ/kg calorific value.

Sample	Coke %	Tar %	Water %	Gas %	H % (daf)
KwaZulu/Natal wood	43,0	6,0	29,0	22,0	5,83
North West wood	36,6	9,0	20,7	33,7	6,1
KwaZulu/Natal 1 S/r	49,6	4,0	22,8	23,6	5,05
KwaZulu/Natal 2 S/r	54,4	4,8	23,6	17,2	5,71
G'teng 1 S/r	68,8	8,4	15,6	7,2	5,6
G'teng 2 S/r	62,8	8,0	19,6	9,6	6,1
G'teng 3 S/r	73,4	4,6	14,6	7,4	4,2
North West S/r	65,2	4,8	20,8	9,2	4,1

Table 2: Fischer assay (daf) of some selected peats

Fischer Assay (Table 2).

Peat wood (the part of peat that can be recognised as wood) gives a low coke, high water and high tar yield. Since the tar yield is primarily dependent on the hydrogen content one would expect this to be reflected in hydrogen analyses. Inspection of the ultimate analysis of these peats indeed points this out (see H content in the last column in Table 2).

Conclusion and recommendations

It is concluded that a number of mires that retain significant reserves of peat do occur in South Africa (Table 3). The quality and characteristics of the peats would make them eminently suitable for a number of applications both as an energy source and as soil ameliorants or growing media. In the energy context, the peat and bio-matter can be applied directly in open fires or various types of stoves, or used as raw material in the generation of biogas. The biogas application also leads to double use of the material as it can be used as compost after digestion in the gas pit.

Based on an environmentally sensitive management regimen many peatlands can be utilised on a sustainable basis as a source of domestic and small-scale energy. Peat and bio-matter compare favourably in terms of energy content, cost and ease of application to most other energy sources available to developing communities. It has, however, the added benefits that it is environmentally friendly and has potential for job creation. Mires will be utilised increasingly in future by rapidly expanding populations with a craving for natural resources. Therefore it is of paramount importance that the significance and potential of this resource be recognised and management strategies developed accordingly to ensure its sustainability.

Designation **Reserves (106 t)**	**Kz/Natal**	**G'Teng/N.West**	**W. Cape**	**Total S.A.**
Proven reserves Probable reserves Potential reserves **Quality parameters**	256,645	2,743	0,612	250,45 691,63 264,00
Water (%)	12,3	9,5	10,98	10,9
Ash (%)	20,9	28,44	21,15	23,6
Volatile matter (%)	48,27	41,72	41,13	43,7
Sulphur (%)	0,015-0,75	0,004-0,89	0,02-0,75	
Fixed carbon (%)	18,53	20,34	26,74	21,8
Calorific value (MJ/kg)	16,5	13,3	14,3	14,7
Deposit parameters				
Thickness (m)	0,5-7	0,5-9	0,5-7	

Table 3: Generalised reserve characteristics for four provinces[21]

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The Songai perspective on sustainable energy procurement and small-scale farming: Possible applications for South Africa

* M WENTZEL

Energy plays a vital role in agriculture and rural development. The important link between energy and agriculture, and therefore rural development, has in the past been largely ignored in the approach to development economics. One of the most serious mistakes of the past was that technology transfer was emphasised (often without any thought as to its applicability) over research into optimal utilisation of local resources. This type of technology transfer strategy is the antithesis of sustainable economic development as it creates schemes that lead to ongoing dependency on imports.

The Songai Training Centre and Songai Village in Benin, West Africa, aims to raise the standard of living of the subsistence farmers and rural communities by a rational use of local and indigenous resources in a spirit of self-reliance and independence. The Songai Centre serves as a training centre for students in various agricultural and small business practices. An integrated agro-ecological system based on the concept of synergy is employed by Songai. Energy is placed at the centre of their main activities, namely, agriculture, aquaculture and animal husbandry.

Many valuable lessons can be learnt from Songai. These include the integration of energy, agriculture and rural development, greater emphasis on the development of broad agricultural and economic skills, as well as the management of foreign aid. The application of the Songai system in South Africa could produce significant economical, social, agricultural and environmental benefits, as well as contribute to the achievement of rural development goals as identified by the Reconstruction and Development Programme (RDP).

Keywords: sustainable energy; small-scale farming; rural development; training; Songai; Benin; Songai Centre

Introduction

Until recently, development economics was dominated by the ideas of the orthodox, traditional schools where the major tools of analysis had been borrowed from neo-classical economics. The basic assumptions embedded in these strategies were wrong in the sense that the conceptual and institutional frameworks in Africa often do not match with the system of production or the economic system being introduced. Failure of development programmes in Africa can be ascribed to the following[1]:

* It was mainly assumed that development would be an automatic result of the injection of capital and Western know-how into a developing country;
* The measure of economic performance and the goals set were based on the criteria of the industrialised countries;
* In many programmes, designers failed to recognise and take into account some socio-economic realities in the developing countries. The present day preoccupation of the majority of Africans does not match with the social behaviour necessary to support the economic structures introduced.
* The most serious mistake made is that technology transfer has been emphasised over research into local resources. This type of technology transfer strategy often resulted in schemes being introduced that created ongoing dependency on imports.
* The promotion of economic activities in the developing nations was more or less restricted to the formal sector and a great number of people, particularly women and the rural poor, were virtually left out of the economic equation.

The role of rural and agricultural development in South Africa is currently the subject of much debate and dramatic change. In the past, agricultural policy favoured the establishment and support of large commercial farms and the responsibility for rural development was largely delegated to the independent homelands. Serious doubts exist whether rural development could have taken place at all in South Africa during the past few decades, due to the illegitimacy and undemocratic nature of the State[2].

Since the election in South Africa of the Government of National Unity (GNU) an ambitious agenda for rural development has been formulated and identified as one of the main policy objectives of the Reconstruction and Development Programme (RDP). The new approach is characterised by three themes, namely, equity, efficiency and sustainability. The reality of a large number of mostly poor landowners, together with the general poor agricultural potential, highlights the need for the establishment of institutions and technologies to support profitable small-scale agricultural production. Some of the major goals of rural development defined by the GNU through the RDP[3] include the following:

* Helping rural people set the priorities for development in their own communities and supporting their access to government and non-government funding in promoting local economic development;
* Creating greater equality in resource use in the rural areas, especially
  - **land**, through better security of tenure, restitution and reform programmes and farmer support to all producers;
  - **water**, through extension services, extension of rights and changes in the Water Act;
  - **financial services**, for production inputs, infrastructure development and access to land through extension of services and through

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appropriate policy development following the report of the Commission of Inquiry into the Provision of Rural Financial Services;

- **management**, through training and capacity-building.

* Increasing access to services through the provision of physical infrastructures and social services, such as water and sanitation, transport, health services and schooling;
* Increasing farm and non-farm production in poor rural areas and increasing the incomes of poor rural men and women;
* Improving the spatial economy of rural South Africa, through co-ordination and co-operation with the Southern African region;
* Ensuring the safety and security of rural people.

Energy and rural development

Access to energy in rural areas is limited and energy use patterns are dictated by poverty, neglect and underdevelopment. Domestic use accounts for most of the energy used, with fuelwood as the main energy source. The purposes for which energy is used in rural areas are diverse and include a range of end-uses, such as cooking, lighting, water- and space-heating, refrigeration, draft power and shaft power[4]. These services are required by a variety of energy users, including (i) community facilities, such as clinics and water-supply systems, and (ii) economic enterprises, such as farming and trading and households.

Within the economic sector, probably the most important activity is farming. Energy constitutes a major input to the development of agricultural production and in sustaining this production. At present there is a critical shortage of suitable energy services in the small- and medium-scale farming sector, particularly to meet the two most important energy needs, i.e. draft power for land preparation and transport, as well as water pumping. Other energy uses include: heating for egg incubation, refrigeration for the storage of perishables and crop processing, particularly shelling and milling[3].

Future demand for energy services in agriculture could be influenced by agricultural and land reform initiatives. Schemes currently being investigated with the aim to increase the viability of the small-scale farming sector and to address problems in the present commercial farming sector include: small-scale commercial farming, outgrower schemes, profit sharing, joint ventures, equity options and tenants rights, and house ownership for farmworkers.

Closer links need to be established between rural consumers and policy-makers. For energy policies to address priority energy and development needs, rural end-users must be involved in the policy process, particularly on research prioritisation and the setting of research agendas. There also needs to be co-operation within energy research sub-sectors and with the research establishment of other sectors, such as water and health.

Although energy is not a proven catalyst for economic growth, a lack of adequate energy services is certainly a constraint on development. It limits the potential of meeting the basic needs of those who need energy to undertake essential domestic, agricultural and educational tasks; to support health and transport services, and to initiate or develop manufacturing or trading enterprises. Economic development in rural areas will involve an increased demand for locally provided support services, resulting in an increase in the demand for energy services.

Integrated, sustainable energy procurement and small-scale farming: The Songai perspective

Between 3-13 April 1995, two energy specialists from the Department of Mineral and Energy Affairs, accompanied by Mr Willem Smuts from GENRES cc, had the opportunity to visit the Songai Training Centre and Songai Village development project in the West African country of Benin. The Republic of Benin is situated on the west coast of Africa, bordering Togo, Nigeria, Burkina Faso and Niger. Southern Benin has an equatorial climate with two rainy seasons while northern Benin is less humid and drier. The major ethnic groups are the Fon, Yoruba, Boriba and Somba. The official capital is Porto Novo, although most government and diplomatic functions take place in Cotonou. The official language is French.

The objectives of the visit included:

* To visit and investigate the Songai integrated energy and rural development model for possible application in South Africa;
* To meet officials from the Minestere De L'Energie des Mines et de L'Hydraulique for discussions and exchange of information;
* To view some of the peat deposits and to investigate possible approaches for the utilisation of peat.

Songai Centre

The Songai Centre was established in 1985 by Father Nzamujo, a Dominican priest. Father Nzamujo was born and raised in America by parents of Nigerian descent. He taught as a professor in Engineering and Biochemistry at the University of Berkeley, California, U.S.A.. During a sabbatical leave in 1984 he travelled extensively through Africa and decided to settle there permanently and tackle the problems of underdevelopment in Africa.

The Songai Centre was started with very few resources and virtually no government support. The Marxist government in power at the time viewed all efforts with great suspicion but allocated one hectare of land to the project. The Centre has since expanded considerably.

The aim of the Centre is to raise the standard of living of Africans by the rational use of local resources in a spirit of self-reliance and interdependency. The Centre rejects the traditional, orthodox ideas of Western neo-classical economic principles. Instead, it strives to foster development within the realities of the African situation, with the specific needs of Africans in mind. For example, World Bank aid was refused since Songai could be reconciled with the World Bank's view of development.

The Songai Centre serves as a training centre for students in various agricultural practices. Students can study by way of self-financing or with the aid of bursaries. Apart from agricultural courses, specific training in management and accounting are also provided. Great emphasis is further placed on initiative, creativity, courage, discipline, responsibility, innovation and planning. The Centre is currently training 120 students. Apart from training activities, the Songai Centre also functions as a demonstration centre for sustainable agricultural practices. Attached to the Songai Centre is the Songai Village. This is a demonstration centre where the Songai farming principles are replicated on a village scale. This is to illustrate that all concepts taught at the training centre can be adapted to fit local conditions and, more importantly, the financial ability of the particular farmer. Although the expression "small-small" is used to convey this concept, Songai rejects the concept of subsistence farming which is regarded as a "rural development strategy of despair". The Songai Centre also carries out research and provides an extension service to former students and communities farming on the Songai principles.

An integrated agro-ecological system, based on the concept of synergy, is employed by Songai. The system helps to recycle and revalorise dispersed energy, thus creating negative entropy. Graphically, the system can be illustrated as shown in Figure 1.

