PAPER Nº 11

Energy supply options for low-income urban households

Anthony Williams

SOUTH AFRICAN ENERGY POLICY RESEARCH AND TRAINING PROJECT

widening access to basic energy services for the urban and rural poor

ENERGY FOR DEVELOPMENT RESEARCH CENTRE
University of Cape Town

'The household management strategies employed by the women...have their own rationality which warrants further investigation and understanding, and should be taken into careful consideration in the planning of a "woman-friendly" national energy policy for a future South Africa.'

Annecke (1993)

Executive summary

Introduction

Urban energy planners are faced with a range of energy-related needs and problems, all of which compete for attention with the myriad other, often more visible and politically important needs and problems faced by the urban poor such as housing, water supply and sanitation.

This study's focus group is the urban poor of South Africa. Lack of access to convenient and affordable energy carriers, and more specifically, lack of access to electricity are characteristics of urban poverty in South Africa. Despite a well-developed national grid, and current surplus of generating capacity (which enables South Africa to generate 52% of the total electricity on the African continent), only about 40% of South African homes have access to this convenient energy source.

The majority of the urban poor are reliant on expensive and less convenient energy sources such as wood, coal, paraffin, candles and batteries, their range of choices dependent, to a large extent, on geographic location. Comparatively speaking, poor urban households spend a significant proportion of their income on energy.

This study strives to address this by investigating the dynamics of the urban household energy sector, and by defining policy interventions aimed at widening the urban poor's access to their desired, more convenient energy sources.

Urban and housing policy developments

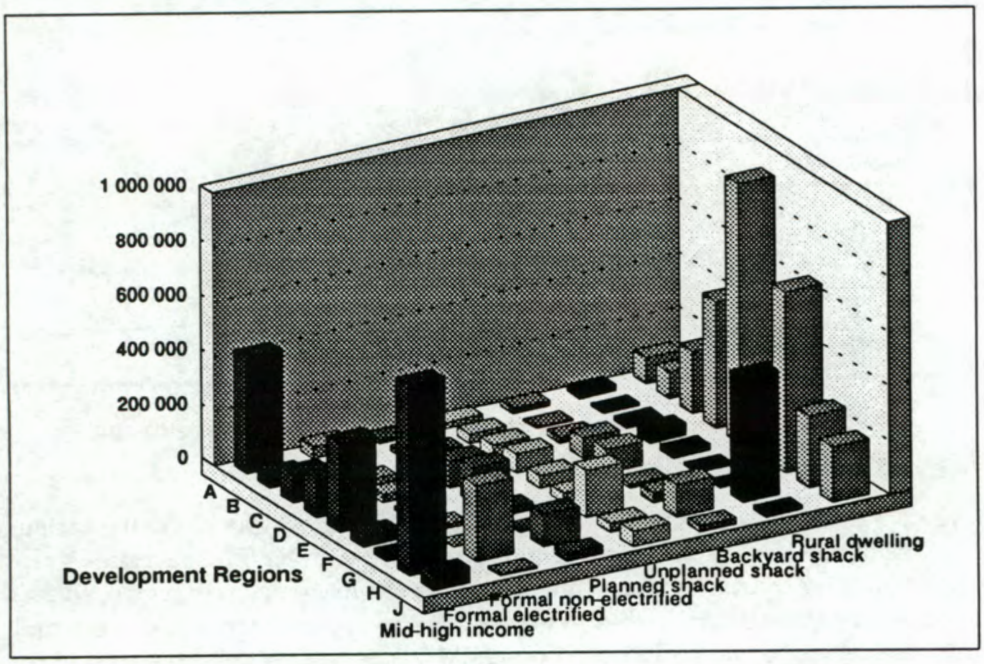


FIGURE 1 Distribution of South African household categories in 2010

The urban informal category with about 1.5 million households is large and experiencing high growth. It is estimated that by 2010 there could be more than 4 million urban informal dwellings, which will be distributed as shown in the above figure. The major urban concentrations are the metropolitan areas of Pretoria-Witwatersrand-Vereeniging (PWV), the Durban Functional Region (DFR), Cape Town, Port

Elizabeth and East London. These areas account for two thirds of the urban poor. In the last few years about half of the *formal* houses in these townships have been connected to the electricity grid, while almost all the *informal* dwellings remain unconnected.

The balance of what has been defined as the urban population resides in towns and closer settlements[1] distributed throughout the country. The poor populations in towns generally live in townships on the outskirts of the 'white' centre. The economic bases and commercial centres of the closer settlements are the metropolitan areas, to which workers commute, often over distances of more than 80 kms. This category accounts for about 350 000 dwellings.

Current energy consumption patterns

At the household level, there are numerous determinants of energy demand both macro, that is, external to the household, and at the micro level, within the household itself. In South Africa it has been found that the primary macro determinants of a household's energy consumption relate to its geographical location, the two most significant being climatic conditions and access to cheap coal. Figure 2 shows the bio-climatic regions, and the location of the major coalfields.

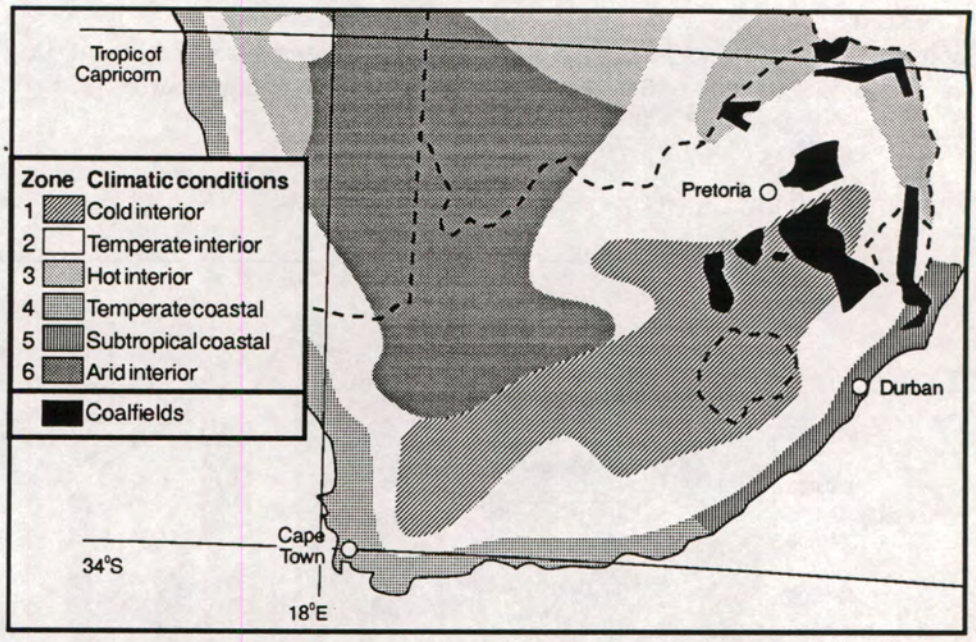


FIGURE 2 Map showing the location of South African coalfields and bio-climatic zones

Figure 3 gives a broad picture of the use of different energy carriers in the various regions of the country. A comparison of this figure with Figure 2 reveals some of the reasons for the differences in energy carrier use from region to region, such as the predominance of coal in the PWV area. It is also important to note that multiple fuel use is very common in poor households, as is indicated by the sum of the various percentage uses in the regions, which total more than 100.

1. Closer settlements are agglomerations of mainly informal dwellings in essentially rural areas. They occur on homeland boundaries and are often described as being 'functionally urbanised'.

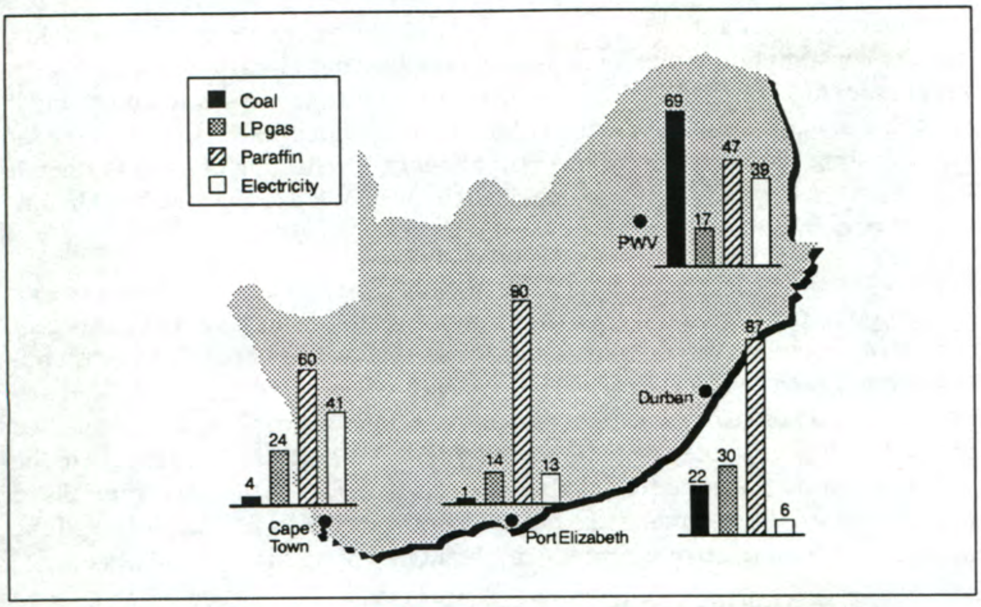


FIGURE 3 Map showing the percentage usage patterns of different energy carriers in different regions

The following sections illustrate the diversity and complexity of the household energy sector.

Pretoria-Witwatersrand-Vereeniging

The PWV region contains 41% of all the low-income urban households in the country. Their overriding characteristic is a high consumption of coal, with just under 70% of households in the region using it, with average consumption at 56 kg per month. Over 80% of non-electrified households use it at a rate of between 115 and 160 kg per month. This results in the highest average monthly delivered energy consumption of poor households in the country, with non-electrified households consuming in excess of 4 GJ per month on average.

This high use of coal can be accounted for by its relative cheapness because of the proximity of the Eastern Transvaal coalfields. Furthermore, when used in a stove, it is a fuel of multiple utility, providing three services, cooking, water heating and space heating. The value of this multiple utility is demonstrated by the continued use of coal by 45% of the electrified households in the PWV.

Figure 4 shows the important role that coal plays in PWV low-income households' energy economies.

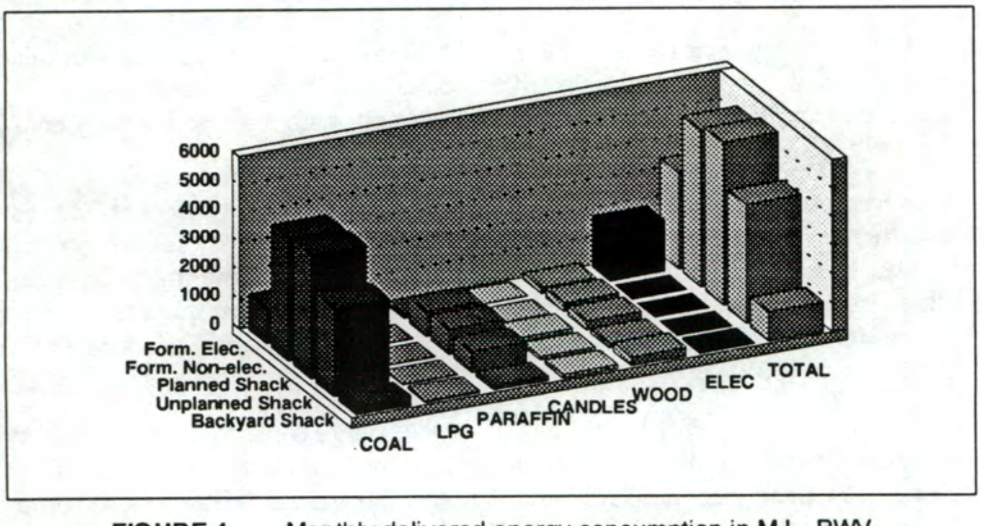


FIGURE 4 Monthly delivered energy consumption in MJ - PWV

Paraffin is an important fuel in the PWV, particularly in non-electrified households, and its consumption drops once households become electrified, indicating its importance for illumination. However, its use for other services is also high, and it is named in many surveys of non-electrified householders as the fuel of choice for quick heating requirements such as water boiling or reheating of food. Further, it can be bought in small quantities, making it ideally suited to the cashflow circumstances of poor households.

A survey conducted by Eskom in the PWV found that average monthly electricity consumption per household was 426 kWh per month (Van Gass 1991). Another survey representing 190 000 households found that average household consumption ranged from 380 kWh to 676 kWh per month (Berrisford & Bluff 1991). However, there is a possibility that these consumption rates were inflated. There are two reasons for this: first, they were determined on the basis of the total supply to the area being apportioned to the number of electrified *plots* in the area. This fails to take account of the fact that there may be backyard shacks on the plots, and the measured consumption may actually represent that of up to three households.

The second reason for possible inflation of the figures is that consumer non-payment was not considered. The effects of non-payment are shown by a recent survey in which it was found that Kagiso had an average monthly household consumption of 730 kWh, compared to the 390 kWh found in Alexandra, where prepayment meters were being used (Palmer Development Group 1993b).

The lack of sufficiently disaggregated data on energy expenditure by poor households hinders analysis of this important parameter. Analysis of the data available for the PWV shows households with an average monthly income of less than R400 spending from 15% to 40% of total household income on energy. The next category with incomes of between R400 and R800 per month, spend between 10% and 15%. These relative energy expenditure levels are typical of low-income households in South Africa. Poor households are spending substantially more on energy than the rest of the population.

Durban Functional Region

The DFR metropolitan area enjoys a subtropical climate, with a much reduced need for space heating. Pietermaritzburg, on the other hand, experiences somewhat cooler winters. These factors, in combination with greater distances to the coalfields, result in lower coal consumption. Nonetheless, for these areas combined, coal is still the most important energy carrier on a delivered energy basis, for formal non-electrified houses and planned shacks. These respectively consume an average of 60 and 40 kg of coal per month, which represents 50% and 40% respectively of their gross monthly energy requirements.

Taking the country as a whole, LPG has the highest overall penetration in this region, with around 30% of non-electrified households using it. In energy terms it contributes around 14% of their gross consumption, with average monthly consumption at about 7.5 kg.

Eskom has found that coastal area consumption levels are of the order of 300 to 400 kWh per month (Berrisford & Bluff 1991). A recent survey found median monthly consumption levels in Umlazi to be 500 kWh per month on average (Palmer Development Group 1993b). Once again it is significant that the median consumption in newly-electrified areas with prepayment meters was found to be much lower, at 150 kWh.

Figure 5 shows the monthly household delivered energy consumption profiles for this region. The vertical axis has been chosen to allow easy comparisons with other regions. It is clear that these households consume markedly less energy on a delivered basis than do those in the PWV. However, the lack of data on energy consumption by particular end-use, makes it is impossible to provide a satisfactory analysis of this phenomenon.

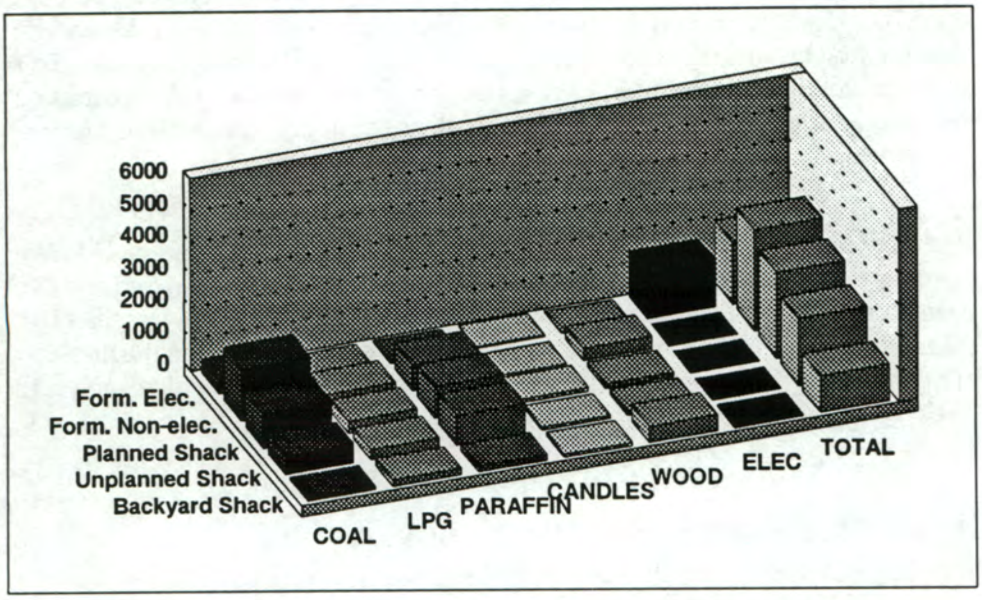


FIGURE 5 Monthly delivered energy consumption in MJ – DFR

Cape Town metropolitan area

Cape Town has a temperate Mediterranean climate. As the winters are fairly cold and wet, it is surprising that the total delivered energy consumption of households is lower than that of the DFR. This underlines the extent to which the availability of cheap coal increases delivered energy consumption. Low-income households in this area are dependent on paraffin as their primary source of energy, and it provides an average of 50% of the delivered energy for all non-electrified households. Figure 6 shows the consumption levels for this region.

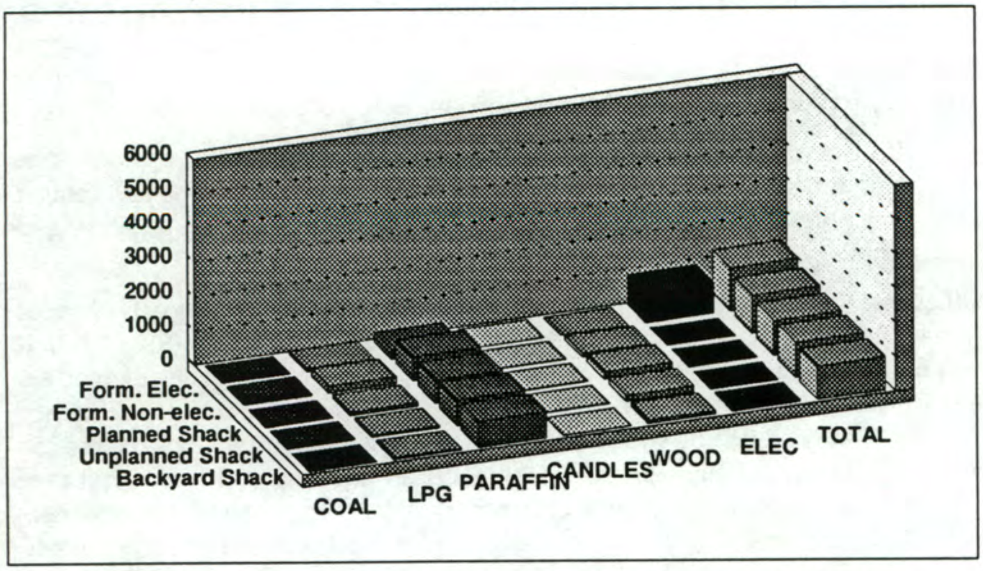


FIGURE 6 Monthly delivered energy consumption in MJ – Cape Town metropolitan area

LPG is also used quite extensively in Cape Town, with formal non-electrified households using about 7 kg per month, and planned and unplanned shacks both using around 5 kg per month.

A 1992 survey found that annual mean monthly consumption levels for Langa and Guguletu households were 497 kWh and 523 kWh respectively (Thorne & Theron 1993). The first households in these areas were electrified in the 1960s, and the

1. These consist essentially of white households.

electrification levels are currently at 73% and 89% respectively. In both areas 85% of the households were found to be in arrears, with the average outstanding amount at R1 700. However, it was also found that there was no significant difference in consumption between those paying and those not paying for their electricity. This suggests that these households, having been electrified for at least five years, and in many cases longer, have reached their appliance ceiling, and hence their electricity consumption ceiling.

In 1991 in Khayelitsha it was found that households which had had access to electricity for longer than five years had average consumption levels of 450 kWh per month (Theron 1992). Those that had been connected for between two and five years, consumed an average of just over 300 kWh, while those with less than two years of access consumed around 240 kWh per month. The increase in the first year of connection was found to be about 60%, from 162 kWh in the first month to 259 kWh in the twelfth month.

Household energy end-use behaviour

The principal end-*users* and managers of household energy and indeed household budgets are women. Yet we know very little 'about how women make decisions about expenditure or how they order their priorities, *particularly when survival is an issue*'. Furthermore, 'Equally little is known about women's perceptions of fuel and its use in appliances' (Annecke 1993). Research has revealed that the household management and survival strategies employed are indeed complex, and deserve serious consideration when formulating energy policies for the poor.

Incomes for the poor are unpredictable in their size and periodicity. This severely limits their capacity to plan for the longer term, and can lock them into a cycle of poverty which is extremely difficult to break. These cashflow patterns lock them into the use of particular energy carriers, for two reasons. First, they never they experience difficulty in accumulating enough cash to buy the appliances necessary to use another energy carrier. And second, their cashflow restricts them to buying fuels that are available in small quantities, such as wood, coal, candles and paraffin. This predicament is aptly described by a woman named Zodwa (Annecke 1993):

> If I buy only one bottle of paraffin and one candle a day, I use only that amount, so I am disciplining myself. Also if I have only some few cents, I must buy some food, some paraffin, one candle and maybe something to drink.

Other research has looked at another complex issue governing energy use in poor households, personal relationships and decision-making processes (Ross 1993). It was found that things are not as simple as energy planners would like them to be. Of particular importance is the finding that household income and fuel efficiency are not the only criteria by which fuel use decisions are made. Obviously these can not be quickly and easily extrapolated to cover all informal settlements, but they serve to emphasise the complexity of the energy planning context for poor households. The central finding of Ross' investigation can best be summed up as follows.

> In order to examine and explain fuel use in such settlements it is necessary to look at the micro-context of the resident's lifestyles, at the conditions of tenure and security which they experience, and most of all, at the ways in which they are able to use and construct social relationships around fuel. It is these relationships which shape fuel patterns in Die Bos rather than overtly economistic decisions to utilise the most efficient fuel.

It is apparent that fuel use in poor households has deep social roots and implications. It is therefore imperative that policy options be flexible and broad enough to give household decision makers, primarily women, sufficient space within which to operate.

Energy is used by people to provide themselves with a number of services, essentially social in nature, being principally cooking, space and water heating, lighting, entertainment, and refrigeration. Households derive utility from cooked meals, hot water, light and entertainment, through services involving the transformation of energy through appliance-energy carrier combinations.

Although quantitative energy consumption shares for individual end-uses has not been gathered by the energy use surveys in South Africa, a few have looked at the proportions of households which use certain energy carriers to satisfy different end-use needs. Some of the general patterns which have emerged in these studies are not dissimilar to those reported in other developing countries. First, multiple fuel use is common, and it is not unusual to find two, three or more fuels being used for the same end-use.

Second, the structure of energy use is different for differing types of household. An important determinant here is economic status, but household size and location both nationally, *and* within the city itself are also significant, thereby complicating the simple income-related relationships one would expect to find. Third, patterns of consumption are dynamic, changing as social contexts, fuel prices, household incomes, and access to different energy sources vary.

Cooking

Cooking is arguably the most important energy service sought by households. However, it is often but one of a range of services delivered by the same appliance-fuel combination. For example, a coal stove provides space and water heating at the same time as cooking. This makes it difficult to determine the actual efficiency of delivery of the individual services provided, as it is impossible to establish where the one ends and the next begins.

On a national basis paraffin is the principal cooking energy source, being used by 44% of households. This aggregation masks area-specific end-use patterns. For example, in the Port Elizabeth and Cape Town regions, paraffin is used by between 50% and 99% of informal households while similar levels of use are found in the DFR (Kessel 1988). In the PWV 63% of electrified households were found to cook on coal stoves, underlining the importance of their multiple utility (Gervais 1987).

Water heating

Water heating in low-income households is a service which is often provided by the same appliance-energy carrier combination used for cooking. Thus the percentages of households using various energy carriers for water heating are broadly the same as those given under the cooking section. It was found that paraffin was the most frequently used water heating fuel, used by 45% of households (Uken & Sinclair 1991).

Space heating

Space heating requirements can double energy consumption in the winter as compared to the summer. Space heating is a difficult energy end-use to quantify, given that it is often provided at the same time as a cooking or water heating service. Two fuels dominate this service: paraffin and coal, which are used by 42% and 39% of households on a national basis (Kessel 1988). It was found that 35% of a national sample used electricity for heating, primarily in the PWV region, where it was used by around 55% of households (Uken & Sinclair 1991).

Lighting

Although relatively little energy is consumed for lighting, this service has a very high utility for the household, in that it can contribute substantially to the achievement of better living standards. The following shows the lengths to which the poor will go to get good lighting (Annecke 1993):

> In one home the poor lighting was effectively boosted by waxing the newsprint wallpaper. The polished surface reflected the light and enhanced the visibility, allowing the mother and daughter to read at night.

The poorest of families use candles for lighting, and this can be a major expense for them. Obviously bulk buying can reduce this burden, but sufficient money is not always available for such purchases, and even when they are other factors could intervene (Annecke 1993):

> I tried by all means to buy a packet of six and not let my husband know, otherwise he will sit up the whole night using all the candles.

This reveals a problem which not only pertains to the purchase of lighting energy sources, but moves into the realm of household management and authority. What is of importance here is that for poor families, improved lighting usually incurs substantial expense relative to their meagre means. Real improvement of lighting quality requires capital costs such as the purchase of a paraffin pressure lamp, or electrical connection charges and house wiring.

All households able to afford it will use electricity for lighting. Thus this will be the case for the 22% of low-income households in South Africa currently electrified. On a national scale however, paraffin and candles are the most important sources of lighting, with 34% and 31% respectively of homes using them (Uken & Sinclair 1991).

Televisions, radios and hi-fis

Although these appliances consume small amounts of energy, they play an important role in domestic life, providing recreational and educational opportunities. The value attached to the utility of these services is evidenced by the lengths that poor households will go to to obtain them. They make use of dry cell and vehicle batteries, both costly energy sources. In addition, the latter are inconvenient, as they must be taken to a recharging point and back home again on a regular basis.

It was found that use of vehicle batteries differed widely over eleven townships surveyed, ranging between 2% and 47% (Golding & Hoets 1992). On average 21% of households in the PWV, and 30% in the DFR used them. In Cape Town 50% of non-electrified households were using dry cell batteries, while 23% used vehicle batteries (Viljoen 1990).

Refrigeration

Refrigeration is a service ranked very highly by low-income householders. One survey indicates that they are the most common electrical appliance, found in 83% of electrified households. Irons, with 79% of households using them, were next (Golding & Hoets 1992).

Refrigeration is a service which allows bulk purchases of perishable goods, thus enabling households to extend the value of their incomes. However, the entrance barriers to this service are high in terms of the capital cost of the appliance. Important income-generating uses of refrigerators are the cooling of beer and other drinks in shebeens, and the preservation of perishable goods in spazas.

Energy policy proposals

There are two household energy demand scenarios that could emerge in the short to medium term.

- The 'business-as-usual' scenario. In this case current trends follow their present course and no major policy interventions, other than those already planned are implemented.
- The integrated energy plan. In this scenario a range of policies are implemented aimed at widening the access of low-income households to desired, affordable sources of energy.

Which of these emerges as the dominant approach will depend primarily on whether an integrated energy plan is implemented or not. The following sections outline the principal characteristics of the second of these two scenarios.

A careful examination of the energy-related data available has revealed that the currently available longitudinal, cross-sectional and micro-scale energy-use data is inadequate. There is substantial scope for the deepening of our understanding of the determinants which influence energy use patterns in low-income urban households. Development of knowledge in this area will be essential if future household energy policies are to make any significant impact, and on a more pragmatic level, if the planning of organisations such as Eskom is to be based on sound assumptions.

