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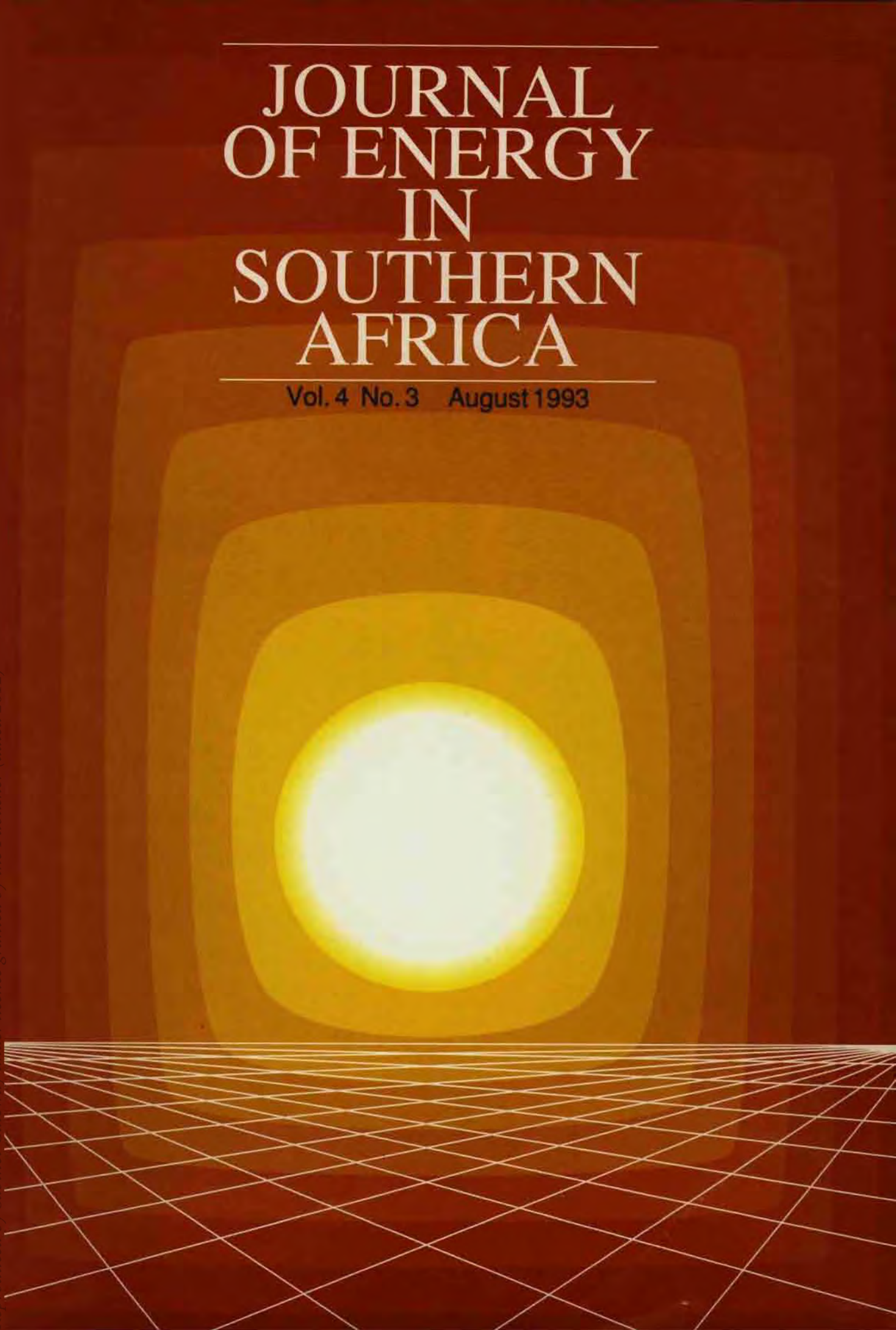

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## Contents







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Enquiries may be directed to:
The Production Editor, Journal of Energy in Southern Africa,
Energy Research Institute, University of Cape Town, P O Box 33,
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# Profile: Robert (Rob) John Angel

Rob Angel was born in Adelaide, South Australia, on 26 February 1942. He completed his schooling at Prince Alfred College in Adelaide, and later received his Bachelor of Chemical Engineering degree with honours from the University of Adelaide.

Mr Angel started his career as a chemical engineer at Mobil's Adelaide Refinery in 1967. After several management appointments, he was transferred to the Altona Refinery in Melbourne in 1973, and in 1975 to the Jurong Refinery in Singapore. After two years, he was transferred to Mobil's Head Office in Melbourne, where he managed the group's Supply and Distribution function.

In 1978, he took up an assignment in New York, the Mobil Corporation's headquarters, as Area Co-ordinator for Australasia. Thereafter he moved to Cyprus as the Corporation's Chairman and Managing Director. Two years later, in 1981, he was appointed Refinery Manager at Mobil's Coryton Refinery in the United Kingdom, and Manufacturing Director of Mobil Oil Company Limited.

Mr Angel was posted to Cape Town in February 1986 as Deputy Managing Director. The following year he was appointed Chairman and Managing Director of Mobil Oil Southern Africa (Pty) Limited, giving him the responsibility for Mobil's entire Southern African operation.

In 1989, the Mobil Corporation disinvested from South Africa and sold Mobil Southern Africa to Gencor. Rob Angel decided to stay on in South Africa, and was appointed Chief Executive Officer of Gencor's newly created energy arm, Engen Limited, which was floated on the Johannesburg Stock Exchange in May 1990.

Mr Angel is presently the Chairman of Engen's key group holdings, which include Engen Marketing (Mobil, Trek, Sonap) and the oil refining complex, Genref, in Durban. He is also a director of Mossgas, the fuel-from-gas project off the southern coast of Africa. During March 1993, Mr Angel was appointed to the Gencor Board of Directors.

Rob Angel is married to a South African, Lynn, and has four grown-up children. He is also interested in sport, but presently has little time to participate actively. In his youth, he played competitive cricket and Australian Rules football.

# NGOs and the dissemination of alternative energy technology in South Africa

* G B HUGGINS and * * P V HALL

Research into non-governmental organisations (NGOs) in South Africa has shown that few of these organisations are actually involved in the dissemination of alternative energy technology (AET). The paper argues that political, funding, and infrastructural/structural factors mitigate against the widespread involvement of NGOs in AET. The paper further argues that this situation may change in the future and that, while there are pros and cons to NGOs as channels for the dissemination of AET, certain categories of NGOs are potentially highly suited to the role. This is particularly so for community-based organisations operating in rural areas. However, certain structural conditions would have to be met to optimise the potential that NGOs have as viable conduits for AET. Most important here is the need for a co-ordinated national and/or regional policy of energy utilisation. In summary, the paper argues that energy is part of the wider development issue and cannot be seen in isolation from other aspects of rural development. Integrated rural development, with the appropriate NGOs acting as facilitators between the regional and local stakeholders, the appropriate state and para-statal organisations and the local inhabitants, could be the most suitable means of addressing energy issues in rural development.

**Keywords:** alternative energy; NGOs; rural development; Eskom

### *Definition of terms*

NGO = Non-governmental organisations are typically private, not-for-profit, tax-exempt organisations whose purpose is to engage in voluntary relief and development assistance[3].

AET = Alternative energy technologies are those technologies which exclude conventional grid electricity, petrol- and diesel-powered generators, and atomic energy. Energy in the form of human and animal labour was also excluded.

## Introduction

Access to affordable, appropriate and sustainable sources of energy is a major problem for many of the inhabitants of Southern Africa's poorer sectors and is particularly acute in the "black" rural areas. While a great deal of attention has been focused on the issues of water, unemployment, food security, and access to education as the primary issues in rural development, the problem of adequate energy provision is becoming increasingly important as the environmental and opportunity costs of the over-exploitation of fuelwood sources become apparent. As such, the issue of energy is becoming crucial to any meaningful debate on integrated development strategies for Southern Africa's "black" rural areas. Non-governmental organisations (NGOs) are seen to play an important role in formulating and executing development strategies (even if only at a local level) in some of the rural areas of Southern Africa.

With these factors in mind the National Energy Council (now the Chief Directorate: Energy, Department of Mineral and Energy Affairs) approached the Social Development Research Unit within the Human Sciences Research Council (HSRC) to undertake research on their behalf***. The research hypothesis which was originally set out was that so-called NGOs may play an important role in the dissemination of alternative energy technology (AET) in the rural areas of South Africa and that their role needs to be fully explored. More specifically, the research attempted to answer three questions, namely:

(a) do NGOs play a significant role in the dissemination of AET in Southern Africa's "black" rural areas?

(b) are NGOs equipped/suitable to play a significant role in the dissemination of AET in Southern Africa?

(c) if so, how can this role be optimised?

## Research design

In order to operationalise the study parameters a number of steps were followed. A scan of the *Prodder* and *Bridge* databases of development organisations and other relevant literature was undertaken to identify those organisations in South and Southern Africa (including the Transkei, Bophuthatswana, Venda and Ciskei) that concern themselves with development and the provision of alternative energy knowledge and technology. Preliminary research (i.e. consultation with NGO database experts, key informant interviews, telephonic interviews with members of NGOs) eliminated most of the organisations as not participating in the dissemination of AET. A short list of approximately 35 organisations (out of a total of some 300) that were thought to be involved in the dissemination of AET was eventually compiled. A questionnaire was constructed and mailed to each of these organisations.

Regular mailed and telephonic reminders were utilised to ensure as large a return of the questionnaires as possible. The questionnaire included a request for the names of other organisations involved in the dissemination of AET known to the respondent. In this way, any organisations that had been left out in the first round of mailed questionnaires were identified and included in the survey. In addition, interviews were held with various NGO database experts to identify any additional organisations. This "second round" identified a further 13 organisations, over and above the 35 identified initially. In the end, 48 organisations, including some that could not be

* Social Development Research Unit, Human Sciences Research Council, Private Bag X41, Pretoria 0001, South Africa
** Development Policy and Planning, Human Sciences Research Council, Private Bag X41, Pretoria 0001, South Africa

*** The views expressed in this paper are those of the authors and do not necessarily reflect those of the Department nor of the Human Sciences Research Council.

strictly defined as NGOs but still deemed to be relevant to effective data generation, were identified. Responses from the organisations were closely monitored and eventually a reply was obtained from all the relevant organisations approached (except one organisation that chose not to participate in the research).

The data were catalogued and contextualised. In the end only 18 of the 45 organisations proved to be involved in the dissemination of AET, and most of these organisations were only peripherally involved. In a second phase of the study, 4 of the 18 organisations identified were selected for further in-depth research, while interviews were held with a number of other organisations which were not strictly NGOs but involved in the dissemination of AET.

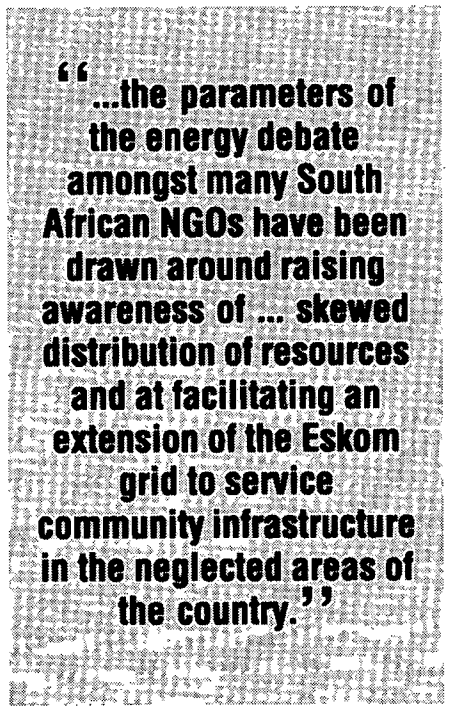
During the course of the research it became apparent that the answer to the first question that was posed, namely, *do NGOs play a significant role in the dissemination of AET in "black" rural areas of Southern Africa?*, was negative. This is somewhat surprising given that access to energy is an important issue in the poverty/development debate in South Africa, and it was felt initially that many more NGOs in Southern Africa would have concentrated on the AET issue. However, after closer consideration of the data, it was concluded that two major factors are probably responsible for this lack of interest. These are explored in more detail below.

## NGOs and the politics of energy

Historically, South African NGOs have occupied a position of great importance but have been subject to certain restrictions. Until very recently the State had concentrated on developing a capitalist economy dominated largely by "white" interests. Thus, according to Cloete[1], the distance between the government and the majority of the population, in terms of development objectives and priorities, has been extremely wide. While South African NGOs have played a crucial developmental role, they have generally not been seen by the State as "partners in development". In fact, the relationship between the State and NGOs has often been hostile, and many NGOs have been faced with State-imposed restrictive measures aimed at curbing their activities. This applies particularly to those organisations historically concerned with "community mobilisation" against the State machinery.

For many (although not all) NGOs in South Africa it has been the counter-hegemonic struggle that has been important. The fundamental problems of poverty and development have been identified by many NGOs as emanating from the State and as such, community and education organisations aimed at carrying out the "struggle" against the State have been regarded as of primary importance. For these organisations certain aspects of development (which would include AET) have been given a relatively low priority.