The merit of the system lies in the interaction between the three poles. Each aspect depends and contributes to the other. Nothing is wasted. Animal waste and offal from the butcheries are used to farm maggots which are fed to the fish. Low-energy waste, i.e. intestines and dung are converted by flies and maggots into a high-energy protein to feed the fish. Approximately 1,7 tons of maggots are currently produced per month. Water from the toilets is purified by aquatic plants, hyacinth and pistia. The plants are chopped up and used with animal waste in the biogas digesters. This integrated system has economic, ecological and social advantages. The central role of

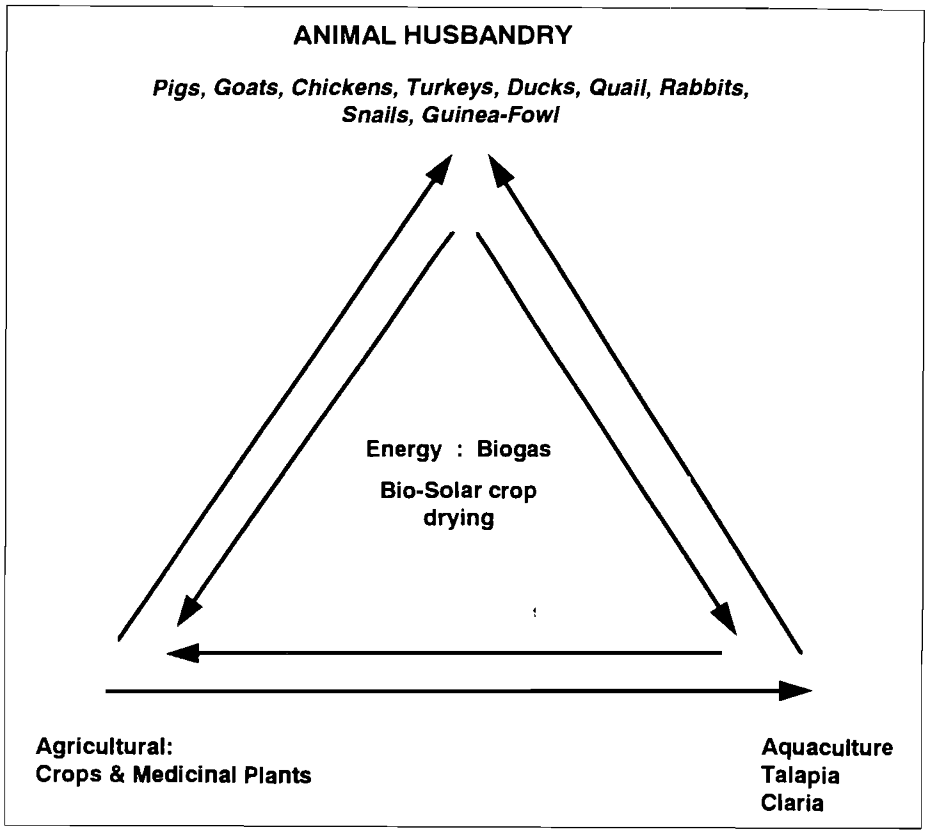

Figure 1: The Songai system

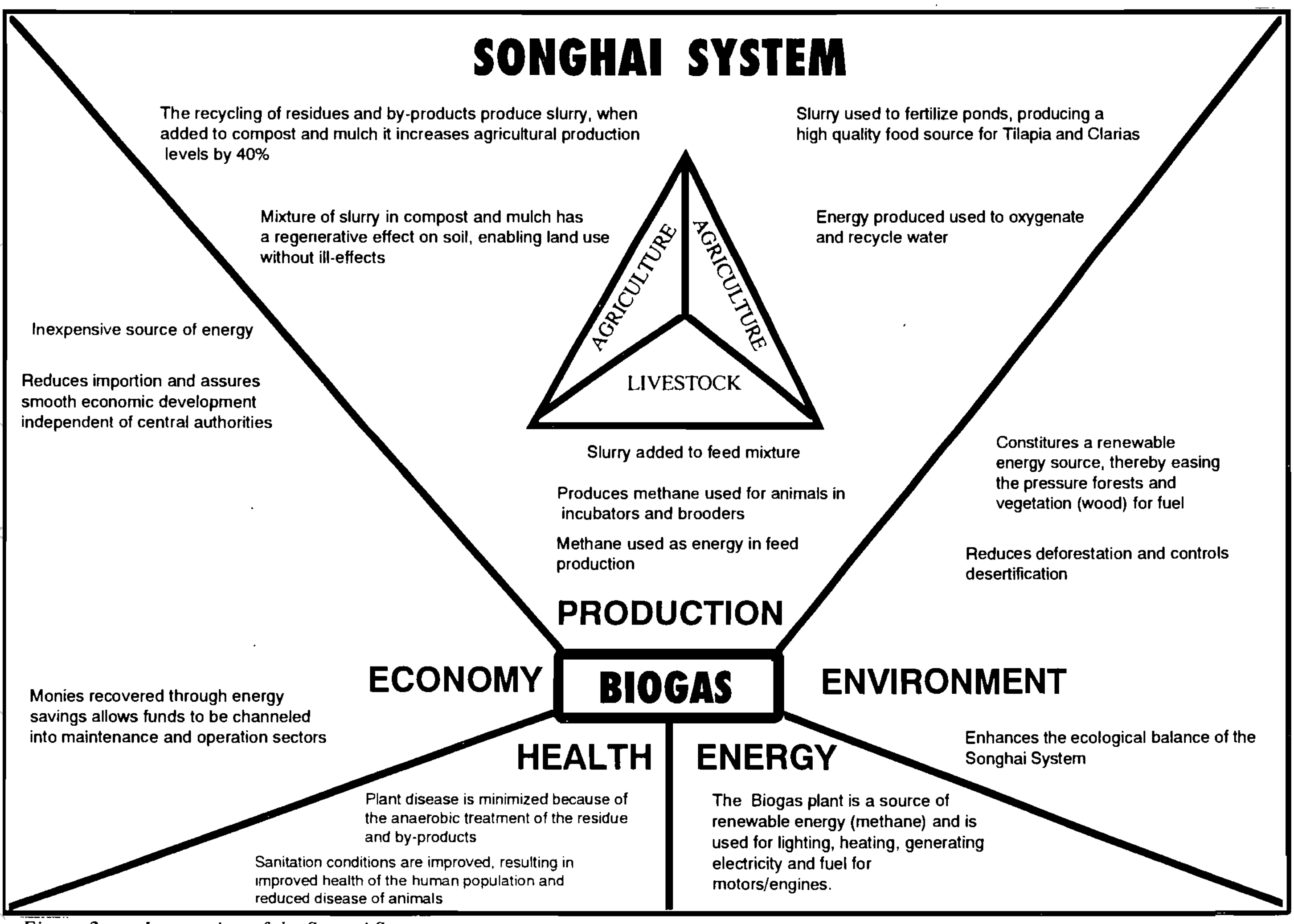

Figure 2: Integration of the Songai System

energy, specifically biogas, in the system is illustrated in Figure 2.

Apart from the existence of the Songai Centre and Songai Village, two Songai Farms are also in existence at Ouando and Tchi. Farmers supported by extension officers or so-called animators, are farming using the Songai principles. After completion of their studies at Songai, students return to their villages or rent land where available to farm. What is very important is that students do not try to convince villagers to follow their farming methods. Instead they act almost secretively and keep to themselves. Once their farm starts generating a profit and is clearly seen to be successful, people normally approach them to learn the secret of their success. Only then will the former student try to convince these people to change their old farming practices and share with them the knowledge acquired at Songai. Students are therefore utilised as catalysts and extension workers at the same time. This represents a novel way of approaching rural development extension and could be employed with success in South Africa where the country desperately needs to move away from a paternalistic, top-down, authoritative approach.

The general impression of Songai and the farmers working on their own away from the Centre was almost too good to be true. People are incredibly motivated, committed and hard-working. The farmers in the outlying villages were extremely well organised and have adopted management structures and lines of responsibility to accommodate all their needs. They keep records diligently - breeding records, although recorded on a piece of plank, were nevertheless up-to-date and correct. Meticulous records enabled them to ensure that they sell their produce at a profit and the profits were all ploughed back into the farms. Farmers also adapted their production according to local demands. One farm is even breeding aghouti (river rats) to supply the local demand. It seems that the most important thing being taught at Songai is not how to increase agricultural production but that people are responsible for their own success and that "empowerment means telling people to work".

Possible applications for South Africa

South Africa can learn many lessons from Songai. The first lesson is that energy and agriculture and therefore, rural development, must be viewed as inseparable. To achieve true integration, energy needs to receive much more attention than it is currently receiving in rural development.

The second important lesson is that broader "human development" must be addressed simultaneously with other development issues. Apart from new farming methods, people must be taught basic economic principles, administrative, organisational and managerial skills. Motivating and inspiring people emerged as a very important aspect but **how** to do it remains somewhat of a mystery.

South Africa could also benefit from the Songai farming method, with adaptations where necessary. Water is not as abundantly available in South Africa as in Benin but in parts of the country, e.g. KwaZulu/Natal, the system could be introduced. Songai is more than willing to co-operate and support South Africa in such an endeavour. Closer ties should be fostered with Songai and experience and knowledge shared where possible. (Songai is particularly interested in the use of solar panels for electricity generation and requested information from the project team.)

Lastly, South Africa could learn much from Songai in the management of foreign aid. Songai was very particular in choosing which organisations' aid would be accepted. If the organisation's development aims or requirements could not be reconciled with those of Songai, Songai elected to forfeit the aid and could rather go it alone than sacrifice what it believed in. South Africa needs to be and stay in charge of its own development destiny and not prostitute its vision of development for a few foreign aid dollars. The possibilities of introducing the Songai concept in South Africa is very positive and could contribute to the achievement of attaining the goal of sustainable rural development in South Africa.

A meeting with the Special Adviser to the Minister of Energy and Mining in Benin, Mr Hessouh, and his staff was also arranged to discuss the energy situation in South Africa and Benin.

Wood, mainly in the form of charcoal, is the main source of energy for cooking in Benin. Space-heating is not a requirement, due to the climate. Attempts are being made to promote agroforestry, especially the planting of the *Luceniea* species. Trees are considered to be very important. Land-owners will rent their land, although the products of the trees situated on this land remain their property.

Paraffin is the most important commercial fuel and is utilised for cooking and lighting. Paraffin is sold as "gazoline" or "gaz" at petrol stations. Paraffin is imported from Nigeria at ± 1000 CFA/litre (about 80c). Officials and most other people questioned were not aware of problems surrounding paraffin poisoning in children due to ingestion. Paraffin fridges are used in clinics.

More than 80% of electricity is imported from Ghana where it is generated by means of hydropower. It is envisaged that Benin will erect its own power station in two year's time. Electricity is mainly used for lighting, fans, radio and television. It is considered expensive and cost ± 70 CFA/kWh. Government representatives were interested in renewable energy technologies and discussed developments in this area in South Africa at length.

In an attempt to improve the quality of life of rural people through electrification and as a result of the official Beninese visit to South Africa in 1993, Benin has embarked on a solar energy demonstration programme. The aim of the programme is to supply 5 000 villages with solar power within 10 years. Four villages have been supplied with solar power to date. The project is solely financed by the Government with no foreign aid or investment.

The first solar demonstration village to be supplied was Sedjé Demon, situated 30 km from Cotonou. The project supplies power for streetlighting, lighting for a community- or cultural centre and public school, as well as for operating the radio, television and fridge for bar facilities in the community centre. This is to facilitate income-generating activities. The village market-place was also supplied with lighting and the local clinic with a fridge and sterilisation equipment. Solar water pumping facilities were also provided. The total cost of the project amounted to 70 million CFA (R500 000).

Villages were approached to participate in the project. The systems were installed for free but each household in the village has to pay 100 CFA (80c) per week. Technical committees were established in the villages which were responsible for the maintenance of the system through a technical team. People were also trained to wash the solar panels and to keep them free of dust. The installation of the PV panels was done by a private local company, currently the only company of its type in Benin. A battery charging centre was established in one of the villages and solar lamps are also rented out. Opportunities for income-generating activities have therefore been explored and pursued.

Plans are afoot to extend these systems to provide electricity to private homes. Households will have to pay for the extension of the system. Funding possibilities from the World Bank and EU are currently being investigated. Villages are very eager to participate in the project and one village, 600 km north of Cotonou, managed to collect 11 million CFA for the project - a very substantial amount for a rural village!

Visit to wetlands and peat deposits

The project team, accompanied by officials from OBEMINES (equivalent to our Geological Survey), visited the various wetlands and peat deposits in the vicinity of Cotonou. Benin has just recently completed the mapping of its peat resources. No exploitation of the resource occurs on a large scale at the moment, but communities are already utilising peat for vegetable production. OBEMINES, however, proceeded with the experimental briquetting of peat for burning. The project team visited the site where the briquettes were being manufactured and viewed the process. However, utilisation of the resource is being hampered by political constraints.

Possible areas of co-operation

South Africa and Benin are relatively in the same position with regard to their peat resources. Both countries need to formulate suitable policy guidelines for the sustainable utilisation of these peat resources. Measures also need to be formulated which would ensure that communities benefit from the resource, and that the process is not hijacked by big business or politicians.

Conclusion

The RDP vision[3] for the rural areas of South Africa for the next fifteen years includes:

* Freedom from poverty;
* Full and productive employment that enriches the lives of rural people;
* A more diverse agriculture, with farms of many sizes providing incomes (or part incomes) to many more people;
* More diverse commercial and service sectors in country towns and the countryside, and greater integration between towns and the rural areas, especially on market days;
* Much greater access by rural people to government support and information, and to commercial services, with a more logical spatial network of towns, services, roads and transport systems;
* Close availability to water, sanitation and fuel sources, giving everyone more time and health for economic productivity;
* Local government structures to which everyone has easy access and within which women play an equal and active role;
* Local government being linked more closely to the relevant organs of civil society and business through which are expressed the needs and priorities of the different groups of rural people;
* Dignity, safety and security of access for all, including women, to useful employment, housing and land, with people being able to exercise control over their society, community and personal lives and to plan for the future;
* Fewer, healthier, safe, well-nourished children, with access to well-resourced schools;
* A healthy and productive environment capable of sustaining the biological components upon which the many agricultural, social and cultural activities depend.