Despite the above constraints, the EPRET team has been able to identify a number of policy interventions which are felt to be consistent with the emergent understanding of low-income household energy use behaviour. These have been described in detail elsewhere in the body of this and other papers of the EPRET series.

Electrification

An extensive electrification drive will spearhead the effort to widen access by the urban poor to affordable energy. For the electricity supply industry (ESI) to achieve the 500 000 connections per annum over a decade which are envisaged, fundamental restructuring and rationalisation will have to take place. An important aspect of this will be the introduction of a single national flat-rate tariff. This measure would allow the generation of revenue to cover a substantial portion of the capital outlay required for the programme. It would also have a significant effect on balancing the equity situation as regards electricity supply to domestic consumers.

Further funding requirements of the electrification programme would be met in part from the substantial resources that the ESI itself has at its disposal. In addition, the establishment of an Electrification Fund, would act as a channel for funds, and as further finance is required, would seek this from national or international sources.

At the local level, the majority of the electrification projects would be defined in an agreement to be negotiated between the community involved, and the responsible distribution authority. The negotiation process would deal with aspects such as the level of supply and service to the particular community, including issues such as overhead or underground cabling, the type of metering to be installed, and the involvement of community labour. The tariff structure, however, would not be negotiable as this would be set nationally.

It is our contention that this negotiation process is of paramount importance in ensuring the successful outcome of electrification projects, and it will help to establish good relations between the community and the supply authority. It is imperative that women, the primary end-users of energy in the domestic context, be included in this process. The importance of this negotiation process should be recognised, and attempts to short-circuit it discouraged, even if it does result in connection rate targets not being met.

Low-smoke coal

The continued extensive use of coal by households within the PWV area brings with it appalling air pollution problems. Attention is already being given to this, and research has been initiated into the development of low-smoke alternatives to the bituminous coal currently used by domestic consumers.

It is proposed that the continuation of this work be given the highest priority, and that every effort be made to bring suitable products into the market-place as soon as possible. If further research and development of these fuels is required, support for this must be given as a matter of urgency by the state. The successful penetration of these fuels in the market will require a thorough investigation of the current coal marketing chain, so as to determine how to stimulate the use of these low-smoke fuels. Support should then be given to prospective producers to successfully enter the market, particularly if it is found that small-scale, labour-intensive production of these fuels is a viable proposition. Finally, a high-profile, national media campaign should be mobilised to promote the use of these clean fuels.

Paraffin

Paraffin is an important source of energy for low-income households. It is therefore vital that this fuel be made more accessible and affordable to them. A restructuring of the current paraffin price is proposed, whereby it will become more attractive for the oil companies to efficiently take the product further down the distribution chain, this in turn facilitating better control of the regulated price. Low-income households would then be able to purchase the paraffin nearer their homes at or close to the controlled price. Measures will have to be introduced to prevent operators of diesel-powered vehicles from abusing this initiative by substituting this cheaper fuel for diesel.

Paraffin poisoning also needs to be addressed. It is proposed that current research into the production of low-cost childproof containers be continued, and that the oil companies assist in the funding of this work. Initiatives to reduce or remove the unpleasant odours associated with paraffin should also be pursued. However, the costs of these improvements should not be passed on to the already beleaguered consumers.

LPG

This is an efficient and clean fuel which is not as widely accessible to the poor as it should be. Problems of affordability are partly responsible for this, but its distribution could also be improved. A number of interventions are proposed. First, the oil companies should investigate the possibility of introducing smaller canisters, the cost of which would be more in line with the types of cashflow experienced by low-income households. Second, they should consider the possibilities of marketing LPG appliances at lower cost, recovering the discounted amount through a marginal increase in the LPG price. Finally, a consumer education exercise is required to teach people how to use LPG safely, and to allay their fears about its use.

Institutional requirements

South Africa is on the brink of a new era in which democracy will become a reality for the majority of its hitherto disenfranchised citizens. The current initiatives in the housing and service sectors will provide an opportunity to reinforce this process of democratisation, empowering communities by putting in place community-based decision-making structures.

For the above energy policy proposals to be effectively implemented, institutional support will be required at a number of levels. The most important of these is at the level of the affected communities themselves. The negotiating processes that will accompany the electrification drive, will engender an awareness of energy-related matters in each community. One way of maintaining and nurturing this would be through the establishment of an energy centre in each community.

These centres should be constituted to represent all parties interested in household energy matters. It is therefore envisaged that 'ownership' of the centres should be tri-partite, with the community, the state and the energy service sector involved. It is proposed that an evaluation of the currently operational Eskom energy centres should be conducted. This would serve to highlight the shortcomings and strengths of these centres. If this evaluation is positive, careful thought should then be given to the location of the centres, and the way in which they should be linked to community-based development initiatives such as small-scale industry centres, building material cooperatives and community centres.

An important role of the centres would be the education of energy consumers in various aspects of energy. These would include the efficient use of energy, the demand-side management options available to them, allaying fears about various energy carriers, the safe handling of fuels and help in achieving the best mix of energy carriers. For these efforts to meet with success it would be important for strong contacts to be made and fostered with women's groups in the community. These contacts would serve a dual purpose, as they would not only allow a flow of information to end-users, but would also provide them with a more efficient line of communication to the energy suppliers and policy makers.

This improvement in information flow would accelerate the learning process energy policy makers will have to go through regarding the complexities of energy-related decision making processes in poor households. The information that could be gathered through the centres would facilitate the improvement of the longitudinal energy database, thereby allowing energy planners to respond more efficiently to the energy needs of communities, and furthermore, allow greater sensitivity and flexibility in answering the specific energy problems of a particular community. On a national scale it would greatly facilitate a truly integrated approach to planning the rational use of the nation's energy resources.

With regard to institutional support at the regional and national levels, it is proposed that the embryonic initiatives to develop national integrated energy planning capacity should be fostered, and the lead should be taken by the Department of Mineral and Energy Affairs. The national Energy Policy Council mentioned earlier, will provide a forum for the formulation of a nationally integrated energy plan. At the regional and local levels, similar fora should be constituted to allow full coordination and integration of development planning at these levels. The energy centres would obviously play an important role in this planning, by allowing the end-users of energy the maximum possible opportunity to engage in and inform this process.

Table of contents

List of figures

List of tables

CHAPTER ONE

Introduction

Urban energy planners are faced with a range of energy-related needs and problems, all of which compete for attention with the myriad other, often more visible and politically important needs and problems faced by the urban poor such as housing, water supply and sanitation. There is, in addition, a lack of institutional capacity to deal with the specific and complex energy problems of the urban poor. This paper is the first attempt to formulate a coherent South African urban energy policy directed at widening access for the urban poor to adequate and affordable sources of energy. It forms part of the South African Energy Policy Research and Training Project (EPRET) which has been running for the past year at the Energy for Development Research Centre (EDRC) of the University of Cape Town.

Patterns of energy consumption in poor urban communities are complex and varied, and solutions should be sought from within this complexity. An integrated and flexible end-use driven approach, commonly referred to as integrated energy planning (IEP)[1] must be adopted if energy planning is to offer any solutions to the focus group. In addition, urban energy strategies are most likely to succeed if they involve the target community, particularly at critical decision making stages. The consequences of the failure to do so have already been felt in various initiatives around South Africa, particularly in the electrification of black townships.

A further important factor that needs to be borne in mind is the great variation in the characteristics of South African urban areas, both with regard to their climatic conditions and economic circumstances. As will be seen later, these factors play an important role in determining the energy economies of households.

1.1 Characterisation of the study's focus group

The focus of this study is the urban poor of South Africa[2]. Attempts to characterise this group have not been unproblematic, and as Wilson and Ramphele (1989) point out, 'we must be careful not to confine our thinking to those characteristics that appear important to people living within the sheltered walls of an urban university.' Thus, for example, classic statistical and economic analyses are sometimes found lacking when attempting to describe the poor. For this reason it is sometimes necessary to resort to 'unscientific' and anecdotal evidence to elucidate a particular point. As Chambers (1983) points out, the problems of the poor tend to fall into the gaps between the domains of 'classic' professions such as medicine, engineering and agriculture, professions which would supposedly be able to directly touch their lives. This inadequacy of professionals arises through their education, even in developing countries, being directed more towards satisfying the needs of the 'cores' of the developed economies; the large industrial complexes, agro-industry, and treatment of the diseases of the affluent.

Turning now to the South African context, whilst poverty is not confined to any one racial-caste, it is concentrated mainly amongst blacks. As would be expected, apart from their common financial and economic circumstances, the urban poor are by no means a homogenous grouping, with a range of characteristics which are to a large extent dependent on their geographical location. A broadbrush picture of their demographic distribution, and general socio-economic circumstances has been given in Theron (1992). In section 1.3 of this paper we will look at some of the characteristics that have specific bearing on their energy use behaviour.

1. See Paper 1 (Eberhard 1992) pf the EPRET series for a fuller explanation of this approach to energy planning.

2. South Africa is understood to be that land area within the borders defined at the creation of the Union in 1910.

Lack of access to suitable and affordable energy carriers is an important characteristic of urban poverty in South Africa. Lack of access to electricity, arguably the most convenient energy carrier for domestic use, is probably the clearest defining characteristic of the focus group. Despite the well-developed national grid which generates 52% of the total electricity on the African continent, and currently has a surplus of generating capacity, only about 40% of South African homes have access to electricity (Trollip 1993).

The majority of the urban poor are reliant on more expensive (on a useful energy content basis) and less convenient energy sources such as wood, coal and paraffin. Their range of choices depending to a large extent on geographic location. Thus, comparatively speaking, poor urban households are spending a significant proportion of their income on energy. In addition, the energy carriers on which they rely are often difficult to obtain or are only available at inflated prices. The following comment recorded by Eberhard (1984) captures the sentiments of a poor Cape Town householder on these issues:

> Ons voel sleg omdat daar baie geld moet betaal word vir gas, batterye, ens. Dit is veel meer as elektrisiteit. Die mense wat die minste verdien betaal die meeste[1].

This study will attempt to address this situation by investigating the dynamics of the urban domestic energy sector, and by defining policy interventions which, it is hoped, will widen the urban poor's access to desired energy sources.

In order to develop these interventions, it is important to have an understanding of some of the less quantifiable characteristics of poor households, the ways in which they deal with the vagaries of everyday life, and more specifically, meet their energy needs. Important research has recently been done by van Gass (1993), Ross (1993) and Annecke (1993), to investigate and document the survival strategies devised by poor households, paying particular attention to energy-related problems and activities. This type of research is invaluable in the contribution it makes to broadening policy makers' understanding of the processes at work in poor households, and will be examined more closely in Chapter 3. The following gives a brief description of some of the important characteristics of poor households.

Figure 1.1 provides an overview of household income profiles. Some readers may wonder how households with incomes of more than R2 000 per month can be classified as 'poor.' Two points must be borne in mind. First, these are not per capita income levels, but represent the total income of the household. And second, although these households may have incomes at these levels, they can still be considered as 'poor' in the context of this paper, as they may lack access to their desired energy sources.

1. Translated, this is, 'We feel bad because so much money has to be spent on gas, batteries etc. It is much more than electricity. The people who earn the least, pay the most.'

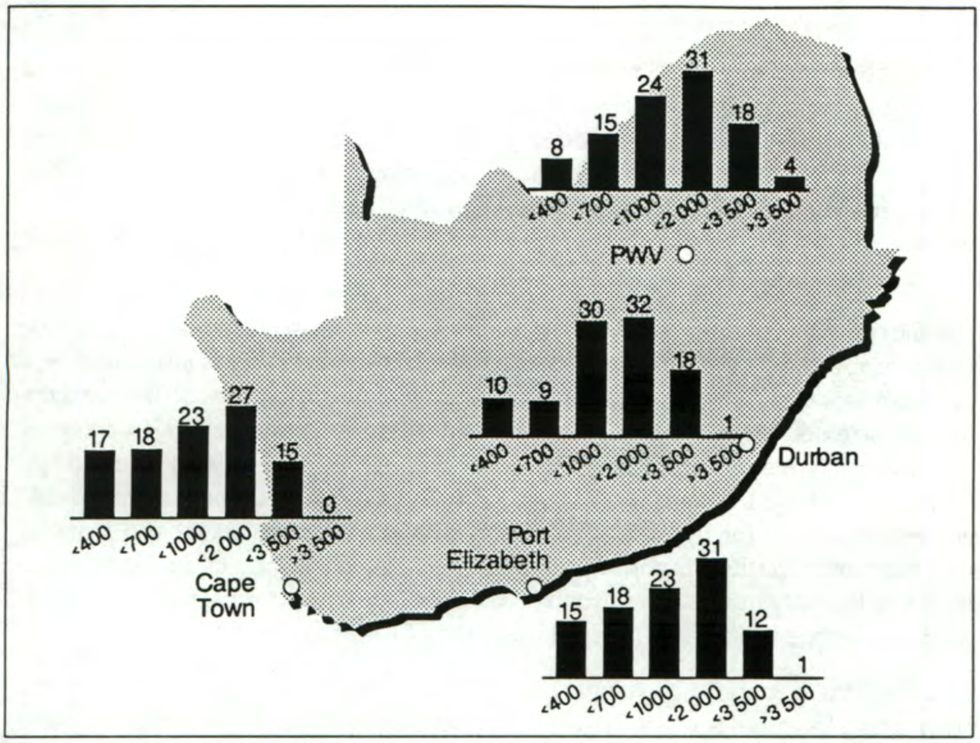


FIGURE 1.1 Monthly household income distribution profiles for the major metropolitan areas (Rands per month)
Source: Markinor

The majority of the poorest households operate largely in the informal economy, but have access to both the formal and informal economies. This is particularly true when one looks at their position with regard to urban energy services. It is only relatively recently that they have begun to be structurally included to any significant extent in the formal provision of urban energy services. In the past the majority were almost totally reliant on the informal sector for their energy supplies, and this is still the case for many of the urban poor, particularly those living in the many informal urban settlements, whether planned or unplanned, and backyard shacks. Informal society evolves financial and social strategies to better access services and benefits. These can to some degree diminish its dependence on the formal sector, but these local systems can also be extremely vulnerable to outside interventions emanating from the formal sector.

The strategies developed by the poor households are prompted to a large extent by the nature of their incomes, which are usually made up of multiple sources each characterised by its size, predictability and periodicity. Space does not allow a detailed discussion of this subject here, but some of the aspects which impinge on the energy economy of the household will be highlighted. Probably the most important of these is the extremely short cashflow cycles, involving small income amounts. This results in households having to meet needs as and when cash is available, and in general, income is spread in small amounts over a range of necessities on a daily basis.

This type of income-expenditure pattern presents problems in the provision of energy sources which can only be bought in fixed amounts, such as gas, or those which are billed over a period of time, such as credit-metered electricity. It also denies households the benefits of discounts realised through bulk purchases of fuels such as paraffin. Finally, it impacts on the ability of households to surmount the entrance barriers that exist for the use of certain energy carriers. Some examples are the cost of a stove to use paraffin or gas, the cost of wiring a house for the use of electricity, or the cost of electrical appliances.

1.2 Energy and basic needs

In most countries, migration to the city usually implies an improvement in access to various services. However, urbanisation also creates a range of problems which frequently widen existing inequalities between different groups in society. There are few stronger examples of this phenomenon than present day South Africa. The growth in urban population is paralleled by the growth of demand for a range of goods and services, including energy, which are needed to meet people's basic needs.

The move by the poor to the city is, sometimes erroneously, assumed to provide greater opportunity for them to meet their needs. However, life is still harsh, and although new opportunities may be available for the new urbanites, so too are there new constraints. The poor generally cope with these constraints through complex survival mechanisms based on communal organisation which maximise the few openings available to them. These community links make an otherwise impossible situation tolerable for them, and for some, open the door to social and material advancement. Another important phenomenon which must be taken into consideration is the way in which an urban base is used to support rural families. This is particularly true in some of the most marginal of urban areas.

Satisfying their energy needs is just one of the many challenges confronting the urban poor. Essential needs such as shelter, water, food, health care, education and transport must all be catered for in one way or another. Many of these goods and services are more or less free in rural areas, but in cities they are traded commodities which must be paid for. Thus, for the urban poor, meeting basic needs is a battle which is as severe as, if different in nature from, that facing the rural poor. This paper will examine ways in which the problems faced by the urban poor in meeting their basic energy needs can be eased.

The goal of energy planners is, ideally, to create a sustainable energy economy which increases access to the energy sources available to meet growing demand at an affordable cost, without detrimental environmental, social, financial and economic impacts. However, the planning process occurs within a context of great complexity, particularly in the case of the urban poor, and many of the problems presented challenge the abilities of energy planners. Urban energy planning frequently becomes a form of crisis management. Foremost among the problems faced is the rapid growth of urban settlements accompanied by housing shortages, pressure on all forms of infrastructure and increased poverty levels. The following section will deal with these issues in more detail, and will describe the extent to which these factors determine the South African urban energy planning context.

The household or domestic sector has energy demand and supply characteristics which make it particularly difficult to assess and analyse. It consists of a multitude of individual users who fall into a wide variety of energy use categories. There is tremendous diversity in the availability and costs of energy supplies; in the levels of consumption and mixes of fuels employed; in the desired services such as cooking, water heating, space heating and lighting; and in the technologies and energy-related preferences and behavioural modes. In the analysis of current energy consumption patterns in poor South African urban households in Chapter 2, these characteristics are revealed.

1.3 Urban and housing policy developments

It is widely accepted in South Africa that we are facing a significant crisis with respect to the provision of shelter for the urban population. While there are differing opinions on the exact number of families requiring housing, both currently and over the next 20 years, there is consensus on the orders of magnitude of the requirement.

Based on its population growth model, the Urban Foundation (1990) estimated the need for 170 000 houses in urban areas to accommodate population growth in that year alone. In addition, because housing delivery has been unable to keep pace with effective housing demand, a backlog has emerged. It is difficult to determine the size of this backlog because of the lack of data and because estimates vary according to the assumptions made.

Prior to 1980 black urban housing was predominantly provided by the public sector. The policy was, broadly speaking, to provide people with brick or block structures with a fairly high level of services comprising water supply, sanitation, paved roads, and in some cases, electricity. The houses were rented, and both the rent and service provision were often subsidised. This housing supply policy was firmly rooted in the Government's influx control policy. During the early 1980s the housing situation changed dramatically; first, because of generally increased levels of urbanisation, to some extent augmented by removal of influx control measures, and second, through the inability of the economy to support public sector housing delivery.

Despite the limitations of the data, the following analysis of the housing situation is offered as a framework for this study. There are a total of about 7.5 million households in South Africa. Of these, 30% are mid-to-high income[1], 30% urban low-income and 40% are rural low-income households. For the purposes of this study, the so-called Development Regions as defined by the Development Bank of Southern Africa (DBSA) have been used to geographically classify the urban poor. Figure 1.2 gives a graphical representation of the household types found in South Africa in 1990.

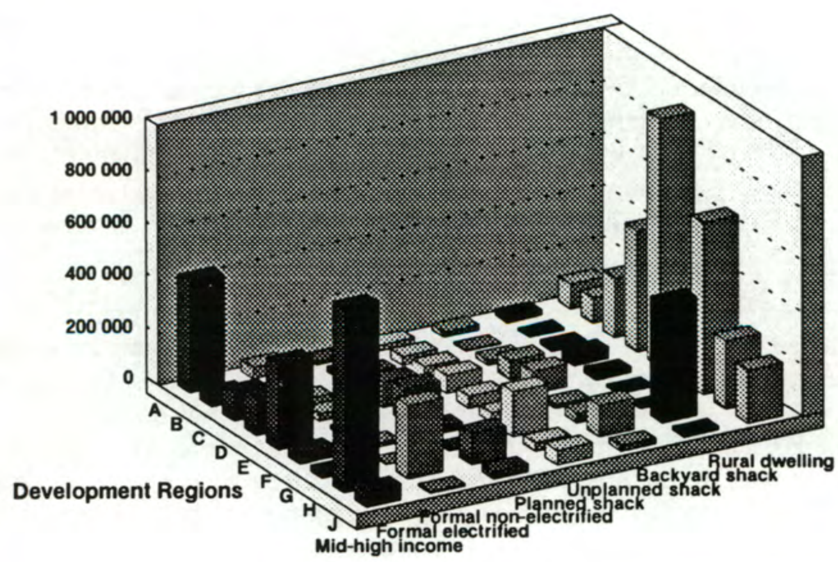


FIGURE 1.2 Distribution of South African household categories in 1990
Source: EPRET database, Trollip (1993)

As can be seen from the figure, further disaggregation of data within these regions has been carried out to two subsequent levels. The first is along the split, formal and informal, with the former referring primarily to fixed structures, usually of bricks or blocks, conforming to building codes and situated within declared township areas. This group is further split into those houses that are electrified and those that are not. The informal classification refers to structures of a less permanent

1. These consist essentially of white households.

nature which may be in declared or undeclared township areas. This group therefore has further levels of disaggregation being backyard, planned and unplanned shacks. The latter two groups distinguish between those shacks that are on planned sites and those that are not.

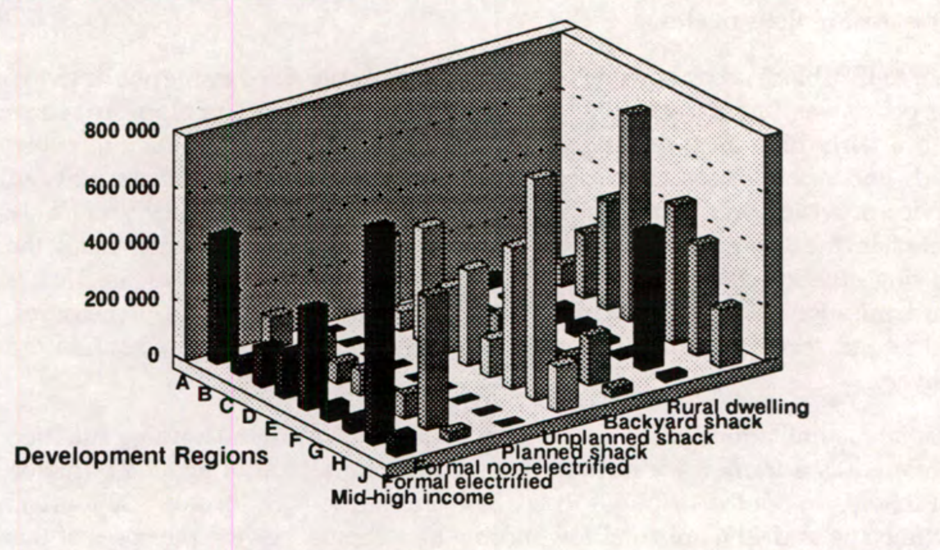


FIGURE 1.3 Distribution of South African Household Categories in 2010
Source: EPRET database, Trollip (1993)

The urban informal category with about 1.5 million households is large and is experiencing high growth. It is estimated that by 2010 there could be more than 4 million urban informal dwellings. Figure 1.3 illustrates the distribution of these dwellings. These, and other housing figures come from averages and estimates compiled by the EDRC and are based on information from a variety of sources including the DBSA, Council for Scientific and Industrial Research (CSIR) and the Urban Foundation (UF). The process of data collection and synthesis is documented more fully in Paper 5 of the EPRET series (Trollip 1993).

The major urban concentrations are the metropolitan areas of Pretoria-Witwatersrand-Vereeniging (PWV) which fall in Region H, the Durban Functional region (DFR) in region E, Cape Town in region A, Port Elizabeth and East London, both in region D. These areas account for two thirds of the urban poor. Urban poor households usually live in townships which originated as dormitory areas for black workers, outside the bounds of the 'white' cities. In the past few years about half of the *formal* houses in these townships have been connected to the electricity grid, while most of the *informal* dwellings remain unconnected.

The PWV area is the largest of the metropolitan areas, accounting for just over one million low-income households, thus representing 40% of poor urban households. It is expected to grow to one and a half times its present size by 2010 with most of the growth occurring in the low-income informal sector. Climatically the PWV area is temperate, and in the winter months temperatures dip below 0°C at night, thus making domestic space heating a necessity. There are roughly 300 000 poor households in the DFR, 300 000 in Port Elizabeth and East London combined, and nearly 120 000 in the Cape Town area. The DFR enjoys a subtropical coastal climate, while East London has a coastal climate somewhere between the DFR and the Port Elizabeth metropolitan area which has a temperate coastal climate. Cape Town is also in the temperate coastal belt, but has very wet winters.

The rest of what has been defined as the urban population resides in towns and closer settlements distributed throughout the country. The poor populations in towns are generally found in townships on the outskirts of the 'white' centre. Closer settlements are agglomerations of mainly informal dwellings in essentially rural areas. They occur on homeland boundaries and are often described as being 'functionally urbanised'. The economic bases and commercial services of these latter areas are the metropolitan areas, to which workers commute, often more than 80 kms. This category accounts for about 350 000 dwellings.

The categorisation of urban households in the abovementioned manner was to some extent prompted by recent in-depth studies of energy usage in low-income households which have categorised users according to similar dwelling type definitions (Golding & Hoets 1992; Rossouw & van Wyk 1993). Although differences in consumption patterns are not necessarily pronounced across *all* dwelling types for *all* fuels, this categorisation is useful in describing and understanding energy usage patterns and therefore for designing and evaluating energy supply interventions.

The city as spawned by apartheid can in very broad terms be described as consisting of a 'white' nucleus surrounded by black residential areas separated from it by 'buffering' zones of various types. With the relaxing of influx control, a process of infilling of these buffer areas and other open spaces within the boundaries of both the white and the black areas began. This process continues in the planning of new residential areas, and there is no doubt that densification will typify the urban settlements of the future. However, also of some importance, but not yet well-understood, are peri-urban or semi-rural informal settlements. These can be regarded as functionally urban but often have strong links to deeper rural areas, and it seems, provide something of a temporary urban base for rural people. As mentioned earlier, these areas could be very important in sustaining rural areas, and may merit special attention as regards their services provision.

To conclude, the study's focus group can be broadly characterised by its extreme diversity. As a result a variety of strategies and a great deal of flexibility will be required to be achieved in widen access to energy sources for this group as a whole. It is the aim of this paper to explore the complexity with which energy planners are faced in poor urban areas, and to present possible strategies to overcome the problems identified.

1.4 Overview of paper

Chapter 2 of this paper looks at the data contained within the EPRET database, and gives a description of the energy consumption and expenditure patterns found in low-income urban households around South Africa. It deals with these on a region by region basis, and draws out the chief characteristics of these patterns in each.

Chapter 3 assesses the various end-uses of energy in these households. Appliance ownership patterns are investigated, as are the problems that households experience in the meeting of their energy service requirements. Chapter 4 deals with the potential for demand-side management of energy in the low-income urban domestic sector.

Chapter 5 focuses on the supply side of the equation, first giving a brief description of existing the distribution, pricing and institutional arrangements in each supply sector. The various policy interventions envisaged for each sector are described. Finally, Chapter 6 draws the policy proposals together and makes some recommendations for future integrated energy planning processes.

The energy consumption data in this study, unless otherwise stated, refers to 1990 levels, costs and prices. In addition, unless otherwise stated, energy consumption will be stated in terms of 'delivered' energy units. Delivered energy refers to the energy content of the energy carriers as they arrive at the household's threshold, that is, before they have undergone any form of transformation into 'useful' energy. This approach has been adopted because of the lack of sufficient disaggregation of existing energy consumption data on an end-use basis. Thus for example, when paraffin consumption data is given for a household, it is generally impossible to determine what proportion of it is used for which particular end-use.