In this regard the authors point out that




South Africa is regionally relatively well-equipped with a conventional energy infrastructure. However, as previously mentioned, the South African government has traditionally given priority to infrastructural development aimed at promoting the mining and capital-intensive sectors of the economy, as well as the "white" urban domestic and rural commercial agricultural sectors. As a result, dissemination of conventional energy, via the para-statal Eskom, to the broader segment of the South African population has been largely neglected.

Eberhard[2] points out that South Africa generates approximately 60% of the total electricity supply in Africa but that "whites", who comprise only about 17% of the population, consume about 67% of electricity used in the domestic sector.

Against this background the parameters of the energy debate amongst many South African NGOs have been drawn around raising awareness of this skewed distribution of resources and at facilitating an extension of the Eskom grid to service community infrastructure in the neglected areas of the country. To this end, much of the debate has focused not on alternative energy sources but on the maldistribution of access to conventional energy sources. In this sense, the debate is similar to that which surrounds primary health care and education, namely, is it legitimate to provide access to a certain resource for one sector of the people of Southern Africa while providing what may be regarded as an "inferior" alternative to others?

By the same token, and as a generalisation, the "less politicised" NGOs (or at least those with a less overtly political agenda) have tended to see themselves as having to work within the *status quo* (however much they may dislike it). Therefore, rather than aim their activity at redressing the imbalance in resource allocation at a political level, they have been more willing to engage in projects with material benefits at a local level. It is often these NGOs that incorporate projects that include dissemination of AET as part of a wider integrated approach.

## NGOs and the politics of funding

The second major factor that may mitigate against NGO involvement in AET is funding. Firstly, the channelling of funding has tended to exacerbate division between the two types of NGOs referred to above. Foreign funders with explicitly anti-apartheid stances have tended to fund organisations with overtly political agendas (those promoting the counter-hegemonic struggle), while funds generated by businesses via social responsibility programmes (including foreign business funds) have tended to finance NGOs with primarily poverty alleviation agendas.

Secondly, much of the funding, particularly social responsibility funding, has been channelled into the urban rather than the rural areas. As a result, many NGOs prefer to work in urban areas. These areas afford better access to

conventional power sources and greater potential for the extension of the Eskom grid which, in turn, tends to mitigate against NGO involvement in AET.

Thirdly, the large number of NGOs competing for a relatively restricted funding base has often led to the "flavour of the month" syndrome. NGOs suffering from this syndrome direct their activities towards issues that will easily secure funding. As health and education have been the issues with the largest amount of donor interest, it is not surprising that many NGOs have concentrated their activities in these areas.

Therefore, given the political and funding situation, it is not surprising that certain specific issues, such as, the dissemination of AET, have been marginalised.

## The changing nature of NGOs

A second way in which the apparent lack of interest in AET among NGOs can be viewed is by utilising Korten's generational model[3]. This model allows some insight into the dimensions of NGOs across a continuum and the likely concentration of their activities. Essentially, the model divides NGOs into four generations. While Korten himself maintains that NGOs often do not fit neatly into a single category, few NGOs would have characteristics extending across more than two generations (see Table 1). The model is therefore best understood as a continuum, with the orientation and activities of NGOs reflecting a position on the scale rather than occupying a single category.

During the research for this project it was found that NGOs involved in AET in South Africa tended to come from the second or third generational phase (see Table 1). This is in contrast with the trend in South Africa where most of the NGOs fit the first and, to a lesser extent, the fourth generational phases of the model.

It should be borne in mind that while few NGOs in South Africa fit Korten's fourth generation very neatly, particularly with regard to the scope of their activities, the political nature of many of South Africa's NGOs places them closer to the fourth generational side of the continuum than to the third. Second and third generation NGOs in South Africa tend to be community-based organisations with integrated approaches to development. It is here, as part of the integrated approach, that most NGOs involved with the dissemination of AET were located.

To project the argument a little further, it is contended that, while the concentration of NGO activities in South Africa and the funding impetus have been within the ambit of typically first and fourth generational NGOs, there are a number of reasons why this is likely to change to a concentration of resources in second and third generation NGOs.

Firstly, with the changing nature of the South African political scenario, an intense debate pervades the NGO community. Crucial to the debate is the changing relationship between the State and the NGOs. While some resistance to being fully "co-opted" by the State can be expected from many previously "activist" NGOs, the probability exists that many of these organisations will alter their focus from promoting "counter-hegemonic" ideologies/organisation to the provision of material/community development. The implication here is that issues, such as, the dissemination of AET (as part of an integrated development approach), may become increasingly important across the spectrum of NGOs.

A second dimension to the debate currently pervading the NGO scene concerns the nature of "development" itself. At the crux of this debate is a critique of "growth-centred development" and the promotion of "people-centred development". Integral to this is an argument that questions reliance on conventional (fossil fuel) energy sources and advocates a "return" to renewable energy sources. The issue of alternative energy is likely to again become one of the focal points.

## The pros and cons of NGOs as disseminators of AET

Having addressed our first question, attention can now be focused on the second question, namely, *can NGOs play a significant role in the dissemination of AET, and if so, what is the role that they can/should play?*

Research on NGOs (and a great deal has been carried out) has identified the "strong points" of these kinds of organisations. In order to answer the question a number of these points have been selected to illustrate how NGOs could function to effectively disseminate AET.

Thus:

— NGOs are sensitive to the actual needs at community level. This would benefit effective dissemination of AET, as NGOs at the community level are in a position to evaluate and select the most *appropriate* forms of alternative energy for local conditions.

— NGOs promote local participation, enthusiasm and democratic decision-making at the local level. This could help to ensure that alternative energy projects are sustainable.

— NGOs generally have greater legitimacy than government agencies at the community level, and alternative energy projects would probably be seen in a better light coming from NGOs than from State or State-allied organisations. That is, they are more *acceptable*.

| | GENERATION | | | |
|---|---|---|---|---|
| | FIRST: RELIEF AND WELFARE | SECOND: COMMUNITY DEVELOPMENT | THIRD: SUST.SYSTEMS DEVELOPMENT | FOURTH: PEOPLE'S MOVEMENTS |
| Problem definition | Shortage | Local inertia | Institutional & policy constraints | Inadequate mobilising vision |
| Time frame | Immediate | Project life | 10-20 years | Indefinite future |
| Scope | Individual or family | Neighbourhood or village | Region or nation | National or global |
| Chief actors | NGO | NGO + community | All relevant public and/or private institutions | Loosely defined networks of people and organisations |
| NGO role | Doer | Mobiliser | Catalyst | Activist/educator |
| Management orientation | Logistics management | Project management | Strategic management | Coalescing and energising self-managing networks |
| Development education | Starving children | Community self-help | Constraining policies and institutions | Spaceship earth |

*Table 1: Korten's generational model of NGOs*

— NGOs are in a position to identify with the needs of the poor and underprivileged. NGOs could evaluate AET projects to ensure that they do not increase levels of differentiation and further *marginalise* the vulnerable.

— NGOs are generally more ready to apply *traditional knowledge* or appropriate technology because of the close co-operation that exists between themselves and local communities.

— NGOs tend to be more *flexible* and adaptable to changing community needs and would be prepared to experiment with AET.

— NGOs, through mobilising people at the local level, can often keep the *costs* of development comparatively low and thus incur smaller bureaucratic costs. AET could probably be more cost-effectively disseminated through NGOs.

— NGOs generally have a greater *affinity* with communities, which is beneficial in crisis situations, and will have a greater understanding of why things go wrong.

— NGOs, through greater legitimacy, are often able to mobilise people so as to *integrate* local communities into existing institutions. NGOs are ideally placed to play the role of facilitators for community interests by providing information, mediation and intercession with government agencies and charitable institutions.

— NGOs are generally characterised by their commitment to their mission of carrying out the task of development, and their focus on human matters makes for a *dynamic and integrated* approach to development. AET projects are probably only viable within an integrated approach.

— NGOs could act as a *viable* conduit for the funds and resources needed to disseminate AET at the local level.

— NGOs are able to support, strengthen or influence *local institutions* without undermining or destroying them, thereby integrating alternative energy projects into the existing social order.

The above list reflects an ideal that unfortunately not all NGOs meet. It is also comparative in character in that it is highlighting the ways in which NGOs are better developmental tools than government organisations. As such, while the advantages of disseminating AET through NGOs are numerous, there are a number of disadvantages. These include the following:

— NGOs often experience problems in defining and planning a clear strategy. This applies particularly to NGOs that carry out a number of functions. The optimal dissemination of AET will require a strategic approach along national/regional lines.

— Sustaining longer-term development projects and continuity in larger projects often causes problems for NGOs. Sustainability and continuity must be key features of alternative energy dissemination.

— Competition for funding often makes NGOs reluctant to co-operate and share information with other NGOs.

— NGOs often lack the technical expertise and funding base to carry out large physical development projects.

**"To this end, much of the debate has focused not on alternative energy sources but on the maldistribution of access to conventional energy sources..."**

— Some NGOs have a political agenda that serves to divide communities.

— NGO funding may be terminated with detrimental consequences for the development process.

— NGOs may have a bias towards a particular form of AET.

Having considered these elements, it is concluded that certain types of NGOs are better equipped to carry out effective dissemination of AET than others. In terms of characteristics these "suitable" NGOs should:

— Be community-based, so as to be able to select locally appropriate forms of AET for dissemination, and be able to monitor and evaluate the AET after dissemination.

— Be relatively well-established and have a positive track record in the communities in which they operate.

— Have sufficient (preferably technically) trained staff to be able to deal with time demands imposed by the dissemination and monitoring of AET. This necessarily implies that "larger" NGOs would be more suitable.

— Have clear strategic development plans in place. This is to ensure that the dissemination of AET takes place within an integrated context and not merely on an *ad hoc* basis. NGOs should be sophisticated and flexible enough to be able to review and adapt development strategies as the need dictates.

— Have a sound funding basis and a long-term outlook that will place the dissemination of AET on a sustainable footing.

— Have the capacity to educate people in the community so that the technical knowledge needed to sustain the AET is passed on.

## AET and national energy policy

In order to *optimise the role that these NGOs would play* (the third question considered) in the dissemination of AET, a number of issues, external to the NGOs, have to be addressed. Many of the respondents in the study felt that there is a need for a co-ordinated national and/or regional policy for energy utilisation in South and Southern Africa. As the situation stands, many of the respondents in the study felt that alternative energy technologies were largely being utilised as "stopgap" measures in the face of impeded access to conventional energy sources. In other words, some of the NGOs mentioned that they used alternative energy sources in development projects (particularly solar energy systems) *in lieu* of conventional sources.

Had the Eskom electricity grid been available, NGOs would have preferred to make use of the more conventional electricity sources. The reasons given for this rest largely on the reliability of Eskom as a supplier of energy. Eskom is seen as a large and powerful organisation with a well-developed infrastructure and backed by good support services. The Eskom product is an extremely reliable energy source, is relatively cheap (see Wilson and Ramphele[5]) and, for the consumer, it is low-maintenance. The organisational strength of Eskom and the reliability of the product contrasts with the "weakness" of many of the organisations

which supply AET and the unreliable nature of the product that they supply.

This contrast was expressed in the view that organisations supplying alternative energy products are largely profit-driven. Unlike Eskom, which is cost recovery-driven, they often tend to be "fly by night" operations whose back-up for the product ends when they go out of business.

Some of the people interviewed complained that motivating the supplier to provide a back-up service was almost impossible, even when the organisation was still operating. Others of those interviewed complained that alternative energy technologies (particularly solar energy) were often unreliable and needed frequent maintenance. Maintenance for alternative energy systems is continuous, and frequently the technology is of such a nature that it is almost impossible to maintain the systems oneself.

It should be borne in mind, however, that, although the opinion was expressed that Eskom is a reliable supplier and has recently committed itself to an "electricity for all" drive, this does not in fact mean that all areas of the country will be electrified in the short or even medium term. While Eskom is not overtly profit-driven it makes strategic sense for the organisation to choose those areas where prospects for cost recovery are best. The major implication of this is that the electricity grid is likely to be extended to serve urban areas first since economies of scale and levels of affordability create the best conditions for cost recovery in urban areas. As such a very real danger of inherent urban bias exists in the "electricity for all" approach currently being mooted. Although cost-effective rural reticulation technology can also be considered, expectations that Eskom will solve rural energy problems are probably highly optimistic in the short and even medium term. However, it was not only the issue of access to the Eskom grid that was mooted as a problem with alternative energy by the respondents.

A further complaint was that very little information on which alternative energy sources are available is readily accessible. Even more critical, according to respondents, is the fact that little information on which AET is appropriate within a given context and at a given time is readily available. The view was expressed that it is often only the supplier of AET or the sales representative (who has a vested interest in selling specific products) that is a readily accessible information source. As the situation stands, NGOs are often forced to expend funds on costly experiments to decide which energy strategies are appropriate and which are not.

Two suggestions for overcoming these problems were made. The first suggestion was that a national and regional energy plan, that incorporates a repository of information on the suitability and availability of the different technologies for specific areas would go some way toward integrating energy programmes and allowing NGOs to make informed decisions on rural energy strategies, should be established. Furthermore, it was suggested that a network of NGOs involved in alternative energy dissemination be established. This would foster communication and allow NGOs to compare notes on the suitability of energy strategies.