For this vision to be realised, priorities in rural development, such as energy and agriculture, need to be stressed and addressed within an integrated development approach. An agricultural training centre, based on the Songai model, could contribute to the realisation of the rural development goals and transform the rural areas of South Africa to sustainable, supporting and income-generating areas.

Acknowledgements

Thanks to Mr Willem Smuts of GENRES cc for the opportunity of visiting Benin, his patience and support during the trip. Thanks also to the DMEA for making the visit possible. Lastly, thanks to Mr AC Olivier of the DMEA for his support and valuable contributions during all group discussions.

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Energy utilisation in the domestic sector in Kumta taluk, Uttara Kannada district, Karnataka

*** T V RAMACHANDRA AND * C M SHASTRI**

The energy consumption figures for Karnataka (one of the states in India) reveal that 53,20% of total energy is met by non-commercial energy sources, such as fuelwood (43,60%), cow dung (1,40%) and agricultural residues (8,20%). On the other hand, commercial energy sources, such as coal (5,80%), oil (11,60%), kerosene (paraffin) (2,60%), liquefied petroleum gas (LPG) (0,70%) and electricity (26,10%) constitutes 46,80% of total energy. A significant part of these non-conventional energy sources caters for the domestic heating needs of the rural population (about 70-80% of the total), followed by village industries. This paper discusses the energy studies undertaken in the Sirsi and Kumta taluks of the Uttara Kannada district in India, taking into account (a) seasonal and regional variations in the quantity of fuel consumption; and (b) fuelwood and residues collected from various sources at no cost. An assessment of fuelwood savings in the utilisation of fuel efficient stoves for cooking and water heating purposes was carried out, taking into account socio-economic aspects, food habits, and cooking practices.

This study showed that about 27,45% fuel can be saved by using fuel efficient devices. Potentially, such fuel savings will help to alleviate local pressure on wood resources, shorten the walking time required to collect the fuel, reduce cash outlays for the purchase of wood, improve the kitchen environment and diminish the air pollutants released into the environment.

Keywords: sustainable development; ecological development; wood-burning stoves; micro-catchments; fuel consumption; developing countries; energy efficiency; rural energy; fuelwood; household energy

Introduction

The sustainable development or eco-development of a region depends critically on the health of its renewable resources, such as soil, water, vegetation, livestock and genetic diversity. The integrated development of all these components is essential for sustainable and environmentally sound development. Unfortunately, with the short-term perspectives in the planning process, this has led to the indiscriminate pursuit of development, which has in turn led to problems, such as the depletion of natural resources, extensive deforestation, large-scale soil erosion, siltation, floods and droughts, waterlogging and salination, the lowering of the groundwater-table, and the gradual depletion of the fertility of fields. This demands (i) a greater community participation in development programmes, (ii) working out least-cost options and extending basic services to all, before providing more elaborate services to the economically advantaged, and (iii) better management of common property resources with the active involvement of non-governmental organisations (NGOs) and institutions.

Energy has been a dynamic force in the growth and development of human society. The demand for energy is not for the sake of energy itself but for the services it provides, *viz.:* illumination, mechanical power, cooking, heating and other services that satisfy human needs. Therefore sustainable energy management is an essential part of achieving sustainable development. The main features of this energy strategy are

* satisfying basic human needs through economically efficient, environmentally sound and viable options;
* meeting the energy needs of the poor and disadvantaged groups;
* promoting energy efficiency improvements;
* beginning a transition to renewable energy sources.

Energy utilisation could have a better chance of succeeding if it is limited to perceived development priorities, such as (a) using renewable sources of energy for expanding irrigation facilities; and (b) providing alternative energy sources for cooking in agriculturally prosperous and biomass-scarce areas. Biogas, solar and improved chulas (wood-burning stoves are also referred to as chulas) are obvious options which would cater for the needs of the local people. Apart from these, the development of rural industries that utilise energy from renewable sources are an effective option not only as a suitable resource but also in the creation of employment for the local population.

Thus the energy strategy set out in this paper is based on a detailed look at how energy is used, rather than on the traditional preoccupation with energy supply and aggregate demand. With this approach the planning process considers (a) the end-uses of energy or the energy services performed, such as cooking, lighting etc.; and (b) technical and economic details of present and alternate end-use devices, e.g. stoves, lamps etc. It is suggested that this would help in meeting future energy requirements for energy services. These may be broadly classified as:

* more efficient end-use devices e.g. cooking stoves, water heating systems, boilers, cars, efficient motors;
* new supply options, e.g. those using renewable and decentralised resources, such as the development of solar, wind, small-hydro resources for energy which are not considered in conventional centralised energy planning.

Under the eco-development programme of the Western Ghats region, the dissemination of fuel efficient stoves (2-pan and 3-pan) was undertaken with the objective of fuelwood/forest conservation, elimination of smoke, drudgery and health hazards particularly to women and children. The ecological improvement of the region was undertaken in the hamlets of Lukkeri, Hoskeri, Masur, Sannakuli, Kalbavi, Halasamavu, of the Kumta taluk in the Uttara Kannada district. In this paper the survey undertaken by the authors was to investigate the fuelwood requirements in rural households and the status of improved cook-stoves disseminated

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under the regional eco-development programme.

Fuel efficient cooking and water heating systems

The fuel efficient stoves disseminated by various agencies were designed and developed at the Indian Institute of Science's Centre for the Application of Science and Technology to Rural Areas (ASTRA). In these stoves, the fuel is fed into the combustion chamber through an enclosed bin, while secondary and primary combustion air enters the stove through openings above and below the grate. Hence, by separating the fuel- and air inlets, the supply of combustion air can be controlled. Water boiling tests have shown that the size of the air inlets, the distance between the grate and the first pot, and the clearance for hot gases under the second and third pots are critical design parameters. These designs were optimised on the basis of fuel efficiency and additional measures, such as insulating the inside of the stove with a mud-rice husk mixture, were incorporated. As a part of the eco-development programme, dissemination of fuel efficient stoves was undertaken in the nine hamlets in the Kumta taluk to conserve and optimise the fuelwood in the area and hence, arrest the rate of deforestation due to exploitation through growing population demand. It was hoped that this would also assist in improving the kitchen environment and hygiene. Promotion of these stoves on a large scale would not only create jobs for local unemployed youths but also provide avenues for the use of local materials and skills.

In order to disseminate fuel efficient stoves for cooking and the heating of bath water, a meeting with the villagers was organised, followed by the training of a few youths to build the stoves. The stoves were constructed in the homes of those who originally responded to the authors' programme. The cost of the stove construction materials, etc. were met entirely out of the funds earmarked for the eco-development programme. Fuel gathering for domestic use and the raw materials for the forest-based industries were identified as the major causes of deforestation which is clearly evident from the barren hilltops. This has resulted in a low rate of return of crop residues and dung to the soil. Existing biomass use patterns by households and industries were found to be unsustainable in these areas. This is what prompted the authors to embark an examination of ways and means to improve end-use efficiency in cooking and the afforestation of the barren hilltops to a more sustainable level.

Objectives

The specific objectives of this study are therefore:

(1) to determine seasonal and regional variations, if any, in the fuel consumption of households;

(2) to determine the efficiency of water heating systems;

(3) to determine the factors influencing the acceptability of improved cookstoves;

(4) to estimate the daily per capita consumption of fuelwood for cooking and water heating in the villages;

(5) to examine the amount of fuel saved and hence, time saved for women in terms of fuelwood collection by switching to the improved stoves for cooking and water heating;

(6) to identify the problems faced by those families using traditional (conventional) stoves and the improved stoves/chulas.

> "A planning approach based on significant social input, and in which the beneficiaries of any proposed intervention have been comprehensively involved, will have greater and more sustainable benefits. Such an approach would therefore have its roots at the micro-level and any interventions planned in this way would provide a platform for the integration of related developmental goals. The household energy sector, being closely related to both the grassroots and national planning levels, offers great potential for this micro/macro integrated approach based on strong social contributions."

Materials and methods

The survey was carried out in different stages.

(1) In order to determine regional variation in fuelwood consumption, the survey was undertaken by means of a questionnaire in 42 villages of the Kumata taluk (representing a coastal region) and 22 villages in the Sirsi taluk (representing a hilly region) of the Uttara Kannada district, Karnataka state. This study also attempted to determine seasonal variations by collecting data from the same households in each of the seasons in order to ascertain whether there is any seasonal variation in energy consumption.

(2) The thermal efficiency of water-heating stoves in bathrooms was determined by a water heating test in 15 households. The heat gained by 50 litres of water was measured by burning a measured quantity of wood. The heat from the water varied from 27°C to 44°C.

(3) Out of the 404 households in the Masur village in the coastal belt of Western Ghats, 118 households were randomly selected. Data were collected pertaining to (a) the type of stoves used; (b) the type of fuel used; (c) the mode of collection/ procurement of fuelwood; (d) cooking time, (e) energy requirements for cooking.

In order to assess the quantity and type of fuel used, types of cooking devices used, a survey was conducted, by means of a questionnaire, of the stratified random sample of 118 households from the six hamlets of Masur village. The actual quantity of fuel required for one day's cooking was weighed beforehand as well as the fuel left over, using a single pan balance of 50 gm accuracy. This experiment was conducted in the sample households over four consecutive days (that is, three days cooking data), in order to take into account the day-to-day variations in

SIRSI						
	Fuel type	Summer	Winter	Monsoon	Year Avg.	Std.dev.
Cooking	Fuelwood	0,80	0,94	1,25	1,00	0,19
Water heating	Mainly agric. residue & fuelwood	0,85	1,65	1,67	1,39	0,38
KUMTA						
	Fuel type	Summer	Winter	Monsoon	Year Avg.	Std.dev.
Cooking	Fuelwood	0,78	0,90	0,98	0,89	0,08
Water heating	Mainly agric. residue & fuelwood	0,60	1,20	1,40	1,07	0,34

Table 1: Daily fuelwood and agricultural residue consumption for cooking and water heating purposes (kg/person/day)

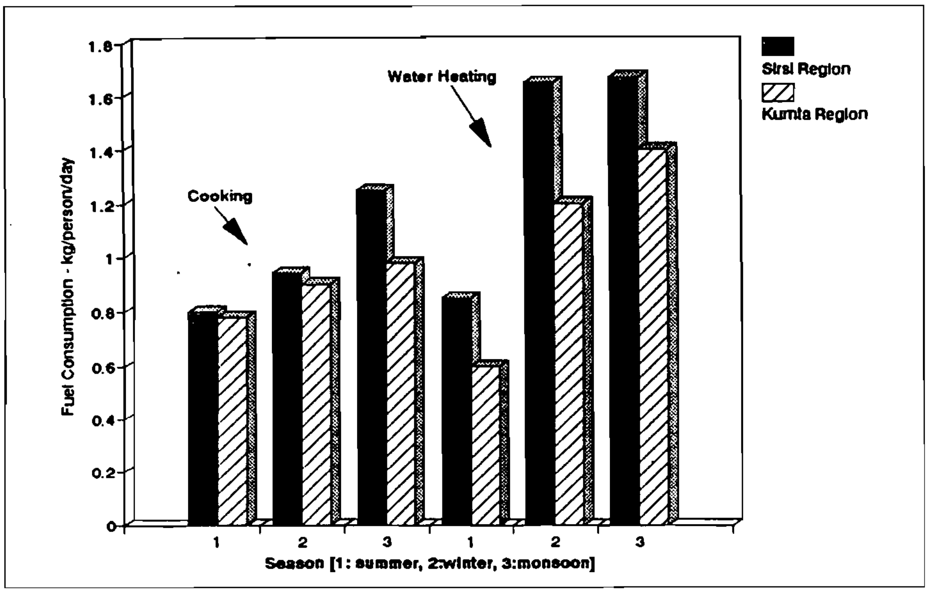

Figure 1: Seasonal variation in fuel consumption for domestic purposes

the type of food cooked, quantities cooked, etc.

The stratified random sampling technique, based on the land held by the various households, was used so as to incorporate the interrelationships within households and the use of non-conventional sources of energy. Also, the data collection in the different households was done with special emphasis on:

* consistency in the measurement of the consumption of the different types of fuels;
* inclusion of different kinds of fuels, such as twigs, branches, logs, etc.
* proper classification according to end-use, such as fuel, fodder and building materials
* time spent in the collection of these fuels by human labour
* the measurement of the efficiency of the different end-use devices.

Study area

Stage 1 of this study was carried out in the Kumta taluk (Latitude 74° 24' to 74° 45', Longitude 14° 17' to 14° 35') and the Sirsi taluk (Latitude 74° 35' to 78° 5', Longitude 14° 27' to 14° 48') of the Uttara Kannada district. In terms of bio-resource availability, Kumta and Sirsi are categorised as "scarce" and "surplus" respectively.