CHAPTER TWO

Current energy consumption and expenditure patterns

This chapter will examine the current energy consumption behaviour of poor South Africans in urban households, and the factors affecting this. A truly integrated approach to domestic energy planning concentrates on energy usage from the perspective of the consumer, starting with the energy end-uses, that is, the services required by the consumer. This has, for reasons that will become apparent later, been extremely difficult in this policy formulation exercise.

The EPRET study has been totally reliant on secondary data sources. These are energy consumption and other energy-related surveys which have mostly been carried out under the direction of the Department of Mineral and Energy Affairs (DMEA), the now defunct National Energy Council (NEC) or Eskom. During the past fifteen years some one hundred dedicated household energy surveys representing a sample of 17 000 urban households, and numerous other non-dedicated surveys, such as syndicated market research surveys containing energy-related questions representing an additional 10 000 households have been conducted.

These surveys were collected by EDRC, data extracted from them, synthesised, and entered into what is probably the most comprehensive household energy database[1] currently available in South Africa. A comprehensive explanation of the process, and the structure of the EPRET database is given by its architect, Trollip (1993). The development of this database has been extremely useful in evaluating the adequacy of the surveys conducted to date, especially with regard to their ability to furnish the data required for an IEP approach to household energy planning. A few general comments on their quality are therefore in order.

All too often basic methodological errors are made by the survey report writers. Some examples are, failure to record the sample size, omission of the survey fieldwork dates, and insufficient discussion of assumptions made in the analysis of the data. There is no doubt that useful data have been collected. However, it is also remarkable how many seemingly comprehensive surveys have failed to collect one, often very small, additional piece of information, the inclusion of which would greatly enhance the usefulness of the data. Space does not permit a comprehensive critique of the surveys, but two of the most often noted omissions of this type will serve to illustrate this point.

Frequently, surveys fail to record the price paid by a household for a unit of a particular energy carrier, with less than 5% of the reports containing any energy carrier price data. This probably arises out a lack of understanding by the survey designers of the context within which they are working. The assumption is probably made that, because most of the energy carriers being considered are commercial, the price can be obtained from the petrol companies or coal merchants, independently of the survey itself. There is thus a failure to understand the complexity of fuel marketing mechanisms in low-income areas, and indeed the way in which poor households use energy.

Another example is the failure by many of the surveys to quantify the consumption of a particular energy carrier for the provision of a specific energy service. For example, the different proportions of paraffin used for cooking and lighting are seldom recorded, with only the aggregated consumption figures being registered. It is true that these data are not as easily collected as fuel prices, but they are nonetheless vital for a complete understanding of a household's energy consumption behaviour. Some attempt, however rough, should have been made to estimate

1. This will be referred to as the EPRET database throughout this document.

the split of one energy carrier between different end-uses. Indeed, many surveys fail to mention the particular end-uses for which the energy consumed by a household is being used. From an IEP perspective, this lack of specific end-use data places severe limits on the usefulness of the available energy use statistics. For IEP methods to be applied, there is a real need to improve the quality of information available on specific end-use consumption levels. For the EPRET study, it has been necessary to turn to documentation of household energy consumption behaviour in other countries in order to obtain this further level of insight into the energy requirements for different services.

A final criticism of many of the surveys evaluated is their lack of sensitivity to seasonal influences on energy consumption. There is scant evidence of any attempt to collect anything but data related to the time of survey. The resulting 'snapshot' of the energy consumption situation is then assumed to apply over the whole year. This inevitably skews the data, depending on the season in, or time of month at which it was captured.

At the household level, there are numerous determinants of energy demand some of which can be described as macro, that is, external to the household, while others act at the micro level, within the household itself. Table 2.1 provides a list of these determinants in no particular order of importance.

- Household size, including lodgers (concept of number eating from the same 'cooking pot')
- House structure, insulation, orientation, number of rooms
- Tenurial rights
- Water supply type
- Household income, including patterns and reliability
- Expenditure on all household requirements
- Status (gender, age, education) of fuel and appliance user
- Extraordinary energy use, feasts, funerals
- Preferences, for example dietary
- Home-based productive activities
- Health and safety considerations
- Fuel prices, including alternatives
- Availability of and access to energy carriers
- Reliability of supply and uniformity of quality
- Cost of access to energy carrier, for example electricity connection fee
- Appliances, source, cost, length of ownership
- Technical and economic characteristics of appliance-fuel combination, convenience of use, multiple end-uses

TABLE 2.1 Major determinants of household energy consumption patterns

In South Africa it has been found that one of the primary macro determinants of a household's energy consumption is its geographical location. Thus there are two major geographical factors which appear to affect energy use patterns in South African low-income urban households: climatic conditions and access to cheap coal which is determined by the distance from the coal mines. The Figure 2.1 shows the bio-climatic regions, and the location of the major coalfields.

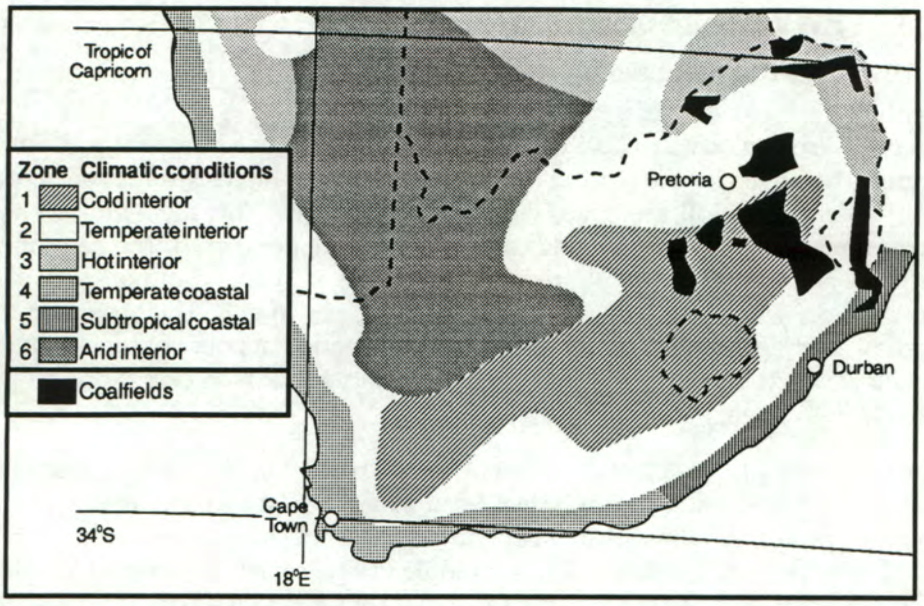


FIGURE 2.1 Map showing the location of South African coalfields and bio-climatic zones

We will now take a closer look at the energy consumption patterns found in the household categories as defined earlier. Our analysis will be conducted on an area by area basis, and is based on data drawn from the EPRET database (Trollip 1993), standardised to 1990 money and 1990 levels of consumption as most of the significant surveys are clustered around that year. However, this approach does present problems in certain regions where reliable data for energy carrier 1990 prices is not available. For this reason all expenditure figures should be treated with care.

Figure 2.2 gives an overview of the use of different energy carriers in the various regions of the country. A comparison of this with Figure 2.1, demonstrates some of the reasons for the differences in energy carrier use from region to region, such as the predominance of coal in the PWV area. The following sections will discuss these differences more exhaustively. It is also important to note that multiple fuel use is very common in poor households, as is indicated by the sum of the various percentage uses in the regions which total more than 100.

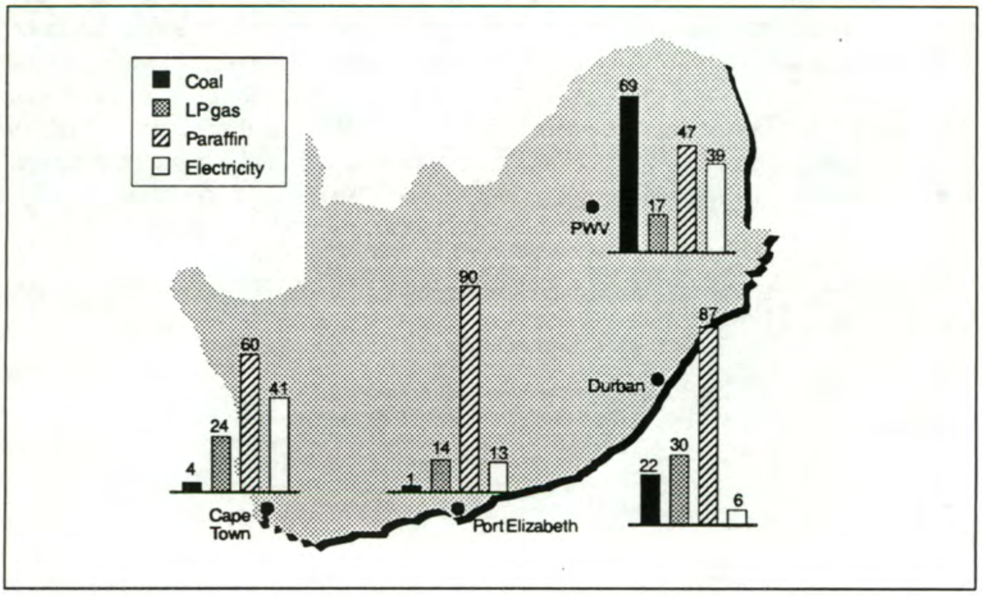


FIGURE 2.2 Map showing the percentage usage patterns of different energy carriers in different regions
Source: EPRET database, Trollip (1993)

2.1 PWV metropolitan area

2.1.1 Energy consumption patterns

Coal

The PWV region contains 40% of all the low-income urban households in South Africa. Their overriding energy use characteristic is their high consumption of coal. Just under 70% of all the households in the region use this fuel, with average consumption across all household categories at 56 kg per month. The percentage of households consuming coal rises to above 80% in the case of non-electrified households, which use between 115 and 160 kg per month. This results in the highest average monthly delivered energy consumption of poor households in the country, which in the case of non-electrified households is in excess of 4 GJ per month on average.

Coal is cheap in this region because of the proximity of the Eastern Transvaal coalfields[1]. In addition to this, when used in a stove, it is a fuel that provides multiple utility, simultaneously supplying three services, cooking, water heating and space heating. The value of this multiple utility is most demonstrated by the 45% of electrified households in the PWV that continue to use coal. However, the adverse effects that this fuel has on the household and general environment must be weighed against these advantages (see Chapter 6).

The ownership and use of coal stoves is therefore an important energy consumption determining parameter, which has tended to be overlooked, particularly by surveys of electrified households. Nonetheless, the available data and records of total coal stove sales give an indication of their ubiquity in the PWV region. According to sales figures quoted in Dickson & Baldwin (1990), in the period 1980-90, a total of 995 000 solid fuel burning stoves were sold in South Africa. Although these statistics include wood burning stoves, it can be assumed that the majority are coal burners. Golding & Hoets (1992) found that an average of 69% of all households in four PWV townships had coal stoves. Significantly, Gervais (1987) found that 63% of electrified households in Soweto still cooked on a coal stove, 50% of them even using it in the summer.

It must also be remembered that a coal stove represents a significant investment on the part of a poor household, costing anything from R335 to R1 400[2] (Dickson & Baldwin 1990), depending on the features included. Of course hire purchase options are available, thus spreading the financial burden over several years. However, this greatly increases the final cost of the appliance. It can therefore be safely assumed that, in addition to the multiple utility aspects mentioned above, resistance to the disposal or replacement of such an asset would feature prominently in an electrified household's decision to continue using coal. Total replacement of all the utilities of the coal stove necessarily implies a further investment in the equivalent electrically-powered appliances needed to provide all three of the services identified above.

Figure 2.3 graphically shows the important role that coal plays in PWV (Region H) low-income households' energy economies. The wood consumed is primarily used for kindling coal fires.

1. The structure of the coal market will be dealt with in a later section, where it will be seen that coal could be even cheaper than it is.

2. This, and all further costs and prices in this study are given in 1990 Rands.

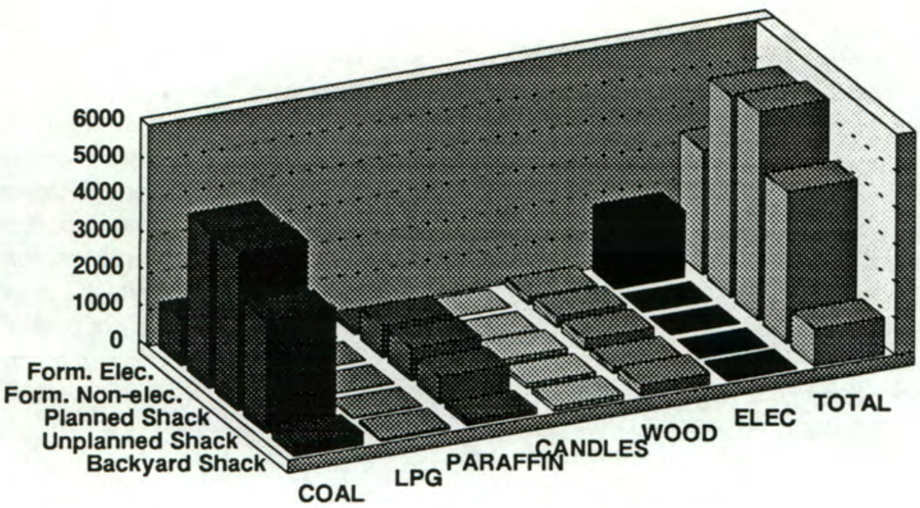


FIGURE 2.3 Monthly delivered energy consumption in MJ – PWV
Source: EPRET database, Trollip (1993)

Paraffin

It can be seen from Figure 2.2 that this is also an important fuel in the PWV, particularly in non-electrified households. It is significant to note how paraffin consumption drops once households become electrified. This indicates the importance of paraffin for illumination, but its use for other services is also significant. In many surveys on fuel preference, it is named by non-electrified householders as the fuel of choice for quick heating requirements such as boiling water or reheating food. It can be bought in small quantities and is thus ideally suited to the cashflow circumstances of poor households. This characteristic is explored in Chapter 6.

A surprising feature of energy consumption in Region H, and indeed throughout the country, is the low consumption of what is a very convenient and efficient fuel, liquefied petroleum gas (LPG). Reasons for this will be discussed in more detail later, but it is possible that factors such as the quantities in which it can be purchased, perceptions as to its safety, the existing marketing structure, and appliance costs are retarding its penetration of the poor domestic sector.

A marketing survey conducted by Eskom in 31 townships in the PWV found that average monthly electricity consumption per household was 426 KWh per month (Van Gass 1991). Another survey covering seven electrified communities, and representing 190 000[1] households found that average household consumption ranged from 380 kWh to 676 kWh per month (Berrisford & Bluff 1991). However, there is a possibility that these consumption rates were inflated for two reasons which were not discussed by the authors. First, the consumption rates were determined on the basis of the total supply to the area then being apportioned to the number of electrified *plots* in the area. This approach fails to take account of the fact that there may be backyard shacks on the plots, and the consumption per plot may actually be for up to three households. The second reason for possible inflation of the figures is that non-payment by households was not considered.

The effects of non-payment are shown by the findings of the Palmer Development Group (1993b) in their survey of ten townships nationwide. They found that Kagiso[1] had an average monthly household consumption of 730 kWh (Summer 500 kWh; Winter 900 kWh) compared to the 390 kWh (Summer 320 kWh; Winter

1. 60% of the low-income electrified households in the PWV at the time.

500 kWh) found in Alexandra, where prepayment meters were being used. The Alexandra residents had had access to electricity for the past four years, and their credit meters had recently been replaced with the prepayment type.

2.1.2 Energy expenditure patterns

The lack of sufficiently disaggregated data on energy expenditure by poor households greatly limits analysis of this important parameter. However, certain surveys have dealt with it, the most comprehensive in the PWV region being Golding & Hoets (1992). Figure 2.4 has been synthesised from their data, and although drawn from a relatively small sample, about 600 households, it reveals some important characteristics of the energy expenditure habits of poor households. Unfortunately, given the limitations of the data available, it was not possible to generate the graph with reference to the housing categories shown in Figure 2.3. Thus it is not possible to draw firm conclusions as to the effects of different energy carrier use on energy expenditure as a percentage of income. This is an further area which has been earmarked for future study by EDRC.

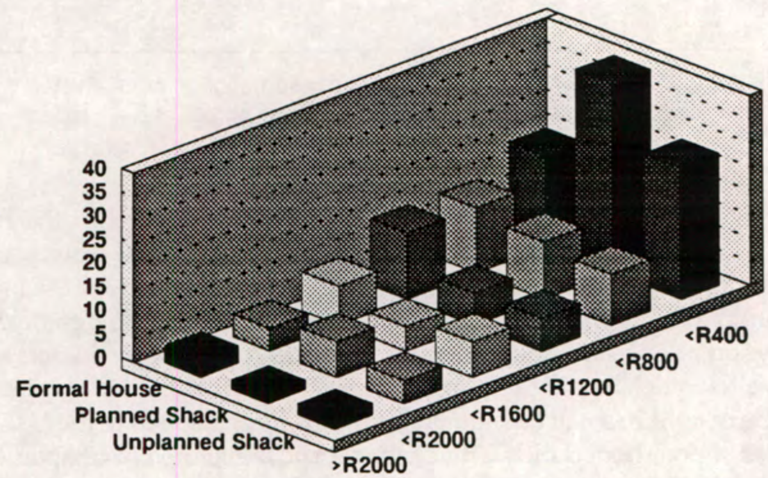


FIGURE 2.4 Energy expenditure as a percentage of income - PWV
Source: Golding & Hoets (1992)

A most significant feature is the high percentage of income being spent on energy by the poorest category (those households with an average monthly income of less than R400). This ranges from 15% to 40% of total household income, but with high standard deviations. By contrast, those households with incomes of between R400 and R800 per month, only spend between 10% and 15% of their income on energy.

These features would tend to indicate two things. First, the high standard deviations of the lowest income category's energy expenditure percentages suggest that the survey methods used are inadequate. Generally a question is asked of households as to what their expenditure on energy was 'last month'. Given the short cycle cash flows of poor households, and the unreliability of such recall-based information, such a question will inevitably throw up a wide range of answers. However, despite this unreliability, it is evident that poor households are spending substantially more on energy than the rest of the population.

Secondly, this high energy expenditure indicates that there is a certain minimum energy consumption required to sustain a minimum standard of living. Consumption below this level would constitute a state of energy 'poverty', and could

1. In the outlying parts of Central Kagiso it is estimated that there are 2 000 to 3 000 illegal connections. In addition, non-payment of accounts is rife, and the arrears for payment for bulk electricity bought from Eskom was R22 million in February 1992 (Palmer Development Group 1993b).

prejudice the household's welfare. The dataset available for this study is not sufficiently comprehensive for the concept of a minimum energy consumption level to be thoroughly tested in the South African context.

However, EDRC is compiling a database of the primary data collected in the many surveys already conducted countrywide, and it is hoped that further analysis of this complete dataset will throw light on this and other important issues. Of particular importance is an exhaustive analysis of existing energy consumption and use data, along with available socio-economic data, in order and improve understanding of the determinants of energy consumption and use patterns. This type of analysis is particularly important in trying to determine the types of interventions required to stimulate rational energy use.

The following expenditure data should be treated with circumspection, because of their aggregated nature. Nonetheless, they do give some idea of the orders of magnitude of expenditure on energy. Based on the data available to EPRET, the absolute amounts being spent on energy by PWV households range from R32 per month in the case of backyard shacks, through to R86 in the case of planned shacks, with an average of R56 across all categories. The most costly energy carrier is paraffin, which in the case of non-electrified households with outlays of between R25 and R35 per month represents between 35 and 45% of the household's total energy budget which ranges from R65 to R87. Electrified households spend around R60 per month on electricity, which represents about 76% of their energy budget.

2.2 Durban Functional Region (DFR) and Pietermaritzburg

2.2.1 Energy consumption patterns

The DFR metropolitan area is in development region E, and enjoys a subtropical climate, thus resulting in a much reduced need for space heating. Pietermaritzburg, on the other hand, is higher, and therefore experiences somewhat cooler winters, although not as cold as the PWV. This factor, in combination with greater distance to the coalfields, results in much lower coal consumption than in the PWV area. Nonetheless, for the DFR and Pietermaritzburg areas combined, coal is still the most important energy carrier, on a delivered energy basis, for formal non-electrified houses and planned shacks. These respectively consume an average of 60 and 40 kg of coal per month, which represent 50% and 40% respectively of their gross monthly energy requirements. This is roughly a quarter to a third of their PWV counterparts' consumption, and it is significant to note that their paraffin consumption is very similar to that in the PWV.

It is interesting to note that in South Africa as a whole, LPG enjoys the highest overall penetration in this region, with around 30% of non-electrified households using it. In energy terms it contributes around 14% of their gross consumption, with average monthly consumption at about 7.5 kg. Unfortunately no detailed analysis of LPG use in the DFR has been conducted by any of the surveys available, but its penetration may be related to the proximity of the two refineries, Sapref and Genref.

Electricity

Berrisford & Bluff (1991) stated that coastal area consumption levels were found to be of the order of 300 to 400 kWh per month. The Palmer Development Group (1993b) found median monthly consumption levels in Umlazi to be 500 kWh (Summer 600 kWh; Winter 750 kWh) per month on average, although they added the rider that the data could be inaccurate. It is significant that the median consumption in newly-electrified areas with prepayment meters was found to be much lower at 150 kWh. In Sobantu near Pietermaritzburg, the mean consumption was at 365 kWh (Summer 320 kWh; Winter 450 kWh) for those households that were billed. However, it appears that there are problems of theft in the area, with disconnected households reconnecting themselves. If these are taken into account, the mean for the area rises substantially to 500 kWh.

Looking at the overall picture, Figure 2.5 shows the monthly household delivered energy consumption profiles for region E as a whole. The vertical axis has been chosen so as to allow easy comparisons with all other regions. Thus it can be seen that region E households consume markedly less energy on a delivered basis than do those in region H. However, given the lack of data on energy consumption by particular end-use, it is impossible to satisfactorily analyse this phenomenon.

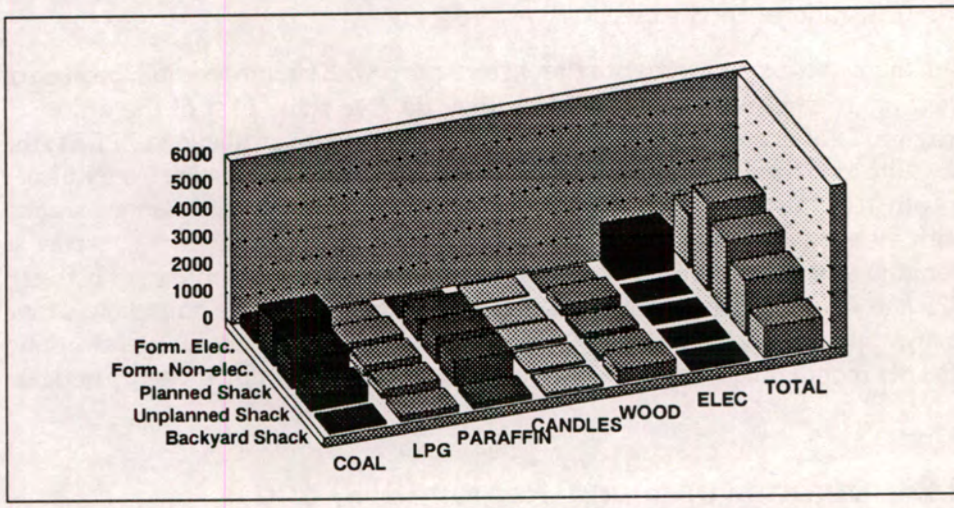


FIGURE 2.5 Monthly delivered energy consumption in MJ – DFR
Source: EPRET database, Trollip (1993)

2.2.2 Energy expenditure patterns

Energy expenditures as a percentage of income for DFR households show very similar characteristics to those found in the PWV. It is apparent from Figure 2.6[1] that households in this region with incomes below R400 per month are spending proportionately more on energy than are those with incomes above R400 per month.

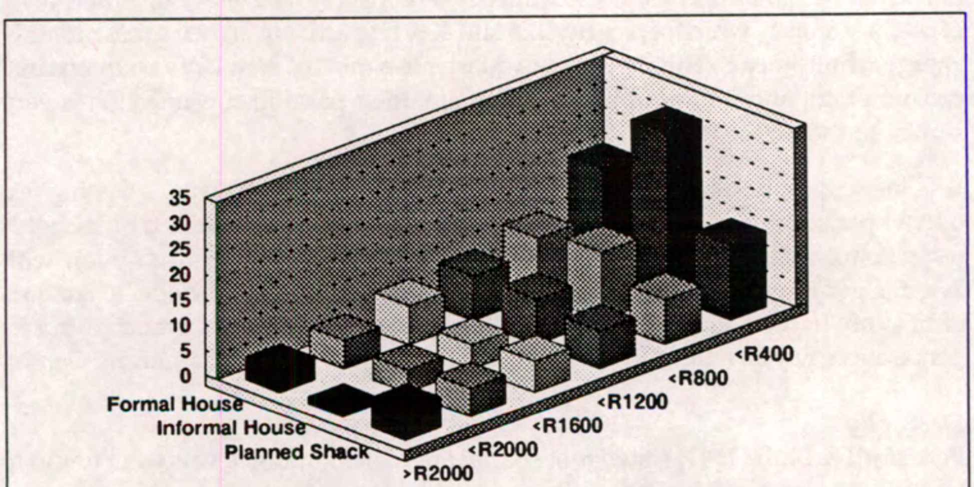


FIGURE 2.6 Energy expenditure as a percentage of income — DFR
Source: Golding & Hoets (1992)

1. Synthesised from Golding & Hoets (1992), and checked against DRA (1989).

The absolute amounts being spent on energy in the DFR are slightly lower than those in the PWV, with the average amount across all housing categories at R60 per month, based on the EPRET dataset. Paraffin is the most costly of the energy carriers, representing around 40% of a household's energy budget. This is of course not the case for electrified households which spending an average of R60 per month on electricity, 88% of their total energy expenditure.

These expenditure figures agree quite closely with those found by the DRA (1989) survey carried out in the Edendale-Imbali Complex. It would therefore seem that the Pietermaritzburg area has similar energy consumption patterns to the DFR.

2.3 The Eastern Cape metropolitan areas

2.3.1 Energy consumption patterns

Port Elizabeth and East London will be considered together, as they have very similar socio-economic profiles. There is only one sufficiently detailed energy-related survey that has been conducted in this region (Rossouw & van Wyk 1993). Despite the vast amount of data contained in this report, it concentrates on penetration of various energy carriers, and lacks information on their actual consumption by households. Although energy expenditure data has been quite exhaustively analysed, there is no record of the prevailing prices for different energy carriers, and thus it was not possible to calculate accurate consumption figures from the expenditure data. Assumptions therefore had to be made on the prices paid, and consumption was then calculated using these.

Figure 2.7 shows the monthly delivered energy consumption profiles typical of households in these metropolitan areas.

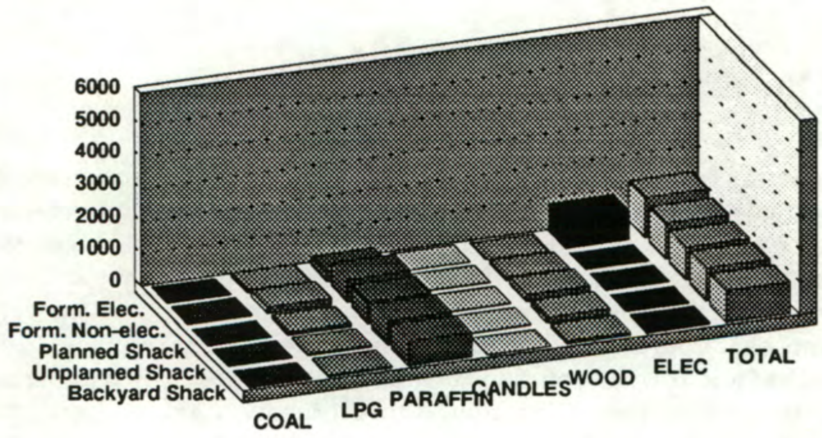


FIGURE 2.7 Monthly delivered energy consumption in MJ – East London and Port Elizabeth
Source: EPRET database, Trollip (1993)

This figure shows the low consumption of delivered energy compared to consumption in the PWV and DFR metropolitan areas. This is probably attributable to two factors. First, in comparison to the PWV, the climate is much milder, with this region enjoying higher average winter temperatures. The second, and probably more important reason, is the lower incomes of households in Port Elizabeth and East London, when compared to the former two regions.