# Conclusions

The view was expressed that alternative energy technologies could be utilised in areas where access to the Eskom grid is unlikely in the near future. The expansion plans of Eskom are of critical importance to many NGOs and many wanted policy clarification in this regard. A spread of energy technologies (including the electricity grid and alternative energy systems) could be utilised in rural areas to ensure that the most appropriate technology is used to address each specific need. Thus, while some of the respondents felt that rural electrification was probably the most cost-effective and appropriate way of meeting many of the energy demands, there was nevertheless a feeling that alternative energy technologies had a role to play for two major reasons.

Firstly, while electricity is relatively cheap *vis-a-vis* some of the other energy sources, the environmental cost of coal-generated electricity is high. Pollution is a major environmental issue and is quite high on the NGO agenda. While respondents were generally aware of the health benefits of electricity at the point of consumption, as opposed to many other forms of domestic energy, questions about pollution and health at the point of production were raised. Furthermore, coal-generated electricity was not regarded by many respondents as a sustainable resource at current utilisation levels. As the notion of sustainability is of critical importance to the current development debate, coal-generated electricity (as opposed to hydro power) is considered to be out of step with certain trends in development thinking.

Secondly, although Eskom-supplied electricity is relatively cheap it is still beyond the means of many people in rural areas. In this regard alternative energy technologies are regarded as options, although some problems were identified. For example, biomass (particularly woodlots) is often an affordable alternative for some domestic fuel needs. However, it was pointed out that while the option seems attractive, it is difficult to motivate poor people to provide for future needs when immediate survival needs are paramount. As woodlots are relatively long-term projects they are often difficult to initiate. Furthermore, other alternative energy sources (such as PV systems and solar panels) also require substantial capital outlays that are beyond the means of most sectors of the rural population.

In addition, the capital cost of these systems cannot easily be built into a long-term utilisation repayment scheme as is incorporated into electricity bills. This often increases the initial financial outlay, and therefore AET is often seen as less attractive than the conventional power grid. There is clearly a need to look into mechanisms for mobilising capital for alternative as well as conventional energy sources. Despite these constraints and concerns the general feeling was that a co-ordinated expansion of available options was desirable.

In summary, the authors feel that energy is part of the wider development issue and cannot be seen in isolation from other aspects of rural development. Integrated rural development with the appropriate NGOs acting as facilitators between the regional and local stakeholders, the appropriate state and parastatal organisations, and the local inhabitants, could be the most suitable means of addressing energy issues in rural development.

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# Fuel use in six rural settlements in Gazankulu

* N J GRIFFIN, * * D I BANKS, * * * J MAVRANDONIS, * * * * C M SHACKLETON and * * * * * S E SHACKLETON

Problems with rural energy supplies are acknowledged in many countries around the world. Energy supply problems in underdeveloped regions are often accompanied by deforestation, resulting partly from wood harvesting, owing to residents' reliance on wood for fuel. Decreases in available wood quantity consequent on deforestation force wood users to use other fuels to satisfy their energy requirements. This paper reports on domestic energy consumption in six rural settlements in Gazankulu. The settlements were chosen to cover a range of sizes, locations, assumed degrees of development, rainfall regimes, and vegetation densities.

Twelve energy carriers were used to a greater or lesser degree by residents of the six settlements. Four of these, namely, candles, dry-cell batteries, paraffin, and wood, were commonly used by residents of all the settlements. Wood was by far the most important source of net energy in all settlements. Paraffin and, in certain settlements, dung and coal were other significant energy sources.

This paper discusses, using examples from the six settlements, the transition from reliance for domestic energy on collected wood to reliance on commercial fuels, and briefly comments on the possible impact of this transition on settlement residents.

**Keywords:** rural energy; domestic energy; energy consumption; traditional fuels; transitional fuels; Gazankulu

## Introduction

A complex relationship exists between the quantity and nature of energy used in societies, and their level of social and economic development. This relationship is not causative. However, the availability of suitable forms of energy has been proposed as a necessary but not sufficient condition and driving force for economic growth and development[1,2].

The oil shortage of the 1970s focused attention on the dependence of developed countries on fossil fuels. It also highlighted that large parts of the population in less developed countries had little or no access to fossil fuels, and relied on traditional fuels for their energy requirements. Most notable amongst these are wood and its derivative, charcoal[3,4]. It is recognised that in those societies where they are important, traditional fuels will not easily be replaced and will remain important for some time[5].

In the past, energy planning in South Africa concentrated on commercial fuels for industry and the metropolitan centres. This has resulted in abundant and cheap energy being available in the developed sectors of the economy, while other sectors of the population suffer under conditions of energy scarcity[6]. A result of this pattern of development is that in rural areas and, particularly in the "homelands", biomass energy is one of the major forms of energy[7,8]. This pattern is common in rural areas in most underdeveloped, or developing, countries, and, indeed, in a large part of Africa[3,9]. In South Africa, Eberhard[8,10] estimated that wood comprises 78,5% of the net domestic energy of rural people and is used as fuel in 99% of rural households.

Population growth and the associated increased demand for fuelwood, changed grazing practices, and increased clearance of land for agriculture, contribute to deforestation[5], and this, in turn, results in a decrease of available wood. Local wood shortages occur around larger settlements where there is a high concentration of wood users. When wood collection is no longer feasible, people who previously collected wood for fuel are forced either to purchase wood or to substitute other fuels for wood. For example, dung and crop residues, though less satisfactory fuels, are used as fuelwood substitutes. The most common substitute for biomass fuels in rural areas is paraffin[11]. With the exception of residents of commercial farms, rural South Africans have little access to reticulated electricity[8].

This paper reviews some of the results of a survey of energy use in six settlements in Mhala, the southernmost fragment of Gazankulu. In common with other "homelands" in South Africa, Gazankulu has a population that is considerably more densely settled than that of rural "white" South Africa, there is a high incidence of unemployment, per capita income is low, and there is little infrastructure[12,13,14,15].

This survey was one of several commissioned and funded by the Energy Branch (now the Chief Directorate: Energy) of the Department of Mineral and Energy Affairs of South Africa. The complete report[16] is available from the Department of Mineral and Energy Affairs.

## Materials and methods

Six settlements in the Mhala region of Gazankulu were studied. These were Athol (24°43'S 31°21'E), Okkerneutboom (24°36'S 31°07'E), Rolle (24°44'S 31°13'E), Welverdiend (24°35'S 31°20'E), Xanthia (24°50'S 31°09'E), and a Mozambican refugee settlement adjacent to Welverdiend. The settlements were chosen to reflect variation in spatial dispersion, population size, proximity to major centres and transport routes, assumed economic development, rainfall regime and vegetation density.

Settlement boundaries were determined from 1:15000 aerial photographs (1988) and 1:250000 and 1:50000 topocadastral maps, and the number of households in each settlement was ascertained from the aerial photographs. Recommended sample size in each settlement was based on the assumption that a sample of 80 households was the maximum that could logistically be dealt with, and that there was no change in the variance of the parameters being investigated from one settlement to the next. Previous studies

* Research Officer, Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa.
** Department of Mechanical Engineering, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa.
*** Director (Administration), Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa.
**** Lecturer, Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa.
***** Lecturer (Part-time), Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa.

have obtained useful data from samples of less than 80 households per settlement[2,8,17,18]. The following equation was used to calculate recommended sample size:

$$n_f = \frac{n_i}{[1 + (\frac{n_i}{N})]} \quad (1)$$

where: $N$ = settlement population size

$n_i$ = sample size for infinite population

$n_f$ = sample size for settlement

Households to be included in the sample were randomly selected from all the households identified on the aerial photographs.

Significant changes in the refugee settlement since 1988 precluded the use of aerial photographs to determine settlement size and structure. Settlement size was determined instead from data supplied by the Phalalani Relief Committee******. Eight parallel transects were drawn through the settlement, and every second household along each transect was included in the sample.

After a review of interview schedules used in similar studies[8,18], an interview schedule was developed and refined in consultation with Wits Rural Facility colleagues, Energy Branch staff, and local residents. Seven local residents were selected and appropriately trained as enumerators. The enumerators visited selected houses in each settlement and conducted structured interviews with household members. Seventy interviews were completed in Athol, 72 in Okkerneutboom, 73 in Rolle, 69 in Welverdiend, 72 in Xanthia, and 68 in the refugee settlement (424 households overall).

The household member interviewed in each case was, in order of preference, the person doing most of the cooking, the head of the household, one of the daughters-in-law, or older children. The enumerators also weighed respondents' estimates of the quantity of fuelwood consumed daily by the household.

The interviews, which took place from October to December 1991, included questions on fuel consumption, cost of fuel, fuel preferences, and appliance usage in each household. Respondents were asked for their opinion of each fuel and reasons were sought for the non-use of particular fuels. Some socio-economic data were also collected from each household.

An in-depth study to determine wood consumption was conducted in ten households in Welverdiend from 10 March 1992 until 18 March 1992. These households were randomly selected from those being interviewed. Respondents' daily wood consumption was monitored by weighing all wood prior to use. Residents were asked to use wood from a weighed stockpile only. New wood was placed on a separate pile, and only added to the stockpile once it had been weighed by the researchers. The number of people eating and sleeping at these households was also monitored on a daily basis. Respondents' estimates of their daily wood consumption were compared to their mean measured daily consumption using a signed-ranks test[19].

**"In poorer households, obtaining sufficient energy for domestic purposes will have an increasing financial or time cost..."**

Data on the net energy of the various fuels were derived from fuel quantity using the following calorific values: paraffin (37,0 MJ/l$^{-1}$); candles (3,45 MJ/candle$^{-1}$); gas (49,8 MJ/kg$^{-1}$); batteries (PM9 - 0,081 MJ/battery$^{-1}$; PM10 - 0,297 MJ/battery$^{-1}$; R20 - 0,0198 MJ/battery$^{-1}$); wood (17,0 MJ/kg$^{-1}$)[20]; sun-dried dung (12 MJ/kg$^{-1}$); and coal (27 MJ/kg$^{-1}$)[8]. Net energy consumed as reticulated electricity was determined from household electricity expenditure knowing that reticulated electricity for domestic use cost 9,7c/kWh$^{-1}$ when households consumed 400 kWh or less per month, and 16c/kWh$^{-1}$ when households consumed more than 400 kWh per month*******. The calorific value of generator fuel was taken to be 30,7 MJ/l$^{-1}$.

## Results and discussion

Of the 12 energy sources examined all were used by at least one respondent. The fuels most widely used were wood, paraffin, dry-cell batteries, and candles (Figure 1). Charcoal and reticulated electricity were infrequently used.

An examination of Figure 1 shows that the refugees' patterns of fuel use differed from those in the other five settlements.

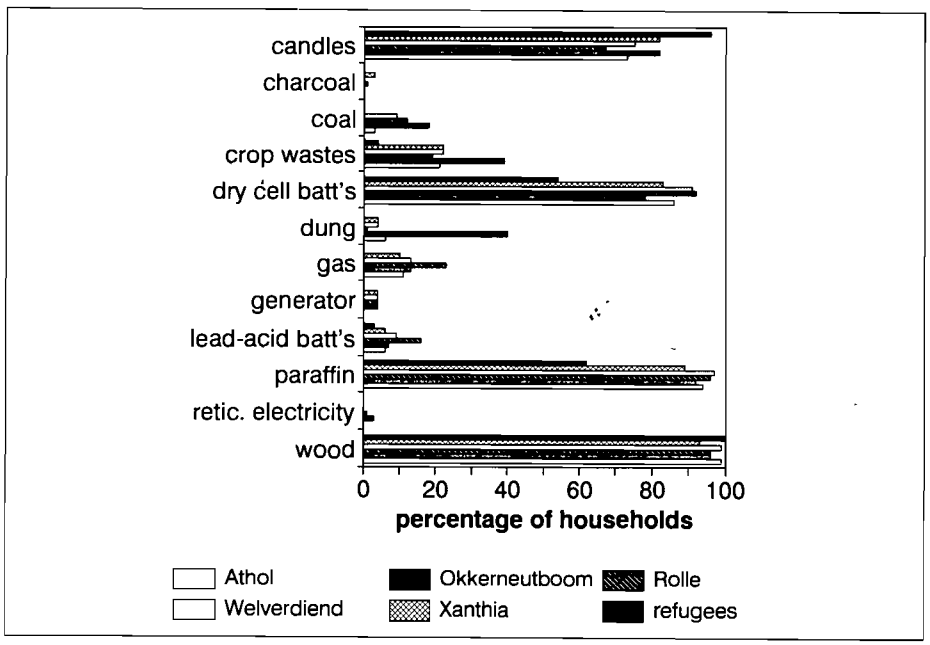


*Figure 1: Proportion of households using various fuels in the six settlements*

****** Phalalani Relief Committee, P O Box 5, Ximlungwe 1281, South Africa

******* Personal communication, Mr A B Mashego, Marketing Department, Gezikor, Phalaborwa 1390, South Africa

| Fuel [unit] | Settlement | | | | | |
|---|---|---|---|---|---|---|
| | Athol | O'boom | Rolle | Welverdiend | Xanthia | Refugee |
| Candles [No.] | 13,3 | 28,0 | 37,5 | 20,7 | 26,2 | 10,7 |
| | (1,1) | (3,4) | (8,3) | (2,9) | (5,0) | (1,8) |
| Coal [Kg] | 103,1 | 106,4 | 86,3 | 45,2 | | |
| | (53,1) | (16,8) | (22,6) | (14,8) | | |
| Dry-cell batteries | 3,8 | 3,6 | 2,6 | 5,1 | 3,3 | 2,4 |
| [No.] | (0,5) | (0,4) | (0,3) | (0,6) | (0,3) | (0,5) |
| Dung [Kg] | 64,4 | 387,5 | | 65,9 | 10,0 | |
| | (46,7) | (61,5) | | (50,0) | (5,9) | |
| Gas [Kg] | 14,0 | 10,4 | 16,0 | 11,3 | 15,8 | |
| | (4,7) | (2,2) | (2,2) | (2,1) | (6,0) | |
| Generators [l] | | 50,0 | 10,4 | 71,7 | 42,5 | |
| | | (10,0) | (9,6) | (64,2) | (37,5) | |
| Paraffin [l] | 10,3 | 17,3 | 14,4 | 14,6 | 14,8 | 4,6 |
| | (1,2) | (1,5) | (1,3) | (1,3) | (1,7) | (0,6) |
| Retic. electricity | | 216,5 | 416,4 | | | |
| [kWh] | | – | (158,6) | | | |
| Wood [Kg] | 309,3 | 250,9 | 305,2 | 399,9 | 353,0 | 345,5 |
| | (22,3) | (17,5) | (28,0) | (27,2) | (22,5) | (27,3) |

*Table 1: Monthly domestic fuel consumption in those households using that fuel in the six settlements. Fuels shown are those for which monthly household consumption data are available. Standard errors are given in parentheses below the means.*

While all refugee households used wood and most used candles, relatively few used paraffin, lead-acid batteries, dry-cell batteries, and crop wastes. None used generators, gas, dung, or coal. Only the refugees stated that their preferred fuel for heating and cooking was wood. Respondents in all the other settlements preferred reticulated electricity.