Stages 2 and 3 of this study were conducted in the hamlets of Sankuli, Masur, Halasmavu, Kalbavi, Hoskeri of the Masur village in the Kumta taluk. The Masur village lies approximately 4 km from the town of Kumta at 14°28' N Latitude 74°23' E Longitude. It consists of a cluster of nine hamlets on an island in the estuary of the Aghanashini river. This island is situated on a hillock at an altitude of 75 m and is surrounded on all sides by brackish water. The soils are lateritic, acidic and reddish brown in colour. The mean annual precipitation is 3 200 m, concentrated in the months of May to November. The total area in this region is 358,3 ha. with minor forest covering 103,0 ha., private grasslands 23,4 ha., upland paddy cultivates 22,3 ha., coconut groves 2,2 ha., fresh water paddies 55,3 ha., areca 2,0 ha., brackish water paddy-fields 87,6 ha., and a river course 62,5 ha.

This region has a population density of 949 per sq.km with 15 endogamous communities. The main communities are Patgars, Halakki Gouda's, Hawyak Brahmins, Ambigas and Madivals. The average land holding per family is 1,1 acres, and there are about 86 landless families.

Results and discussion

(1) *Seasonal and regional variations in the consumption of fuelwood*

The preliminary results of the survey carried out in the 42 villages in Kumta and the 22 villages in Sirsi are listed in Table 1. It is evident from this table that there is a seasonal variation in fuelwood requirements for cooking and water heating purposes. The seasonal variations in fuel consumption in the Sirsi and Kumta taluks are depicted in Figure 1.

The fuelwood requirement for cooking in the summer season is about 0,80 kg/person/day at Sirsi and 0,78 kg/person/day at Kumta. In the monsoon season the fuelwood requirement at Sirsi is 1,25 kg/person/day and at Kumta it is 0,98 kg/person/day. A significant regional variation was noted only during the monsoon season. This is mainly due to the incessant rain, and that hot food is preferred in the Sirsi region. During the winter, fuel consumption at Sirsi and Kumta are 0,94 kg/person/day and 0,90 kg/person/day respectively.

A similar variation in the fuel requirement for water heating was also noted. During the monsoon and winter seasons hot water is preferred by the villagers for bathing and for washing purposes, while in summer, hot water is used only for bathing. Hence fuel consumption during the monsoon and winter seasons is higher than in the summer season. It was also noticed that during all the seasons, fuel consumption for water heating was higher at Sirsi than at Kumta.

(2) *Efficiency measurement of stoves used for heating water*

The efficiency of stoves used for heating water in bathrooms was done by testing the heat of this water. Heat gained by the 50 litres of water was measured by burning a measured quantity of wood. The water was heated from 27°C to 44°C. The quantity of wood required, as per the experiment conducted, was found to be in the range of 0,64 kg to 1,15 kg. The thermal efficiency was found to be in the range 23,86(%)±5,21(%) (avg. efficiency: 23,86%, standard deviation: 5,21). The results are listed in the Table 2.

Household	Time (min.)	Burning rate of wood (kg/hr)	Heat utilised (kcal.)	Thermal efficiency (%)	Quantity of wood (kg)
1	27,69	2,50	921,0	19,34	1,15
2	13,20	5,09	1 609,0	19,96	1,12
3	29,25	2,35	1 656,0	19,54	1,14
4	16,05	3,12	1 430,0	26,77	0,83
5	26,23	2,35	1 458,0	21,77	1,02
6	15,76	2,59	1 725,0	32,79	0,68
7	16,49	2,89	1 135,0	28,06	0,79
8	27,04	2,64	1 100,0	18,77	1,19
9	28,09	2,28	907,5	20,90	1,07
10	13,44	3,24	1 771,0	30,80	0,72
11	12,25	3,16	2 845,0	34,60	0,64
12	15,50	3,65	1 919,0	23,66	0,94
13	28,00	2,66	1 040,0	22,88	1,02
14	28,00	3,47	1 140,0	17,35	1,21
15	35,00	2,91	1 131,0	20,69	1,09
Average		2,99		23,86	
Std.		0,69		5,21	

Table 2: Thermal efficiency and quantity of wood required (in kg's) (for heating 50 litres of water)

(3) *The cook-stoves' fuel consumption patterns*

In order to assess the quantity and type of fuel used, types of cooking devices used, a survey was conducted by means of a questionnaire in the sample of 118 households from the six hamlets of Masur village. The actual quantity of fuel required for one day's cooking was weighed beforehand and the next day the fuel left over was weighed, using a single pan balance of 50 gm accuracy. As previously stated this experiment was conducted in sample households over four consecutive days (that is, three days' cooking data), in order to take into account the day-to-day changes in the type of food cooked, quantity cooked, etc. The fuel required for cooking from these sample households is 0,835±0,225 kg/person/day (avg. value: 0,835 kg/person/day, standard deviation: 0,225 kg/person/day) in the improved cook-stoves (with a sample size of 20) and 1,151±0,65 kg/person/day (average value 1,151 kg/person/day, standard deviation: 0,65 kg/person/day) in the traditional cook-stoves (with a sample size of 98). This means that there was a saving of 27,45% in the quantity of fuelwood used by switching over to the fuel-efficient cook-stoves.

(4) *User reactions to the improved cook-stoves*

(a) Two-pan stoves were preferred by 65,2% households from the Patgar, Naik, Halakki Gouda and Ambiga communities, while 34,8% preferred the 3-pan stoves (mostly from the Hawyak Brahmin, Gouda Saraswat Brahmin and Deshbhandari communities);
(b) 31,25% of the sample households complained about the space problem in the switch to improved cook-stoves;
(c) 46,87% of the households preferred the traditional 3-pan stove despite a lack of energy efficiency with regard to space-heating, protection from insects provided by smoke, flexibility for using a wide variety of fuels in different seasons;
(d) Out of the 92 stoves constructed by various agencies, 68 stoves were disseminated by the Block Development Office and 24 stoves by the Centre for Ecological Sciences (CES) at the Indian Institute of Science. It was found that 92% of these stoves had to have their design modified to suit the vessels and cooking needs of the users.
(e) 8-10% households with thatched roofs expressed fear of fire due to the presence of the chimney in the improved cook-stoves. During use unburned particles often settle on the inside of the chimney mainly due to difficulties in maintenance and the poor durability of the chimney. These particles are highly inflammable and often pose a fire hazard.

(5) *Fuel consumption*

The average daily consumption of fuelwood in the improved cook-stoves was 0,835 kg/person while in the traditional cook-stoves, it was found to be 1,151 kg/person. A 27,45% reduction in fuelwood consumption was seen because of the switch to the improved cook-stoves. For statistical comparison of the sets of measurements for the improved cook-stoves and traditional cook-stoves, the t-test was performed and the t value computed by:

$$t = \frac{\bar{X}_{TC} - \bar{X}_{IC}}{\left[\frac{S^2_{TC}}{n_{TC}} + \frac{S^2_{IC}}{n_{IC}}\right]^{1/2}}$$

where $\bar{X}_{IC}$, S_{IC}, n_{IC} are the mean standard deviation and number of households (tests for improved cook-stoves), while $\bar{X}_{TC}$, S_{TC}, n_{TC} represent the mean standard deviation and number of households using traditional cook-stoves. The computed t value was compared to values in student t-tables to determine if the mean from one group is significantly greater than the mean of other.

The t-table is used by comparing the calculated t value to the numbers in the table at the appropriate degrees of freedom. It can be said that the mean from one group of tests is greater than the mean from the other at a certain level of significance if the computed t value is greater than the number in the table at that level.

(a) Improved cook-stoves (ICs)			
Community type	**No.of h/holds**	**Fuel consumption (kg/person/day)**	
		Avg.	**Std. deviation**
Halakki Gouda (Gouda)	3	0,907	0,145
Hawyak Brahmin (Brahmin)	1	0,846	
Naik	2	0,877	0,017
Patgar	14	0,818	0,258
Total	20		

(b) Traditional cook-stoves (TCs)			
Community type	**No.of h/holds**	**Fuel consumption (kg/person/day)**	
		Avg.	**Std. deviation**
Ambiga	3	1,061	0,407
Hawyak Brahmin (Brahmin)	9	1,355	0,523
Deshbhandari	2	1,231	0,053
Halakki Gouda (Gouda)	15	1,137	0,483
Gunaga	4	0,955	1,346
Kodeya	2	1,453	0,216
Madval	2	1,085	0,207
Mukri	1	0,950	
Naik	5	0,908	0,358
Gouda Saraswath Brahmins (GSB)	3	1,377	0,358
Patgar	52	1,066	0,528
Total	98		

Table 3: Fuelwood consumption using ICs and TCs (by community)

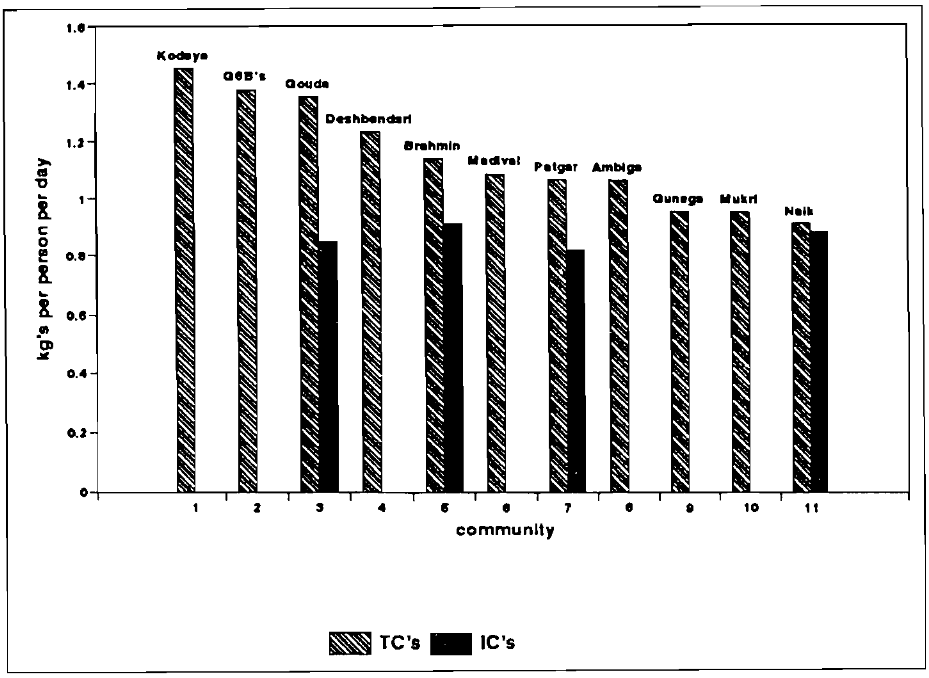

Figure 2: Community fuel consumption

The t value computed for the data from 20 households using the improved cook-stoves and 98 households using the traditional cook-stoves is 3,79. There are 116 degrees of freedom (since 118 experiments were made) and two parameters (the means for each group) were estimated. Based on the entries in the t-table at 116 degrees of freedom, the t value is greater than the number in the table at a level of significance of 0,5%. Thus this test further confirms that households using the improved cook-stoves have a higher probability of saving fuel compared to households using the traditional cook-stoves.

Confidence limits for the difference between means

The 95% confidence interval for difference in means is computed by:

$$\overline{X}_{tc} - \overline{X}_{ic} + t_{0,5\,(2),v}\, s_{X_{tc}-X_{ic}}$$

$$= (1,15-0,835) + (1,981)*(0,0829) = 0,4792$$

$$= (1,15-0,835) - (1,981)*(0,0829) = 0,1507$$

At a 95% confidence interval the difference in fuel consumption in households using traditional cook-stoves and improved cook-stoves is not lower than 0,1507 (or the probability of this difference being less than 0,1507 is 0,025).

(6) *Community fuelwood consumption*

In order to examine the variation in fuelwood consumption patterns, if any, data were further analysed, based on the community, number of persons in each house, and type of fuel used. Table 3 lists community fuelwood consumption. The authors found that only four communities used the improved cook-stoves in these villages. It can be seen that the Patgar community using the improved cook-stoves has an average fuel consumption of 0,818 kg/person/day (standard deviation 0,258 kg/person/day) and that households using traditional cook-stoves have a fuel consumption of 1,066 kg/person/day (standard deviation 0,528 kg/person/day). This means that there is an average saving of 23,18% in fuel consumption by using the improved cook-stoves.

(a) The average fuelwood consumption among Patgars using traditional cook-stoves was 1,066 kg/person/day, while for the improved cook-stoves it was 0,818 kg/person/day. The t-test was performed on 14 Patgar households using the improved cook-stoves and 52 households using traditional cook-stoves respectively. The t value computed was 2,46. From the t-table for 64 degrees of freedom, this is greater than the number in the table at the level of significance of 1% but less than 0,5%. The change in average values for the improved cook-stoves and traditional cook-stoves respectively, and the lower mean for the improved cook-stoves indicates that there is scope for fuel-saving with these stoves.

(b) The average fuelwood consumption among the Halakki Gouda using traditional cook-stoves is 1,137 kg, while for those using the improved cook-stoves it is 0,907 kg. The t-value computed for the data collected for the three households using the improved cook-stoves and fifteen households using traditional cook-stoves is 1,53. For the degrees of freedom of 16, the computed t value is greater than the t-table value at the level of significance of 10% but less than the number at 5%.