Paraffin is the dominant energy source for poor households in these two metropolitan areas, providing an average of 68% of the domestic energy requirements for non-electrified households. No other energy carriers feature prominently, and it is surprising that LPG does not enjoy a higher penetration, although there do appear to be pockets of fairly high usage around Port Elizabeth, where the frequency of use out of a sample of 425 households was about 18% (Rossouw & van Wyk 1993). The householders ranked LPG highly, but, surprisingly, below paraffin. Neither the fuel nor the appliances necessary for its use are perceived to be expensive, nor is access a problem. Its major disadvantage was perceived to be its danger, a response which is often heard when questions are asked about LPG.

According to the Palmer Development Group (1993b), mean monthly electricity consumption levels for Ibhayi and Motherwell were found to be 345 kWh (Summer 320 kWh; Winter 420 kWh) and 366 kWh (Summer 300 kWh; Winter 400 kWh) per month respectively. Again it was found that prepayment meters in the newly-electrified areas cut consumption levels to 200 kWh (Summer 150 kWh; Winter 250 kWh) per month, although this could be as a result of these households still being on the consumption growth curve.

2.3.2 Energy expenditure patterns

Unfortunately, the data available for these areas is not stratified according to income brackets. Thus it is not possible to see whether the same trends exist here as were found in the PWV and DFR with regard to the lowest income categories. According to Rossouw & van Wyk's (1993) survey, the mean energy expenditure did not exceed 12% of household income for any of the sample categories, while the majority had energy expenditures below 10% of total household income. East London showed an average energy expenditure over the whole sample of 5%, at R46 per month, while Port Elizabeth had a mean of 6.7%, or R56 per month. This was one of the few surveys that considered both summer and winter energy expenditure, and over the whole Port Elizabeth sample it was found that energy expenditure hardly rose at all, while in East London an increase of 11.5% over summer expenditure levels was recorded.

2.4 The Cape Town metropolitan area

2.4.1 Energy consumption patterns

Cape Town is situated in development region A, and enjoys a temperate Mediterranean climate, with winter rainfall. As the winters are fairly cold and wet, it would seem surprising that the total delivered energy consumption of households is lower than that of the DFR and Pietermaritzburg region. This once again shows the extent to which coal can greatly increase delivered energy consumption. Removing the coal component from the region E consumption figures brings them into line with those of the Cape Town region. Similarly to the Eastern Cape, low-income households here are dependent on paraffin as their primary source of energy, and it provides an average of 50% of the delivered energy for all non-electrified households. Figure 2.8 shows the delivered energy consumption levels for this region.

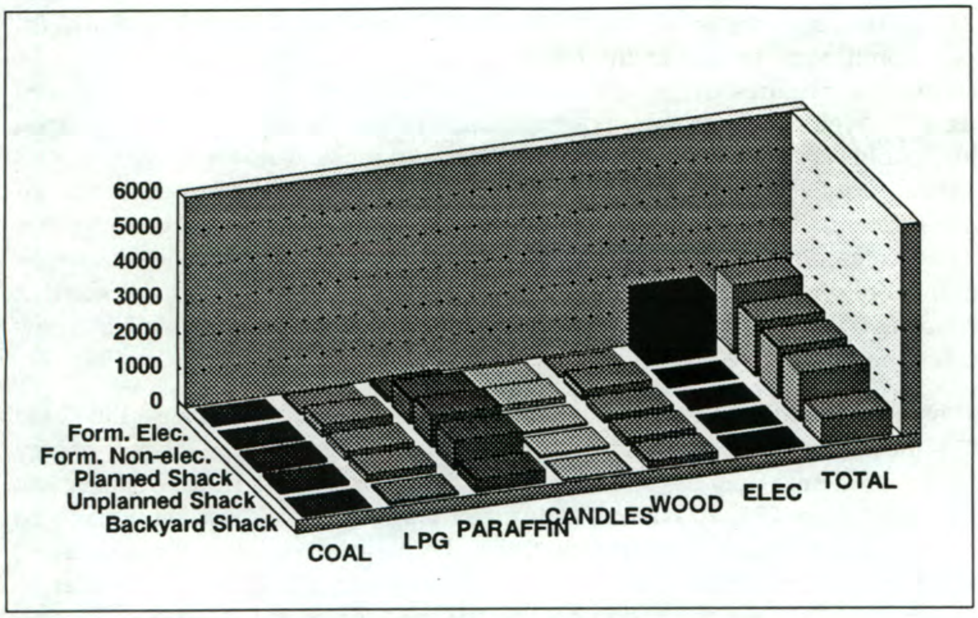


FIGURE 2.8 Monthly delivered energy consumption in MJ – Cape Town metropolitan area
Source: EPRET database, Trollip (1993)

It is interesting to note that LPG is also used quite extensively in Cape Town, with formal non-electrified households using about 7 kg per month, and planned and unplanned shacks both using around 5 kg per month. It is possible that the proximity of the Caltex refinery has something to do with this. It is in some ways surprising that fuelwood does not feature more prominently in this area, given the large quantities of invader bush found in the Western Cape. A possible reason for this are problems of access. Fuelwood is, however, used for informal commercial activities such as the cooking of meat and other snacks in public areas. It is also significant to note that coal consumption has effectively dropped to zero in the Cape Town area, especially when compared to the findings of Eberhard (1986) that coal consumption was as high as 90 kg per month in some informal households.

Thorne & Theron (1993) found that annual mean monthly consumption levels for Langa and Guguletu households were 497 kWh (Summer 411 kWh; Winter 508 kWh) and 523 kWh (Summer 453 kWh; Winter 538 kWh) respectively. The first households in these areas were electrified in the 1960s, and the electrification levels are currently at 73% and 89% respectively. In both areas 85% of the households were found to be in arrears, with the average outstanding amount at R1 700. However, it was also found that there was no significant difference in consumption between those paying and those not paying for their electricity. This suggests that these households, having been electrified for at least five years, and in many cases longer, have reached their appliance ceiling, and hence, their electricity consumption ceiling.

Theron (1992) found in a Khayelitsha sample that households which had had access to electricity for longer than five years had average consumption levels of 450 kWh per month. Those that had been connected for between two and five years, consumed an average of just over 300 kWh, while those with less than two years of access consumed around 240 kWh per month. The increase in the first year of connection was found to be about 60%, from 162 kWh in the first month to 259 kWh in the twelfth month.

The study by Thorne & Theron (1993) is one of the few that has tracked electricity consumption longitudinally in newly-electrified areas. In addition, the survey included households with both credit- and prepayment-metered supplies. It was found that the credit-metered consumers had the highest consumption levels in

Khayelitsha, at an annual average of 599 kWh (Summer 490 kWh; Winter 596 kWh) per month, very similar to the levels found in Langa and Guguletu. Average consumption figures for the period from November 1990 to June 1992 were tracked for *all* Khayelitsha consumers, that is the credit-metered and pre-payment metered households combined. It was found that the summer means for Khayelitsha increased from 154 kWh to 248 kWh per month, while the winter means had increased from 210 kWh to 290 kWh per month. The average annual consumption had increased from 200 kWh to 244 kWh per month, despite an increase in the number of consumers from 1 865 to 5 414. What was observed, however, was that consumption had increased the least in those areas with the greatest number of new connections.

Thorne & Theron's study revealed other important factors. From Phase 1 to Phase 2 of the survey, the percentage of households with electricity as the *only* energy carrier used on a *daily* basis had increased from 60% to 81% in Khayelitsha, but decreased from 72% to 66% in Langa and Guguletu. This was thought to be attributable to the perceived deterioration in the quality of supply in the latter areas, and the resultant loss of confidence in electricity as a reliable source of energy. About 25% of the electrified households surveyed still used LPG or paraffin on a daily basis. Theron (1992) found a significant correlation between the principal type of cooking appliance-energy carrier combination used and electricity consumption. Those households using electric stoves (with ovens) daily for cooking consumed an average of 445 kWh, while those making daily use of hot plates consumed 323 kWh per month. Interestingly, those using gas stoves on a daily basis consumed 307 kWh per month, thus indicating that hot plates do not contribute significantly to electricity consumption.

A third phase of this survey is currently being completed, and has included monitoring of the demand profile of a number of houses in the sample. This should serve to further deepen understanding of the behaviour of newly-electrified households, and especially the behaviour of those in the more informal type of housing. It is becoming apparent that previous assumptions that all electrified households would exhibit similar electricity consumption trends are probably questionable. More of these longitudinal type surveys are needed to provide insights into the complex variables that determine electricity, and indeed, all energy consumption patterns.

2.4.2 Energy expenditure patterns

No recent data stratified by income category are available on energy expenditure for this region. Figure 2.9 indicates that households with incomes of less than R200 per month were spending 38% while those with incomes between R200 and R400 were spending 21% of their income on energy in 1983. This figure dropped to 13% for the next category between R400 and R600, thus replicating the trends found in the PWV and DFR.

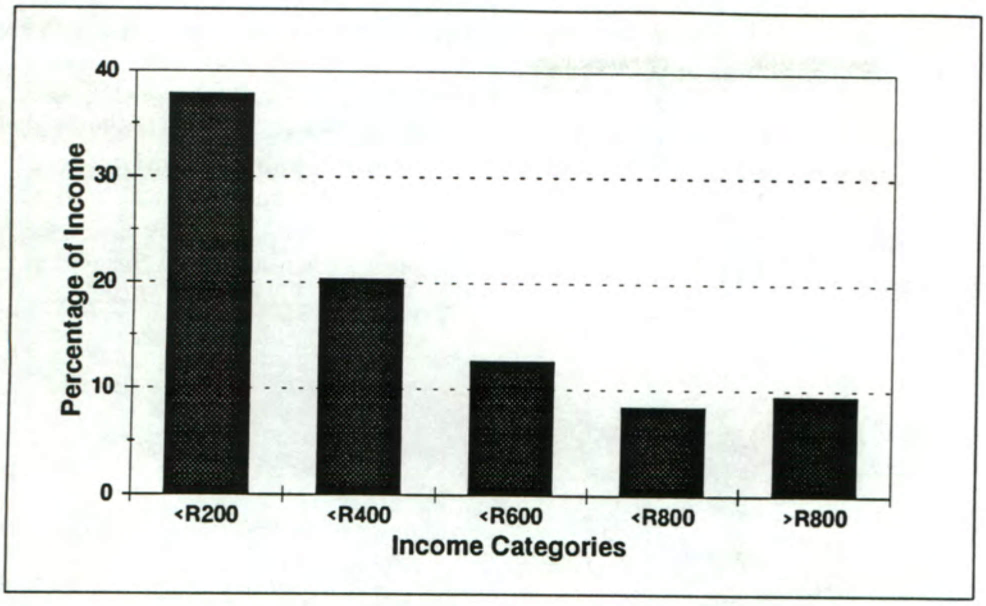


FIGURE 2.9 Energy expenditure as a percentage of income – Cape Town metropolitan area
Source: Eberhard (1984)

Further, those households using electricity spent significantly less than those using other energy carriers, with the ratio in Valhalla Park being R59 to R150 (Eberhard 1984). These trends have been borne out by the Macroplan (1992) survey in Khayelitsha which found that non-electrified households were spending R127 per month compared with the R68 per month spent by electrified households.

The survey conducted by Viljoen (1990) showed a range of expenditure from 7% to 11% of household income for poor households in various types of formal and informal settlements. A more recent survey of low-income electrified households in the Cape Town area (Thorne & Theron 1993) found that energy expenditure lies between 8% and 17% of monthly household income.

These expenditure figures should be treated with circumspection, but particularly the more recent ones, as there is no doubt that data aggregation is masking finer details. This is probably particularly true in the case of very poor families who are, no doubt, spending similar proportions of their income on energy as their PWV and DFR counterparts. This is a good example of how aggregated data could mislead one into believing that the poor in the Cape Town region are now 'better off' energy-wise than poor families elsewhere in South Africa. Further investigation of income-energy expenditure links is needed before such a conclusion can be drawn.

2.5 Energy consumption and expenditure patterns in secondary urban areas

The energy use patterns of the smaller urban areas such as Kimberley and Bloemfontein, and the small towns will be dealt with in this section. Unfortunately the data available for these areas are very patchy. The areas to be considered mainly fall into development regions B, C, F, G and J, although some small towns in the other development regions will be included. Rather than give a comprehensive analysis of their energy use patterns, we will concentrate on those aspects that are of particular interest, and that may require specific interventions. This section should serve to further demonstrate some of the complexity and diversity of low-income households' energy use behaviour.

Galeshewe outside Kimberley was surveyed by Golding & Hoets (1992), and found to be a coal consuming area, despite its distance from the coalfields. It is an area that experiences cold winters, and therefore has a space heating requirement. As is the case in the PWV, even electrified households were found to be consuming coal, with about 35% of their delivered energy coming from this source. The driving force again appears to be the ownership of coal stoves prior to electrification, and underscores the value households attach to the multiple utility of this appliance. Figure 2.10 gives an indication of the delivered energy consumption in this region.

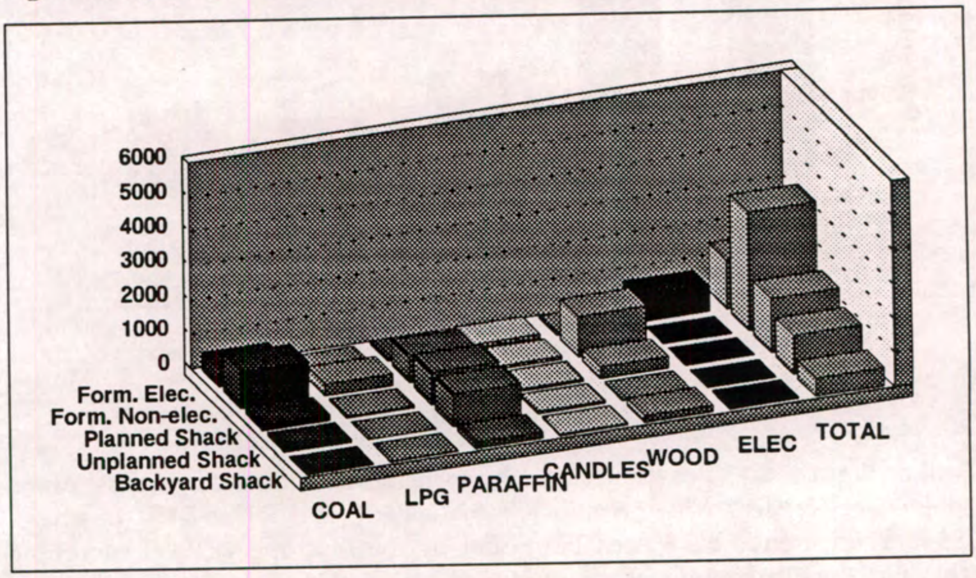


FIGURE 2.10 Monthly delivered energy consumption in MJ – Kimberley
Source: EPRET database, Trollip (1993)

Because of coal's higher price, at around 40c per kg as compared to between 20c and 30c per kg in the PWV, not all households can afford to use it, and there is significant use of paraffin, particularly in informal households. Patterns of energy expenditure were not found to be any different from those found in the regions we have already discussed. The Palmer Development Group (1993b) found mean electricity consumption levels of 570 kWh (Summer 330 kWh; Winter 530 kWh) per month in Galeshewe. The first connections in this area were made in 1965, and there is a mixture of different connection types. Some 1 000 of the 9 000 connected households have 1.5A circuit breaker supplies while the remainder have credit metering systems.

In the Eastern Cape, Rossouw and van Wyk (1993) conducted a survey of 198 households in Lingelihle near Cradock. Although no quantitative measurements of energy consumption were made, some interesting energy use patterns emerged. For example, 8% of households were found to be using coal stoves. This could be as a result of the fact that some of the first coalfields developed in the country were nearby in the Molteno district. In addition, this area experiences cold winters, sometimes with the occasional snowfall, thus creating the need for space heating. All households mentioned the need for space heating, 62% of them using paraffin, 25% using wood and 7% using electricity.

Paraffin is also the dominant fuel used for cooking and lighting, being used by 80% and 85% respectively of households. LPG enjoys a fairly high penetration here, with 21% of households using it for cooking, but, curiously, none use it for heating. Finally, the median expenditure on energy as a percentage of income across the whole community was 7%, with the high income group spending 8% of a median income of R696 per month, middle income group spending 7% of R276 and the lowest income group spending 7% of R199. The two poorest groups' expenditure seems extremely low, but the use of fuelwood (some of which could be collected) by 40% of them, could account for this.

A number of studies have been conducted in the Orange Free State (OFS), which is essentially development region C. It has been found that coal is an important energy carrier for low-income households in this region, as can be seen from Figure 2.11. It is also apparent that consumption profiles are very similar to those for the PWV.

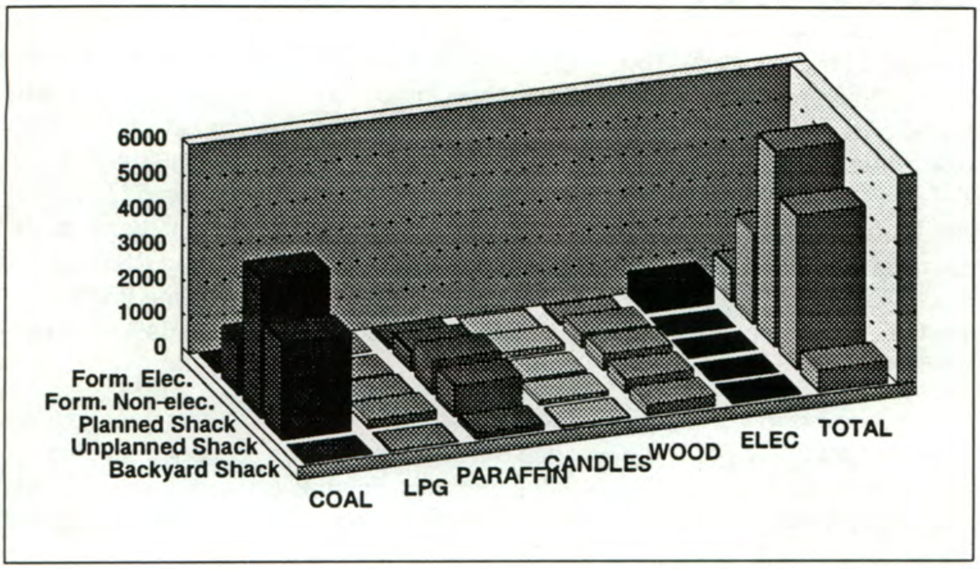


FIGURE 2.11 Monthly delivered energy consumption in MJ – Orange Free State
Source: EPRET Database, Trollip (1993)

Simon & Norval (1987) conducted a survey of Botshabelo and Mangaung outside Bloemfontein, which bears out the above. Once again it was found that electrified households in Mangaung were still using coal, with 70% of them owning coal stoves, and only 20% possessing an electric stove or hot plate. Energy expenditure as a percentage of income in Botshabelo was found to have increased from 14% in the summer to 23% in the winter, with households having a mean income of R507. In Mangaung, the corresponding percentages for electrified households were 11% and 16%, with a mean monthly income of R1 366, and for non-electrified households with a mean income of R617, the percentage expenditures were 14% and 19% respectively.

The Palmer Development Group (1993b) found mean monthly electricity consumption levels in Mangaung to be 530 kWh (Summer 400 kWh; Winter 800 kWh) in those households with credit metering, and 230 kWh (Summer 175 kWh; Winter 300 kWh) in those with prepayment meters. What is also of interest is the fact that average consumptions were at 1 000 to 1 200 kWh per month prior to responsibility for the area being taken over by the Bloemfontein Municipality in 1990. It was estimated that only 10% of the consumption was being paid for at the time.

Some studies have been conducted in areas of Bophutatswana which fall in region J. Dickson & Eberhard (1987) found that peri-urban households exhibited the familiar characteristic of multiple fuel use, with fuelwood, on a delivered energy basis, contributing 43% of their energy needs, coal 29% and paraffin 23%. Of note, however, was the fact that mean annual delivered energy consumption in peri-urban areas was half that in rural areas of Bophutatswana, while the useful energy consumption was only 76% of that in rural areas. This clearly demonstrates the higher efficiency of use afforded by the substitution of fuelwood by commercial fuels.

It was found that fuelwood use did not appear to be influenced by household income. However, the higher income households used transport to collect their fuelwood, while the poorer families collected it on foot. Of the commercial fuels, coal was used almost exclusively by the lower income bracket, and the little gas consumed was used by the higher income group.

A more recent study in Bophutatswana by Golding & Heron (1990) looked at the village of Bapong. Although a village, it gives a good idea of energy consumption behaviour of a functionally urbanised community, given the fact that a large number of the employed commute to the PWV and Rustenburg areas. Unfortunately this study did not quantify the energy consumed by households, but concentrated on energy expenditure questions. However, given the fact that it is probably one of the best studies on a closer settlement, we will look at its findings in some detail. The survey sample consisted of 40 electrified, and 58 non-electrified households out of a total of 1 000 households. The first striking distinction between the groups was the difference in their median incomes, being R1 010 and R500 respectively. Energy expenditure was however much closer together, being R81 for the electrified households and R68 for the non-electrified, that is 8% and 14% of income respectively.

The survey found interesting shifts in expenditure on the different energy carriers after electrification. For non-electrified households, the largest expenditure item at 26% of the total was petrol for small generators. Small generators are quite often found in low-income urban areas, where they are used primarily for lighting and power media appliances. It is interesting to note that petrol, at 14%, is still the second largest contributor to energy expenditure for electrified households, after electricity which represents 55%. This probably demonstrates the need for back-up systems in the event of power cuts, as does the 3% expenditure on candles[1]. Coal is also still consumed by electrified households, representing 7% of expenditure, and all of them were found to still have their coal stoves. Non-electrified households were found to be spending 16% and 11% of energy expenditure on coal and wood respectively, while 95% of them had coal stoves.

Golding & Hoets (1992) conducted a survey in Jouberton near Klerksdorp, where they found that mean monthly delivered energy consumption was above 5 000 MJ, that is, of the same order of magnitude as that in the PWV informal households. The predominant energy carrier in use was paraffin, being used by 77% of households. Close to 100% of the informal households were using it, and only 61% of the formal households. Of the latter category, 59% were using coal, 37% were using electricity, and 27% were using LPG. The reason for the high use of LPG was probably the proximity to the township of a gas store. Of the electrified households, 96% claimed to be paying for the service, and according to the Palmer Development Group (1993b) mean consumption was 570 kWh (Summer 420 kWh; Winter 750 kWh) per month. Energy expenditure in Jouberton averages 15% of household income for the whole sample, while the 19% of households with incomes below R400 per month were found to be spending a massive 33.7% of their income on energy (Golding and Hoets 1992).

Regions F and G have not been well covered by energy-related surveys, and only very sparse information is available. As far as region G is concerned, Viljoen (1992) with the assistance of the Environmental and Development Agency (EDA) conducted a survey of 327 households in Mmotong, Lebowa. This is another functionally urbanised area, lying about 20 km outside Pietersburg. Paraffin was found to be used by 95% of households, with coal use ranking quite highly at 50%. Although he does not provide consumption levels of individual energy carriers, Viljoen does give delivered energy consumption of what he calls 'fuel groups'[2]. Thus he finds that the coal group, which comprises 39% of the survey sample, has a gross monthly consumption of 6 600 MJ, which seems very high when compared to other areas, but nonetheless follow the trends found elsewhere.

1. This phenomenon is found in many of the surveys dealing with electrified areas, and reliability of supply is often commented on by interviewees. It would appear that thunderstorms, common in the Highveld, were the most frequent cause of power cuts.

2. Defined as having more than half of their delivered energy provided by any one energy carrier.

However, what is of greater interest is the fact that the paraffin group, which also constitutes 39% of the sample has a gross delivered energy consumption of 2 128 MJ per month. This is substantially higher than the levels found in paraffin consuming households in Cape Town, Port Elizabeth and East London. This could be attributable to the fact that Mmotong is fortunate enough to have a petroleum products depot close by. Thus the majority of the population buy their paraffin directly from it, and are able to benefit from the mark-up of a mere 18% of the bulk fuel price, compared to the 59% to 129% mark-ups found in townships in the PWV (McGregor 1993).

CHAPTER THREE

An examination of household energy end-use patterns

An attempt will be made in this chapter to examine energy end-use characteristics, at least qualitatively. Despite this lack of detailed quantitative data on energy use for specific end-uses in South African households, some beginnings have been made to try and understand the way in which poor households use energy (for example, Viljoen 1990; Uken & Sinclair 1991; van Gass 1993; Annecke 1993; Ross 1993; Thorne 1993).

3.1 Household energy-use behaviour

The principal end-*users* of energy in the household context are women. Women are also largely responsible for managing household budgets and thereby, the purchase of fuel and food. Yet in South Africa we know very little, as Annecke (1993) says, 'about how women make decisions about expenditure or how they order their priorities, *particularly when survival is an issue*' (italics introduced). Annecke goes on to say that '(e)qually little is known about women's perceptions of fuel and its use in appliances.' Through some very elucidatory work in cooperation with[1] ten households, Annecke has revealed that the household management and survival strategies employed by women are complex, and deserve very serious consideration when formulating energy policies for the poor.

Incomes for the poor are unpredictable in their size and periodicity. This severely limits the capacity of poor households to plan for the longer term, and can lock them into a cycle of poverty which is extremely difficult to break. These cashflow patterns also lock them into the use of particular energy carriers, for two reasons. First, they never have sufficient cash in hand, or the opportunity to save enough to be able to buy the appliances necessary to use another energy carrier. And second, their cashflow never allows them to buy fuels other than those available in small quantities, such as wood, coal candles and paraffin. This predicament of managing a meagre household budget on a day-to-day basis is perfectly described by the following comment by a woman named Zodwa, recorded by Annecke:

If I buy only one bottle of paraffin and one candle a day, I use only that amount, so I am disciplining myself. Also if I have only some few cents, I must buy some food, some paraffin, one candle and maybe something to drink.

The research conducted by Ross (1993) in an informal settlement in the Western Cape looked more at another complex issue which governs the use of energy in poor households. This is the nature of the relationships and decision-making processes which determine energy use. She found that things are not as simple as energy planners would like them to be. Of particular importance was her finding that household income and fuel efficiency are not the only criteria by which fuel use decisions are made. Obviously her findings for the community with which she worked cannot be quickly and easily extrapolated to cover all informal settlements, but they serve to emphasise the complexity of the context within which energy planning for poor households takes place. The central finding of her investigation can best be summed up in her own words.

> (I)n order to examine and explain fuel use in such settlements it is necessary to look at the micro-context of the resident's lifestyles, at the conditions of tenure and security which they experience, and most of all, at the ways in which they are able to use and construct social relationships around fuel. It

1. This is an important aspect of Anneke's work. She used a participatory approach to the collection of information on energy use patterns in ten households, with the women themselves monitoring their energy consumption over the survey period.

is these relationships which shape fuel patterns in Die Bos rather than overtly economistic decisions to utilise the most efficient fuel.

It is apparent from her findings that all fuel use in poor households has deep social roots and implications. It is therefore imperative that policy options be flexible and broad enough to give household decision makers sufficient space within which to operate.