Borchers *et al.*[20], reporting on fuel use in Namaqualand, observed that the popularity of electricity increased as settlements became less rural and residents had more exposure to reticulated electricity. This may help explain the refugees' preference for wood as a heating and cooking fuel.

The mean quantities of each fuel consumed per month per household are shown in Table 1. It is important to note that the data in Table 1 are derived only from households using each particular fuel, and so are not representative of all households surveyed.

When the data on the percentage of households using any particular fuel were examined in conjunction with data on the quantities of fuel consumed it became apparent that candles, dry-cell batteries, paraffin and wood were widely used and considered important energy sources in the six settlements.

The use of other fuels varied considerably from settlement to settlement. Transitional fuels, like coal and gas, were used to some extent in most settlements, but not at all in the refugee settlement. Charcoal and reticulated electricity were used by very few households.

Of the three charcoal users interviewed, none were able to estimate their consumption of charcoal, as they used it infrequently. Charcoal, when used, was used exclusively to cook food. Depending on the settlement, 54% to 93% of the respondents who did not use charcoal did not know what it was.

Reticulated electricity was not available, except in Okkerneutboom and Rolle, where it was used in only three households. The majority of respondents in Okkerneutboom and Rolle said electricity was not available to them, and it seemed that electricity was available only in some areas and on certain streets in the settlements. Many respondents said that electricity was expensive. Of the electricity users, one claimed it was cheap, while another complained about the cost. Reticulated electricity was always used for lighting, and two of the three households used it for cooking, powering radios, and running television sets.

In Okkerneutboom, a high proportion of households used dung (Figure 1), and these burnt more per household than dung-burning households in the other five settlements (Table 1). This resulted in per capita dung consumption in Okkerneutboom being nearly fifty times higher than in any other settlement. Okkerneutboom households used less wood than households in other settlements, and most of their wood was purchased. The wood and dung use patterns in Okkerneutboom indicate that there was a severe shortage of available wood around the settlement, and that residents had been driven to find substitutes for collected wood as a fuel.

The contribution of the fuels listed in Table 1 to the net energy consumption of an average household is given in Table 2. Data in Table 2 are calculated from the fuel consumptions of all households in the settlement, not, as in Table 1, from only those households using each fuel. The data in Table 2 are therefore a function of both the proportion of houses using a fuel and the quantity of that fuel consumed in each house.

Most noticeably, the data in Table 2 show the importance of wood as an energy source in all six settlements. Paraffin was also an important source of energy and, except in Okkerneutboom, was second to wood in terms of net energy consumed. The quantity of net energy supplied by dung was negligible in all settlements except Okkerneutboom. Coal contributed a significant proportion of net domestic energy in Okkerneutboom and, to a lesser extent, in Rolle.

Residents of the refugee settlement were conspicuously dependent on wood for domestic energy, as they derived 86% of their net domestic energy from wood. All wood consumed by respondents in the refugee settlement had been collected. None was purchased.

The quantity of net energy consumed is not always the best way nor is it the only way to determine a fuel's importance within a household. Other measures of a fuel's importance include the useful energy derived from that fuel[20] and the cost of that fuel to the household, especially in relation to total household expenditure[15]. In this survey, it was frequently found that fuels were being used in different applications and in different appliances even within one household (e.g. paraffin used for lighting in lamps and cooking in stoves), and, without measurements of the amount of fuel consumed in each appliance, the researchers were unable to reliably estimate the quantity of useful energy contributed by the various fuels. Nevertheless, some general points about fuel use efficiency should be noted: open wood fires, in which most wood was burnt, are notoriously inefficient, while appliances using energy sources, such as,

| Fuel | Settlement | | | | | |
|---|---|---|---|---|---|---|
| | Athol | O'boom | Rolle | Refugee | Welverdiend | Xanthia |
| Candles | 33,1 | 80,4 | 86,8 | 35,3 | 53,5 | 73,8 |
| | (3,8) | (10,6) | (20,5) | (6,1) | (8,5) | (14,7) |
| Charcoal | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| | (0,0) | (0,0) | (0,0) | (0,0) | (0,0) | (0,0) |
| Coal | 79,6 | 518,9 | 259,0 | 0,0 | 106,2 | 0,0 |
| | (63,0) | (153,2) | (107,9) | (0,0) | (52,6) | (0,0) |
| Dry-cell batteries | 0,2 | 0,1 | 0,2 | 0,2 | 0,1 | 0,2 |
| | (<0,1) | (<0,1) | (<0,1) | (<0,1) | (<0,1) | (<0,1) |
| Dung | 33,6 | 1752,1 | 0,0 | 0,0 | 34,4 | 5,0 |
| | (27,7) | (387,4) | (0,0) | (0,0) | (29,0) | (3,7) |
| Gas | 70,9 | 58,1 | 159,4 | 0,0 | 58,9 | 76,7 |
| | (33,9) | (22,6) | (44,1) | (0,0) | (23,5) | (38,8) |
| Generators | 0,0 | 43,2 | 8,9 | 0,0 | 95,7 | 37,3 |
| | (0,0) | (31,0) | (8,5) | (0,0) | (89,0) | (35,1) |
| Paraffin | 349,4 | 585,4 | 516,5 | 104,9 | 524,4 | 486,2 |
| | (44,1) | (56,2) | (49,3) | (16,5) | (48,1) | (60,0) |
| Retic. electricity | 0,0 | 1,1 | 5,8 | 0,0 | 0,0 | 0,0 |
| | (0,0) | – | (4,7) | (0,0) | (0,0) | (0,0) |
| Wood | 5258,5 | 4266,0 | 5188,3 | 5873,0 | 6798,2 | 6001,5 |
| | (378,9) | (296,7) | (475,9) | (461,5) | (461,5) | (382,0) |

*Table 2: Fuel contribution to mean monthly net domestic energy consumption in households in the six settlements (MJ/month$^{-1}$). Fuels shown are those for which monthly consumption data are available. Standard errors are given in parentheses below the means.*

gas and electricity are generally far more efficient[20,21]. Paraffin and candles fall between these extremes.

Despite the negligible amount of energy contributed to the household by dry-cell batteries, expenditure on dry-cell batteries was high (Figure 2). In Athol, Welverdiend, Xanthia and the refugee settlement, more was spent on dry-cell batteries than on any other energy source. The high quality energy from dry-cell batteries was used predominantly in radios, radio-cassettes, hi-fis, and tape recorders. Between 8% to 30% of users used dry-cell batteries in torches.

In terms of financial cost per unit net energy, energy from dry-cell batteries is the most expensive energy consumed by the households. Respondents' opinions support this, and, depending on the settlement, 35% to 46% of battery users complained that dry-cell batteries were expensive. Nevertheless, dry-cell batteries are popular in all settlements (see Figure 1), and 17% to 32% of users said that they lasted for a long time. The number of households using dry-cell batteries, and the money spent on them, illustrates the demand for high quality energy in the six settlements.

Expenditure on wood varied considerably between settlements, with households in Okkerneutboom and Rolle spending, on average, more on wood than households in other settlements. Expenditure on wood was minimal in Athol and non-existent in the refugee settlement. The amount spent on wood is a function of the quantity of wood purchased and the price of that wood. There was wide variation from settlement to settlement in the proportion of households purchasing wood, as evidenced by 68% of Okkerneutboom households buying wood versus the 0% and 1% respectively of the refugee and Athol households. The quantity of wood purchased each month in those households that purchased wood also varied, ranging from 374±39 kg/ month$^{-1}$ in Okkerneutboom to 858±227 kg/month$^{-1}$ in Welverdiend. Wood prices varied by a factor of approximately two between Welverdiend (R0,07 kg$^{-1}$) and Okkerneutboom (R0,13 kg$^{-1}$).

Total fuel expenditure varied widely between settlements. Households in Rolle spent, on average, four times more on fuel than the refugee households did. Mean fuel expenditure in Okkerneutboom, Welverdiend and Xanthia was relatively high, while in Athol, mean household fuel expenditure was about half that in Rolle.

Mean total household expenditure did not differ significantly between Athol, Okkerneutboom, Rolle, Welverdiend and Xanthia (Figure 2). Mean household expenditure in the refugee settlement was lower than in the other settlements. In his work in the Cape Peninsula and the Transvaal, Viljoen[15] observed that proportional fuel expenditure (i.e. fuel expenditure expressed as a percentage of total household expenditure) was greater in formal than in informal settlements. Of the six settlements, residents of Okkerneutboom and Rolle allocated the largest proportion of their expenditure to fuel (16% and 15% respectively), and residents of Welverdiend and Xanthia the least (9% and 10% respectively). Households in the least formal of the six settlements, the refugee settlement, dedicated

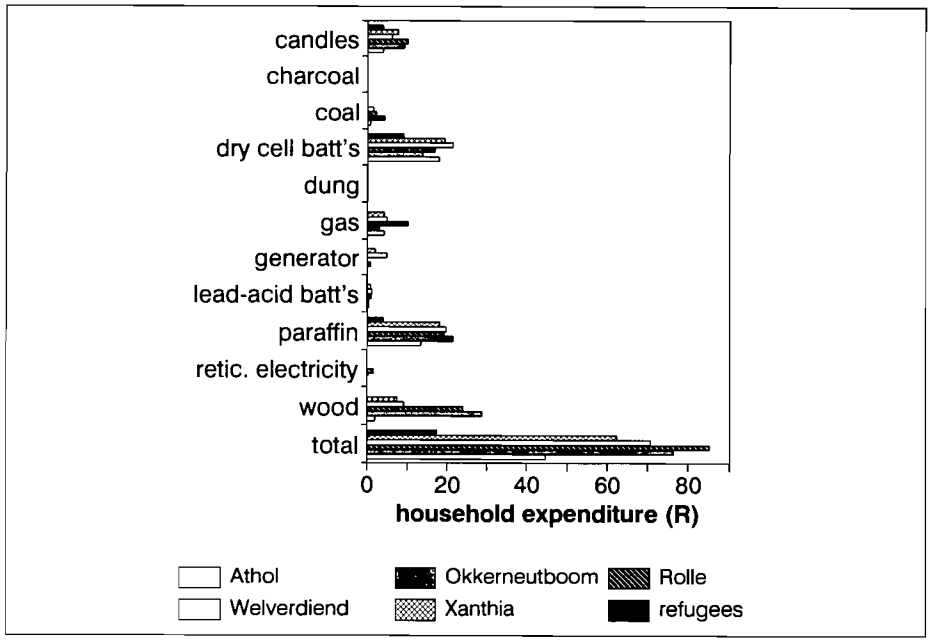


*Figure 2: Mean monthly expenditure on various fuels in the six settlements*

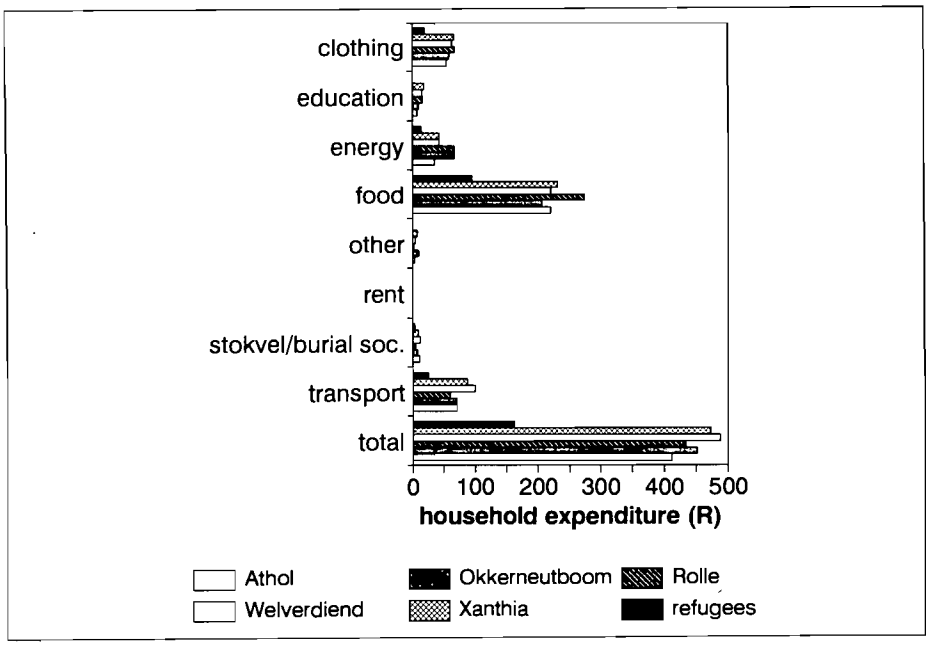


*Figure 3: Mean monthly household expenditure in the six settlements*

13% of their expenditure to fuel. This relatively high proportional expenditure is surprising in view of the fact that refugee respondents relied heavily on collected wood for their domestic energy requirements. However, refugee households' mean expenditure was very low (R162/month$^{-1}$), and, in absolute terms, so was their mean fuel expenditure (mean refugee household fuel expenditure was 22% of that of an average household in Okkerneutboom or Rolle).