The series of statistical tests for the various communities further indicates the scope for savings in fuelwood if improved cook-stoves are used. A community percentage for fuelwood saving by switching over to the improved cook-stoves is 20,25% for the Halakki Gouda, 23,18% for the Patgars and 37,52% for the Brahmins. Figure 2 shows the community breakdown of fuelwood consumption for the improved cook-stoves and traditional cook-stoves respectively.

(7) *Number of persons per household*

A scatter plot of per unit fuel consumption versus number of persons per household shows the declining trend both for the households using traditional cook-stoves (Figure 3) and improved cook-stoves (Figure 4), with an increase in the number of persons per household. A regression analysis was carried out of the data collected from (for 3 days' cooking) the 98 households using traditional cook-stoves and the data collected from 20 households (3 days' cooking) using the improved cook-stoves. Based on a good correlation coefficient and the lowest percentage error, the linear relationship between the variable PCFC (per capita fuel consumption/day) and P (no. of persons per household) was found to be the best relationship.

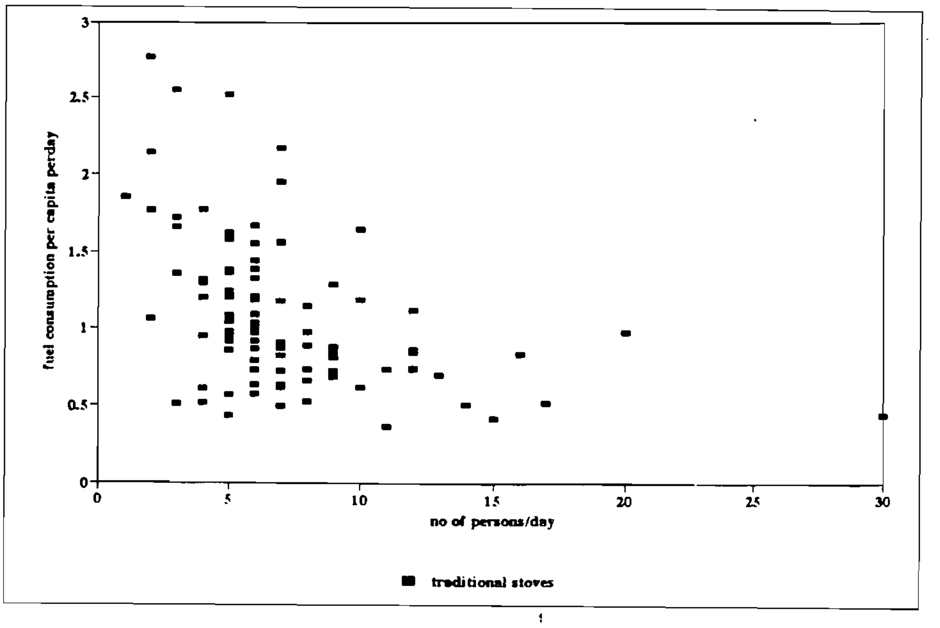

Figure 3: *Per capita fuelwood consumption (using traditional cook-stoves)*

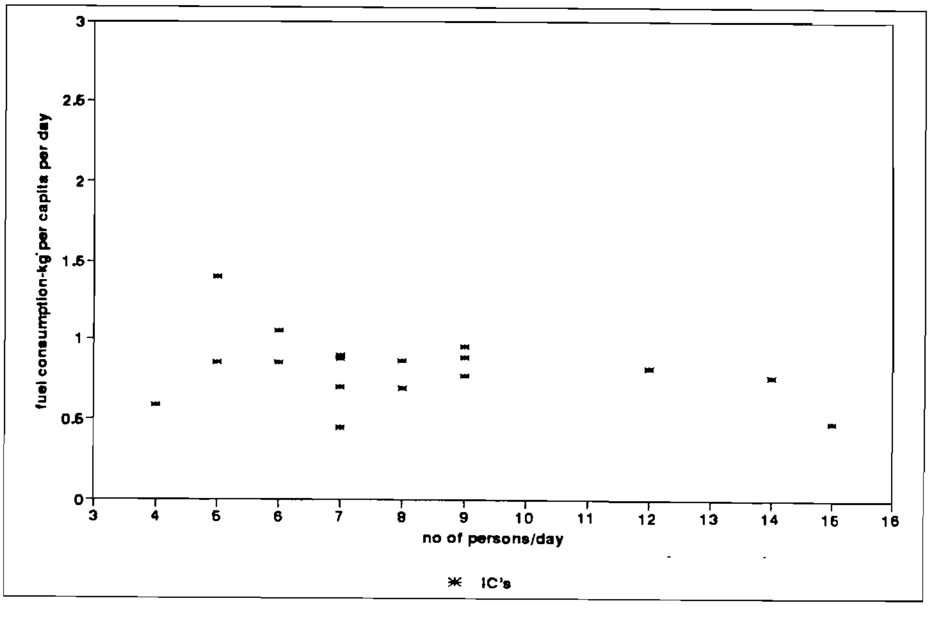

Figure 4: *Per capita fuelwood consumption (using improved cook-stoves)*

The relationship for the households which used the improved cook-stoves is:

$(PCFC)_{IC} = 0,9368 - 0,012\ (P)$, where P is the number of persons/household,

with $R^2 = 0,442$, $R = 0,665$, % error of Y estimate = 13,42, n = 60 (3 days data from the 20 household sample).

Y = dependent variable, in this case Y = PCFC.

With the partial removal of scatter (removing scatter points beyond the range [Avg ±(1)Sd], PCFC for the improved cook-stoves is:

$(PCFC)_{IC} = 0,8416 - 0,0106\ (P)$, where P is the number of persons/household, with $R^2 = 0,542$, $R = 0,735$, % error of Y estimate = 9,42.

For the traditional cook-stoves: PCFC is given by : $(PCFC)_{TC} = 1615,53 - 65,92\ (P)$, with $R^2 = 0,516$, $R = 0,72$, n = 296 (3 days data from the 98 household sample), % error of Y estimate = 8,68.

With the partial removal of scatter, PCFC for traditional cook-stoves is: $(PCFC)_{TC} = 1509,50 - 56,40\ (P)$, with $R^2 = 0,594$, $R = 0,77$, % error of Y estimate = 6,67.

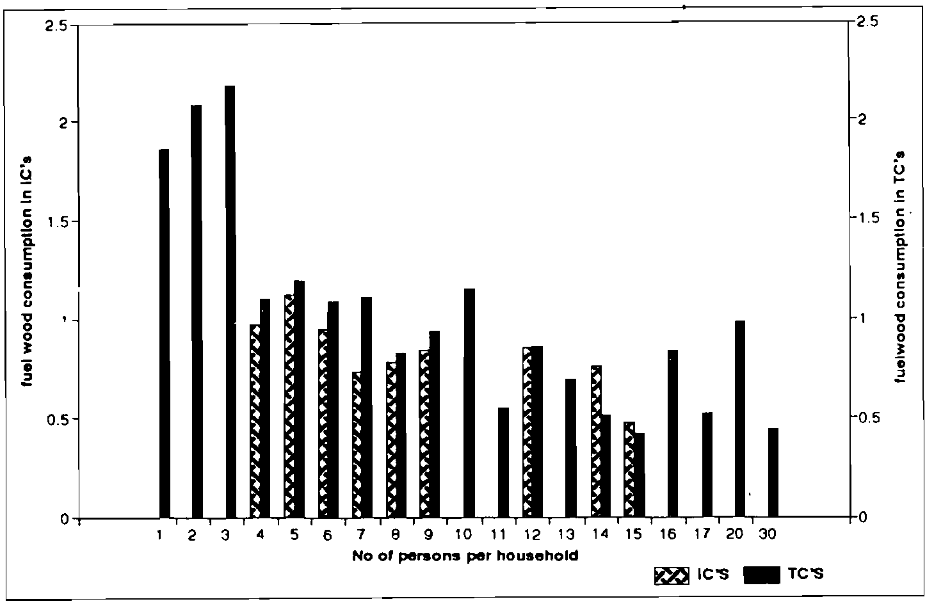

Figure 5: *Per capita fuelwood consumption in improved cook-stoves and traditional cook-stoves*

(a) Improved cook-stoves

No. of persons per household	No. of h/holds	Fuel consumption (kg/person/day)	
		Avg.	Std. deviation
15	1	0,473	
14	1	0,757	
12	2	0,852	0,233
9	4	0,84	0,079
8	2	0,775	0,084
7	4	0,727	0,18
6	2	0,948	0,101
5	3	1,122	0,083
4	1	0,967	
Total	20		

(b) Traditional cook-stoves

No. of persons per household	No.of h/holds	Fuel consumption (kg/person/day)	
		Avg	Std. deviation
30	1	0,437	
20	1	0,977	
17	1	0,515	
16	1	0,837	
15	1	0,415	
14	1	0,507	
13	1	0,692	
12	5	0,858	0,139
11	2	0,550	0,182
10	3	1,150	0,420
9	7	0,931	0,232
8	6	0,822	0,204
7	13	1,104	0,514
6	20	1,083	0,292
5	15	1,191	0,453
4	7	1,095	0,406
3	7	2,175	1,500
2	5	2,076	0,623
1	1	1,850	
Total	98		

Table 4: *Fuelwood consumption (in kg/person/day) - based on number of persons per household*

These results reveal that with cooking for large numbers of persons, the per capita fuel consumption per person decreases both in traditional cook-stoves and the improved cook-stoves. This observation of decrease in per capita fuel consumption as the number of persons in the household increases is due to the coefficiencies of cooking and water heating that results from increasing the scales of cooking and water heating. Hence, the proper design of the stoves and the correct vessels being used in relation to the number of persons in household are the other essential parameters in bringing down fuelwood consumption. Table 4 lists fuel consumption in improved cook-stoves and traditional cook-stoves based on number of persons per household. It can be seen that fuel consumption in improved cook-stoves is lower than that for traditional cook-stoves. For example, for a household consisting of 4 persons, fuel consumption in a traditional stove is 1,095 kg/person/day and in an improved cook-stove it is 0,967 kg/person/day (Figure 5). One of the purposes of this study is to determine the impact of large families and small families on fuelwood consumption. Figure 5 illustrates that the average values of per capita fuel consumption per person per day required for both improved cook-stoves and traditional cook-stoves declines with an increase in the number of persons per household.

(8) *Type of fuel used*

Table 5 lists the fuel consumption in the improved cook-stoves and traditional cook-stoves based on the type of fuelwood used. Improved cook-stoves also have better fuel utilisation compared to traditional cook-stoves. The difference in the level of fuel consumption is evident in households using a species like *Terminalia paniculata* (traditional cook-stoves: 1,093, improved cook-stoves: 0,765), *Memecylon umbellatum* (traditional cook-stoves: 1,231, improved cook-stoves: 0,786).

From these results it is evident that fuel consumption in the improved cook-stoves is significantly lower than that of traditional cook-stoves irrespective of various parameters such as, (a) community, (b) number of persons per household, and (c) type of fuel used.

Integrated planning

From the above discussion, it is evident that the integrated approach involves:

(a) research to understand the socio-cultural setting;

(b) orientation around the expressed needs of the community;

(c) participatory project design and implementation, with links between the laboratory and field, such as, improving the living conditions of the rural community through

* conserving fuelwood energy by means of using improved cook-stoves;
* increasing fuelwood, food and fodder supply through polyculture of specific tree species which cater for the needs of the local people;
* decentralised production of alternate devices and exploitation of renewable sources of energy, such as wind, solar, etc. to reduce distribution costs, to create more local interest and employment;
* close study of a region in all aspects and ascertaining the capacity needs of that region, targets to implement various programmes are to be fixed.

(d) consideration in social and environmental sustainability

(e) building on local skills

(f) provision of training in the required skills

(g) follow-up, monitoring and evaluation at micro- and macro-levels

(h) involving and training NGOs in the dissemination and implementation programme which would lead to environmentally sound and sustainable development. A planning approach based on significant social input, and in which the beneficiaries of any proposed intervention have been comprehensively involved, will have greater and more sustainable benefits. Such an approach would therefore have its roots at the micro-level and any interventions planned in this way would provide a platform for the integration of related developmental goals. The household energy sector, being closely related to both the grassroots and national planning levels, offers great potential for this micro/macro integrated approach based on strong social contributions.