3.2 Energy services

Following on from the above, energy is used by people to provide themselves with a number of services, which are essentially social in nature, being principally cooking, space and water heating, lighting, entertainment, and refrigeration. In conventional economic analysis households are assumed to maximise utility, which is a function of all the goods and services enjoyed by them. In the case of energy, the household derives utility from the cooked meals, hot water, light and entertainment, all services provided through the use of appliance-energy carrier combinations. Energy thus undergoes transformations through the appliances into useful end-use services. In the case of cooking, for example, of the energy 'delivered' in the fuel, only a fraction is usefully employed in providing the desired energy service. This quantity, the 'utilised' or 'useful' energy, is a function of the efficiency of a fuel-appliance combination.

Although quantitative energy consumption shares for individual end-uses has not been gathered by the energy use surveys carried out in South Africa, a few have looked at the proportions of households which use certain energy carriers to satisfy different end-use needs (Gervais 1987; Markinor 1988; DRA 1989; Uken & Sinclair 1991). Some of the general patterns which have emerged in these studies are not dissimilar to those reported in many developing countries (for example, Leach and Gowen 1987; Jannuzzi 1989; Soussan et al 1990; Dunkerley et al 1990; Fitzgerald et al 1990).

First, for individual households, multiple fuel use is common, and it is not unusual to find two, three or more fuels being used for the same end-use. Second, the structure of energy use is different for differing types of household. An important determinant here is economic status, but household size and location both nationally, *and* within the city itself are also significant, thereby complicating the simple income-related relationships one would expect to find. Third, patterns of consumption are dynamic, changing over time as social contexts (both within and outside the household), fuel prices, household incomes, and access to different energy sources change. Having established something of a context, let us now look at the various energy services sought by households.

Uken & Sinclair (1991) conducted the only nationwide study to date of energy end-use covering all categories of low-income households. The survey sample was drawn from the major metropolitan[1] regions, with a mean of 0.5% of the population being sampled in each. It covered a sample representing 4 478 'newly-urbanised'[2] households, 2 239 of which were surveyed in the summer, and a *different* sample of 2 239, however, apparently drawn from the same sample blocks, were surveyed in the winter. This methodological approach unfortunately places a question mark over the claimed usefulness of this study for reliable seasonal energy-use comparisons.

A second study, conducted by Markinor (Kessel 1988) surveyed 1 000 squatter households in metropolitan areas throughout the country. This is therefore useful for cross-checking some of Uken & Sinclair's findings, while at the same time giving greater detail on the informal household categories. Unfortunately, this survey was

1. The PWV was separated into five zones, namely, Soweto, East Rand, West Rand, Pretoria and the Vaal Triangle.

2. Those households that had moved to urban areas during the previous ten years.

only conducted once in September 1988, and therefore only gives us an insight into winter energy end-use patterns.

3.2.1 Cooking

This is arguably the most important energy service sought by households, as it renders many foodstuffs edible, and is therefore fundamental to people's welfare. This is borne out by the fact that, along with space heating in colder climates, cooking accounts for 90% to 100% of a household's energy consumption in most developing countries (Leach & Gowen 1987).

The amount of energy used for cooking depends on many factors: the type of food cooked, the number of meals cooked, household size, the specific combination of fuel and cooking equipment employed, and the way in which these are used. Foods vary greatly in the amount of cooking time and rate of heat input they require. Thus, as Ross (1993) and Annecke (1993) have observed, there are changes in fuel use patterns as meal types change. These can be short term in nature, being determined by the income available to the household, with, for example, meat, vegetables and maize meal being cooked in periods of sufficient income, being replaced by maize meal alone as cash becomes scarce. Furthermore, cooking is often but one of a range of services delivered by the same appliance-fuel combination. For example, a coal stove provides space and water heating at the same time as cooking. This makes it difficult to determine the actual efficiency of delivery of the individual services provided, as it is impossible to gauge where the one ends and the next begins.

In the South African context, on a national basis paraffin is the principal energy source for cooking, being used by 44% of households (Uken & Sinclair 1991). This aggregation will, of course, mask area-specific end-use patterns. In the Port Elizabeth and Cape Town regions, paraffin is used by between 50% and 99% (Kessel 1988) of informal households while similar levels of use are found in the DFR and surrounding areas (Kessel 1988; DRA 1989).

In the Cape Town area 24% of all households use LPG (EPRET database), while the Macroplan (1992) study found that LPG was the favoured cooking fuel for 67% of formal non-electrified households in Khayelitsha. In the DFR, 20% of informal households were found by Kessel (1988) to be using LPG for cooking, and this is corroborated by DRA (1989) for the unelectrified areas of Edendale/Imbali.

Between 55% and 70% of Soweto and Pretoria households were found by Uken & Sinclair (1991) to be using electricity for cooking. In East London and Port Elizabeth 9% and 10% respectively use electricity (Rossouw & van Wyk 1993), while Kessel (1988) found that on a national basis only 5% of informal households used electricity for cooking.

However, what is more interesting is the extent to which electrified households did, and probably still do, use coal for cooking in the PWV. Gervais (1987) found that 63% of them cooked on a coal stove, 50% of them even using it in the summer. This underlines the importance of the multiple utility of the coal stove in providing both cooking, space and water heating services. The summer use of coal for cooking by electrified households could be attributed either to the fact that they only had a hot plate and needed the oven at times, or that they found coal cheaper.

Nationally it was found by Uken & Sinclair (1991) that coal is used by 25%, and wood[1] by 23% of households for cooking. However, in the PWV it is found that around 40% of households in the Vaal Triangle, East and West Rand, and 36% of the Soweto and Pretoria households use coal. In his sample, Kessel (1988) found even higher uses, with 46% on a national level, 63% of PWV, and 76% of Bloemfontein informal households cooking with coal.

1. Although Uken & Sinclair (1991) do not discuss this, it would appear from the data presented in the report that the wood is being used principally by the coal-consuming households as kindling, as it tracks coal use closely, and there is little evidence of wood being used where coal is not.

Cooking appliances
The cooking appliances used by low-income households are varied, given the variety of energy carriers used. Unfortunately, no national surveys are available to give the overall picture for all cooking appliance types. It must also be remembered that many surveys record ownership of appliances, which does not necessarily imply that they used regularly or at all, and may even be unusable.

Households cooking with paraffin use either pressurised primus stoves, or simple wick stoves. Golding & Hoets (1992) found that 42% of households had wick stoves, while only 29% had primus stoves. Thorne & Theron (1993) found that 28% of the electrified households in Langa and Guguletu had primus stoves in 1991. This percentage had increased to 33% in 1992, thus indicating the increasing lack of confidence in electricity, and the increase in the number of disconnections. In Khayelitsha, on the other hand, primus ownership decreased from 14% to 10% over the same period.

Both wick and primus stove types are widely available in South Africa, and are reasonably priced. However, there is room for improvement in their efficiency. Some important work on the improvement of paraffin stove performance has been done by researchers in India and the Netherlands. It is recommended that the results of this work should be evaluated, and if found appropriate, applied in South Africa.

LPG cooking appliances are also widely available in South Africa, and range from simple single ring burners right up to full four-ring stoves with ovens. The cost of LPG appliances does, however, present a barrier to the poor using this efficient fuel more extensively. Thorne and Theron (1993) found that 47% of the electrified households they surveyed in 1991 in Khayelitsha had LPG stoves, but this percentage decreased to 34% in 1992. Over the same period the percentage ownership in Langa and Guguletu had increased from 17% to 22%.

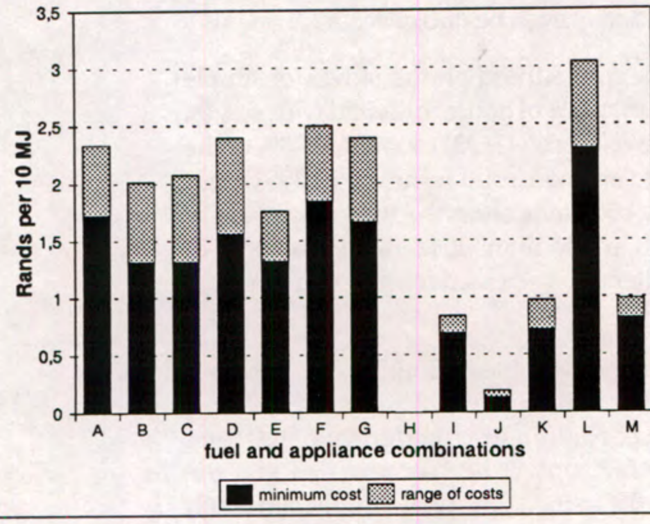
Electric cooking appliances are increasingly being used by low-income households. Gervais (1987) found that 48% of electrified households in Soweto had hot plates, while 33% had full electric stoves. In addition, he found that 68% of non-electrified households in Soweto, and 66% of households in other townships placed stoves at the top of their list of appliances to buy upon becoming electrified. Theron (1992) found that 86% of the households sampled in Langa and Guguletu had stoves, while 46% of the Khayelitsha households had stoves, and 39% had hot plates. However, in the period of one year, stove ownership in Khayelitsha rose to 52% (Thorne & Theron 1993). They found that 25% of households had remembered buying a stove first out of all appliances purchased, while 18% had bought hot plates.

Rossouw & van Wyk (1993) found that 71% of the electrified households surveyed in Port Elizabeth had a stove with an oven. Golding & Hoets (1992) found that 68% of their electrified sample had electric cooking appliances of some type. Golding & Heron (1990) found that 43% of the electrified households in Bapong had stoves with an oven, with 34% giving this appliance as their first priority. What is interesting is that *all* of the electrified households in Bapong had coal stoves.

Robust cast iron coal stoves are manufactured in South Africa. They are widely available, and hire purchase agreements can easily be entered into for their purchase. In addition to being used for cooking, many of them also have a geyser attached, thus providing hot water, and of course space heating during the winter months. Gervais (1987) found that 95% of Soweto households had coal stoves, and 67% of the electrified households continued to cook with coal.

Thorne (1993) has investigated the life-cycle costs of various appliance-fuel combinations, under present pricing regimes, to give an indication of the economic efficiency of the options. In these calculations, no attempt has been made to separate out the various services provided by a particular stove-energy carrier combination.

Instead, he has used a range of efficiencies of the appliance-energy carrier combinations, thus indicating the variation that exists. This diversity can be attributed to the skill of the user at managing the technology in use, and the condition of the appliance and cooking utensils.



A	elec	hot plate
B		oven
C		micro-wave
D	paraffin	wick
E		primus
F	gas	ring
G		stove
H	wood	3-stone
I		stove
J	dung	stove
K	coal	stove
L		brazier
M	low-smoke	stove

FIGURE 3.1 The life-cycle costs of cooking appliances
Source: Thorne (1993)

Figure 3.1 clearly demonstrates the economic advantages of using coal for cooking, and shows how rationally electrified PWV households are behaving in economic terms! However, even more striking are the similarities between the life-cycle costs of cooking with paraffin, gas and electricity. It is clear that the real costs to a poor family cooking with an inconvenient fuel such as paraffin are very similar to those of a family using electricity. The problem for the poor family is the entrance barriers that they face in trying to move from one energy carrier to another more convenient one. These barriers are factors such as: the cost of the necessary appliances to use a particular energy carrier; the cost of the minimum amount of the energy carrier that can be purchased, such as is the case with LPG; the cost of connection to the grid, and the wiring necessary to use electricity; or, social factors such as resistance from household members.

It is evident from the studies mentioned above that multiple fuel use for cooking is common. This can be attributed to various factors. In the case of an electrified households, apart from the coal use in the PWV discussed above, in other regions they could also be using paraffin or LPG in emergencies when there is a power cut. Coal consuming households often use paraffin for quick heating services such as boiling of water for beverages or the reheating of food. Finally, multiple fuel use could be part of a conscious strategy on the part of a poor household to maximise utility, by realising trade-offs between convenience and cost.

3.2.2 Water heating

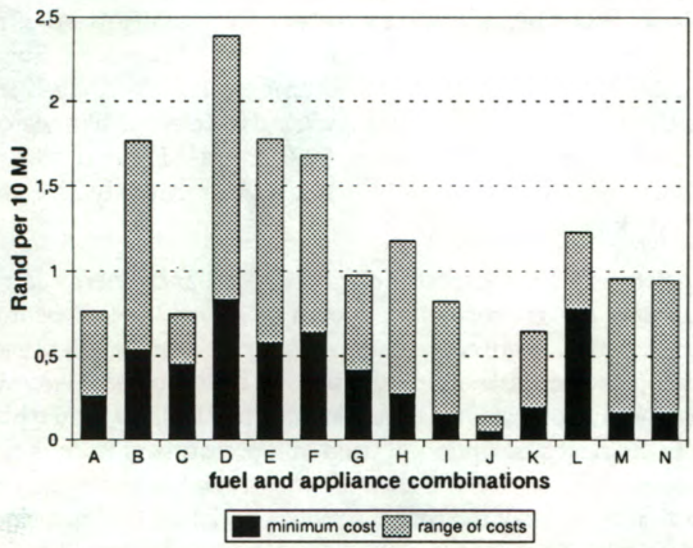
In low-income households, this is a service which is very often provided by the same appliance-energy carrier combination as is used for cooking. Internationally, there is therefore often a significant degree of correlation between the energy carriers used for the provision of these two services (Leach & Gowen 1987). Thus, not surprisingly, it appears that this is also the case in South Africa, and the percentages of households using various energy carriers for water heating are to all intents and purposes the same as those given under the cooking section. Uken & Sinclair (1991) found that paraffin — the most frequently used water heating fuel — was used by 45% of households. Electricity was high in Soweto and Pretoria, at around 61% in both areas. In the Vaal Triangle about 50% of households used coal, with the balance using paraffin and electricity.

Water heating appliances

Golding & Hoets (1992) found that only 19% of the electrified households they surveyed had electric geysers. Gervais found that 23% of electrified Soweto households were using geysers, while 30% of the same group used pots on the stove to heat water. Surprisingly, only 2% of the electrified and 5% of the non-electrified households had geysers attached to their coal stoves. Golding & Hoets (1992) found that 7% of coal stoves in households they surveyed had geysers attached.

Thorne & Theron (1993) found that 65% of the electrified households in Khayelitsha surveyed had electric geysers, while only 10% of households in Langa and Guguletu had them installed. This is a result of the fact that most of the Khayelitsha houses were built by a property developer who had installed the geysers when constructing the houses.

Once again it can be seen from Figure 3.2 showing Thorne's (1993) calculations of the life-cycle cost of water heating, that coal is a cheap alternative to almost all appliance-energy carrier combinations. However, it is apparent that very real savings could be made by low-income households if they could make use of solar water heaters. Once again, the adoption of this technology is hindered by the capital outlay that would be required by the households. There is therefore a need for strategies to remove this entrance barrier. These will be discussed later in this chapter.



A	elec	hot plate
B		geyser
C		on line
D	paraffin	wick/pot
E		primus/pot
F		ring/pot
G	gas	geyser
H		pot/fire
I	wood	pot/stove
J	dung	pot
K	solar	SWH
L	mix	solar/elec
M	coal	stove(jacket/pot)
N	low-smoke	stove(jacket/pot)

FIGURE 3.2 The life-cycle costs of water heating appliances
Source: Thorne (1993)

3.2.3 Space heating

Space heating requirements in some developing countries can double the energy consumption in the winter as compared to the summer (Leach & Gowen 1987). As mentioned earlier, space heating is a difficult energy end-use to quantify, given that it is very often provided at the same time as a cooking or water heating service.

Two fuels dominate the space heating service provision in low-income households in South Africa. Paraffin and coal are used by 42% and 39% of households on a national basis (Kessel 1988). However, once again there are regional differences, with coal being more important in the PWV (48%) and around Bloemfontein (85%), while in the Cape, paraffin is used by 72% of households. In Natal, only 53% of households mentioned the need for space heating, and of these almost all used paraffin (Kessel 1988), with wood being used by 27% of households (DRA 1989). These households are in the higher lying areas around Pietermaritzburg, as the DFR has very low space heating requirements.

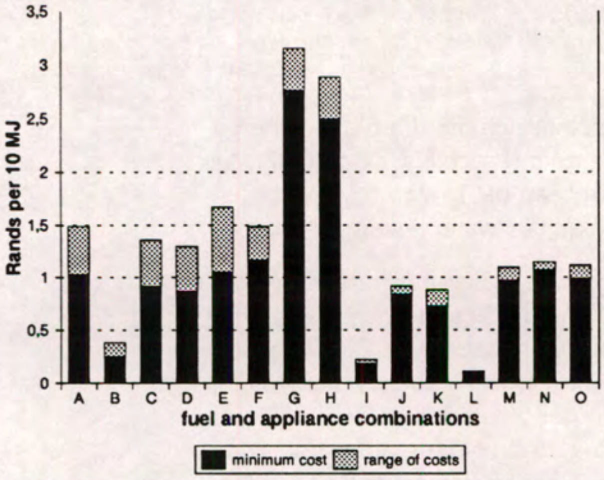
It is of interest to note that, although very few Cape households use coal for cooking, according to Kessel (1988), 20% use it for space heating. Uken & Sinclair (1991) found that 35% of their national sample used electricity for heating, primarily in the PWV region, where it was used by around 55% of households. In Port Elizabeth and East London, as would be expected from the climatic conditions, space heating does not appear to be a high priority from Rossouw & van Wyk's (1993) findings, as only 29% and 49% respectively of the survey sample gave replies to questions on space heating.

Space heating appliances

Paraffin heating appliances are similar to the paraffin cooking appliances in that they are either wick or pressurised primus types. Very few households use the latter type, as they are expensive by comparison. Thorne & Theron (1993) found that paraffin heater ownership in Khayelitsha was 38%, and for Langa and Guguletu 59%. Rossouw & van Wyk (1993) found that 15% of the households surveyed in Port Elizabeth had paraffin heaters, while 14% had them in East London. In Botshabelo, Simon & Norval (1987) found that 36% of households had paraffin heaters, while in Mangaung 47% had them. Gervais (1987) found that 26% of non-electrified households in Soweto had paraffin heaters, 13% of which were the primus type.

Golding & Heron found that 45% of electrified households in Bapong had electric heaters, while Gervais (1987) found that 64% of the electrified households he surveyed in Soweto had electric heaters of some type. Of these 51% were of the simple resistance bar type, while 12% were asbestos panels. In Mangaung, Simon & Norval found that 22% of the households had electric heaters. In Khayelitsha, Thorne & Theron (1993) found that 44% of households used electric bar heaters, while in Langa 28% had them and in Guguletu, 59%. In East London 43% of electrified households had electric heaters, while in Port Elizabeth only 27% used them (Rossouw & van Wyk 1993).

Thorne (1993) has calculated the life-cycle costs of various appliance-energy carrier space heating combinations, and the results are shown in Figure 3.3. The assumptions underlying these calculations are contained in his paper. From the figure it is apparent that those people who have access to coal are in the most favourable position to meet their space heating service requirements, particularly if they have a coal stove. Paraffin is the next best option, if used in a pressurised Primus-type heater. However, most households use the cheaper wick-type heaters, which are the most expensive option in terms of the cost of service provision. LPG is the next best option, but cost presents a barrier to its use.



A	elec	radiant heater
B		heat pmp
C		blower
D		panel
E	paraffin	heater
F		primus
G	gas	heater
H		ring/stove
I	wood	open fire
J		stove
K		pot
L	dung	fire place
M	coal	stove
N		brazier
O	low-smoke	stove

FIGURE 3.3 The life-cycle costs of space heating
Source: Thorne (1993)

3.2.4 Lighting

Although relatively little energy is consumed for lighting, this service has a very high utility for the household, in that it can contribute substantially to the achievement of better living standards. The following extract from Annecke (1993) shows the lengths to which the poor will go to get good lighting:

> In one home the poor lighting was effectively boosted by waxing the newsprint wallpaper. The polished surface reflected the light and enhanced the visibility, allowing the mother and daughter to read at night.

The poorest of families generally use candles for lighting, and this can be a major expense for them. Obviously bulk buying can reduce this burden, but sufficient money is not always available for such purchases. When the women working with Annecke on monitoring their energy consumption became aware that they were spending 20% more for their lighting by buying one candle at a time, only two out of the ten households had the means to buy a packet of candles per week. Even when they were able to purchase candles in this manner, other problems emerged.

> I tried by all means to buy a packet of six and not let my husband know, otherwise he will sit up the whole night using all the candles.

This is a problem which exists, not only with regard to the purchase of energy for lighting, but moves into the realm of household management and authority. These factors will be dealt with in more detail in a later section of this paper. What is of importance here is that for poor families, improved lighting usually involves substantial expense relative to their meagre means. To improve the quality of their lighting, this capital outlays such as those required for the purchase of a paraffin pressure lamp, or electrical connection charges and house wiring would be incurred.

Clearly, all households able to afford it would use electricity for lighting. Thus this will be the case for the 22% of low-income households in South Africa currently electrified (Trollip 1993). On a national scale, however, paraffin and candles are found to be the most important sources of lighting, with 34% and 31% respectively of homes using them (Uken & Sinclair 1991). Kessel (1988) found a higher use of paraffin in the squatter areas, at around 50%. Looking at the regional differences, it was found that in the Cape metropolitan areas between 70% (Rossouw & van Wyk 1993) and 95% (Kessel 1988) of households use it.

In the PWV there appears to be a higher use of candles with Golding & Hoets (1992) finding between 70% and 95% of households using them, while only 30% use paraffin (Kessel 1988). Gervais (1987) confirms this with 79% of non-electrified households in Soweto using candles, but what is also of interest is that 25% of electrified households also used them, no doubt as a stand-by for power cuts. In non-electrified households in Natal, candles are being used by 65% and paraffin by only 28% of them (DRA 1989).

Thorne (1993) has carefully analysed the efficiencies and life cycle costs of various appliance-energy carrier combinations. What is very important about the move away from lighting sources such as candles and paraffin to electricity is the quality of light that is offered by the latter source. This is very powerfully shown by experience in Java, where empirical evidence revealed that households which moved from paraffin to electricity enjoy six times more light, of a better quality and at lower cost (Fitzgerald et al 1990).

3.2.5 Media — television, radio and hi-fi

Although these appliances only consume small amounts of energy, they nonetheless play an important role in domestic life, providing recreational and educational opportunities for households. The value attached to the utility provided by these services is evidenced by the lengths to which poor households go to obtain them.

They make use of dry cell and vehicle batteries, both costly energy sources on a MJ basis. In addition they are inconvenient, and the recharging of vehicle batteries takes up time in getting them to a recharging point and back home again.

Documentation of battery use is scattered, and there is no information on their use on a national scale. Golding & Hoets (1992) found that use of vehicle batteries differed widely between the eleven townships they surveyed, ranging between 2% and 47%. On average 21% of households in the PWV, and 30% in the DFR used them. This use was found to be highest in formal non-electrified households, 59% of which are using them. Of the planned and unplanned shack dwellers 31% and 23% respectively used vehicle batteries. Gervais (1987) found that 57% of non-electrified households in Soweto were using them for television.

DRA (1989) found that over 33.3% of non-electrified households in the Edendale-Imbali complex owned television sets and hi-fi systems, which implies the use of batteries. In East London, only 8.9% of the non-electrified households were found to be using vehicle batteries for television or hi-fi, while 9.4% were using dry cell batteries (Rossouw & van Wyk 1993). In Port Elizabeth, 9.8% of the non-electrified households were using vehicle batteries, and 11% used dry cell batteries. Viljoen (1990) found that 50% of non-electrified households in the Cape Town metropolitan area were using dry cell batteries, while 22.8% used vehicle batteries.

Viljoen also found that households were spending around R20 per month on recharging batteries in Cape Town, averaging 8.5 charges per month. Rossouw & van Wyk (1993) on the other hand found that households were only spending around R10 per month in Port Elizabeth and East London, while in PWV townships households were spending R15 per month (Golding & Hoets 1992). PWV households were also found to own between 2 and 3 vehicle batteries. In Galeshewe, outside Kimberley, households owned an average of 3.9 batteries, and spent on average R20 per month for recharging. These expenditure figures clearly demonstrate the high value attached to the use of media apparatus by low-income households, as these amounts are significant in relation to their total energy expenditure. Unfortunately, sufficiently disaggregated data were not available from any of the studies to allow the expenditure on car batteries as a percentage of total energy expenditure to be calculated accurately, but it would appear to be as high as 20% to 30%.

3.2.6 Refrigeration

Refrigeration is a service apparently ranked very highly by low-income householders. Golding & Hoets (1992) found in their survey of eleven townships that an average of 83% of electrified households had refrigerators, and that they were the most common electrical appliance in the houses surveyed, the next most common being irons, with 79% of households using them. Gervais (1987) found a high level of refrigerator ownership in Soweto at 76% of electrified households.

Rossouw & van Wyk (1993) found that 14% of a total of 430 households surveyed in Port Elizabeth had refrigerators. Of these 58% were powered by electricity, 34% by LPG and 8% by paraffin, while of the 58 (15% of sample) found in the 400 households surveyed in East London, 57% were electric-powered, representing 62% of the electrified households surveyed. The remaining energy sources used were LPG constituting 28% and paraffin for 15%. In Cradock, they found that 18% of the 198 households had refrigerators, 44% powered by electricity, 50% by paraffin and 6% by LPG. Simon & Norval (1987) found that 57% of Mangaung households owned refrigerators, 51% of which were powered by paraffin, 44% by electricity (64% of the electrified households) and 5% by LPG. In poorer Botshabelo, 21% of households owned them, with 54% powered by paraffin and 46% powered by LPG.

It is evident from the above that refrigeration ranks highly as one of the desired services in poor households. It is a service which allows them to make bulk purchases of perishable goods, thus enabling them to extend the value of their meagre incomes. However, the entrance barriers to this service are high in terms of the capital cost of the appliance. Important income-generating uses of refrigerators are the cooling of beer and other drinks served in township shebeens, and of perishable goods sold by spazas[1].

3.3 Environmental and health impacts of current energy usage

The poor are aware of the health effects of the energy carriers that they most frequently use, as is shown by the following comments (Eberhard 1984):

> Die baie rook en gasse is ook baie ongesond vir ons borse[2].
>
> Die kerslig maak die skoolkinders se oe swak[3].

The reliance of a large number of households on inconvenient and polluting energy carriers has impacts which are felt at various levels and by different sections of poor communities. Thus, environmentally the impacts can be felt both in the dwelling and the community at large. Health impacts are experienced to differing degrees by different members of the community. This section will look at some of the negative impacts of current low-income urban household energy use. These fall into three broad categories: air pollution from fuel combustion, paraffin poisoning, burns from fires, and possible changes to dietary patterns. This section will take a brief look at these topics which are all dealt with in greater detail in van Horen (1993).

3.3.1 Air pollution exposure

The combustion of the hydrocarbon fuels used by poor households generates emissions which affect their indoor air environment in a number of ways. The most serious is caused by the combustion of coal, which is used by some 950 000 households countrywide, 52% of which are in the PWV metropole (EPRET database).

South African coal is of varying quality, with an average sulphur content of about 1%, fairly low by world standards, but with high ash contents. The coal most often used by poor households are the so-called 'nuts', which generally have a size of between 22.4 and 40 mm, calorific value of 22 to 30 MJ/kg, and ash content of between 10 and 36% by mass and a volatile matter content of 20 to 31% by mass (Minerals Bureau 1990). Domestic combustion of coal brings with it a number of pollutants which have serious impacts on air quality in the home. The most serious of these pollutants is particulate matter which is directly a product of the high ash content of the coal.

Pollution studies in South Africa have historically measured ambient levels of pollutants at fixed monitoring stations. It is only recently that air pollution and health studies have introduced the total exposure assessment (TEA) approach. This recognises that the health effects suffered by people are not only a function of the concentration of pollutants, but also the duration of exposure to them. Thus TEA simultaneously gathers information about exposure to pollutants and movement patterns, thereby including a mixture of both indoor and outdoor exposure concentrations.