Households in Okkerneutboom, while still relying to a considerable degree on biomass fuels, were moving away from a situation in which fuel for domestic use was collected at no financial cost. Instead, Okkerneutboom households purchased most of their fuel. The 51% of Okkerneutboom households that collected wood collected only 92±48 kg of wood per month. In comparison, 68% of households in Rolle, another large settlement, collected 214±42 kg of wood per month. Although 40% of Okkerneutboom households collected dung and 39% burnt crop wastes (the latter mostly as kindling), a high proportion of households used commercial fuels. Although wood was the main fuel in the majority of Okkerneutboom households, 68% of households purchased most of their fuelwood. More coal and paraffin were consumed on a per capita or per household basis in Okkerneutboom than elsewhere. A transition from collected biomass fuels to commercial fuels is also evident in Rolle, although it is in an earlier stage there. Residents of Rolle consumed, on average, 1,1 kg/capita$^{-1}$/month$^{-1}$ of collected wood, 36,4 kg/capita$^{-1}$/month$^{-1}$ of purchased wood, and relatively large quantities of coal and paraffin.

"... in settlements where little collectable wood is available, those unable to afford energy will be forced to reduce their domestic energy intake, possibly to levels where providing light, heating food, or boiling water become luxuries."

At the other end of the scale, households in Athol and the refugee settlement relied heavily on collected wood for their domestic energy. Only one household in Athol purchased fuelwood, while no households in the refugee settlement purchased wood. Paraffin and coal consumption were low in Athol, and minimal in the refugee settlement. The high dependence on collected biomass for energy in the refugee settlement may reasonably be attributed to the privation that those households report: household incomes of R253±35 per household (8,2±0,5) people, no livestock, and household members with little education or vocational training. Nevertheless, the majority of the refugee households said that they preferred wood as a fuel for cooking and providing heat. Athol residents' preferred energy carrier was reticulated electricity, but this is presently not available in Athol. Athol is a small settlement (260 households in 1988), and, for the moment, there is sufficient collectable wood available to satisfy the domestic energy needs of the residents. However, crude models indicate that this supply may be exhausted in 24 years[16].

Most of the domestic energy of the Welverdiend residents and the refugees was supplied by collected wood. As the combined population of Welverdiend and the refugee settlement is greater than that of Okkerneutboom or Rolle, considerable strain was placed on the woody vegetation around Welverdiend. Projections of wood availability around Welverdiend in the near future suggest that, irrespective of the refugee presence, the amount of wood available will sharply decrease within 10 years[16]. It therefore seems that residents of Welverdiend and the refugee settlement will increasingly be forced to use other, probably commercial, fuels during the next decade.

## Conclusions

Stocks of collectable wood, in the past the major fuel of the region, have been seriously depleted. Instead of collecting wood, residents of settlements in the area have been increasingly compelled to rely on commercial fuels as domestic energy carriers. The transition from collected to commercial fuels is of concern in a region where, in the settlement with the highest mean household income, 25% of households have incomes of R225/month$^{-1}$ or less (in the refugee settlement, which has the lowest mean household income, 25% of households earn R100 or less per month). In poorer households, obtaining sufficient energy for domestic purposes will have an increasing financial or time cost, and, in settlements where little collectable wood is available, those unable to afford energy will be forced to reduce their domestic energy intake, possibly to levels where providing light, heating food, or boiling water become luxuries.

## Acknowledgements

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# Enertek: The energy industry's technology partner

* D L W KRUEGER and * * P S DE WET

The authors discuss the activities of the CSIR's Division of Energy Technology (Enertek), one of 13 operational units which carries out the CSIR's research, development and implementation function. Enertek has 7 technical programmes focusing on the areas of coal, electric power and chemicals from carbonaceous feedstocks, with coal being the largest of the three. The Division's areas of expertise in these areas are listed, and its sources of funding discussed briefly.
Enertek's work is undertaken with funding from three main sources, viz.:

— the CSIR's parliamentary grant, for exploratory research in future growth areas of importance to industry, and for research in specific national priority areas, such as, developing communities;

— the Chief Directorate: Energy, Department of Mineral and Energy Affairs, for approved projects aimed at promoting effective resource utilisation, as well as the generation, distribution and utilisation of energy;

— industry, for solutions to specific problems, undertaken under contract.

This paper is mostly devoted to examples of important achievements in each of Enertek's focus areas. Enertek's commitment to environmental issues is illustrated by listing a number of projects which were initiated as a direct result of environmental problems, or which have a direct impact on the environment.
In conclusion, the authors comment on coming funding changes and give a short description of Enertek's future strategy.

**Keywords:** Enertek; energy research; coal; electric power; petrochemicals

## Introduction

Enertek was established in 1987 with the restructuring of the CSIR. It is a streamlined amalgam of the former National Institute for Coal Research (NICR) and the energy-related activities of the National Chemical and National Electrical Engineering Institutes, aimed at addressing the needs of a wide variety of energy users and producers. Like the rest of the CSIR, Enertek has come a long way since the days when its research was largely funded by Government and its services were provided almost free of charge. Today the Division strives to provide cost-effective and appropriate solutions to its clients in both the public and private sectors, while also undertaking work aimed at providing technology solutions to improve the quality of life in developing communities.

* Director, Division of Energy Technology, CSIR, P O Box 395, Pretoria 0001, South Africa.
** Manager, Marketing Services, Division of Energy Technology, CSIR, P O Box 395,

For many years Enertek and its main predecessor, the NICR, received a portion of the coal levy and the so-called Rand-for-Rand contribution from the government. With the repeal of the Coal Act in 1991, this fell away and made Enertek more dependent on direct contracts with industry. These have grown from a negligible base in 1987 to around R6,9 million, or 32% of the total budget, in the current financial year. Nevertheless, it is not foreseen that Enertek will ever be totally independent of state funding, nor is this its goal. Such funds will always be required for exploratory research in future growth areas of importance to industry, and for research in specific national priority areas, such as, developing communities.

The Division has currently a total of 185 employees, of whom 80 are graduates and diplomates. Through specialist technical programmes, it undertakes industry-oriented research and development work, and provides products, processes and services mainly in the fields of coal, electric power and chemicals from carbonaceous feedstocks, with coal being by far the largest of the three.

## Funding

Enertek's budget for the current financial year amounts to R20,7 million. Projects are funded in one of three ways in almost equal proportions. Firstly, funds are supplied from the CSIR's parliamentary grant for longer-term projects and the development of new sales capacity. The remaining two-thirds of the budget is obtained on a direct contractual basis with external clients. Of these, the Department of Mineral and Energy Affairs, (DMEA), through its Chief Directorate: Energy, is Enertek's most important client, currently accounting for just over half of the Division's external sales. Funding is also received from contracts with industry.

### *Projects funded by the DMEA*

Over the years the DMEA, initially via the National Energy Council and currently via the Chief Directorate: Energy, has contracted Enertek and its predecessors to undertake various projects aimed at promoting effective resource utilisation as well as the generation, distribution and utilisation of energy. Some of the major DMEA-funded projects undertaken by Enertek in the fields of coal and electric power are listed below.

### *Coal*

(1) Coal oxidation

The coal oxidation project, which was initiated in 1984, concerns the conversion of coal into high-value products by means of the non-catalytic controlled oxidation of a coal slurry under high pressure. The process has been demonstrated in a fully automated process development unit over a total period of 2 000 hours. The plant, which is presently equipped with a 120-litre reactor, has a daily throughput of about one ton, depending on the coal and the desired product properties. Modelling and engineering studies aimed at the detailed design of a demonstration plant have been completed.

A number of products have been developed and successfully evaluated in field trials for different applications. These include the reclamation of mine

dumps, water purification, and the rectification of agricultural soils with structural problems, including crusting and compacting, as well as chemical problems associated with pH and macro-element availability. The results clearly demonstrate the value of this unique development and its notable contribution towards improving the environment.

The commercialisation of the coal oxidation project is being undertaken by ENERKOM, which is a holding company jointly owned by the DMEA and CEF (Pty) Ltd.

(2) Coal extraction

This project involves the production of carbon fibres and carbides from coal. Some very interesting and encouraging results have been obtained from this high-risk, but potentially lucrative project. Possible applications include low-cost carbon fibres suitable for cement reinforcement, and fine silicon carbide powder for use in the manufacture of ceramic components.

(3) Waterberg coalfield

This project is aimed at identifying the beneficiation response of Waterberg coal when liberated to varying topsizes. The Waterberg coalfield, which contains about 30% of South Africa's coal reserves, has been identified as a priority area for future development. Due to its unique nature, it is important that knowledge of this coalfield is expanded to ensure optimum future utilization of the coal. One of the first aspects to be addressed in this regard is a study of the beneficiation characteristics of the coal. The data resulting from this project will enable decision-makers to evaluate the economically optimum routes for raw coal from this coalfield.

(4) Coal Bulletin

The CSIR publishes an annual bulletin containing the results of certain chemical and physical analyses of the commercial coal products of every producing colliery in the country. About 1 500 copies of this publication, which was first issued in 1955, are distributed to the coal industry annually, i.e. to collieries, mining houses, marketing agents, universities, laboratories, and geologists. It is also distributed overseas as an aid to the international marketing of South African coal products.

(5) Coal mine safety

Enertek's work in the field of coal mine safety is carried out at the G P Badenhorst Research Facility (Figure 1) at Kloppersbos, about 40 km north of Pretoria. The Facility was established in 1987 with financial support from the Department of Mineral and Energy Affairs. It has a mild-steel explosion tunnel, 200 m long x 2,5 m in diameter, which is equipped with sophisticated instrumentation for measuring flame, static and dynamic pressures, temperature, etc. Coal dust explosions are initiated to characterise South African coals and also to measure the effectiveness of preventive measures.

Over the past six years the CSIR has been responsible for managing the Facility on behalf of the Government Mining Engineer (GME), who required specific research to be undertaken in order to promote safe underground practices in South African collieries. The work was funded via the Coal Mine Research Controlling Committee (CMRCC).

Most of the objectives set by the GME have now been achieved. Future work will be awarded on a tender basis via the Safety in Mines Research Advisory Committee (SIMRAC). A close liaison with industry will be maintained on the formulation of these project proposals to ensure that the Facility is utilised optimally in the interest of the South African coal mining community.

Other functions of the team at Kloppersbos include the holding of safety seminars and demonstrations of explosions for colliery workers. These have already had a major impact in promoting safety awareness and in explaining the reasons for certain safety practices. In addition, the team is available for consultation and carrying out testwork directly for the industry.

## *Projects funded from the CSIR's parliamentary grant*

### *Coal*

(1) Developments in the field of coal preparation

Enertek recently completed three developments in the area of coal preparation aimed at assisting the coal industry in lowering costs, improving efficiency and reducing environmental problems. The first of these is the **Kangela**, an on-line ash monitor developed jointly with the Atomic Energy Corporation. The system, which is mounted above a conveyer belt, utilises low-energy transmission nuclear sources to monitor the ash content of coal on a continuous basis, thus enabling the accurate separation of coal with a high ash content (low quality) from coal with a low ash content (export quality). It has been extensively tested at Iscor's Grootegeluk Colliery where its accuracy in a production environment has been proven and its performance on different types of coal evaluated. The first production unit has already been sold to industry, with an order for four more units in the pipeline. The company Hartmann and Braun has been appointed as the sole agent responsible for marketing the instrument.

Work is currently also underway on a moisture analyser for the Kangela, to enable simultaneous measurement of both the moisture and ash content parameters of coal.