(a) Improved cook-stoves

Species	No. of h/holds	Fuel consumption (kg/person/day)	
		Avg.	Std. deviation
Acacia auriculiformis	1	0,690	
Cinnamomum zeylanicum	1	0,846	
Artocarpus integrifolia	1	0,847	
Memecylon umbellatum	4	0,786	0,119
Terminalia paniculata	5	0,765	0,200
Eugenia jambolana	3	0,896	0,336
Terminalia sps.	2	1,021	0,264
Aporosa lindleyana	3	1,139	0,225
Total	20		

(b) Traditional cook-stoves

Species	No. of h/holds	Fuel consumption (kg/person/day)	
		Avg.	Std. deviation
Acacia auriculiformis	2	0,517	0,101
Spondias mangifera	1	1,355	
Areca catechu	1	1,661	
Caryota urens	6	0,930	0,232
Cocus nucifera	3	1,715	0,630
Cinnamomum zeylanicum	1	0,920	
Anacardium occidentale	3	0,942	0,261
Memecylon umbellatum	12	1,231	0,764
Terminalia paniculata	23	1,093	0,471
Pterocarpus marsupium	1	1,384	
Terminalia sps.	13	0,985	0,271
Xylia xylocarpa	1	0,988	
Dillenia pentagyna	1	1,904	
Careya arborea	1	2,550	
Mappia oblonga	1	0,608	
Careya arborea	1	0,722	0,227
Mangifera indica	9	1,170	0,389
Eugenia jambolana	14	1,503	1,120
Ochrocarpos longifolius	2	0,709	0,076
Cocus nucifera	2	0,892	0,165
Total	98		

Table 5: Fuel consumption (based on type of fuelwood) (in kg/person/day)

Conclusions

The energy survey carried out in the 42 villages of the Kumta taluk and the 22 villages of the Sirsi taluk reveals that there is seasonal variation in the quantities of fuel consumed for domestic purposes, such as cooking and water heating. Fuel requirements for cooking in the Sirsi and Kumta taluks during the summer season are 0,80 and 0,78 kg/person/day respectively, while during the monsoon season they are 1,25 kg/person/day (for Sirsi) and 0,98 kg/person/day (for Kumta). For water-heating purposes, the range is 0,85 kg/person/day (during summer) - 1,67 kg/person/day (during the monsoon season) for Sirsi. For the Kumta taluk, the range is 0,60 kg/person/day (during summer) - 1,40 kg/person/day (during the monsoon season).

It is evident that by using the fuel efficient stoves for cooking, about 27,45% of rural energy could be saved. The average fuel needs for cooking, based on the sample households, is 0,835 kg/person/day in the improved cook-stoves and 1,151 kg/person/day in the traditional cook-stoves. Even with different cooking patterns among the various communities and variations in the number of persons per household, it was found that a significant amount of fuelwood was saved by using the improved cook-stoves.

Training and service back-up are the serious constraints in the dissemination of alternate devices using renewable sources of energy. Setting up technical centres (at taluk level) under the District Industries Centre to train unemployed youth and provide service back-up in the villages, would assist in providing employment for rural youths. By providing better training, technical back-up, propagation of information regarding the improved cookstoves, their operation, maintenance and the highlighting of their advantages through the various mass media (e.g. television, regional newspapers and magazines) would further assist in the success of these programmes. This in turn helps in the conservation of fuelwood and hence, the eco-development of the region.

Acknowledgements

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Comments on the Symposium on Power Sector Reform held in Johannesburg, South Africa, 5-7 December 1995

* S MUJAKACHI

The desirability, feasibility and potential benefits of electric power sector restructuring and efficiency improvement were the main themes of the symposium held by the World Bank and other co-sponsors at the Eskom Conference and Exhibition Centre in Johannesburg from 5-7 December 1995.

The symposium was opened by South Africa's Public Enterprises Minister, Stella Sigcau, and Eskom's Chairman, John Maree, and was attended by ministers as well as other high-ranking officials representing African Ministries of Finance and Energy, Chief Executives and representatives of international electric utilities, and a number of private sector executives. Mr Christopher Bam, Vice-President of the International Finance Corporation, delivered the inaugural address.

In her opening address, Minister Sigcau stressed that power sector reform is critical to the economic success of Sub-Saharan Africa. In dealing with such a process, one of the biggest challenges facing the country is the question of how public enterprises can be transformed, deliver more higher quality products and services, and improve access to electricity. Minister Sigcau stated that world-wide there is a strong correlation between electricity usage and economic success. Electrical power plays a pivotal role in the development and expansion of any modern economy. Therefore the need for co-operation between Government, the private sector and electric utilities, and co-operation on a regional basis is becoming increasingly important. The importance of such regional co-operation cannot be overemphasised, and thus the concept of a Southern Africa Power Pool (SAPP) is vital for the economic growth of the region.

Dr Maree stated that as Southern African utilities become aware that to survive they need to be competitive, they have realised that they cannot operate as islands, as the synergies that can be developed and exchanged could benefit all. Over the years, this has resulted in some utilities interconnecting their infrastructure to exchange and trade in electricity. The SAPP has added value for co-operation in the SADC countries and a number of cross-border connections have already been made and more are now being made for the interconnection of their respective national grids.

> "... power sector reform in Sub-Saharan Africa is welcomed, particularly where evidence shows that it will promote competitiveness and productivity. Present legal instruments governing the activities of the power sector would need to be modified so as to cater for the new business structure. The legal framework should facilitate a new environment conducive to accommodating an increased number of power players either competitively or co-operatively."

Dr Maree emphasised that power sector reform in Sub-Saharan Africa is welcomed, particularly where evidence shows that it will promote competitiveness and productivity. Present legal instruments governing the activities of the power sector would need to be modified so as to cater for the new business structure. The legal framework should facilitate a new environment conducive to accommodating an increased number of power players either competitively or co-operatively. Power utilities need to be entrusted with full accountability and responsibility to ensure that business is not compromised. The primary objective of any reform should focus on technical issues, efficiency improvement and reinforcement of tight management of electricity companies. As a result the enhanced levels of performance of electric utilities could result in the private sector contributing to the development of the region.

Mr Richard Stern, Director of the World Bank's Industry and Energy Department, said that experience in developing countries pointed towards meaningful reform in the power sector as the key to mobilising private sector funds for appropriate investment in power generation plants and distribution systems. The objective must be to address the generally inefficient performance of the power sector in Africa, where plant availability is inadequate, technical and non-technical losses are unacceptably high, return on assets is low, tariffs do not cover costs, and collection rates tend to be low while receivables are high compared to world standards.

These related problems on the cost of production and on utilities' revenues mean that profitability has been low for many utilities. The lack of profitability means that utilities are (a) not able to self-finance investment; (b) not able to raise commercial borrowing; and (c) not able to sign long-term contracts, that is, generation on a BOO basis, without government or other guarantees. The power sector thus tends to have two linked sources of inefficiency to its operation. Firstly, the direct involvement of

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governments in price-setting places a barrier to financial viability and hence to investment, either by the state industry itself or by the private sector. Secondly, the structure of the industry provides little competition and few direct incentives for efficiency. Therefore, this tends to reinforce the problems created by financial weakness.

The Symposium addressed five main themes:

* Issues and options for power sector reform;
* Design of power sector reform programmes;
* Performance improvement of electric power utilities;
* Mobilising financing for power sector development;
* Beyond the reform debate: Issues and challenges.

Some of the key success factors that emerged from the three days of discussion were as follows:

* Africa's power sector challenges require "home grown" solutions. It is vital that there should not be the presumption that a single model of reform will work well for every country.
* It is important that an enabling environment be developed within which both domestic savings and foreign capital can be sourced for investment in the power sector.
* In the long term, inefficient subsidising is unsustainable and almost always amounts to higher income households. The objective must be to do away with general subsidies and to target subsidies at the poorer sectors of society.
* Improving people's access to power in rural areas must become a top priority. Innovative solutions, such as the promotion of locally owned, decentralised power companies, for example, photovoltaic power, must be sought to make power available on an efficient basis to areas remote from existing power grids. It was pointed out that there exists a clear demand for electricity in remote rural areas and that customers were prepared to pay the real economic cost of access to electricity, provided that they could enjoy a reliable service.
* Power trading and regional interconnection should be key elements of a meaningful reform programme in Sub-Saharan Africa. In addition, capital available for power sector investment could be channelled towards developing an interconnected distribution system. Therefore, power trade between countries has the potential for realising significant investment savings and benefits for the countries involved.

There was a broad consensus that governments must gradually shift their emphasis away from owning power assets to one of facilitating investment in energy through private power companies and rural co-operatives.

* The World Bank could play a catalytic and facilitating role in the power sector reform process by, *inter alia*
  (i) promoting reform and the consideration of new options in those countries which have yet to embark on a reform path;

  (ii) developing credit enhancement instruments to mobilise debt financing and provide comfort to private partners and investors, for example through limited guarantees on specific risks, in addition to directly funding investments.

* Energy balances in South Africa

The Energy Research Institute undertook a project to construct energy balances for South Africa for the periods 1970 to 1993. During this process it was found that there were insufficient up-to-date published energy statistics for the compilation of complete annual energy balances. Although the infrastructure for the collection of energy statistics in South Africa already exists, there needs to be a substantial improvement in the collection of final consumption figures. Currently, except for coal, detailed sectorial breakdowns under the Standard Industrial Classification of All Economic Activities (SIC) codes for final energy consumption have not been collected. It was recommended that future consideration of the aspect is essential if detailed annual energy balances are to be constructed. Further details regarding the need for the collection of energy statistics and the methodology used in this project are gives below. The energy balances constructed for the years 1990, 1991, 1992 and 1993 are included (Figures 1, 2, 3, 4).

Introduction

The detailed examination of energy flow in a country is an important prerequisite for understanding the functions and interrelationships of the energy economy. This requires a comprehensive, consistent and reliable series of statistics on all energy commodities. The systematic compilation of these data, in the form of a balance sheet, is essential to reveal the complete range of energy activities from production, through trade and conversion to end-use. An annual series of such energy balances can reflect the present situation, as well as past evolution, of the energy economy. Based on this information, a realistic scenario of future energy requirements and availability can therefore be constructed. This offers a vital tool for decision-making and policy formulation concerning the national development and management of energy resources.

In South Africa, energy statistics are collected by the Central Statistical Service (CSS), the Department of Mineral and Energy Affairs (DMEA), Eskom and other energy-related organisations. *South African Energy Statistics No.2*[1] of the Department of Mineral and Energy Affairs is so far the most comprehensive statistical publication produced and is based on statistics compiled by the relevant organisations. Despite this extensive information on energy statistics, pertinent and comprehensive national energy balances are still not available.

Although energy balances for South Africa are published and updated annually by the International Energy Agency (IEA)[2], it is known that there are deviations in the balances. The local compilation of the energy balance is, therefore, indispensable.

Up-to-date published energy statistics for coal, oil, gas and electricity from 1970 to 1993 have been used to compile energy balances for South Africa along the lines of the IEA's energy balance format. Energy data were essentially obtained from local publications. During the data collection process, it was revealed that present published statistics are inadequate to compile overall energy balances. Despite these shortcomings, basic energy balances from 1970 to 1993 have been compiled, as far as possible based on these readily available statistics. Although these are only partial balances, they do, however, provide the basis for further compilations.

Methodology

The methodology used in the construction of the energy balances for South Africa is, in principle, the approach used by the International Energy Agency (IEA) in the production of their *Energy Balances of Non-OECD Countries*[4]. The adoption of this international approach allows for both national reference and comparison with other countries.

Energy sources

In the energy balances, a distinction has been made between primary energy and secondary energy production. Primary energy sources are those energy sources that are not subject to any transformation. Among the primary sources, there are anthracite and bituminous coal, crude oil and natural gas. Nuclear and hydropower generation are also considered to be primary energy sources. Secondary energy sources are the outputs of the transformation processes. Oil products, gas and electricity generation are the main secondary sources in South Africa. Renewable energy sources, such as fuelwood, bagasse, charcoal and wood waste, are not included in the energy balances. For example, based on published statistics, in 1993 renewable energy accounted for 20% of the total final energy consumption in South Africa.

Format

The energy balances have been produced in the same format as those of the IEA. The three main sections in the balance are as follows: (i) production, (ii) transformation and (iii) final consumption.

(i) Production - this shows the elements of supply and total requirements;

(ii) Transformation - this indicates all secondary energy production and the amount of energy lost through the transformation process;

(iii) Final consumption - this shows the local sectorial consumption by end-use. This sectors are the same as those classified in accordance with the International Standard Industrial Classification of All Economic Activities (ISIC)[3]. For the locally published statistics the local SIC was used, which is compatible with the ISIC.

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* Summarised from: Wong C T and Dutkiewicz R K, Energy balances in South Africa: 1970-1993. November 1995. Energy Research Institute. ERI Report No. GEN 176.