The first personal exposure studies in South Africa were conducted in 1991, and formed part of an ongoing longitudinal study, called the Vaal Triangle Air Pollution Health Study (VAPS). This is aimed at assessing the effectiveness of South Africa's air pollution control programme to adequately protect its people's health. In one element of the study, a group of 45 black children, aged 8 to 12, living in and near

1. Small shops in townships trading in various essential houshold goods, and usually situated in the home.

2. The smoke and gasses are also unhealthy for our chests.

3. The candlelight makes the schoolchildren's eyes weak.

Sebokeng in the PWV area, carried personal exposure monitors to collect data on their exposure to air pollutants (Terblanche et al 1992). The results of this investigation indicated extremely high levels of exposure to Total Suspended Particulates (TSPs). The 12-hour exposure levels exceeded the USA Environmental Protection Agency's (EPA) 24-hour maximum level of 260 μgm^{-3} in 99% of cases, and the lowest-observed-effect level of 180 μgm^{-3} documented by the World Health Organisation (WHO) in 100% of cases.

However, of greater concern to energy planners was the finding that mean concentrations on a *weekend* summer's day were 387 μgm^{-3} and 620 μgm^{-3} respectively for electrified and non-electrified areas. As expected, increased winter coal consumption was reflected in higher TSP exposure levels, with mean concentrations on weekdays at 1 168 μgm^{-3} in electrified and 1 363 μgm^{-3} in non-electrified areas. This relatively small difference between electrified and non-electrified areas is an especially significant finding. This was attributed by the researchers to the close spatial proximity of electrified, partially-electrified and non-electrified areas, and to the high background TSP levels found in the Vaal Triangle[1] caused by coal burning in areas where smoke dispersal conditions are bad. The implication is that only a complete switch from bituminous coal to cleaner energy carriers will have the desired effect of reducing TSP exposure to acceptable levels.

The VAPS programme concentrated only on the exposure of children to TSPs, the air pollutant which represents the most serious hazard to the PWV's urban poor. The effects of exposure to such high particulate levels on health are serious, as is revealed by the fact that acute respiratory infections (ARI) constitute the second most important cause of death in South African children, after gastro-related illnesses. Significant difficulties exist, however, in establishing cause-effect relationships between air pollution and human health. Some of the problematic factors include spatial and temporal variability in pollution levels; subjective symptom reporting; long delays before emergence of symptoms; and confounding factors such as parental smoking. Nonetheless, several epidemiological studies conducted in South Africa have demonstrated harmful health effects associated with pollution exposures.

As part of the same study in the PWV, a health survey was conducted with mothers of over 1 500 children aged 8 to 12 years in various townships. There was a trend of higher prevalence of upper respiratory illnesses (URI) in groups using coal compared to those using paraffin, LPG or electricity (Terblanche et al 1992). Coal use was found to be the most significant predictor of respiratory illnesses when compared to crowding, socio-economic status and parental smoking. Significantly, the health survey was carried out in summer which represents the most favourable possible outcome, as pollution exposure levels are at their lowest.

A range of other pollutants are also produced by coal combustion, such as sulphur dioxide, carbon monoxide, nitrogen dioxide, polycyclic aromatic hydrocarbons and benzo(a)pyrene. In addition, households in other urban centres use a range of other fuels, such as paraffin, LPG and wood, the impacts of which on *indoor* air quality have as yet not been measured in South Africa. Outdoor air pollution has been fairly well documented in South African urban areas, particularly in Soweto and other townships in the PWV. The first intermittent surveys were done in Soweto in the 1970s, and a more comprehensive picture only emerged in the 1980s when various monitoring programmes were established (Turner et al 1984). The scope of these has subsequently been widened to include not only sulphur dioxide and particulates, but also nitrogen oxides, carbon monoxide, ozone, and other pollutants. Recently, similar studies have been carried out in other coal-burning areas in the PWV region, such as Sharpeville (Tosen et al 1991). The results of these studies present a bleak picture of air quality in these townships.

1. Another investigation in the VAPS porgramme recorded the exposure levels of white children in the area. Recorded levels of TSP exposure were well below those experienced by black school children: 63% exceeded the EPA 24-hour standard, and the median level on a winter's weekday was 310 μgm^{-3}. These children came from homes which were fully electrified, thus suggesting high background pollution levels.

The quality of air in Soweto has been studied more intensively than that of other townships in South Africa, partly because its air is so heavily polluted, and partly because its electrification was expected to result in substantial improvements. As was seen in Chapter 2, despite electrification, coal continues for various reasons to be used extensively in Soweto and, consequently, air pollution problems remain serious. Eskom commenced its monitoring programme in Soweto in June 1983, and results from the first few months revealed concentrations of TSPs frequently exceeding the EPA's primary and secondary 24-hour standards (Turner et al 1984). Long term sulphur dioxide (SO_2) levels approached the EPA standards, while nitrogen dioxide (NO_2) levels were well within the limits.

Measurements conducted from August 1990 to July 1991 again revealed unacceptably high TSP levels. The mean annual concentration of fine particulate matter (FPM) over this period was 112 μgm^{-3}, more than double the US standard of 50 μgm-3 (Turner & Lynch 1992). In addition, there were 84 days during the year under examination in which the 24-hour EPA standard was exceeded (Sithole et al 1991). As is apparent from Figures 3.4 and 3.5, strong seasonal and diurnal fluctuations in concentrations occur, thus suggesting that particulate pollution is closely related to household coal usage patterns, as well as to the dust created by vehicle traffic on unpaved roads.

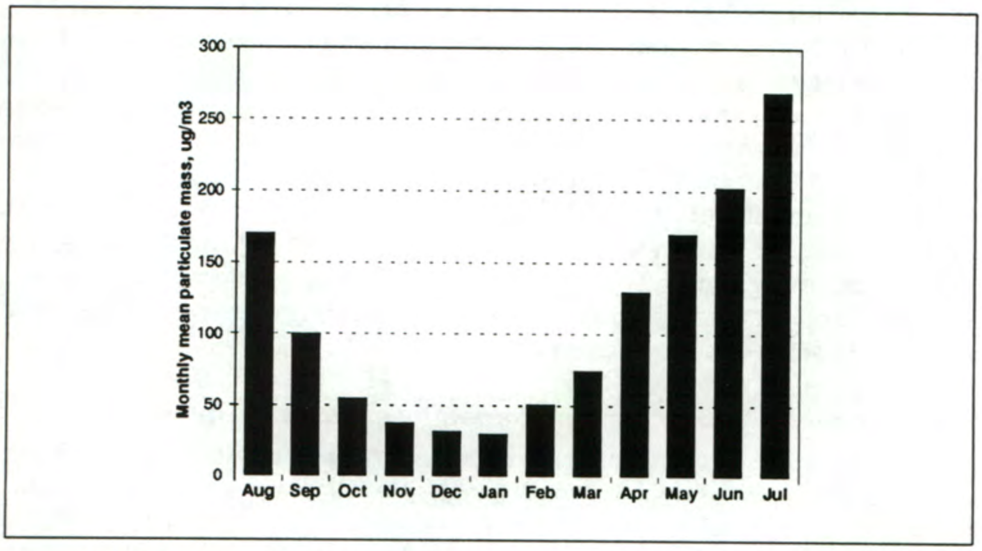


FIGURE 3.4 Monthly mean fine particulate concentrations in Soweto

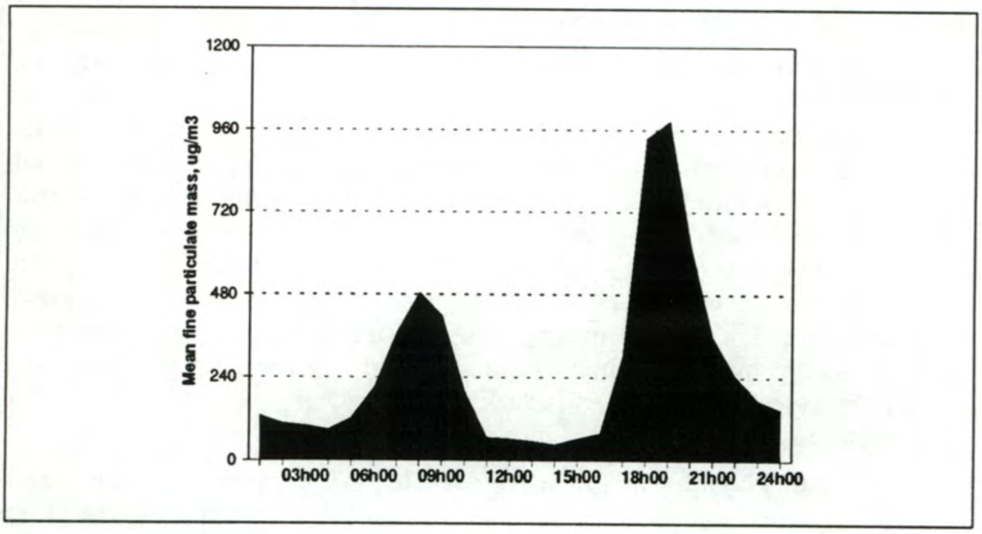


FIGURE 3.5 Diurnal distribution of mean fine particulate concentrations in Soweto

3.3.2 Paraffin poisoning

A further threat to the safety of poor household members in the form of paraffin poisoning. The VAPS programme mentioned above also recorded domestic safety data from 2 124 people in low-income households and found that 6.5% of the sample had suffered poisoning from drinking paraffin, and that some deaths had occurred (Terblanche et al 1992b). In the survey conducted by Rossouw & van Wyk (1993) in 1 624 households in the Eastern Cape, 3.1% of households reported having suffered illness due to the drinking of paraffin, and death had resulted from paraffin poisoning in ten households.

In a study conducted by the Medical Research Council, (MRC) patient data from six major hospitals in the Cape Peninsula was examined to determine the incidence of paraffin poisoning, and to identify high risk areas (De Wet et al forthcoming). They found that a total of 436 children, 63% male and mostly between the ages of 12 and 36 months, were treated for paraffin poisoning during 1990 alone. The implications of this will be discussed later under the policy proposals relating to paraffin.

3.3.3 Injuries, deaths and loss of property caused by fires

In addition to the abovementioned risks of using fuels in the domestic context, the use of paraffin, candles and LPG presents a real fire hazard. This is especially true in high density informal settlements where shelters are often constructed from flammable materials such as wood and cardboard. These fires not only result in the loss of shelter and the inhabitants' belongings, but have caused numerous deaths. In South Africa as a whole, burns are one of the top four causes of injury-related deaths in children under fourteen (Lerer (forthcoming)). In a study of all burn deaths registered at the Salt River State Mortuary in Cape Town from January 1990 to December 1991, residential fires accounted for 75% of the child fatalities, the majority occurring during winter, over weekends and in informal settlements. Domestic accidents mainly related to cooking or heating were responsible for a further 21% of fire-related child deaths.

3.3.4 Changes in dietary patterns caused by energy poverty

This is a field of research that has only recently begun to receive attention in South Africa. Annecke, for example, is conducting some follow-up studies to her initial work in Canaan, Natal. It is a field worthy of further investigation, and should be given attention as a matter of priority. Although it obviously does not fall totally within the ambit of energy planning, it can nonetheless be significantly influenced by it. The following extracts from Annecke (1993) give examples of the effects that energy poverty can have on dietary patterns.

> Beans and bread were commonly cooked when there was very little money because both were enjoyed by the whole family who then did not notice (so much) that their favourite food (meat and samp or mieliemeal) was too expensive for that day's allowance. But this may, as Nolwazi pointed out, involve the consumption of two litres of paraffin in addition to the ingredients, and would cost the equivalent of buying meat and cooking it on the fire outside. However, this would imply the walk to the butcher (there were no fridges at Canaan), a further walk to the dump or the bush to collect wood, and the tediousness of making the fire. This involved a great deal more physically tiring and time-consuming work than buying the beans and paraffin from the spaza, and usually, the women agreed, was not worth the effort because it was not as filling as beans and bread.'
>
> On another occasion a woman explained to the group how she overcame the limitations of a single-burner and still fed her family nutritiously by cooking samp and then adding vegetables to the same pot to make stew.

Ross (1993.) found that dietary patterns in Die Bos changed quite drastically in relation to the money available to households. Thus, people who received a weekly wage tended to eat meals consisting of several components, for example meat, vegetables and maize meal, after being paid, but towards the end of the week switched to only samp. The latter, although a cheap foodstuff, requires a lot of simmering. This in turn results in changes in fuel use patterns and labour requirements, as most households used wood to cook it. Another example of energy-related dietary pattern changes is the story of Margie and Hendrik which was related earlier in this chapter.

CHAPTER FOUR

Possibilities for demand-side management

Efficient use of energy has been a desirable goal ever since the first fire was lit, and especially for the poor. For them efficiency of energy use has meant less time spent gathering fuel or lower energy costs to meet energy service requirements. In the commercial energy world, prior to the so-called energy 'crises', energy suppliers were always ready to provide ever increasing amounts of energy. More recently it has been realised that profligate use of energy resources brings with it the costs of environmental degradation, resource depletion and, in the case of electricity, high generation costs. Electricity utilities are now turning to least-cost planning methods, also known as integrated resource planning, 'to determine the best mix of power resources, e.g. new power plants and conservation programs(*sic*) which can be used to meet future power requirements at the lowest possible cost' (Nadel et al 1991). This has resulted in the investigation of strategies such as demand-side management (DSM) to achieve efficient electricity consumption.

Electricity suppliers are extremely vulnerable to domestic end-use patterns, as electricity generation and use occur simultaneously. Thus the added demand for power at the peak consumption time requires that additional power generation capacity be activated in a matter of seconds. In contrast, coal, LPG, paraffin and candle suppliers have longer time periods over which to respond to changes in end-users' consumption patterns. This reduces the potential opportunities for DSM partnerships between suppliers and consumers in these sectors when compared with the electricity sector. The reasons for this are various, but two key issues are: the domestic consumption of hydrocarbon fuels is a small fraction of the petroleum companies' total market, and hydrocarbon fuels can easily be stockpiled to meet short term rises in demand. This study will therefore focus on the potential for efficiency gains, and demands for improved efficiency in the electricity supply sector.

4.1 Reasons for considering DSM for the urban poor

DSM must be seen within the context of the massive electrification drive being planned for low-income areas, which will be discussed in more detail in Chapter 5. Particular consideration is given to cooperative initiatives on the part of electricity suppliers and users that would result in the efficient provision of electricity, as well as desirable household energy usage patterns and equity issues. The details of these initiatives are discussed at greater length in Thorne (1993). But to summarise, the primary goal of DSM from the electricity utility's perspective is to defer the building of new power stations, and thus keep the price of electricity as low as possible. To achieve this goal, Eskom is considering '(i)ntervention by the utility on the customer side of the meter to influence and change the magnitude and/or shape of the customer's load' (Ligoff 1993).

There is evidence that access to electricity results in a reduction of energy service costs for poor households. In a recent study conducted in Khayelitsha, households with access to grid electricity spent on average R68 per month in meeting their energy needs, while those without access to electricity spent R127 (Macroplan 1992). Apart from these marked cost advantages, there are other benefits in terms of efficiency and convenience or versatility over other domestic energy sources. Hydrocarbon fuels, particularly coal, have the added disadvantage, as we saw earlier, of producing airborne pollution in the dwelling.

In many newly electrified areas, the low consumption of electricity has resulted in a re-think of the approach to electrification. In order to facilitate least-cost planning, Eskom is considering segmenting their market, and is offering a variety of supply options, in order to reduce the costs of the electrification process. Even if many of the newly-electrified households use little electricity, the effect associated with the electrification of more households is an increase in consumption of electricity at peak times in mornings and evenings, as the main household energy use corresponds to the domestic activities associated with cooking, lighting and space heating at these times. The result is that daily domestic electricity use is very uneven with high peaks in the morning and evening, with relatively low loads in between. In order to satisfy peak demands, the electricity system has to hold the necessary generation and transmission equipment in reserve.

Until 1991, the peaks on Eskom's system on the day of maximum demand coincided with the peak industrial and commercial demand. However, in 1992 the peak occurred on a winter's day, and for the first time at the time of peak *domestic* demand. Household consumers contributed 30% to that peak demand, in spite of the fact that they are responsible for only about 15% of total annual electricity consumption (van Horen et al 1993). The domestic demand thus has a disproportionately large effect on the system demand profile and thus on the electricity system's ability to meet electricity demand. This phenomenon is powerfully illustrated by Figures 4.1 and 4.2.

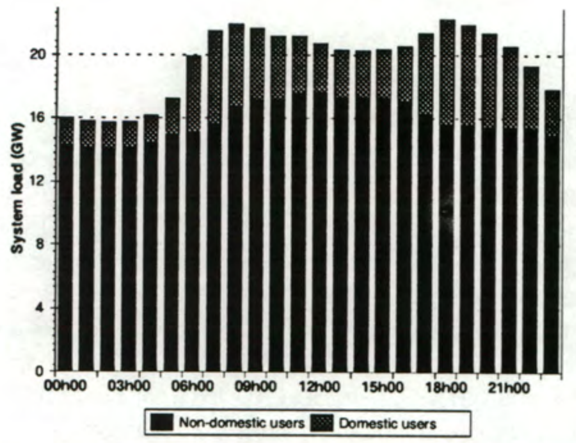


FIGURE 4.1 The day of system peak demand (July 1992)
Source: Van Horen et al (1993)

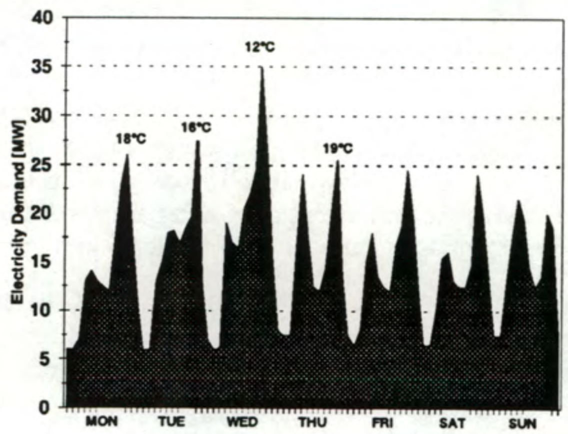


FIGURE 4.2 Electricity demand profile for Katlehong during a 'cold-snap'
Source: Thorne & van Gass (1993)

Figure 4.1 also shows the effect of superimposing the estimated demand of newly-electrified households on the system load in 1995. This assumes an electrification programme reaching 350 000 households annually between 1990 and 1995. Electrification is expected to contribute 5 000 MW to the system winter peak by the year 2000 (Van Gass & Ligoff 1993). Figure 4.2 demonstrates another important phenomenon. It shows the Katlehong electricity demand over a typical *summer* week, when a cold snap hit the area. Of this load, 80% is attributable to the domestic load, which comprises 13 000 households. The profile is not only very uneven, but also appears to be extremely temperature-sensitive.

Another example of the way in which the increased number of domestic consumers is beginning to influence the overall grid demand picture is the following. In 1992 Eskom's total power sales dropped to 138 126 GWh, below the levels for 1990 (Eskom 1993). However, at the same time the peak demand on the integrated Eskom system was the highest ever at 22 640 MW.

It is apparent from the above that the management of domestic demand is vital if its influence on the peak system demand is to be reduced, or the present over-capacity of the South African grid will soon be tested[1]. DSM options aimed at reducing peak domestic consumption levels of electricity include savings obtained from efficient energy conversion characteristics of appliances, and from the rescheduling of domestic energy-related activities to off-peak times. The following are some of the options Eskom are considering in their so-called *Small customer demand-side management 10-year plan* (Ligoff 1993).

4.2 Lighting DSM interventions

In newly-electrified households, electric lighting appears to be the first energy service that is accessed. Despite the low energy intensity of lighting, it is an energy service in which significant economic and energy efficiency gains can be made. For the poor, lighting is a service that contributes significantly to their energy costs, and in many newly-electrified homes it constitutes about 60% of electricity consumption (Berrisford & Bluff 1991). On the national scale, in India for example, 17% of the total electricity consumed in the country and 34% of the peak consumption goes to lighting (Sathaye & Gadgil 1992). In South Africa, at current levels of domestic consumption, 8% of electricity currently sold is estimated to be used for lighting (Ligoff 1993). However, this will rise steeply as new connections are made, and it is therefore apparent that any efficiency gains that can be made would have benefits which would accrue to the electricity utility, the nation and the end-user.

However, the efficiency and economic gains are not the only benefits that are derived as has been clearly demonstrated by Fitzgerald et al (1990) in their investigation of fuel switching in Java. They point out that techniques used in the past to estimate the benefits of electrification 'may be seriously understating the benefits of residential electricity use for lighting'. They go on to say that 'it is widely recognised that when households switch from kerosene[2] to electric lighting it is likely that they will use more, for longer hours, and perhaps change their behaviour and engage in more activities that are made possible by high quality lighting.'

Given the above trends, and the planned electrification drive of around 400 000 new connections per annum over the next fifteen years, it would appear that there is not only a need, but a great opportunity for the introduction of efficient lighting in newly-electrified houses. This would of course require that a consensus is reached between the stakeholders that it is of benefit to them all. If this is achieved, it could avoid many of the problems experienced with retrofitting programmes elsewhere in the world. These have been well documented by Thorne (1993).

1. Of the order of 7 000 MW excluding moth-balled power stations which represent a further 6 000 MW (Eskom 1993).

2. Paraffin

Eskom estimates that successful introduction of efficient lighting by 2002 will contribute potential savings of 1 200 MW generating capacity, 500 MW of which will be as a result of interventions in low-income newly-electrified households (Ligoff 1993). However, there are barriers to this being realised, the most significant being the *cost* of efficient lighting appliances. Although their life-cycle costs are low, they are comparatively expensive if up-front cash payments are required. Thus it is *imperative* for options to be explored to get energy-efficient electric lighting into low-income households, in the cheapest possible way. Thorne (1993) argues convincingly that this is a win-win-win situation with all partners, the end-user, utility and lighting appliance manufacturer, gaining from an efficient lighting programme. Lesser barriers have to do with the lack of knowledge or acceptability of more efficient lighting appliances. This would require an extensive education campaign, but is not insurmountable, as the potential financial advantages for the end-user would make it very appealing to poor households.

4.3 Space heating DSM interventions

The need for space heating, another energy service sought by the urban poor of South Africa, is a direct function of two factors, the thermal performance of a dwelling, and its geo-climatic location. Six different climatic zones were delineated by the National Building Research Institute, as shown in Figure 4.3. However, for thermal performance evaluation purposes, it is sufficient to consider three broad zones, namely; hot-humid, hot-arid and moderate-temperate (Thorne 1993). Thorne gives a detailed discussion of the desired thermal performance of dwelling types in these climatic zones. He then goes on to describe how through appropriate design using passive systems, the need for external or active interventions[1] to achieve these desired conditions can be substantially reduced or even eliminated. Thus, in theory, he finds that the hot-humid zone is the only area that requires any active intervention, in the summer, to achieve optimal thermal comfort. The need for space heating can be 'designed and built away' in the colder areas of the country.

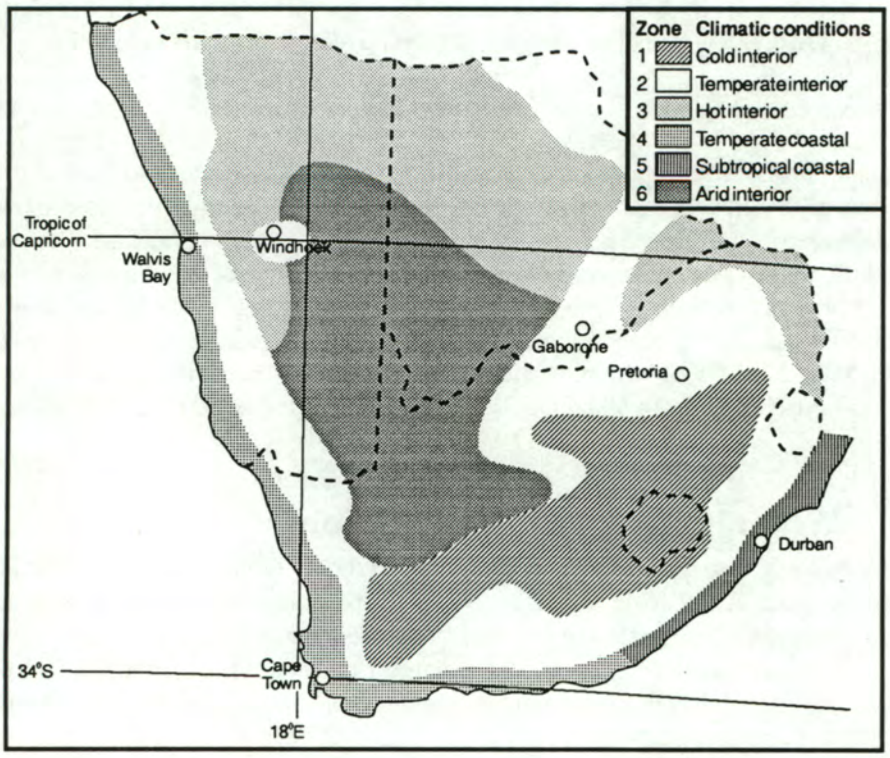


FIGURE 4.3 Bio-climatic zones of South Africa
Source: Thorne (1993)

1. Interventions, such as space heating or air conditioning.

In general, the housing stock of the poor is of low quality, particularly with regard to its thermal performance. The following comment from a township dweller echoes the feelings of many (Eberhard 1984):

> The houses are very cold in winter and in summer it's like hell. The need for electricity is very important for our people.

The main factors determining the thermal performance of a dwelling are the heat gains and/or losses through the walls, windows, roof and floor, the internal heat generation and the ventilation rate. Heat gains or losses are dependent on certain properties of the dwelling's structural elements, such as the colour of outside surfaces, the heat-storage capacities of the walls and the thermal resistance or insulation properties of the roof. The relative importance of these properties is dependent on the climatic and weather conditions. For example, in areas of high daily temperature swings, massive materials with heat-storage capacity are desirable, while in areas of small fluctuations, lighter, highly heat-resistant materials are required.

With careful choice of materials, orientation and design, a dwelling can be built to perform in a thermally efficient manner, thus obviating, or at least greatly reducing the need for the use of energy to achieve thermal comfort. The following table summarises the design and material elements that need to be considered in each of the three South African climatic zones to realise optimal thermal performance in dwellings (Thorne 1993).

Climatic zones	*Roof insulation (ceilings etc.)*	*Walls*	*Depth of rooms*	*Trees*
Temperate	yes	massive	shallow	deciduous east and west
Hot-humid	yes	rapid response	light low partitioning	high shading
Hot-dry	yes	massive	deep	low shading

TABLE 4.1 Shelter design and building elements for the different climates
Source: Thorne (1993)

This is a particularly opportune moment in South Africa's history to look at these options, given the fact that electrification will be accompanying the massive housing delivery programme that will also be implemented in the near future. Therefore dwelling energy performance standards involving the use of good insulation and correct orientation aspects, as well as standards for existing buildings and thermal upgrades *must* be explored. Eskom puts total estimated potential savings by 2002 at 500 MW, 200 MW of which would be contributed by thermal upgrades to the 2 million households that will be newly electrified in that period (Ligoff 1993).