The second development is the **Magmiser**, a magnetic belt separator which improves the recovery of the magnetite used as a dense medium in coal preparation plants. This will reduce costs and

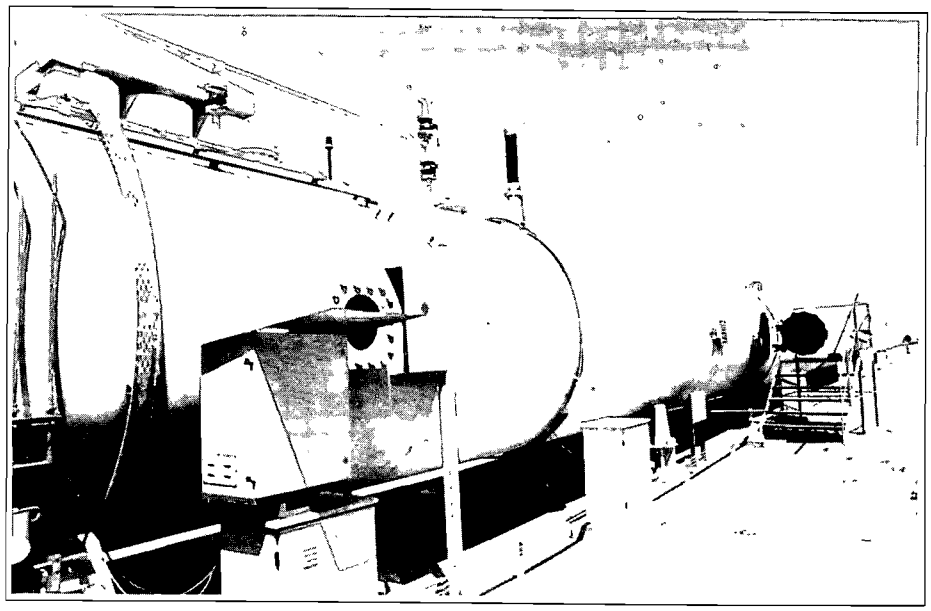

*Figure 1: A view of the 200 m long, 2,5 m diameter tunnel at the G P Badenhorst Research Facility*

improve process efficiencies. A pre-production model of the Magmiser was installed at Amcoal's Kleinkopje Colliery for testing, where it has reduced the normal loss of magnetite in the secondary magnetic separator effluent from 0,3 g/l to 0,06 g/l. Malvern Engineering has been appointed as the CSIR's industrial partner responsible for the marketing of this product.

Enertek's third recent development in the field of coal preparation is a **PC-based program aimed at optimising coal preparation plants**. It entails the testing and analysis of samples from a particular colliery, and then simulating and optimising the coal preparation process for that specific type of coal. This has resulted in considerable cost savings when compared with experiments on operational plants.

(2) Fluidised bed dryer

A very old problem on coal mines has been that fine coal, even if it has been beneficiated to saleable quality, usually contains too much moisture to enable it to be added to the product stream. Because of its particle size, this coal is also usually not suitable for local consumption, but could be added to export steam coal. Here transport costs become a significant factor.

Centrifugal drying can reduce moisture content to about 16%, but reducing it further would mean thermal drying, which can be very expensive. For this reason, Enertek has developed a **dryer based on fluidised bed technology** which can remove moisture cost- effectively down to about 7% or less. It also has considerable safety and operating cost advantages over other dryers. It has already been demonstrated to industry, and a tender for the design of a commercial model has been submitted.

### *Electric power*

(1) $SF_6$ current transformers

Enertek is currently working on the development of $SF_6$ (sulphur hexa-fluoride) current transformers. This technology will replace conventional oil paper insulation technology by making transformers explosion-proof and substantially extending transformer life. An order has already been received from Eskom for nine prototypes, three each for 132 kV, 275 kV and 400 kV respectively. Enertek also recently entered into a partnership agreement with ABB Powertech, who will be responsible for the manufacture and marketing of this equipment.

### *Chemicals from carbonaceous feedstocks*

(1) Catalyst development

Enertek is involved in the development of catalysts for more energy-efficient chemical processes and for processes which will produce fewer unwanted by-products. At this stage the emphasis is on feedstocks for making additives for lead-free petrol, expected to be introduced in the South Africa in 1995.

The development of these fuels will necessitate some changes to the manner in which crude oil is refined. One way in which the octane-boosting effect of lead can be obtained is by incorporating fuel ethers, such as, methyl tertiary butyl ether (MTBE) (which is manufactured from methanol and isobutene) into the fuel. Methanol production is comparatively easy but there is international concern over the availability of isobutene from refinery operations. Enertek is in the process of developing technologies to assist in the manufacture of isobutene, MTBE, and other closely related fuel ethers. The aim of the Division's work is to design process catalysts on which new refining operations will depend. Enertek pursues a policy of active involvement with suitable partners and potential end-users, and maintains close links with important overseas players in this field.

### *Other*

(1) Dust explosion laboratory

Every week at least one industrial dust explosion occurs in South Africa resulting in large insurance claims, loss of capital and human life, and, in extreme cases, even the closure of plants. Any industry which manufactures combustible matter in the form of fine particles or even has it as a by-product, runs the risk of a dust explosion (typically, the chemical, food and timber industries).

In August 1992, Enertek commissioned the first dust explosion laboratory in Africa - a spin-off of the work done at Kloppersbos - to assist local industry in preventing this problem. The main apparatus in the laboratory is a 20-litre explosion vessel, which is used to determine the explosive properties of dust, gas, mist, and hybrid mixtures. This type of vessel is currently being used in 60 laboratories in 18 different countries.

The laboratory enables Enertek to advise clients on the explosion hazard of a specific environment, determine the explosion parameters of the dust, and make recommendations on the prevention of explosions.

### *Projects funded by industry*

### *Coal*

(1) Fluidised bed combustion technology

In 1982, the CSIR was awarded a contract by the Department of Mineral and Energy Affairs to demonstrate the suitability of **fluidised bed combustion** for utilising

**Coal preparation and beneficiation**
* Sampling and analysis of coal
* Coal petrography
* Spontaneous combustion of coal
* Dense-medium separation
* Fine-coal beneficiation
* Coal washing plant optimisation

**Coal utilisation**
* Fluidised bed combustion
* Fluidised bed incineration of aqueous solid wastes
* Beneficiation of minerals
* Fluidised bed gasification
* Agglomeration of fines
* Fine coal dewatering and drying
* Coal-related pollution

**Coal conversion**
* Coal oxidation
* Coal extraction
* Coal-related chemistry and processes

**Coal mine and industrial safety**
* Explosive properties of coal
* Safety regulations
* Safety equipment and procedures
* Industrial gas/dust explosions

**Catalysis**
* Catalysts for the synfuels and allied chemical industries
* Olefin conversion processes
* Alcohol synthesis
* Synthesis of fuel ethers

**Electric power**
* Manufacture and testing of high-voltage equipment
* High-voltage insulation
* Lightning and lightning protection
* Power electronics

**General**
* Low-cost energy for developing communities
* Treatment of toxic chemical waste and municipal refuse

*Table 1: Enertek's areas of expertise*

duff coal. Since then, the National Fluidised Bed Combustor (NFBC) at Enertek's Process Park in Pretoria West has been successfully used to burn duff, discards and coal slurries, whilst organic sludges, wood waste, spoiled cattle fodder and discarded PC boards have also been incinerated successfully. The technology is well-suited for the incineration of chemical wastes, particularly solid and liquid wastes that are difficult to incinerate in conventional fuel burners.

Enertek designed and constructed a **fluidised bed hot gas generator** for an industrial client in Vanderbijlpark, which has been running successfully for the past three years. In 1989, the Division received the Projects and Systems Award of the South African Institute of Mechanical Engineers for the design, installation and commissioning of the plant.

International Combustion Africa Limited (ICAL) and Energy Engineering have both been licensed to market this technology. Earlier this year ICAL was awarded a major contract by an international company to construct a fluidised bed boiler, according to Enertek's design, to incinerate process waste containing 85% water.

Fluidised bed technology is also used for the pre-reduction and beneficiation of other minerals, e.g. manganese, vanadium and chromium, and the regeneration of process chemicals. It also forms the basis of a process developed by the CSIR for the calcination of seashells.

(2) Agglomeration

Enertek has extensive expertise in the field of agglomeration. It operates a 3 t/h roll briquetting test facility to investigate the technical and economic potential of briquetting for producing reconstituted solid fuels and compacts from fine materials, with partial support from the DMEA. This plant is capable of producing briquettes with or without binders, which influences cost to a large extent.

Current work includes contract research and development in charcoal briquetting, while the viability of briquetting various other carbonaceous fines, e.g. anthracite, lean butiminous coal, peanut and coffee husks, wood-derived sawdust, etc., is also being investigated. Another area of work is the briquetting of minerals and other metallurgical products where higher value addition is possible than in the field of coal.

3) Coal analyses

Enertek operates a fully equipped coal analytical laboratory, primarily for its own needs. However, this laboratory is also available to industry for special requirements, in particular for the control and arbitration analyses to the highest international standards.

### *Electric power*

(1) Lightning-related work

South Africa has frequent electrical storms and one of the highest lightning densities in the world. Combined with the relatively high earth resistivity conditions, these factors cause severe stress to electrical and electronic circuits in the country with its vast, growing numbers of advanced electronic systems. South Africa was one of the first countries in the world to become involved in lightning research, and work done by the CSIR has earned it international recognition.

**"Today the Division strives to provide cost-effective and appropriate solutions to its clients in both the public and private sectors, while also undertaking work aimed at providing technology solutions to improve the quality of life in developing communities."**

As is the case in many parts of the world, lightning is a major cause of electronic system failure and upset. Enertek assists industry in establishing protective measures to minimise the disruptive effects of lightning. Its achievements in the field of lightning research include the following:

— The production in 1986 of a ground-flash density map for Southern Africa - a world first at the time - based on the measurement of lightning ground-flash density over an 11-year solar cycle.

— Measurements on a 60 m mast to determine the current parameters of lightning. This information on the anticipated magnitude of currents and voltages which will arise in power systems as a result of lightning activity has proved to be invaluable to system designers. The project is currently being funded by Eskom, which will use the information to correlate the number of strikes to the CSIR's mast with results obtained by means of their newly installed lightning location system.

— Research on an 11 kV test line to determine the lightning performance of woodpole distribution lines. This resulted in the publication of an authoritative guide entitled, *Insulation coordination of unshielded distribution lines from 1 kV to 36 kV*.

— Both methane explosions and premature detonation of explosives are caused by lightning in underground collieries. Enertek has undertaken extensive investigations into lightning-related incidents in coal mines aimed at understanding this phenomenon and assisting the coal mining industry in countering these hazards.

— The CSIR was chosen as the major subcontractor for the design, installation and commissioning of a lightning research station for a Brazilian power supply authority in 1982. No power failure or equipment damage has occurred at the station since its commissioning, despite more than 25 direct strikes to the mast.

— Since 1990, Enertek has been running a course on the lightning protection of electronic systems. The course has been attended by more than 750 delegates to date, and will again be presented in Pretoria and Durban during November this year.

— In 1991, the CSIR entered into an agreement with Strike Technologies for the joint development, manufacture and marketing of a series of lightning protection modules for electrical and electronic systems. In the terms of this agreement various "black boxes" are currently being marketed for the protection of sensitive electronic equipment against sudden voltage surges caused by lightning. Areas of application include pre-payment electricity dispensers or budget energy controllers, electronic distribution networks, computer equipment, industrial electronic systems, telecommunication and television systems,

electronic alarm systems, and low-voltage electrical distribution systems.

— Enertek is currently in the process of developing a programme to investigate the effects of lightning on MV and LV distribution systems typically used in developing communities. This will be a joint undertaking between the CSIR and Eskom.

(2) Substation monitoring system

A computer-based, on-line monitoring system has recently been developed by Enertek to measure the condition and quality of insulation in high-voltage equipment. This will address the problem of explosions in electrical power substations due to the failure of oil paper insulation in high-voltage equipment, which is a major concern to electrical utility companies. The first of these monitoring stations is currently being installed for a local power supplier. The system can either be used as a portable measurement device or for continuous monitoring purposes.

(3) Resonant cable tester

Enertek developed a variable-frequency series-resonant (VFSR) test set to address the problem of testing long lengths of installed high-voltage and super-tension electric cables, with sponsorship from both the DMEA and a private company, African Cables. This light-weight portable field-testing facility enables cable manufacturers to ensure the integrity of new cable installations, and can also be used for factory-type testing.

In addition, VFSR test sets are suitable for use by power utilities in the performance of *in situ* evaluations of new and existing substations and equipment to improve systems reliability.

## Environmental issues

At least 25% of Enertek's budget involves work initiated as a direct result of environmental problems, or which has a direct impact on the environment. The following are examples of work which has been described in more detail earlier in this article which illustrate this aspect of Enertek's research:

— **Fluidised bed** technology enables the utilisation of poor qualities of coal, thus preventing it from degenerating into environmentally harmful gases. This technology is also being used to design effective waste incineration systems.

— The **briquetting** technology that converts fines which would present a waste and dust problem into economically useful products.

— All the products of the **coal oxidation process** have environmentally positive applications, such as, the rehabilitation of mine dumps to restore the ecology, water purification, etc.

— The **$SF_6$ current transformer** is a safer replacement for the conventional current transformers which contain mineral oil and pose an explosion and leakage danger harmful to the environment.

— The development of **catalytic processes for the production of fuel additives** which contribute to the promotion of cleaner fuels, including lead-free petrol.

## Conclusions

In spite of severe funding cuts from particularly the public sector during the past few years, Enertek has continued to expand its service base to both the public and private sectors, and in developing several viable and new products and services.

Recently the Director-General of the DMEA announced that, as from 1994, the Department would no longer financially support research programmes which focused on technological development, but only those that were aimed at policy-directed investigations. This change will certainly affect Enertek's future strategy, with even more emphasis being placed on the needs of developing communities and the environment. Particularly in the former area close co-operation is foreseen between the CSIR and the recently formed National Electrification Forum, in helping to provide affordable electricity to disadvantaged communities.