Energy Balance Sheet (Unit: ktoe)

South Africa 1990

	Coal	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Electr	Total
Indigenous Production	137655.4				1995.6	231.2		139882.3
Imports		14191.3	696.1				23.0	14910.4
Exports	-29660.4		-897.7				-138.2	-30696.3
Intl. Marine Bunkers			-1822.9					-1822.9
Stock Change	?	3558.2		?				3558.2
TOTAL ENERGY REQUIREMENT	107995.0	17749.6	-2024.4	0.0	1995.6	231.2	-115.2	125831.7
Returns and Transfers								0.0
Statistical Differences	357.6	-3968.8	-103.0	-6.0	0.0	0.0	-546.2	-4266.3
Gas Works	-2337.9			505.9				-1832.0
Petroleum Refineries		-13780.8	12748.4				?	-1032.4
Liquefaction	-16937.6		4405.5				-791.1	-13323.2
Oil from Natural Gas			0.0					
Public Service Electricity	-42460.0		?		-1995.6	-231.2	14223.1	-30463.8
Autoproducers of Electricity	-3295.9		?			?	..	-3295.9
Other Transformation								0.0
Own Use	-233.2			?			-1153.6	-1386.8
Distrib. and Transf. Losses	-26708.1			?			-912.6	-27620.7
TOTAL FINAL CONSUMPTION	16379.9		15026.5	499.8	0.0	0.0	10704.4	42610.6
TOTAL INDUSTRY	9296.7		1459.2	457.8	0.0	0.0	7520.7	18734.3
Iron and Steel	4033.3						1260.7	5294.0
Chemical and Petrochemical	967.3						685.2	1652.4
(of which: Feedstocks)								0.0
Non-Ferrous Metals	1517.7						463.4	1981.0
Non-Metallic Minerals	1328.0						113.2	1441.1
Transp. Equip. and Machinery							12.8	12.8
Mining and Quarrying	270.6		326.3				2818.0	3415.0
Food and Tobacco							30.4	30.4
Paper, Pulp and Printing							96.5	96.5
Wood and Wood Products							18.1	18.1
Construction								0.0
Textile and Leather							31.7	31.7
Unspecified	1179.8		1132.8	457.8			1990.7	4761.1
TOTAL TRANSPORT	41.2		10502.4	0.0	0.0	0.0	341.0	10884.6
Air			753.0					753.0
Road			9749.4					9749.4
Rail	41.2						341.0	382.2
Internal Navigation								0.0
Unspecified								0.0
TOTAL OTHER	4454.7		1742.2	18.1	0.0	0.0	2842.7	9057.7
Agriculture	27.9		1005.8				313.0	1346.7
Commerce	2795.4						29.2	2824.7
Public Services	254.5						778.5	1033.0
Residential	1376.9		736.4	18.1			1722.0	3853.3
Unspecified								0.0
Non-Energy Use	2587.3		1322.7	24.0				3934.0
MEMO ITEMS:								
Electricity Generated (GWh)	*155416*				*8934*	*1035*		*165385*
Public	*155416*				*8934*	*1035*		*165385*
Autoproducers	..					*?*		*0*

Keys:- ? data not available

.. breakdown not available but included in other category

___ estimated or partial data

Figure 1: South Africa: Energy Balance - 1990

Energy Balance Sheet (Unit: ktoe)

South Africa 1991

	Coal	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Electr	Total
Indigenous Production	138579.4				2165.6	447.9		141192.9
Imports		12625.6	616.8				21.8	13264.2
Exports	-29420.7		-930.0				-161.7	-30512.5
Intl. Marine Bunkers			-1873.0					-1873.0
Stock Change	?	2347.9		?				2347.9
TOTAL ENERGY REQUIREMENT	109158.7	14973.4	-2186.3	0.0	2165.6	447.9	-139.9	124419.5
Returns and Transfers								0.0
Statistical Differences	1207.9	-862.2	210.8	-1.1	0.0	0.0	-582.8	-27.3
Gas Works	-2345.8			558.3				-1787.5
Petroleum Refineries		-14111.2	13063.3				?	-1048.0
Liquefaction	-16212.6		4790.4				-791.7	-12213.9
Oil from Natural Gas			0.0					
Public Service Electricity	-42257.5		?		-2165.6	-447.9	14475.2	-30395.8
Autoproducers of Electricity	-3254.8		?			?	..	-3254.8
Other Transformation								0.0
Own Use	-234.8			?			-1179.6	-1414.4
Distrib. and Transf. Losses	-29960.0			?			-937.0	-30897.0
TOTAL FINAL CONSUMPTION	16101.1		15878.2	557.3	0.0	0.0	10844.3	43380.8
TOTAL INDUSTRY	8657.4		1492.0	523.1	0.0	0.0	7627.3	18299.8
Iron and Steel	3970.3						1227.4	5197.7
Chemical and Petrochemical	880.4						771.2	1651.7
(of which: Feedstocks)								0.0
Non-Ferrous Metals	1016.1						503.0	1519.1
Non-Metallic Minerals	1179.2						102.1	1281.3
Transp. Equip. and Machinery							11.2	11.2
Mining and Quarrying	252.9		375.2				2828.1	3456.2
Food and Tobacco							31.1	31.1
Paper, Pulp and Printing							99.0	99.0
Wood and Wood Products							17.3	17.3
Construction								0.0
Textile and Leather							31.6	31.6
Unspecified	1358.4		1116.8	523.1			2005.3	5003.6
TOTAL TRANSPORT	21.7		11156.8	0.0	0.0	0.0	316.9	11495.4
Air			753.2					753.2
Road			10403.6					10403.6
Rail	21.7						316.9	338.6
Internal Navigation								0.0
Unspecified								0.0
TOTAL OTHER	4515.9		1903.6	23.6	0.0	0.0	2900.1	9343.3
Agriculture	38.5		1153.4				323.5	1515.4
Commerce	2848.2						29.6	2877.8
Public Services	226.4						801.2	1027.6
Residential	1402.9		750.2	23.6			1745.8	3922.5
Unspecified								0.0
Non-Energy Use	2906.1		1325.8	10.5				4242.4
MEMO ITEMS:								
Electricity Generated (GWh)	*156616*				*9695*	*2005*		*168316*
Public	*156616*				*9695*	*2005*		*168316*
Autoproducers	*..*					*?*		*0*

Keys:- ? data not available

.. breakdown not available but included in other category

___ estimated or partial data

Figure 2: South Africa: Energy Balance - 1991

Energy Balance Sheet (Unit: ktoe)

South Africa 1992

	Coal	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Electr	Total
Indigenous Production	132447.8				2193.6	173.1		134814.4
Imports		13998.5	884.3				28.7	14911.6
Exports	-28042.6		-1039.0				-156.1	-29237.6
Intl. Marine Bunkers			-2133.9					-2133.9
Stock Change	?	1458.3		?				1458.3
TOTAL ENERGY REQUIREMENT	104405.2	15456.8	-2288.5	0.0	2193.6	173.1	-127.3	119812.8
Returns and Transfers								0.0
Statistical Differences	1684.3	-1138.5	-684.4	-0.9	0.0	0.0	-580.3	-719.8
Gas Works	-3612.3			544.4				-3067.9
Petroleum Refineries		-14318.3	13255.2				?	-1063.1
Liquefaction	-14654.6		4906.7				-828.3	-10576.2
Oil from Natural Gas			?					
Public Service Electricity	-42565.9		?		-2193.6	-173.1	14458.9	-30473.7
Autoproducers of Electricity	-3474.9		?			?	..	-3474.9
Other Transformation								0.0
Own Use	-204.9			?			-1044.6	-1249.6
Distrib. and Transf. Losses	-26964.6			?			-761.7	-27726.3
TOTAL FINAL CONSUMPTION	14612.2		15188.9	543.6	0.0	0.0	11116.7	41461.4
TOTAL INDUSTRY	7843.6		1364.4	512.2	0.0	0.0	7413.3	17133.4
Iron and Steel	3314.7						980.3	4295.0
Chemical and Petrochemical	938.1						843.1	1781.2
(of which: Feedstocks)								0.0
Non-Ferrous Metals	820.6						518.2	1338.8
Non-Metallic Minerals	956.9						95.4	1052.2
Transp. Equip. and Machinery							11.4	11.4
Mining and Quarrying	303.4		302.8				2855.4	3461.6
Food and Tobacco							31.9	31.9
Paper, Pulp and Printing							109.0	109.0
Wood and Wood Products							14.6	14.6
Construction								0.0
Textile and Leather							32.2	32.2
Unspecified	1509.9		1061.6	512.2			1922.0	5005.6
TOTAL TRANSPORT	10.8		10832.6	0.0	0.0	0.0	305.0	11148.4
Air			874.2					874.2
Road			9958.4					9958.4
Rail	10.8						305.0	315.8
Internal Navigation								0.0
Unspecified								0.0
TOTAL OTHER	4222.7		1697.0	21.5	0.0	0.0	3398.4	9339.5
Agriculture	127.6		930.9				437.5	1496.0
Commerce	2596.5						32.6	2629.1
Public Services	219.6						833.7	1053.3
Residential	1278.9		766.1	21.5			2094.6	4161.1
Unspecified								0.0
Non-Energy Use	2535.2		1294.9	9.9				3840.1
MEMO ITEMS:								
Electricity Generated (GWh)	*157532*				*9820*	*775*		*168127*
Public	*157532*				*9820*	*775*		*168127*
Autoproducers	..					*?*		*0*

Keys:- ? data not available

.. breakdown not available but included in other category

___ estimated or partial data

Figure 3: South Africa: Energy Balance - 1992

Energy Balance Sheet (Unit: ktoe)

South Africa 1993

	Coal	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Electr	Total
Indigenous Production	133082.3				1730.9	32.6		134845.9
Imports		10262.1	396.9				8.6	10667.6
Exports	-31038.6		-1122.9				-222.7	-32384.1
Intl. Marine Bunkers			-2539.0					-2539.0
Stock Change	?	1268.7		?				1268.7
TOTAL ENERGY REQUIREMENT	102043.8	11530.8	-3264.9	0.0	1730.9	32.6	-214.1	111859.1
Returns and Transfers								0.0
Statistical Differences	2128.5	5058.7	-2835.6	-3.0	0.0	0.0	-575.2	3773.4
Gas Works	-2612.7			562.9				-2049.8
Petroleum Refineries		-16589.5	15354.3				?	-1235.2
Liquefaction	-15141.2		5062.3				-900.8	-10979.6
Oil from Natural Gas			1143.2					
Public Service Electricity	-45495.1		?		-1730.9	-32.6	15014.0	-32244.7
Autoproducers of Electricity	-2856.3		?			?	..	-2856.3
Other Transformation								0.0
Own Use	-208.5			?			-1033.5	-1242.0
Distrib. and Transf. Losses	-24126.8			?			-936.1	-25062.9
TOTAL FINAL CONSUMPTION	13731.7		15459.3	559.9	0.0	0.0	11354.2	41105.1
TOTAL INDUSTRY	7381.3		1418.3	530.9	0.0	0.0	7943.8	17274.2
Iron and Steel	2846.5						1045.6	3892.1
Chemical and Petrochemical	729.7						899.3	1629.1
(of which: Feedstocks)								0.0
Non-Ferrous Metals	1211.0						552.7	1763.7
Non-Metallic Minerals	860.8						101.7	962.5
Transp. Equip. and Machinery							12.1	12.1
Mining and Quarrying	363.3		300.2				3013.6	3677.1
Food and Tobacco							34.0	34.0
Paper, Pulp and Printing							116.2	116.2
Wood and Wood Products							15.6	15.6
Construction								0.0
Textile and Leather							34.3	34.3
Unspecified	1370.0		1118.1	530.9			2118.5	5137.5
TOTAL TRANSPORT	56.2		10910.9	0.0	0.0	0.0	289.4	11256.4
Air			943.8					943.8
Road			9967.1					9967.1
Rail	56.2						289.4	345.6
Internal Navigation								0.0
Unspecified								0.0
TOTAL OTHER	3168.8		1754.9	21.5	0.0	0.0	3121.0	8066.2
Agriculture	130.3		924.8				372.5	1427.5
Commerce	1898.5						42.4	1940.9
Public Services	204.9						866.2	1071.1
Residential	935.1		830.1	21.5			1840.0	3626.6
Unspecified								0.0
Non-Energy Use	3125.4		1375.3	7.5				4508.2
MEMO ITEMS:								
Electricity Generated (GWh)	*166686*				*7749*	*146*		*174581*
Public	*166686*				*7749*	*146*		*174581*
Autoproducers	..					*?*		*0*

Keys:- ? data not available

.. breakdown not available but included in other category

___ estimated or partial data

Figure 4: South Africa: Energy Balance - 1993

Energy news in Africa

Electricity

At a three-day symposium held in December 1995 in South Africa on the reformation of the electricity sector in Sub-Saharan Africa, a growing consensus was seen on the need for "discipline" and for partnerships with the private sector.

The situation in Africa, as seen by the World Bank, was that electricity is vital for development but that the average consumption in Africa at present (excluding South Africa) is only about 200 kWh compared to 350 kWh in India and 600 kWh in China. Electrification rates vary from under 4% (Guinea, Malawi, Mali, Uganda and Zaire) to 5% (Ethiopia, Tanzania) or at best 7% (Kenya). Technical losses are huge, ranging from 40% in Uganda to 50% in Nigeria instead of the 10-12% that is considered to be acceptable. There are only 26 subscribers per utility employee in Tanzania or 22 in Malawi, whereas the norm was considered to be about 150-200. There is also a high percentage of unpaid bills as well as electricity supply billed. For example, in Uganda only 60% of companies supplied with electricity are billed. The unpaid bills of some state-owned utilities amount to the equivalent of 150-160 days of revenue (Mali, Ghana), 250 days (Tanzania, Uganda) or even 450 days (Uganda). It would be normal for companies to be able to finance 25% of their investments but the percentage is far lower (8,9% in Uganda). Governments contributed only 13% of funding for 69 electricity projects in Africa backed by the World Bank since 1978, with 42% coming from the Bank and 45% from other sources. However, lending is not as freely available as in the past, with loans going more to other infrastructure projects, such as water, health.