4.4 Water heating DSM interventions

Water heating also provides opportunities for DSM which would benefit both consumer and utility. This service is currently responsible for 41% of electricity consumption in all electrified South African homes (Beute 1993). An electric geyser can increase a household's electricity consumption by anything from 32% to 66% (Thorne & Theron 1993). Once again, in the light of the national housing delivery programme, options such as improved insulation of geysers, instantaneous in-line water-heating technologies, solar water-heaters and heat pumps in apartment blocks must be considered. Estimated savings in water heating DSM measures are

200 MW, over and above existing ripple control switching of geysers at peak demand times (Ligoff 1993).

4.5 Time-of-use tariffs

The final option being considered by Eskom are time-of-use (TOU) tariffs. This approach involves the introduction of sophisticated meters which allow time-linked tariff changes. This enables expensive electricity to be dispensed to the consumer during morning and evening peaks, the most costly to the utility, and allows cheaper, advantageous rates during off-peak periods. The TOU tariff is a particularly important tool in DSM strategies to manage the pattern of energy demand more efficiently. A system of TOU tariffs should present benefits to households with large electricity needs, such as geysers, stoves and swimming pools, in that these tasks can be shifted to off-peak, and thus cheaper tariff periods. This is obviously also advantageous from the utility and national efficiency perspectives insofar as the price system will more accurately reflect the real resource costs of providing electricity. Estimated savings from this intervention, if successfully implemented by 2002 are 1 100 MW.

4.6 The possible overall effects of DSM implementation

Figure 4.4 summarises the effects that the various DSM measures could have on savings of generating capacity, showing the cost of avoided peak installed capacity (CAPIC) plotted against the megawatts of capacity. The assumptions behind these figures are contained in Thorne (1993). Programmes that are cheaper to implement than the avoided capital costs of new generation facilities, and their operating costs are likely to be of interest to Eskom.

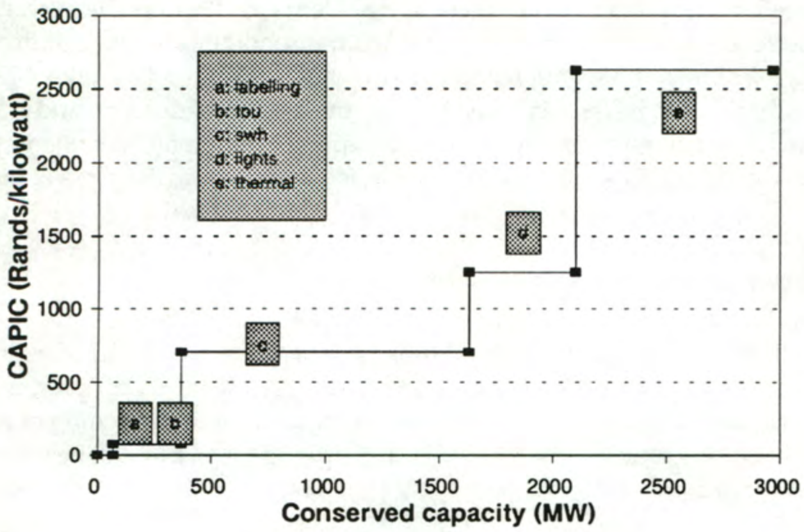


FIGURE 4.4 Potential saving of peak generating capacity realisable through DSM
Source: Thorne (1993)

CHAPTER FIVE

Future urban energy demand scenarios and supply options

5.1 Future energy demand

There are two basic household energy demand scenarios that could emerge in the short to medium term.

- The 'business-as-usual' scenario. In this scenario current trends follow their present course and no major policy interventions, other than those already planned are implemented.
- The integrated energy plan. In this scenario a range of policies are implemented aimed at widening the access of low-income households to desired, affordable sources of energy.

Which of these emerges as the future reality will depend primarily on whether an integrated energy plan is implemented or not. The following sections outline some of the principal characteristics of these two scenarios.

5.1.1 Business-as-usual scenario

Under this scenario, the prevailing household energy sector demand patterns are projected into the future. The only major intervention will therefore be the continuation of the current electrification programme at the planned connection rates of around 300 000 per annum until 1996 when it reduces to 250 000. From 2000 to 2010 200 000 will be made annually. Thus, under this scenario about 64% of households will have access to electricity by 2010. No restructuring of the electricity supply industry (ESI) is envisaged.

There will thus be no attempt to deal with other problems that exist with regard to low-income households satisfying their energy demand. Phenomena such as the widespread continued use of coal by electrified households will not be addressed, and neither will there be any demand side management initiatives taken. Essentially this scenario can be characterised by poor integration of demand and supply, and a narrow focus on increasing electricity supply. There may be some isolated initiatives on the part of the oil and coal companies in reaction to their loss of market share, but these will be implemented in an uncoordinated fashion.

5.1.2 Integrated energy planning scenario

This scenario will involve the implementation of a number of household energy-related policies over the short to medium term, in an integrated and coordinated manner. It will be informed by the three underlying goals of the EPRET programme: equity, sustainability, and efficiency. Equity, in the form of the widening of access of the low-income groups to energy will be the driving force, but will be informed by the other two.

This scenario has three basic elements. The principal goal will be to widen the access of as many households as possible to electricity by 2010. The number of households which will actually be connected will depend on factors such as household income levels, connection costs, tariff levels and the availability of other energy carriers. As will be described in more detail under the electricity section of this chapter, the envisaged electrification programme would entail a peak annual connection rate of around 500 000. If this is sustained, by 2010 over 90% of all low-income urban households will have access to electricity. Thereafter, connection rates will keep pace with household formation.

The second element of the IEP scenario is the recognition that electricity may not be the desired and optimal source of energy for providing all energy services. There will therefore be a need to introduce other policy interventions to optimise the use of other energy resources. The first important intervention will be to replace bituminous coal with low-smoke alternatives. This strategy has arisen from the failure of electrification to deliver the expected improvement in indoor and outdoor air quality that was expected. The main motivation for this intervention will thus be to reduce air pollution levels, given that electrified low-income urban households in the PWV continue to use coal. A secondary environmental goal will be to use some of the approximately 40 million tons of discard coal produced annually by mines in the production of these low-smoke alternatives. In addition, interventions will be required in the paraffin and LPG marketing chains to improve the accessibility and safety of these energy carriers.

The third element of this scenario will be the introduction of demand-side management programmes to improve the efficiency of energy-use at the household and national levels. Given the anticipated increased impact of the domestic sector of the national electricity demand profile DSM measures will be an essential element of an IEP programme. The first measures to be considered will be the improvement of the thermal performance of existing and yet-to-be-built housing stock. Secondly, specific interventions will be required by the ESI to introduce energy-efficient appliances such as compact fluorescent lights and solar water heaters. The third intervention applies less to low-income households than to the more affluent, and will involve the introduction of time-of-use tariffs to encourage shifts in electricity use to off-peak periods. Finally an appliance labelling programme will be introduced to provide consumers with information about the efficiency of appliances.

To conclude, this scenario involves the coordination and integration of existing initiatives in the energy sector. To realise this objective, it will obviously require both the restructuring of parts of this sector and the creation of new structures. Examples of these are the rationalisation of the ESI, and the establishment of a network of energy centres to coordinate the elements of the integrated energy plan.

As this study is primarily concerned with IEP, the 'business-as-usual' scenario will be taken as understood by the reader, and we will now look in more detail at the elements which make up the second scenario.

5.2 Electricity

Electricity has consistently been shown by preference surveys to be the energy carrier of choice for low-income households. Rossouw & van Wyk (1993) found in Port Elizabeth and East London that it stood out well above the next contenders, LPG and paraffin, with a score of above 2.4 out of 3 in all townships. When electricity was placed alongside other services and alternative expenditure items, such as water supply, private telephone and housing improvement, DRA (1989) found that more than 50% of non-electrified households in the Edendale-Imbali complex opted for electricity first. More importantly, when asked who should pay for the connection, 93% of the sample replied that they should pay for it themselves.

When opinions on electricity are sought, replies such as the following are common (Eberhard 1984; Golding & Heron 1990):

> We need electricity because it is safe and convenient. It is also very essential.
>
> It does not produce dirty smoke or fumes.
>
> You simply press the button, and the power is there.
>
> It allows a larger choice of appliances.

> Houses need not to (sic) be repainted.

It is now widely understood that an extensive and sustained electrification programme is set to play a central role in the strategies being formulated to address urban low-income household energy poverty. The scale of electrification is likely to be significant in relation both to the resources it will utilise, and to the positive contribution it can potentially make to the economic and social development of the country. In addition, during the past few years electricity has been placed high on the political agenda. This has occurred by two routes. First, through its use as a political weapon, with service boycotts being used to cripple ineffectual and illegitimate local government structures, and second, as a result of Eskom's 'Electricity for All' campaign. Thus it is a service which enjoys a high profile, and millions of presently unconnected households hold great expectations of it. The following comment made by a person interviewed in a Cape township probably speaks for many (Eberhard 1984):

> Electricity is a right, not a privilege.

Given this background, the rate of connection of new households has increased dramatically since 1991, with a total of about 200 000 households being electrified in 1992, and 250 000 being targeted for 1993, slightly more than 200 000 of which will be made by Eskom (Eskom 1993b). Of the 1992 connections, about 160 000 were made by Eskom itself, and the remainder by Durban, Port Elizabeth and other municipal distributors. Durban Electricity began an extensive electrification programme in 1991. Their present connection rate is 2 000 per month, and is planned to increase to 3 000 in the near future (AMEU 1993). It was the largest single electricity distributor until 1992, when it was overtaken in size by Eskom, which grew through the take-over of black local authorities' (BLAs) rights of supply.

Although the above figures represent a significant increase over previous rates of connections in black residential areas, a substantial, and growing backlog of non-electrified households has still to be dealt with. This backlog is not, however, the only challenge facing the South African electricity supply industry (ESI). A number of significant constraints currently hinder its efficient functioning, and if an effective and viable electrification programme is to be to executed to electrify the majority, if not all households in South Africa, these constraints will have to be removed. The problems to be dealt with include the governance and structure of the industry, electricity pricing practices and financing arrangements. These issues are all discussed in detail in other EPRET papers, respectively Steyn (1993), Pickering (1993) and van Horen (1993). In this paper we will touch on some of the most important aspects that impinge more directly upon the urban poor.

5.2.1 Restructuring of the ESI

The current system of local government allocates legal responsibility for electricity distribution to local authorities. This means that in the context of South Africa's highly fragmented apartheid-based system of local government there are over 600 local authorities with legal supply rights, of which about 430 have exercised these rights (DMEA 1992). The racial differentiation of local government means that BLAs, in addition to their political illegitimacy, generally lack the technical, financial and institutional capacity to electrify new areas or to service existing customers in their jurisdictions. White local authorities (WLAs) on the other hand, usually have well-staffed electricity departments, large capital development funds, access to additional external finance, and profitable returns from well-diversified residential, commercial and industrial customer bases (Steyn 1992).

One highly visible, and problematic consequence of the fragmented ESI is the multiplicity of tariffs applicable to domestic consumers. Households in wealthy residential areas pay tariffs which are often as much as 30% lower than those paid by newly-connected township households. There are several reasons for these discrepancies. Firstly, new customers are generally paying off the capital connection costs through their tariffs, which accounts for approximately 6 c/kWh (van Horen 1993). Secondly, because BLAs generally lack the well-diversified customer bases of white towns, their load profiles are less favourable resulting in their distribution networks being underutilised. Thirdly, there is no regulation of the distribution industry as a whole, thus allowing the 430 distributors to set their tariffs at whatever level they choose. In many cases, WLAs generate surpluses on their electricity trading accounts, part of which is often used to reduce municipal property rates.

It is widely agreed that the ESI requires restructuring in the medium to long term if it is to maintain its viability. However, in the short term certain interim measures are being implemented to try and avert any major problems developing. Firstly, Eskom is negotiating the take-over of the supply rights of larger BLAs, such as Khayelitsha and Soweto. While these arrangements are likely to change as clarity emerges over the future structure of local government and the ESI, this interim measure will at least allow electrification to continue. Secondly, the future structure of the ESI is likely to be influenced by constitutional debates taking place at national level around issues such as regional and local government. At the same time, on a more direct level the National Electricity Forum (NELF) and the Local Government Negotiating Forum (LGNF) are specifically concerned with the future structure of the ESI and the responsibilities for service provision in general.

Many possible models exist for the restructuring of the ESI, and these are amply covered in Steyn (1993). What is clear however, is that the efficiency of the industry could be greatly enhanced by a rationalisation and consolidation of the present 430 different distributors into fewer larger distributors. Similarly, an equity imperative exists which suggests that the resources of the wealthy supply areas be pooled with those of the poor areas, to ensure a more equitable distribution. A high degree of regional autonomy and devolution of power from the centre may frustrate these goals, unless a national ESI regulator is established and granted the power to direct the operations of regional electricity utilities. In addition, horizontal equity[1] considerations will require a mechanism to facilitate the flow of resources between wealthier and poorer supply areas.

A range of other principles will guide the restructuring of the ESI in the long-term. These are factors such as the need to ensure its financial viability as a whole, to rationalise electricity tariffs into a simpler and more equitable system, and to ensure that electricity, and other services are appropriately prioritised from end-user and national perspectives thereby avoiding duplication of infrastructures, or unproductive competition for resources. Many of these issues will be influenced by another crucial aspect of the future ESI, that is, the nature and form of regulation.

While the fragmentation of the industry is an important cause of its failure to electrify households efficiently and equitably, a more fundamental reason is related to the shortcomings of the system of governance over the industry. It is widely recognised from within the ESI that the system of governance and structure of the industry must be overhauled. Steyn & Pickering (1993) have proposed a number of principles to inform the future governance and structure of the ESI, some of these which have more bearing on the subject of this paper are:

- The formulation of policy should be situated in government, in recognition of its political nature, and stakeholders should inform the governing process directly through the political process. Representation on councils and boards, although necessary, does not automatically result in effective performance.
- Electricity utilities should be given clear public mandates and should be held accountable to those mandates (for example, through contract plans).

1. This is the notion of equity between comparable customers in different regions.

- Electricity undertakings should be maintained as public undertakings, in order to provide what is a public service. At the same time, they should operate as commercialised, arms-length corporations.
- A regulator should be established with powers over the *whole* ESI. The independent regulator should be composed of technical experts and should pro-actively mediate the relationship between government and the ESI.
- Planning for capital investment, electrification and operations should be coordinated centrally.
- Distributors should be larger than metropolitan areas for three principal reasons: to achieve economies of scale where these exist, to provide more security for potential financiers, and to provide distributors with a more balanced revenue base.

Restructuring of the ESI in accordance with these principles would, it is felt, lead to a more efficient and equitable development of the industry.

5.2.2 Electricity pricing

As mentioned earlier there are currently as many electricity tariff structures in the ESI as there are distributing authorities. It is not surprising therefore that this subject is receiving a considerable amount of attention from the NELF and other stakeholders in the ESI. In addition, the previously mentioned politicisation of electricity through perceived inequalities in tariffs and service boycotts has played an important role in getting tariffs on to the agenda. There are therefore short-term politically-motivated imperatives to be dealt with in formulating tariff policy, while at the same time it is necessary to ensure the long-term financial viability of the ESI.

Pickering (1993) has identified the following important short-term or interim goals to be met in securing satisfactory tariff policies. It is important that public conflicts over tariffs be minimised, so as to avoid their further politicisation. At the same time interim tariffs should facilitate rapid rates of electrification, at levels affordable to the poor. In the longer term, two additional goals relating to sustainability issues become important. These are maintenance of the financial viability of the ESI, and the encouragement of conservation of electricity to allow the efficient use of the country's resources.

Clearly there are numerous possible tariff structures for domestic consumers, all of which have their particular advantages. However, when evaluated against the above objectives, the options become more limited. Consequently, in a well-argued motivation[1], Pickering (1993) has proposed the rationalisation of *domestic* tariffs and the introduction of a single, national flat-rate tariff. This type of tariff structure will have several advantages over the current assortment of tariffs. It will minimise potential conflict over tariff differences because it is easily understood, and *all* domestic consumers will pay an *identical* unit price. A flat rate for all levels of consumption contains a built-in progressive redistribution from large, generally wealthier consumers to small, often poorer consumers, as is shown in Figure 5.1 below. The calculations on which this figure is based assume relatively stable marginal costs, hence the straight cost line, and a fixed cost component which includes administration and maintenance costs.

1. Of particular importance are the arguements against the so-called lifeline tariff, one which is often considered in developing countries for electricity supply to the poor.

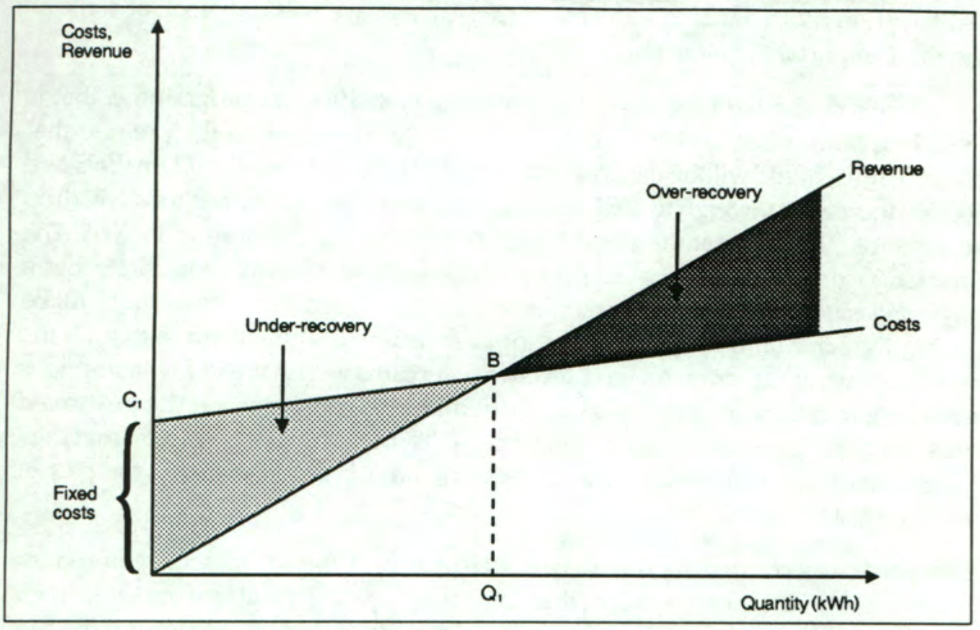


FIGURE 5.1 Costs and revenue profile of single national flat-rate tariff
Source: van Horen (1993b)

It is apparent from the figure that provided the tariff is fixed such that the under-recoveries from low consumption customers are covered by over-recoveries from larger consumers, the supply authority will be financially viable in the short-term. The positive distributional effect from one group to the other is also evident. In the long-term, the authority may have a higher revenue requirement if it has to finance further investment, for example in the case of the need for additional generating capacity. In other words this figure is based on the short-run marginal costs to the utility. This approach is probably justifiable in the medium term in the South African context, given the large excess of generating capacity that currently exists.

Although the flat-rate tariff provides no incentive to conserve electricity, it is an improvement on some current tariffs which are lower at higher consumption levels. Finally, the costs of administering the tariff will be almost as low as is conceivably possible, when using a billing system, and at the same time it is compatible with the prepayment technology currently used by many low-income households.

In the longer term the single flat-rate tariff could be extended by the addition of a time-of-use (TOU) tariff, for those consumers in a position to benefit from shifting their electricity consumption out of peak times. This possibility would contribute to the realisation of the longer term efficiency and sustainability goals of the ESI.

5.2.3 The urban electrification programme

Eskom has been negotiating the takeover of the rights of supply of many of the BLAs, thereby increasing the number of households to which it can potentially supply electricity. However, despite the backlog that exists, the most recent projections made by Eskom for its 'Electricity for All' programme, adopt a cautious approach whereby it will '(f)or the present year', 'endeavour to increase its target from 158 000 connections to slightly more than 200 000' (Eskom 1993b). These are all in urban areas, and represent households in Eskom's area of right of supply that they consider as 'financially viable'[1].

The EPRET study has looked at the need for electrification in the country, based on the housing growth scenario outlined in Chapter 1. As regards the urban sector, an estimate has been made of the costs of an extensive electrification programme which would reach over 90% of urban households by the year 2010. This investigation is

1. The criteria applied to arrive at this assessment are not made public by Eskom.

dealt with in more detail in van Horen (1993b), and we will only look at some of the most important findings in this paper.

The figures presented here cover the complete electrification programme, that is including both urban and rural households. They are based on the premise that 300 000 households will be electrified in 1993, 350 000 in 1994, 450 000 in 1995 and 500 000 thereafter through to 2001. From 2001, the number of connections will drop at a rate of 50 000 per annum and flatten out at 250 000 per annum in 2006. The financing calculations are based on two fundamental assumptions. First, that a *single national flat-rate tariff* is implemented, that is *all* domestic consumers will be paying the *same* amount per kilowatt-hour consumed. The second is that all the revenue generated from the sale of electricity remains within the ESI. Assumptions regarding numbers of households electrified in each category, and their expected consumptions levels are given in van Horen (1993b). Suffice it to say here that they are conservative, and are based on trends that have been observed in the past in South Africa.

As regards any constraints that may exist in terms of the equipment required for electrification, Eskom is confident that local suppliers will be able to meet the high annual rates of connection envisaged. The first anticipated bottleneck is expected to occur in the supply of concrete poles (van Horen 1993b). However, it will be easy to expand production of these as required. Thereafter, the next constraint comes in at 700 000 connections per annum, well in excess of the peak rate of total planned connections.

Figure 5.2 shows the financing requirements of the programme based on a flat-rate tariff of 18c per kWh excluding value added tax (VAT). From this figure it can be seen that the total financing requirement of the programme reaches R15.5 billion in 2010, and the cashflow is still negative, although not by a great amount.

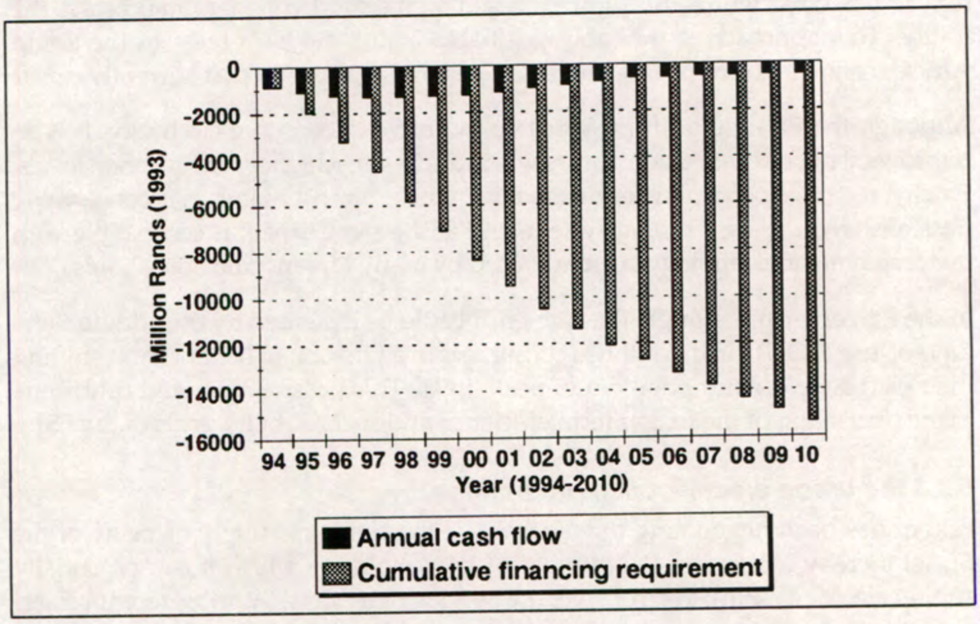


FIGURE 5.2 Total urban financing requirements of the electrification programme at a flat-rate tariff of 18c per kWh
Source: van Horen (1993b)

If the tariff is increased to 20c per kWh, which is below the current S1 tariff, the picture alters substantially as can be seen in Figure 5.3. Here we see that in 2007, the cumulative financing requirement peaks at just over R11 billion, and the annual cashflow is very close to zero. Under this scenario high consumption households would be contributing substantially to the financing of the electrification programme, with potential revenue from them totalling over R1 billion per annum.

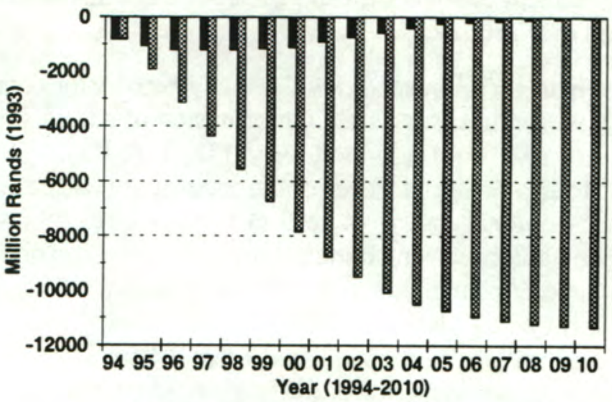


FIGURE 5.3 Total urban financing requirements of the electrification programme at a flat-rate tariff of 20c per kWh
Source: van Horen (1993b)

Some social and technical considerations for the electrification programme

Policy options concerning electricity supply possibilities for the urban poor can not be considered in isolation from other broader issues. Fundamental to these is the assumption that electrification policy decisions will be taken by legitimate, representative, accountable bodies at all levels of government, and not by utility managers. For example, at the consumer level, decisions on the electrification of particular communities, or projects should, wherever practical, be taken with the full participation of the community involved. This approach of real community involvement is also being proposed by the National Housing Forum in its formulation of housing delivery, a process which will be closely linked to electrification in certain areas.

Of particular importance is the involvement of the women whose quality of life could be either improved our adversely affected depending on the way that decisions are taken. It must be remembered that the introduction of a new technology or energy source could radically alter the division of labour within a household. Such issues have been given far too little prominence in the research on energy-use conducted to date, and should be placed high on the agenda of future research in this area.

Let us now turn to some of the more practical aspects of the electrification programme[1]. Decisions on electricity supply options for each community or project should be taken on the basis of the following two criteria. First, the financial viability of the particular project when it is measured against an agreed national viability standard[2] must be considered. And secondly, the broader development plans and aspirations of the community involved need to be taken into account. The application of these criteria will result in communities receiving different priorities for electrification within the context of the national programme, as well as differing supply technologies and levels of service.

The community-driven approach means that the opportunity will be given for them to make choices from the range of supply options available. Examples of these choices are: the type of reticulation technology, the principal choice being whether the lines are underground or overhead; and the type of metering, keypad or magnetic card-based prepayment meters. The above community or project driven approach may limit the freedom of choice of individual households to some extent. However, even given the technical and cost constraints, it will usually be possible to offer a range of supply options to each household within the community. Also given the way in which the South African electrical equipment industry has

1. This section is drawn mainly from Pickering (1993).

2. This will apply mainly to rural electrification, where consumers are located far from the grid.

responded to the challenges of electrification, it is not inconceivable that the options will be broadened in the future.

The level of supply to each household will usually be 60A for consumers on the flat-rate tariff. However, in cases where the provision of such a supply results in capital costs in excess of those provided for in the tariff, the level of supply will either be reduced to an appropriate level, or the community will be given the option of making up the additional cost of connection. Pickering (1993) mentions a figure of R3 500 per urban household, which should cover the cost of an ordinary domestic supply using a prepayment meter and the flat-rate tariff. The actual price of connection, that is the actual charge to the consumer on being connected should be as low as possible, yet still retain a signal value. From Eskom's experience R30 seems to be a realistic amount, while the Durban Electricity Department is charging R137, but includes in that a two-plate stove.

This takes us on to the question of appliance provision by the ESI. Eskom is presently selling appliances at its depots in townships. Its bulk buying capacity allows it to pass on the savings it realises to the consumer, thus reducing the magnitude of this significant entrance barrier to the use of the energy carrier. However, there are other considerations to be taken into account such as appliance efficiency, including the concept of appliance labelling, and consumer education. There is also the question of DSM interventions. The need exists to determine who should take responsibility for the costs involved in implementing measures such as thermal performance upgrades of dwellings, and installation of solar water heaters and efficient lighting sources. As was shown in Chapter 3, there are strong arguments for the ESI to finance these interventions, given the potential reductions in required generating capacity that they represent (Thorne 1993).