TECHNICAL NOTE

# Permanent magnet electrical machine for photovoltaic-powered water pumps

* M J KAMPER

A highly efficient, brushless, permanent magnet electrical machine has been designed and developed for a submersible photovoltaic-powered water pump application. The machine has been designed to operate from a variable photovoltaic (PV) supply of between 100-300 Watt-peak and 30-100 V. The machine has further been designed to operate with a Mono progressive cavity pump at heads of between 30-60 m. High energy product Neodium-Iron-Boron (NdFeB) permanent magnets were used. Performance results showed that the efficiency of the machine varied between 78-89% for torques between 1,0-2,5 Nm. The power density of the machine was found to be remarkably high. Coupled to the RH1110 Mono-pump, the machine-pump efficiency varied between 20-43% for pressures of between 200-600 kPa (≈20-60 m head) and for power input levels of between 100-300 W. The efficiency of the RH1110 Mono-pump was relatively low,typically between 25-50%. The Mono-pump in general was found to be unsuitable for small-scale PV pump systems. It is recommended that more attention be given to the search for high-efficiency positive displacement pumps.

**Keywords:** permanent magnets; photovoltaic water pumps

There is currently a high demand for photovoltaic-powered water pump systems in South Africa, especially for remote stand-alone, small-scale pump systems. The price per Watt-peak (Wp) of the PV cells, however, is still relatively high, which places a special premium on the efficiency and cost of the PV pump system. In order to increase the efficiency and power density of the electro-mechanical converter used in the PV pump system, high energy product permanent magnets can be used. In the report[1] for the Energy Branch (now the Chief Directorate: Energy) of the Department of Mineral and Energy Affairs, the design, development and performance of a highly efficient permanent magnet (PM) electrical machine, which could be used to operate a submersible Mono-pump, was presented. The specified requirements are that the motor-pump unit should operate from a 100-300 Wp (30-100 V) PV supply and should be able to pump at heads between 30-60 m.

The design of the machine is discussed in some detail in the report. The equivalent circuit and important design equations are given. With the machine speed below 3 000 rpm it was decided to use a four-pole machine. Two-pole machines, in comparison to four-pole machines, have disadvantages, such as, high flux densities (for the same iron core) and increased end-turn losses. A 24-slot stator was used with the laminations ordered from a company in Germany. Furthermore, the air gap flux density designed was 0,75 Tesla (within the range of 0,7-0,8 Tesla). Some of the machine's dimensions are as follows: outer diameter = 90 mm, rotor diameter = 48 mm and stack length = 90 mm.

The permanent magnet material used is the Neodymium-Iron-Boron (NdFeB) type of material, which has the highest energy product of all permanent magnets. The magnets were ordered from a company in Hong Kong and magnetised at the National Accelerator Centre, Faure, in the Western Cape. The cost of the permanent magnets ordered for only one machine was R300, which includes courier costs and delivery within 45 days. The thickness of the magnets was calculated to be 4 mm. The magnets were mounted onto the surfaces of rotor-yoke soft steel pieces by means of a special glue and thin PVC rings around the magnets. In order to avoid high cogging torques the rotor magnets were skewed, which is done by dividing the length of the rotor into four separate parts. Each rotor part, i.e. a four-pole magnet rotor piece, was then skewed by a certain number of degrees.

Shaft position sensing is necessary to switch the stator phases according to the position of the magnets. For the 3-phase machine, three position sensors are necessary, placed 60° from each other. The position sensors are then soldered to a PC-board and mounted onto the bottom end-casing of the machine. The rotating position shield is mounted onto the end of the rotor.

Regarding the manufacture of the PM machine, standard outer- and end-casings from existing machines were used and modified where necessary. The use of standard casings kept the cost of the machine down. Also, by using standard casings the new PM machine could be coupled to the standard Mono-pump. An existing rotor shaft was used and modified to the right dimensions.

## Performance results

The wave form of the induced EMF voltage of the PM machine was examined and found to be very close to what was expected. The induced EMF was further used to determine the air gap flux density in the machine. The latter was found to be 0,7 Tesla, which is close to the specified flux density of 0,75 Tesla. The magnets were therefore considered to have been successfully designed.

Load tests were conducted on the PM machine, where it was mounted on a test bench and connected to a high speed d.c. brush machine. The water-seal was removed from the machine during these tests, due to the fact that the seal needs water cooling and may not run dry. In Figure 1 the efficiency of the machine is shown. The efficiency was found to vary between 78-89% for torques between 1,0-2,5 Nm, which corresponds with heads of between 30-140 m. Measurements are focused on speeds above 500 rpm owing to the very low output of the Mono-pump below this speed. However, the iron losses of the machine, which play a dominant role in the low power regions, were found to be somewhat high. The power

* Senior Lecturer, Department of Electrical and Electronic Engineering, University of Stellenbosch, Stellenbosch 7600, South Africa.

density of the machine, however, was remarkably high. Although not directly measured, the load tests showed that the full load power output of the machine, with normal air cooling and even better with water cooling, was typically 750 W. This is considered to be high for a machine with a diameter and stack length of just 90 mm. The efficiency of the machine at this load point was estimated to be 90% (see Figure 1).

Measurements were also taken on the machine-pump unit when the machine was connected to the low-pressure RL1055 Mono-pump, followed by measurements with the machine connected to the high-pressure RH1110 Mono-Pump. With the RL1055 pump, the machine-pump efficiency varied between 17-36% when operating at 300 kPa (30 m head) and 100-300 W power input. At 600 kPa (60 m head) the efficiency varied between 0-30% with 100-300 W power input. From the measured results, some pump efficiencies were calculated to be between 22-46% for pressures between 300-600 kPa and speeds between 750-2 500 rpm.

With the machine coupled to the RH1110 Mono-pump, the performance of the machine-pump unit was considerably better than that of the RL1055 pump. For example, at 600 kPa, with the power input between 100-300 W, the machine-pump efficiency was measured at between 30-43% (compared to 0-30% with the RL1055 pump). At higher power input levels, between 300-600 W (6-12 PV modules), the machine-pump efficiency at 600 kPa varied between 43-48%, and at 1000 kPa between 40-55%. Some pump efficiencies were also calculated from the measured results and found to be between 26-60% for pressures between 200-1 000 kPa at speeds of between 750-2 000 rpm.

The starting torque of the Mono-pump, specifically the high-pressure RH1110 pump, was sometimes found to be higher than 4 Nm. The starting torque was especially a problem at times when the pump had not been used for some time.

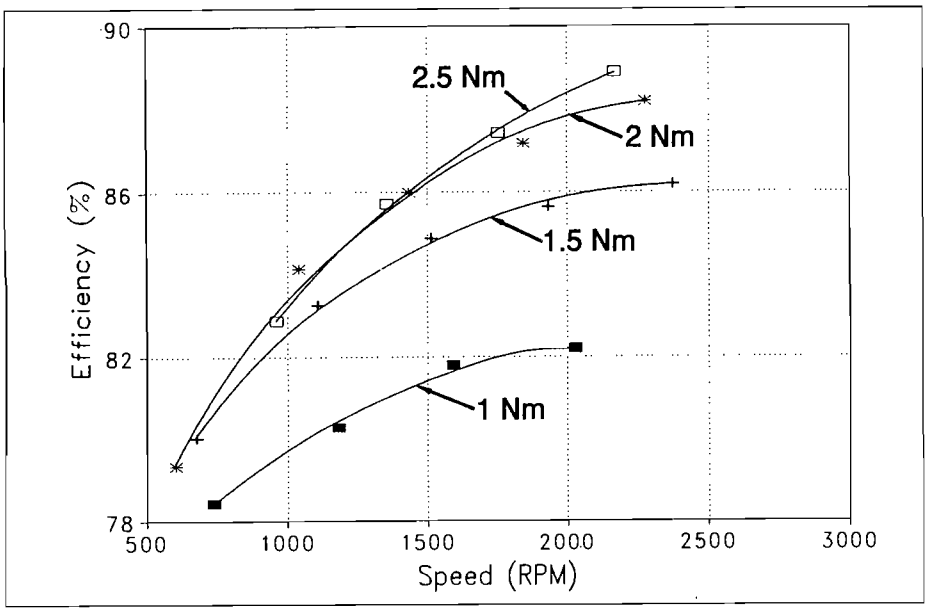


*Figure 1: Efficiency versus speed of the permanent magnet machine with load (in Nm) as a parameter*

# Conclusions

Some of the important conclusions and recommendations are summarised as follows:

— The high flux density obtained in the air gap of the machine with small (small in volume) NdFeB magnets, makes the use of these magnets in small electrical machines very attractive.

— The use of permanent magnets is essential if a special premium is placed on high efficiency and power density for the small electrical machine.

— The low cost and availability of the NdFeB permanent magnets used, makes the use of permanent magnet machines economically justifiable.

— The Mono-pump, in general, is not suitable for use in very small (100 W) PV pump applications due to the high starting torque and low efficiency of the pump.


## Acknowledgements

The author gratefully acknowledges the financial contribution of the Chief Directorate: Energy, Department of Mineral and Energy Affairs, to the project.


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LETTER

**From: A P Dale**
Powerplan Consultants (Zim) (Pvt) Ltd
32 Kingsmead Road
Borrowdale, Harare
Zimbabwe

# Reply to the comment on my paper by P J Visagie

Mr Visagie's[1] comment in the February 1993 issue of the Journal on my paper, *Recent hydrological trends in the Zambezi Basin and their effect on the present electrical energy situation in Zimbabwe and Zambia*[2] that the "storage reservoirs (at Kariba and Itezhi-Tezhi) on the two rivers are not very large compared to the respective run-offs" is valid for the Kafue but not for Kariba. There has been no spilling at Kariba for the last 12 years because the reservoir there can hold nearly three years of the average annual net inflow since a new and lower flow trend established itself in 1981/82. If one considers the "dead" storage also, total storage at Kariba amounts to nine years of post-1980/81 average net inflows. This is a big reservoir with a capacity sufficient to supply all of humanity's domestic water requirements for at least eighteen months! At Kafue, the situation is different as the main reservoir at Itezhi-Tezhi holds only one (post-1980/81) year of average annual net inflow on a river where flow variability is much greater than on the Zambezi.

The main point of my paper was to demonstrate the large reduction in flows that has taken place since 1980/81, and which the authorities responsible for Kariba had been very slow in recognising. As a result, since that time more water has been taken out of the reservoir than has flowed in, with this being the main contributor to the serious electricity shortage experienced recently in both Zambia and Zimbabwe. As similar difficulties were also encountered elsewhere in the sub-continent, it is clear that there is a need for a system to provide better future monitoring of hydrological trends across Southern Africa, commencing with a study, perhaps as simple as the one I carried out for Kariba and Kafue, on the other important hydroelectric catchments in Southern Africa, such as, the Cunene, Shire, Luapula, Great Ruaha and the Senqu/Orange. There is also a need for seasonal and in-season forecasting models to be developed using various new metereological measurement and forecasting techniques.

Mr Visagie's suggestions on the regional aspects of the matter are appropriate. Hopefully it will be possible for the various ideas and information on the subject to be brought together soon, with a view to instituting co-ordinated research at a regional level.

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# Energy news in Africa

## Coal

Duiker Exploration has won more than R500 M in coal contracts with the Taiwan Power Company which are set to run until 1998. The contracts for the supply of 4,4 Mt of steam coal over five years, will nearly double the size of Duiker's present steam coal exports.

These exports are at odds with Duiker's small allocation at the Richards Bay coal terminal and have led the group to back the construction of new facilities at Richards Bay, which have been condemned by South Africa's leading exporters.

(Source: Cape Times, 14 June 1993)

## Electricity

Following the launching of the National Electrification Forum in September 1992, a subsequent meeting of some 100 delegates took place on 14 May 1993 at which consensus was reached on a pragmatic approach for electrification, using existing capacity in the short term while the industry is restructured in the longer term.

A 10-person management committee is to be formed to handle the day-to-day matters of the Forum. The main objective is to accelerate the electrification of South Africa with specific emphasis on disadvantaged communities. At the same time, these communities will be empowered through training in specific skills. Six working groups have also been established.

(Source: AMEU News, June 1993)

The Zimbabwe Electricity company, ZESA, has announced plans to refurbish a number of its steam turbine power plants. A consortium led by the Swedish firm ABB Stal is to carry out the work on plants in Harare and Munyati. ABB Stal will overhaul and refurbish five steam turbines.

Babcock Construction from the U.K., also a member of the consortium, will overhaul and refurbish nine boilers.

The work will cost $30 M and is being supported with soft loans from Sweden and the U.K. It is hoped that work will be completed in 14 months.

(Source: Modern Power Systems, June 1993)

## Hydroelectricity

The upstream cofferdam at the Katse construction site in Lesotho has recently been completed. This means that the diversion of the Malibamatso river around the construction area downstream, where preparations for the foundation of the Katse dam are underway. The cofferdam is 35 m high and has been designed to divert the expected 10-year flood through two completed diversion tunnels, without being overtopped. It will be flooded when the Katse dam has been completed.