It was stressed that investment is badly needed. According to the World Bank, at least $17 billion is required by 2005 without counting rehabilitations and structural reforms: $3,8 billion for hydroelectric projects; $4,6 billion for thermal power stations, $4,1 billion for transmission and $4,5 billion for marketing.

(Source: Africa Energy & Mining, 13 December 1995)

Nigeria

The privatisation of electricity distribution in Nigeria will soon be underway although the sell-off had already been confirmed more than a year ago. The Nigerian Electric Power Authority has become NEP Plc since its official "commercialisation" in June 1993. This privatisation will involve six regional companies and include all equipment downstream from 33 kV lines. The NEP, which will retain generation and the high voltage network, will sell electricity wholesale to private distributors.

(Source: Africa Energy & Mining, 13 December 1995)

Zaire

Zaire's Société Nationale d'Electricité (SNEL) has several problems in keeping its power stations, transmission systems and marketing services running but it has also undertaken several ambitious projects. On the negative side, outstanding payment of electricity bills have surged in certain parts of the country.

With regard to projects being undertaken, Asea Brown Boveri (ABB) group and Marubeni are looking into the possibility of obtaining loans for a high-voltage line to link Shaba to South Africa. This would be in addition to the existing interconnection via Zambia. The project would also involve the upstream building of the line linking Shaba to the Inga Dam, which would boost its capacity from less than 500 MW to 1 000 MW. This project is expected to cost about $1 billion.

SNEL has, together with Zimbabwe's ZESA, Mozambique's EDM, the Botswana Power Corp. and Eskom, signed an operating agreement at the end of 1995 for the future electricity pool. The accord will govern electricity supply between the 12 SADC countries plus Zaire.

(Source: Africa Energy & Mining, 17 January 1996)

Zimbabwe

According to the Zimbabwe Electricity Supply Authority (ZESA) the $350 M Matimba/Insukamini 400 kV interconnector project between Zimbabwe and South Africa is now complete. The project took 14 months to complete and involved the construction of the Insukamini substation and 410 km of transmission line from South Africa, through Botswana, to Zimbabwe. ZESA constructed the substation and the 160 km line between the substation and the Zimbabwe/Botswana border. On the South African side, Eskom was responsible for the line from Matimba, through Botswana, linking up on the Zimbabwean border.

The line is expected to boost Zimbabwe's energy supply. Initially it will be used for emergency support with scheduled imports which started in January 1996.

(Source: Mining Mirror, January 1996)

Hydro-electricity

The permanent Commission for the rehabilitation of the Cahora Bassa dam in Mozambique, has said that work on the project should be completed by March 1997. The Commission, which consists of Mozambique, Portugal and South Africa, has stated that all the financing contracts are now in place and that work on the removal of landmines along the route of the transmission lines linking the 2 000 MW Cahora Bassa dam to the South African border are well underway. The construction contract for the reconstruction of the 1 440 km of transmission lines has been awarded to the Italian consortium, Consorzio Italia 2000. The project is expected to cost US$75 M and the European Development Fund will contribute the remaining US$25 M. South Africa's Eskom will donate US$37 M to buy pylon towers and other accessories.

(Source: International Water Power & Dam Construction, January 1996)

Mining

Anglo American Corporation (AAC) has achieved a breakthrough in the privatisation of Zambia Consolidated Copper Mines. A letter of understanding was signed on 12 January 1996 by Zambia's finance minister and AAC that provides for AAC to set up and lead a consortium to develop the Konkola Mine.

The development of Konkola is expected to cost about $600 M and the project is regarded as crucial to the future of the copper sector in Zambia. Its 380 Mt of high grade reserves are said to contain over 5 Mt of top quality copper.

(Source: Africa Energy & Mining, 17 January 1996)

Oil and Gas

After four years of studies and negotiations, an agreement to proceed with the Songo Songo gas and electricity project at the end of October last year between Tanzania's Water, Energy and Minerals Ministry and the scheme's Canadian promoters, Ocelot Energy and Transcanada Pipelines (TCPL). A final agreement, including the financial package, is set for the first half of 1996 and the project is set to come on line early in 1998. Planned gas production of 450 million m^3/day is earmarked entirely for electricity production according to the current plan and a pipeline spur that is to supply nearby heavy industry from the Ubungo power station has not been included. If it was included the cost would increase to $370 M, while an initial investment of only $300 M has been provided for. The three turbines at Ubungo are now set to provide 146 MW.

The operating company, Songas, will develop the gas field by installing a gathering system for the five existing wells (including three offshore), by building a gas processing plant on Songo Songo island and laying a 12-inch pipeline running for 25 km along the seabed and 207 km on land.

(Source: Africa Energy & Mining, 1 November 1995)

A new round of bargaining was held recently in Washington, D.C. between officials from Enron, the Mozambique government and the World Bank on the Pande gas project. It is uncertain whether these differences can be ironed out quickly. Disagreement had emerged over what the government sees as Enron's "unduly high assessment" of the cost of a 900 km pipeline scheduled to link the field to the South African province of Gauteng. The pipeline is the most costly part of the estimated $600 M project.

(Source: Africa Energy & Mining, 1 November 1995)

The French oil group, Elf, has stated that South Africa's failure to deregulate its oil industry constitutes a legal obstacle to a free trade agreement between the country and the European Union (EU). Elf's main concern is the inability of new operators to break into the market. They claim that their operators cannot even procure supplies in South Africa to ship to their markets in the region. Other European concerns, like Agip, have met with the same problem. An EU representative in South Africa has refuted South Africa's fears that deregulation of the market would result in higher unemployment. Rather, it would bring new competitors into the market, creating fresh retail outlets.

(Source: Africa Energy & Mining, 1 November 1995)

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Sonto is currently an International Affairs Senior Advisor at Eskom. Her primary responsibilities are to contribute to international scanning activities related to regional energy developments and trading, as well as regional economic development. In addition, her extensive involvement in the region has enabled her to establish numerous networks and alliances which is of great importance to the nature of her work.

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T V Ramachandra graduated with a B.E. (Elec.Eng.) from Bangalore University and a Ph.D. in energy from the Indian Institute of Science. His primary interest is energy conservation and modelling. He has carried out energy audits for small, medium and large industries in Karnataka State, India. Currently, Dr Ramachandra is active in developing an ecologically acceptable energy plan for the Uttara Kannada district, Karnataka State, India.

He has also proposed an environmentally sound alternative model for the Bedthi and Aghnashini hydroelectric schemes to minimise submergence costs and maximise net energy.

Other ongoing projects undertaken by Dr Ramachandra include (1) dissemination of efficient cooking and water heating systems; (2) an assessment of the renewable energy potential in the Uttara Kannada District, funded mainly by the Indian government's Ministry of the Environment and Forests.

Resent research is aimed at developing regional energy planning models based on decision support systems using spatial and temporal analysis tools such as, GIS, etc.

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C M Shastri graduated with a B.Sc. from Karnataka University. Since 1985, he has been working at the Centre for Ecological Sciences at the Indian Institute of Science. His field of expertise is the design and dissemination of fuel efficient stoves. He is presently working on the improvement of driers which are used for drying cardomon, arecanut, etc.

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Willem Smuts completed an Honours degree in geology and then a Masters degree in Sedimentology while working at the Institute for Coastal Research (ICR), University of Port Elizabeth. In 1987 he joined the Geological Survey, Fossil Fuels Division, in Pretoria. Willem was appointed Assistant Director - Fossil Fuels in 1989. In May 1994 he left the Council for Geoscience to become the Executive Manager of GENRES cc (Geological and Natural Resource Consultants). His speciality fields are coalbed methane and all aspects of peat and peatlands, from exploitation to conservation. Willem recently completed a Ph.D. dissertation on the classification and characterization of South African peats, at the University of Pretoria.

Some of the recently completed projects of which he has been a part include a report on the energy potential for peatlands in part of KwaZulu/Natal and investigations into the coalbed methane potential for certain Southern African coalfields. Willem has also travelled extensively in connection with his work - through Africa, the then Soviet Union, Poland, Scotland, Ireland and the U.S.A.

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

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

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

Forthcoming energy and energy-related conferences: 1996/1998

1996

MARCH 1996

18-22
THE INTERNATIONAL COAL BUSINESS : AN INTERNATIONAL BUSINESS COURSE Johannesburg, South Africa

Enquiries: Sharon Williams, Programme Manager, College of Petroleum and Energy Studies, Sun Alliance House, New Inn Hall Street, Oxford OX1 2QD, United Kingdom

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Telex: 838 950 COLPET-G
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26-28
COALTRANS SOUTH AFRICA Johannesburg, South Africa

Enquiries: CoalTrans Conferences Ltd, Nestor House, Playhouse Yard, London EC4V 5EX, United Kingdom

Tel.: +44 (0) 171 779 8945
Fax.: +44 (0) 171 779 8946

APRIL 1996

14-17
ELEVENTH INTERNATIONAL SYMPOSIUM ON ALCOHOL FUELS (ISAF XI) Sun City, South Africa

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

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

JUNE 1996

10-12
SUB-SAHARAN OIL & MINERALS Johannesburg, South Africa

Enquiries: Europe Energy Environment, London, U.K.

Tel.: +44 (171) 600 6660
Fax: +44 (171) 600 4044

OCTOBER 1996

7-8
2ND ENVIRONMENTAL MANAGEMENT, TECHNOLOGY AND DEVELOPMENT CONFERENCE Fourways, Gauteng, South Africa

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

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

1998

SEPTEMBER 1998

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

Theme: Interface between developing and developed countries

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

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

Recent energy publications

DE VILLIERS M G

Development of a strategy for improved industrial energy efficiency in South Africa. Nov-1995. 10p.
ERI Report No. REP 063
R5,70

This is a reprint of a paper presented at the 16th Congress of the World Energy Council which was held in Tokyo, October 1995. It describes the findings of a project to develop a strategy for improved industrial energy efficiency in South Africa, recently completed for the South African Government. The project included four discussion workshops with representatives from the government, industry, energy suppliers, energy consultants and universities.

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

Cape Town Brown Haze Study: The role of public awareness in research. Jan-1996. 7p.
ERI Report No. REP 068
R5,70

This is a reprint of a paper presented at the 26th Annual Clean Air Conference held in Durban in November 1995. It describes the public awareness campaign which will run with the technical study on Cape Town's Brown Haze Study being undertaken by the Energy Research Institute. The objectives of the public awareness campaign are to create awareness of the brown haze problem, remove misconceptions about the haze, provide information on the haze, give assurance that the haze problem is being attended to, and to inform the public about the research work and findings of the study.

DRACOULIDES D A and DUTKIEWICZ R K

Evaluation of the ISCST2 model with measurements of SO_2 concentrations in the Greater Cape Town region. Nov-1995. 9p.
ERI Report No. REP 062
R5,70

A reprint of a paper presented at the 3rd International Conference on Air Pollution held in Porto Carras, in November 1995. The paper briefly evaluates the Industrial Source Complex Short Term 2 (ISCST2) model with SO_2 measured concentrations at three monitoring stations in the urban Cape area. The model's performance was quantified by using several statistical measures as well as by additional parameters. The model's performance was poor under very stable atmospheric conditions as well as under low wind speeds at all three sites.

DUTKIEWICZ R K

Energy demand and supply in Sub-Equatorial Africa. Nov-1995. 23p.
ERI Report No. REP 064
R5,70

This is a reprint of a paper presented at the 16th Congress of the World Energy Council, held in Tokyo in October 1995. The paper looks at energy supply and demand in specific Sub-Equatorial African countries, excluding Kenya, Burundi and Rwanda. It includes a discussion of regional resources.

DUTKIEWICZ R K

Photochemical activity and fuel composition. Jan-1996. 13p.
ERI Report No. REP 069
R5,70

This is a reprint of a paper presented at the 2nd International Conference on Volatile Organic Compounds in the Environment held in London in November 1995. The paper is concerned with the evaluation of the emission effects of gasoline fuels when used without catalysts. The main cause for concern was found to be the formation of photochemical smog, and therefore an experimental technique has been used to determine the photochemical smog-forming propensity of various fuels. The primary emissions affecting the levels of photochemical smog produced are VOCs and NO_x.

WONG C T and DUTKIEWICZ R K

Energy balances in South Africa 1970-1993. Nov-1995. 172p.
ERI Report No. GEN 176
R51,30

This report summarises up-to-date published energy statistics for coal, oil, natural gas and electricity from 1970 to 1993 and compiles energy balances for South Africa along the lines of the IEA energy balance format. Specific aspects covered are the methodology of the energy balance, data sources and problems, and data storage and manipulation.

Several of these reports are the result of research funded by the Chief Directorate: Energy, Department of Mineral and Energy Affairs.

These publications may be obtained from: Information Officer, Energy Research Institute, P O Box 207, Plumstead 7800, South Africa.

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