(Source: International Water Power & Dam Construction, June 1993

## Wood

As part of its Rural Afforestation programme, Phase II, the Forestry Commmission of Zimbabwe is to launch a two-year agroforestry programme starting in July this year. Eight districts, identified as those worst hit by deforestation, have been identified for the implementation of a pilot agroforestry programme. With funding from the Danish and Zimbabwean governments, practical models for agroforestry, and manpower training in the Forestry Commission to develop and implement the models, are to be undertaken.

Under the programme, the Commission will identify what trees people already have in their fields and will encourage them to continue growing them, and use them to develop and improve new modes of agroforestry. Although the Commission, in the past, had concentrated on promoting the planting of exotic trees and the establishment of woodlots, it was now felt that tree planting programmes should respond to the needs of the community. Thus integrating the growing of crops with trees was being encouraged.

(Source: Development Dialogue, May/June 1993)

# Details of authors


**BANKS D I**

BSc. (Mech. Eng.) (Cape Town)
Department of Mechanical Engineering, University of the Witwatersrand, Private Bag 3, Wits 2050, South Africa


Douglas Banks is presently researching free cylinder Stirling engines for a PhD in the Department of Mechanical Engineering, University of the Witwatersrand. He was a lecturer at the Wits Rural Facility, and had honorary teaching status in the Department of the Witwatersrand.

Doug is interested in alternative energy technologies, and has undertaken or been involved in research into wood gasifiers, low-cost ceramic stoves and solar heaters, biogas production, and rural domestic energy use. He was also involved in small-scale water supply schemes and dam construction in the area around the Wits Rural Facility, and, with other, initiated the Eastern Transvaal Rural Development Engineers Forum.


**DE WET P S**

BA (Pretoria), HED (Pretoria)
Manager: Marketing Services, Division of Energy Technology, CSIR, P O Box 395, Pretoria, 0001, South Africa
Tel.: (012) 841-4946
Fax.: (012) 841-2135


Petro de Wet started her career in 1973 as Public Relations Officer at the Department of Water Affairs. From 1977 to 1990 she held various public relations positions at the CSIR. In October 1990 she was appointed to her present position, with the responsibility for the planning and management of Enertek's communication and promotional strategies and actions.


**GRIFFIN N J**

BSc. (Wits), BSc. (Hons.) (Rhodes), MSc. (Natal)
Research Officer, Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa
Tel.: (01528) 33991
Fax.: (01528) 33991


Neil Griffin studied as a botanist and initially worked in marine research. In 1991 he joined the Wits Rural Facility as the primary researcher on an interdisciplinary team investigating domestic fuel consumption in rural households and its impact on surrounding communal lands. Neil is particularly interested in factors affecting the supply and demand of wood in a region where wood remains the major fuel.


**HALL P V**

BSoc.Sc.(Hons.) (Cape Town)
Researcher, Development Policy and Planning, Human Sciences Research Council, Private Bag X41, Pretoria 0001, South Africa
Tel.: (012) 202 2246
Fax.: (012) 202 2149


Peter Hall was an HRSC merit bursary holder for his studies at the University of Cape Town, Recent research experience includes projects on income and expenditure patterns, housing affordability, various urban issues, and economic development. He has recently been involved in assessing the impact of Eskom electrification on a small rural town.


**HUGGINS G B**

BSoc.Sc. (Hons.) (Natal)
Researcher, Development Policy and Planning, Human Sciences Research Council, Private Bag X41, Pretoria 0001, South Africa
Tel.: (012) 202 2246
Fax.: (012) 202 2149


Greg Huggins has been a researcher at the Human Sciences Research Council since 1987. Recent research involvement includes research into natural resource management, informal settlements, community development and participatory research, and the role of NGOs in development.


**KAMPER M J**

BEng., MEng. (Elec.), Pr. Eng.
Senior Lecturer, Dept of Electrical and Electronic Engineering, University of Stellenbosch, Stellenbosch 7600, South Africa
Tel.: (02231) 779 111
Fax.: (02231) 774 981


Maarten Kamper is presently a Senior Lecturer in the Department of Electrical and Electronic Engineering at the University of Stellenbosch.


**KRUEGER D L W**

BSc. (Chem. Eng.) (Pretoria), MSc. (Mech. Eng.) (Cape Town), Pr. Eng., MSAIChE
Director: Division of Energy Technology, CSIR, P O Box 395, Pretoria, 0001, South Africa
Tel.: (012) 841-4931/2
Fax.: (012) 841-2135


Dieter Krueger started his career in 1965 as an Assistant Engineer at the SA Iron and Steel Corporation. In 1966 he joined the Palabora Mining Company, initially as Metallurgical Assistant. He later became Plant Metallurgist and, finally, Special Assistant to the General Manager for a feasibility study which was implemented in 1977 at a cost of R80 M. From 1975 to 1982 he worked at Van Eck & Lurie (later E L Bateman) where he was responsible for the turnkey construction of several minerals processing plants. In 1983 he joined the CSIR as Co-ordinator of the National Programme of Energy Research (NPER), a position which he held until his appointment as Director of the newly established CSIR Division of Energy Technology in 1987.

He has authored and co-authored several publications in the fields of coal, coal research and energy resource management. He is a member of the International Committee for Coal Research and the SA National Committee of the World Energy Council.


**MAVRANDONIS J M**

BA DHSM (Wits)
Director (Administration), Wits Rural Facility, P O Box 7, Klaserie 1381, South Africa
Tel.: (01528) 33991
Fax.: (01528) 33991


Joan Mavrandonis moved from a senior administrative position at the University of Witwatersrand to the Centre for Health Policy where she developed an interest in health policy. She joined Wits Rural Facility in 1989, and maintains research interests in health policy and health systems research.

**SHACKLETON C M**

BSc., BSc. (Hons.), MSc. (Wits) Sci. Nat.
Lecturer, Wits Rural Facility, P O Box 7,
Klaserie 1381, South Africa
Tel.: (01528) 33991
Fax.: (01528) 33991

After several years at the University of Transkei, Charlie Shackleton moved to the Wits Rural Facility in October 1989 to join the start-up team of this new multi-disciplinary unit. As an ecologist, his work at the Wits Rural Facility embraces teaching, research and community outreach, focusing on the management of natural resources. Two areas of current emphasis are the structure and functioning of communally managed savannas and biome-based modelling of woody-plant productivity.

**SHACKLETON S E**

BSc., BSc. (Hons.), MSc. (Wits) Sci. Nat.
Lecturer (Part-time), Wits Rural Facility,
P O Box 7, Klaserie 1381, South Africa
Tel.: (01528) 33991
Fax.: (01528) 33991

Sheona Shackleton joined the Wits Rural Facility in October 1989 after five years at the University of Transkei as a junior lecturer in the Department of Botany. Her work at the Facility encompasses teaching and research in rural development issues, in particular natural resource utilisation and management, as well as various community outreach activities. Current projects include a survey of the local wood carving and furniture-making industry, and research into the use of indigenous herbs and fruits by local people. She is one of the three co-ordinators of a major new research trainee programme.

# Forthcoming energy and energy-related conferences:

## 1993

### SEPTEMBER 1993

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**DOMESTIC USE OF ELECTRICAL ENERGY** Cape Town, South Africa

Enquiries: Domestic Use of Electrical Energy Secretariat,
Attention: Ms A le Roux,
Cape Technikon,
P O Box 652,
Cape Town 8000,
South Africa
Tel.: (021) 460 3151
Fax.: (021) 45 1698

### OCTOBER 1993

11-12

**CLEAN AIR CHALLENGES IN A CHANGING SOUTH AFRICA**
Pretoria, South Africa

Enquiries: Conference Planners
(Attention: Ammie Wissing), P O Box 82,
Irene 1675, South Africa
Tel.: (012) 63 1681, Fax.: (012) 63 1680

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**ENERCONOMY '93**
Pretoria, South Africa

Enquiries: Mr T Spencer, Chemical & Auxilliary Plant Engineering, Eskom - Generation, P O Box 1091,
Johannesburg 2000, South Africa
Tel.: (011) 800 3954,
Fax.: (011) 800 2512

21-28

**1ST INTERNATIONAL SYMPOSIUM ON ENERGY AND DEVELOPMENT**
Maputo, Mozambique

Enquiries: Henrique Lopes,
FENEDSA,
Engineering Faculty,
Eduardo Mondlane University,
P O Box 257,
Maputo,
Mozambique

# Recent energy publications

**CLARKE R H and DUTKIEWICZ R K**

Knock resistance of fuels with decreasing lead levels.
Engineering Research (Pty) Ltd,
April 1993, 84p.
Report No. GER 018
R34,20 (incl. VAT)

The purpose of this project was to investigate the effect of various lead levels and fuel types to determine their knock propensity. A range of petroleum fuels with similar RON and MON values but varying lead content were tested. Sasol fuels with varying lead content and common MON values were also tested. The fuels were tested on a cross-section of engines with different combustion chamber configurations.

**DUTKIEWICZ R K**

A techno-economic assessment of reconstituted fuels.
Energy Research Institute,
June 1993, 65p.
Report No. GEN 156
R34,20 (incl. VAT)

The reconstituted or waste-derived fuels considered for use as domestic fuels in the underdeveloped areas of South Africa in this report are coal, wood and bagasse wastes. An attempt has been made to establish the minimum supply cost for a reconstituted fuel product and to compare this with the current costs of energy supply. It is concluded that these fuels could make a significant contribution to the country's national energy needs.

**DUTKIEWICZ R K**

Energy supply and demand in Southern Africa.
Engineering Research (Pty) Ltd,
March 1993, 86p.
Report No. GER 017
R34,20 (incl. VAT)

Energy supply and demand in 16 Southern African countries and their resource potential are summarised. The ability of these countries to produce, distribute and use these energy resources is also examined. A description is given of the state of development of each of the countries in the region, followed by an analysis of the potential for the development of the energy resources in the region.

**MEARNS A J**

Carboniser for bush clearing.
Energy Research Institute,
April 1993, 27p.
Report No. GEN 155
R34,20 (incl. VAT)

The objective of this project was to attempt binderless briquetting with torrefied wood manufactured in a CUSAB (charcoal from useless scrub and brush) kiln. The test results are discussed using a batch mode CUSAB and continuous CUSAB carboniser.

**MEARNS A J**

Survey of municipal solid waste.
Engineering Research (Pty) Ltd,
April 1993, 64p.
Report No. GER 020B
R34,20 (incl. VAT)

An attempt was made to establish the amount and disposal method of municipal solid waste generated by a cross-section of municipalities around South Africa. It was hoped that in this way the potential for energy extraction from the refuse by incineration or landfill gas extraction could be assessed. The survey covered 34 municipalities.

**MEARNS A J**

Aldehyde emissions from cetane-improved alcohols.
Engineering Research (Pty) Ltd,
April 1993, 29p.
Report No. GER 019
R34,20 (incl. VAT)

The report discusses the results of an investigation into comparative aldehyde emissions from a direct injection diesel engine fuelled with alcohols blended with a cetane improver and with pure diesel fuel. The tests were carried out in accordance with the European heavy-duty exhaust emission test procedure (ECE 49). The DNPH method was used for determining the aldehyde concentration in the exhaust gas.

**MEARNS A J and DANCIG A A**

Literature survey into the extraction of municipal solid waste.
Engineering Research (Pty) Ltd,
April 1993, 60p.
Report No. GER 020A
R34,20 (incl. VAT)

This report discusses the literature survey undertaken of the various options available for energy extraction from municipal solid waste (MSW) using current technology. The composition of MSW is discussed and its calorific value around the world is compared to that of South Africa. Municipal waste disposal methods are discussed, emphasising landfill management trends, including the extraction of landfill gas. The report concludes with the pollution problem associated with the disposal of waste, whether by landfill, combustion or pyrolysis.

**SCHABERG P W and PRIEDE T**

Effects of octane enhancers on fuel octane values.
Engineering Research (Pty) Ltd,
March 1993, 127p.
Report No. GER 016
R45,60 (incl. VAT)

The purpose of the investigation was to establish the problems which will be encountered, and the requirements which will need to be met, when unleaded petrol is introduced for cars. Four engines were tested on various blends of unleaded petrol. The effects on spark ignition engines only were examined.

All these reports are Final Reports. They are available from the Information Officer, Engineering Research (Pty) Ltd/Energy Research Institute, P O Box 33, Plumstead 7800, South Africa, at the prices indicated.

# JOURNAL OF ENERGY IN SOUTHERN AFRICA

## INFORMATION FOR AUTHORS

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

1. All contributions should be submitted in English.
2. Only original work will be accepted an copyright in published papers will be vested in the publisher.
3. The suggested length for articles and research notes is 2500 to 5000 words, and for book reviews, approximately 1000 words.
4. The contribution and references should be typed double-spaced with a wide left-hand margin and single-sided using one of the available word processor packages listed at the end. The name and version of the word processor package used must be indicated on the disk. Illustrations, photographs and diagrams should be submitted on separate sheets.
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6. All graphs, diagrams and other drawings should be referred to as Figures. These should be numbered consecutively in Arabic numerals and placed on separate sheets at the end of the contribution. Their position should be indicated in the text. All illustrations must have captions, which should be typed on a separate sheet. Graphs, diagrams, etc. should be printed with a laser printer, using the high quality option. If possible, all graphs should be produced with Harvard Graphics, Quattro Pro or Lotus 123.
7. The format for references should follow that as for footnotes where a number, in superscript, indicates the reference, as shown below:

   Louw [2] states that ...

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