Funding of the electrification programme

It is important to consider how the funding requirements of the electrification programme will be met, over and above the revenue generated by electricity sales. This question has been dealt with at length by van Horen (1993b), so we will only take a brief look at some of the key aspects. There are several major sources of finance in the ESI at present, which are divided between Eskom and other distributors. Eskom has in the past been able to raise loan finance on local and international capital and money markets, and had total debts of R28 billion in 1992 (Eskom 1993). There is no reason why this will not be possible in the future. Eskom also generates surpluses from its operations, and had retained surplus of R1.4 billion in 1992. Many municipal distributors generate surpluses on the trading of electricity in their areas of supply, and these totalled R900 million in 1988/89 (EDRC 1993). Finally,some municipal distributors raise loan finance from their own sources, external capital markets or other sources such as DBSA loans which totalled R230 million in 1992 (Stassen 1993).

Clearly, therefore, there are considerable sources of finance *within* the ESI itself. However, as suggested earlier, electrification will not proceed rapidly under the present structure of the industry, because of the lack of technical and financial capacity of many local authority distributors. Van Horen (1993b) suggests that this problem could be alleviated in both the short and long terms, by the establishment of an Electrification Fund. This fund would have two main objectives, namely the raising of bulk loan finance for electrification, and the allocation of grant finance to benefit all poor electricity consumers as equitably as possible across time.

The equitable allocation of grant finance would involve its application in the reduction of the capital connection costs of all poor households; that is, including those who have already been electrified in the recent past. This could be achieved by the Electrification Fund making allocations to distributors, in proportion to the number of new connections they have made, thus reducing their outstanding capital loan balance. This benefit would then be passed on to customers in the form of lower tariffs, which would be monitored by an independent regulator in the long term, and until then, by NELF.

Van Horen (1993b) has argued that the Electrification Fund should consist of a Loan Fund and a Grant Fund. Figure 5.4 illustrates how the Electrification Fund might operate.

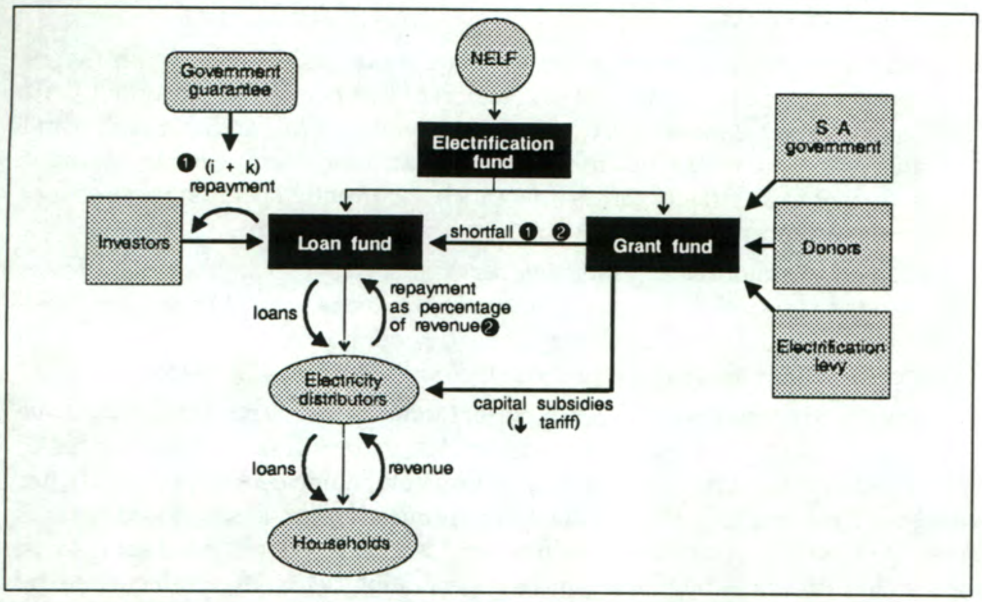


FIGURE 5.4 Proposed structure and operation of the electrification fund
Source: van Horen (1993b)

- An injection of seed finance into the Grant Fund would be required, to provide a capital base to act as a loan guarantee fund. This would be in the order of R500 million to R1 billion.
- The above amount could then be used as security to attract large amounts of loan finance from private and public investors. The recent R600 million issue of the Electrification Participation Note (EPN, or Electrification Bond) by Eskom is an important example of the kind of instrument available to attract private capital on favourable terms. The enormous amounts of savings channelled through institutional investors such as insurance companies and pension funds could thus be directed towards electrification.
- The Loan Fund would on-lend to distributors to finance their electrification projects. These loans would be repaid to the Loan Fund as the distributors recovered their costs from electricity sales.
- The return payable to investors in the Loan Fund would be based on a percentage of revenue from domestic electricity sales, subject to a guaranteed minimum rate of return of say, 8% to 12%. Any shortfalls between this minimum and the actual return from electrification would be met from the Grant Fund. It would in addition be guaranteed by government so as to further lower investors' risks. Thus low-level consumers, generally the poorest, would effectively be subsidised from the fund.

Investors would initially obtain a lower return, but a market-related return over the whole period of their investment period of 15 to 25 years. In effect, the risk attached to the electrification programme would be shared more widely than at present, by distributors, lenders, and government

Expected impacts of electrification on household economies
Household economies vary widely, even within the focus group of this study. As a result they will be affected differently depending on the extent to which electricity

will substitute the energy carriers currently used, and their cost. Some of the impacts envisaged by van Horen (1993b) are as follows:

- In the case of those households in historically white areas, such as for example the Cape Town townships, electricity tariffs will increase if the national flat-rate tariff is implemented. Assuming that 20 c/kWh (excluding VAT) is chosen as the tariff, then most customers in this category will experience an average increase of 5 c/kWh.
- For newly-electrified households consuming about 150 kWh per month, expenditure on electricity would be in the region of R34 per month, including VAT. This would be balanced by a decrease in expenditure on candles, paraffin and battery charging costs. Unfortunately, the degree of disaggregation of data is insufficient to accurately assess how much is currently spent on these energy carriers to allow a comparison with the current expenditure.
- As regards the more energy intensive services, such as cooking, water and space heating, it is probable that the substitution by electricity will be smaller, especially in the initial period of electricity use by poor households. It is here that the effects of other interventions proposed in this document will be felt.

There are clearly a number of other important impacts that electrification will have that are not directly related to the household economy. These are more social in nature and are therefore less easy to quantify, but include benefits such as, better quality of light, improved access to telecommunication services, reduced hazards in terms of poisoning and domestic fires, and less time spent in purchasing fuels. In addition, the possibilities for income-generating activities are increased by facilitating the use of electrical tools and appliances, refrigeration for spazas, and cooling of drinks for shebeens.

5.3 Paraffin

Paraffin is the only energy carrier which is ubiquitous in its use by low-income urban households. The reason for this is quite simple, and is inextricably linked to the survival situation in which poor households often find themselves. Annecke (1993) found that over 50% of the paraffin bought by the 350 households in the settlement with which she was working, was bought from spazas close to the home, while Ross (pers. com.) found that in Die Bos 90% of paraffin came from spazas. Many of the households bought small amounts of between 0.5 l and 1.5 l on a daily basis. This strongly emphasises the fact that these households are living within very tight cash constraints, and paraffin is often the only energy carrier available to them that can allow this type of consumption. It is also important to note that children were usually sent to buy the daily ration, with the consequence that the women in the community are often not aware of price fluctuations that may occur.

When Annecke asked the women she was working with why they used paraffin, their reply was, 'It's the only means.' In response to the question, 'What do you like about paraffin?', 36 out of 40 respondents replied 'nothing', and four just shrugged their shoulders and said 'no comment'. The problems with paraffin are seen as its unpleasant smell, skin irritations it causes and the soot it leaves on pots. Later, when asked why they used wood, the women replied, 'It's the alternative and it's cheaper. It thus became evident that women preferred to use paraffin in the absence of anything better, and because they had so little money. Paraffin and wood appear to be lumped together and compared to something better, such as LPG or electricity. Despite this perception, they did choose paraffin over wood, the use of which seemed to be perceived more as a means of saving money than as a choice. Similar perceptions have been recorded by other researchers elsewhere in the country (Eberhard 1984; Golding & Heron 1990; Golding & Hoets 1992; Rossouw & van Wyk 1993 etc).

We will now look at the way in which paraffin is currently priced and distributed throughout the country, and then consider some of the policy interventions that could remove the problems that exist. Much of the following section is drawn from McGregor (1993) and van Horen (1993b).

5.3.1 Current paraffin distribution systems and pricing

Households in low-income areas purchase paraffin from a number of outlets. The most common are the informal spaza shops and the formal supermarkets. Under existing legislation, retailers are allowed a mark-up of 33.3% on the wholesale price, which is currently fixed at a maximum allowable level by government. However, as is discussed in McGregor (1993), retail prices are not monitored at all and often far exceed the allowed level. The additional mark-ups are made by the various intermediaries in the paraffin distribution chain, and do not all accrue to the final retailers, such as the spaza shopowners, many of whom trade in small volumes.

A number of intermediaries are found between the oil companies and the final retailer. The oil companies distribute their products to depots, of which there are about 178 around the country (EDRC 1993). The depots are shared by the oil companies to minimise capital and administration costs. They represent the wholesale level, and are the last point at which paraffin prices are regulated by government. Included in the regulated price is the so-called service differential, which was fixed at 9.7c per litre in April 1993. This is intended to finance the distribution costs of paraffin from oil company depots to retailers, and is intended to cover both the oil companies' costs and those of the so-called routers who do the final distribution of paraffin to retailers. In addition to the service differential, the routers are often given a discount on the wholesale price by the oil companies. The paraffin market is highly competitive so discounts of around 10c per litre, or 40% of the combined service differential (9.7c) and allowed industry wholesale margin (13.7c), are not uncommon.

The routers are theoretically independent of the oil companies, but in effect are under their control, as they are financially helped by them to set up their operations. The main reason for their existence is their ability to make small drops of product, and to hawk it around the townships. This activity is felt by the oil companies to be unprofitable. In addition, they are afraid of becoming the target of violent attacks in the townships, and therefore prefer to use the routers who are able to establish an independent marketing presence. It appears that this arrangement is relatively successful in maintaining a wide distribution network for paraffin. However, the mark-ups by the routers and retailers often mean that the final prices paid by end-users are high, and way above the allowed 33.3%.

In a recent study of five townships in the PWV and one peri-urban area, Mmotong in the Northern Transvaal the Palmer Development Group (1992) found that very different price structures existed under differing circumstances. This is shown by the figures in Table 5.1 below. Additional, more detailed studies of fuel marketing chains should be carried out to gain a better understanding of how they operate. This is particularly important at the retail end of the chain, where there is a multitude of different players. Of particular interest here are the spaza shops, and it is important to understand the size of the profits they are realising, and how vulnerable they would be to changes in paraffin distribution networks, especially given that many spazas represent an important source of income for many female-headed households.

Township	Bulk price - wholesale (c/l)	End-user price (c/l)	% mark - up*
Jouberton	75 and 85	133	66.3
Mamelodi	75	172	129.3
Tumahole	79 and 87	132	59.0
Mmotong	85 and 94	106	18.4

** The mean of the wholesale price is used to calculate the mark-up.*

TABLE 5.1 Paraffin pricing along the distribution chain
Source: Palmer Development Group (1992)

The impact of middlemen on the final price paid for paraffin by the consumer is clearly shown by the percentage mark-up between the oil company depot wholesale level and the end-user price. However, what is most significant about the above table is the fact that the mark-up in the case of Mmotong is actually below the 33.3% allowed by legislation. This important phenomenon seems to result from the consumers buying directly from a router's depot[1] which had been established near the township. This holds important implications for possible policy interventions to widen access to cheaper paraffin.

Before moving onto the policy recommendations, it is probably important to say something about possible paraffin supply constraints. The supply of any petroleum product is constrained by the demand of other products derived from crude oil in refineries. Paraffin and LPG represent small fractions of a barrel of crude, and growth in the demand for these fuels must be matched by growth in demand for the major fuels, petrol and diesel. However, according to McGregor (1993) there are currently no foreseeable shortages of paraffin and LPG on the horizon.

5.3.2 Policy interventions to widen access to cheaper paraffin

There are two possible interventions to improve access to and the affordability of paraffin for poor households. The first intervention involves an increase in the service differential. The motivation for this proposal is that it will provide the oil companies with sufficient incentive to distribute their products themselves further down the marketing chain. In this way, better control can be exercised over the distribution chain, and it is more likely that the maximum allowed 33.3% mark-up from wholesale to retail level would be achieved and managed. The service differential increase would be offset by a decrease in the retailer or router margin, thus resulting in a lower price being paid by the end-user. Essentially, very similar distribution arrangements would then prevail as currently exist for petrol, where oil companies distribute their product directly to service stations.

The equity-related effects of this intervention would entail a financial transfer from the current intermediaries, in the form of reduced margins, with the benefits being passed on to consumers through lower prices. While the extension of the oil companies' involvement further down the distribution chain may squeeze out some of the routers, or at least reduce their profitability, any negative effects on their livelihoods could be offset by absorbing them together with their operations into the oil companies. It is not foreseen that the spaza shopowners and small retailers' livelihoods would be adversely affected, as they would still retain their market niche through the convenience shopping opportunity they offer to communities. They will continue to be able to sell at the times when the bigger retailers are closed. However, because *they* will be buying at a lower price, they will be able to pass this saving on to the consumer. Obviously, an important part of this intervention would be a consumer education programme to make end-users aware of the new pricing structure.

1. It was set up by a router, as opposed to the oil companies.

The second intervention would be to encourage *bulk* purchases by end-users. There are several ways in which this intervention can be realised. First, service station operators could be provided with finance by the oil companies to install bulk paraffin tanks. They would then be able to supply households and small-scale enterprises in their communities directly. A second option could be the establishment of community-based cooperatives which could themselves buy in bulk. Depending on their size, these may require fairly extensive technical, marketing, administrative and financial support. This would be significant if taken in isolation. However, bulk fuel buying could easily be integrated into other cooperatives, the establishment of which is being mooted around commodities such as building materials. This type of initiative could have very positive effects in strengthening community involvement in energy-related matters. These spin-offs will be discussed in the concluding chapter of this paper.

A third option is to encourage the establishment of paraffin and gas depots which would benefit from bulk purchase discounts, and which would still be close enough to consumers to provide them with easy access to fuels. This would be similar to the situation that exists in Mmotong, as mentioned earlier. It is conceivable that viable small-scale enterprises could be established with the support of oil company and development finance institutions, such as the Small Business Development Corporation (SBDC) and DBSA.

5.3.3 Policy interventions to reduce paraffin health risks

As noted earlier, paraffin poisoning is relatively common in paraffin-using households, particularly those with children aged between 12 and 36 months. In many cases, paraffin ingestion results in severe poisoning, and in some cases, death. Consequently, the prevention of paraffin poisoning should be regarded as a major area for public policy intervention, and moreover, one in which real improvements can be effected very rapidly.

There appear to be four main areas for intervention:

- Education and publicity measures around the dangers of paraffin poisoning.
- Production and use of child-proof lids for existing containers.
- Production and use of dedicated child-proof paraffin containers.

Education and publicity programmes should be aimed at adults and older household members to keep paraffin in safe containers and out of the reach of infants. The costs of such programmes should be borne jointly by government and the oil companies. Experience with some posters to-date has been disappointing because of ambiguity of designs used; this highlights the importance of careful design and the involvement of communities in the process.

It appears from current research that the most significant impact may be derived from child-resistant lids. The Medical Research Council (MRC) is currently involved in research into the types of lids which would fit commonly-used containers such as softdrink and alcoholic beverage bottles[1] (De Wet et al (Forthcoming)). It is expected that lids will be able to be designed for low-cost production at around R1 each. It is possible that the lid manufacture process may be suitable for decentralised production by small-scale enterprises located in the townships. However, it is probable that in practice there will be a need for both mass-production plants and smaller micro-enterprise processes.

From the initial research conducted by the MRC, it appears that communities will respond very favourably to this kind of intervention, and that they would be willing to pay the full price of such a lid. Consequently, there is potential for this to be a financially viable project which can operate on a cost recovery basis, and perhaps even generate incomes for small-scale manufacturers. This would require the same institutional and technical support as any other small business. In addition, estab-

1. Incorrect identification of bottles is, no doubt, one of the reasons for the high incidence of poisoning.

lishment costs would have to be financed, thus requiring the assistance of funders such as the SBDC and DBSA.

A subsequent phase may involve the design and production of dedicated paraffin containers. This, however, first requires further research into the acceptability of various container designs and the willingness of households to pay for them. This option will be more costly than the first. Similar financing and pricing arrangements will probably apply to this option.

A final area for intervention has less to do with health than with the unpleasant smell and smokiness of the fuel. The oil companies are already looking at the possibility of improvements in this regard, and these should be actively encouraged.

5.4 Liquefied petroleum gas (LPG)

There is no doubt that LPG is a desired energy carrier in low-income households, and definitely preferred over paraffin and coal. This is graphically shown by the complex social arrangements and power struggles described by Ross (1993) that developed around an LPG cylinder in Die Bos. Despite its apparent desirability the wider use of LPG is inhibited by a number of factors. These have to do primarily with questions of its accessibility, and in particular its affordability. LPG is only able to be purchased in fixed quantities as determined by the sizes of the gas cylinders available on the market. Thus for very poor households it does not have the advantages of paraffin, as they are forced by their cashflow situation to purchase small quantities of fuel at a time. In addition to these problems, because of the greater safety requirements for the handling of LPG, its distribution network does not extend to points as close to the home as possible. There is therefore the added inconvenience of probably having to use transport to get to the nearest selling point.

The cost of LPG appliances is also somewhat higher than those fuelled by paraffin, essentially because of the higher safety requirements necessitated by the fuel. Thus the purchase of appliances presents another entrance barrier to its wider use. Finally, it is apparent from many perceptual surveys, that there is a general fear regarding the safety of use of LPG.

5.4.1 Current LPG distribution systems and pricing

As is the case with paraffin, a network of LPG distributors exists outside the oil industry. Although independent of the oil companies, the network is effectively under their control, given that they are fully supported in the establishment of their premises, and in some cases merely lease the premises from the oil company concerned. In addition, as mentioned above, these distributors are in general not very close to their potential customers, thus reducing the accessibility of the fuel. Some of the more active distributors do however hawk their wares around the townships, going to their customers.

Although the LPG price is not controlled by government, the oil industry wholesale price is derived in a very similar way to that of paraffin. Thus the price also contains a service differential of 9.7c per litre to cover the distribution costs. However, as almost all domestic LPG distribution is done by means of cylinders on pick-up trucks, and the filling of the cylinders is done by the oil companies at their depots, they generally retain the service differential to cover filling, storage and handling costs. A further 18.8c per litre is retained to provide and maintain the cylinders. There is then an additional distribution cost differential which is currently 25.5c per litre and a wholesale margin of 18.8c per litre. Most of the distribution cost differential is discounted, and where the market is a highly competitive one, oil companies will also discount a portion of the wholesale margin.

A summary of the various LPG and paraffin pricing structures beyond the oil companies is given in Table 5.2 below. The initial purchase points are thought to be primarily oil company depots, although the retailers interviewed would not always divulge this information, nor the discounts they received for bulk purchases.

Fuel	Wholesaler			Retailer			Total
	Buying Price	% Mark-up	Selling price	Buying Price	% Mark-up	Selling Price	% Mark-up
Paraffin c/l	0.88	11.38	0.98	0.96	44.75	1.39	60
LPG c/kg	1.62	63.00	2.65	2.15	74.00	3.73	130

Table 5.2 Hydrocarbon fuel distribution chain summary
Source: Palmer Development Group (1993a)

The wholesale and retail buying and selling prices are averages of the prices reported by the respondents to the survey. Thus the wholesale selling price does not correspond to the retailer buying price as retailers were generally not willing to divulge their buying prices in the surveys. The obvious reason is that their actual mark-ups could then be calculated. In addition bulk selling prices, or trade discounts which are given off the paraffin and LPG wholesale prices, may not have been included. Nevertheless, given the extent of the survey, it is felt that the figures are fairly accurate, and give an indication of what is happening in the market.

5.4.2 Policy interventions to widen access to LPG

The first proposed intervention for improving the accessibility of LPG is that the oil companies investigate the possibility of marketing it in smaller quantities. This would involve some investment on their part, but could result in greatly increased sales. In addition, the results of the investigation could also be of use in other countries where poor consumers are unable to purchase LPG for similar reasons. A second intervention to deal with the entrance barrier restrictions on LPG use would be for the oil companies to reduce the selling price of appliances. The cost of this measure could then be recovered through a marginal increase in the unit price of the LPG.

The oil companies should be encouraged to establish LPG depots at points much closer to poor communities. This would reduce the burden placed on them in having to use expensive transport to get to the nearest depot. Once again, the existing service station network could be used initially, with further depots being erected as the demand increased. Finally, there is a need for an active consumer education campaign by the oil companies, to correct the wrong impressions that exist about the safety of LPG as a domestic fuel.

5.5 Coal and low-smoke fuels

It is apparent that, despite electrification, coal will continue to be an important source of energy for low-income households in a number of areas of the country. This is particularly the case in the PWV, and other areas close to the coalfields. However, it is also apparent that there is a need to deal with the air pollution problems associated with widespread domestic use of coal.

5.5.1 Current coal distribution systems and pricing

South Africa is well endowed with coal and has the fifth largest coal reserves in the world (Minerals Bureau 1990). It is also the fifth largest producer and in 1992 produced 180 million tons. South African coal is generally found in thick, shallow-lying seams in 18 principal coalfields found in Northern Natal, Orange Free State (OFS) and the Transvaal, with the isolated, Molteno-Indwe field in the Eastern

Cape. This last field is currently being reopened. The carbon content of the coal generally increases eastward, but the number of seams and their thicknesses decrease. Consequently, Transvaal coals are usually bituminous in thick seams while Natal coal is found in shallower seams but has a greater proportion of anthracite.

The coal industry is supported by a significant local market with 72% of production used within the country, primarily by Eskom which consumes 40% of total coal production, and Sasol at 20%. Of the balance 7% is consumed by industries comprising producers of cement, bricks, refractories and so on. The principal user of metallurgical coal is Iscor at around 3% of total South African coal production.

Household coal consumption is thought to comprise around 1.7% of total production. Consumption estimates vary between as high as 7.4 million tons according to the Government Department of Mineral and Energy Affairs and 1.5 million tons (Borchers & Eberhard, 1991). For the purposes of this report a consumption of 3 million tons is used, similar to the figure estimated by Gervais (1987). The prime use of coal by low-income households is for cooking, space and water heating. Due to its weight and consequently cost of transport, it is mainly used in the Transvaal and OFS.

A range of coals are sold on the domestic market and these are identified in Table 5.3 below:

Product	*Size mm*	*CV Mj/kg*	*% Ash*	*% Volatiles*
Cobbles	100 – 31.5	21 – 31	11 – 27	20 – 31
Nuts	40 – 22.4	22 – 30	10 – 36	20 – 31
Peas	25 – 6.3	21 – 29	12 – 27	20 – 32
Duff	- 6.3	19 – 29	10 – 24	21 – 32

Table 5.3 Quality range of bituminous coals used in the domestic market (air-dried basis)
Source: Minerals Bureau (1990)

The coal used by households is primarily nuts. Coal is also graded and ranges from grade A (highest energy content) to grade D (lowest energy content), with household coal generally grade C (Palmer Development Group 1993a). It can be seen from the above table that the calorific value of nuts is relatively high, however so is the ash content. The ash content is the parameter which will determine the amount of particulate matter released by the coal when it is burnt, and it is this combined with the volatiles emitted that constitute the pollution hazard.

Because of its bulk and mass, coal is generally distributed by specialist coal merchants. Thus it is interesting to note that the Palmer Development Group (1993a) found only 45 coal merchants operating in the five PWV townships surveyed, while some 563 retailers of paraffin were identified. Coal prices are set individually by the mining companies, although there used to be a certain degree of collusion. Table 5.4 shows the findings of the Palmer Development Group (1993a) with respect to the coal marketing chain.

Township	*Purchase Price (c/kg)*	*Retail Price (c/kg)*	*% Mark - Up*
Alexandra	8.4	31.98	280.0
Mamelodi	9.58	15.78	66.0
Tumahole	8.64	19.00	120.0
Sebokeng	7.57	16.29	114.0
Orange Farm	9.14	19.87	117.5

Table 5.4 Coal price structure along the distribution chain (Retailers)
Source: Palmer Development Group (1993a)

The results of this study indicate that the total mark-up between the pithead price of 4.55c per kg, that is the wholesaler purchase price, and the average end-user price, that is 20.24c per kg, is found to be 247%. This does of course include transport costs, which were not comprehensively surveyed by the Palmer Development Group (1993a).

Further more detailed investigation of the coal marketing chains in low-income areas is necessary. Before the policy interventions outlined later in this chapter can be implemented it is vital that we have a better understanding of how the various players in the market interact. In particular, it is important that the existence of price-fixing cartels be investigated, and to see what their effect is on the inflation of coal prices. The recent announcement of the formation of the joint venture Africoal, between MacPhail and about 20 township coal distributors is a case in point.

5.5.2 Policy interventions to ameliorate the adverse effects of coal use by low-income households

An important part of the IEP scenario outlined at the beginning of this chapter, is the development of low-smoke coals (LSC), with a view to replacing the bituminous coals in general use. The prime reason for this intervention is high levels of indoor and outdoor pollution which result from household coal use, and which have adverse effects on the health of millions of people who rely on coal for cooking and heating.

As yet LSC has not yet been produced in South Africa on a commercial basis[1], at least not on a large scale, and various prototypes are still in their development phases. This section therefore describes the various kinds of low-smoke fuel being developed in South Africa, and makes some preliminary suggestions as to possible policy interventions that could be made. There are three kinds of LSC which are of possible interest. These are currently under investigation in a programme funded by the DMEA, and are undergoing acceptability tests in a PWV township. Each has different technical properties, cost structures, and institutional characteristics, and are described briefly below. These following sections are drawn extensively from van Horen et al (1993).

Enertek reconstituted coal

This fuel is produced by binding coal discards using cement to form a reconstituted fuel. The mixture ratio is 100 kg of coal to 15 kg of cement and 21 kg of water (Tait 1993). The cement acts as the binder and has also been found to reduce the levels of particulates emitted on combustion. Enertek has attempted to optimise the product's performance through testing and further development. For example, through the addition of a small amount of lime sulphur emissions may be reduced, although at additional significant cost.

No detailed costings have yet been made for this fuel, although Enertek's preliminary estimates suggest that the production costs will be higher than the wholesale cost of conventional coal. However, it is entirely feasible that this product could be

1. In the past coke was available for domestic consumption in those cities that had coal-based gasworks.

available more cheaply than the retail price of coal, given the ways in which it can be made. There are two possible processes that can be used to make this fuel. The first uses presses similar to those used for cement brick-making, while the second is more labour-intensive, and involves the casting of large slabs which are then broken up into smaller pieces. Some illustrative and very preliminary cost estimates are shown in Table 5.5. The three main components of the fuel's cost are the cost of coal discards, cement, and labour. Distribution costs must also be considered, and will depend mainly on the distance from the point of production to the point of sale.

By comparison, as we saw in section 5.5.1, conventional coal prices for households in the PWV are in the region of R50 per ton at the pithead, and range widely from R160 to R320 per ton at the retail level (Palmer Development Group 1993a). Of the cost components, cement prices are essentially fixed. Reduction in the quantity of cement used would decrease the product's technical performance and therefore its acceptability to consumers. The other main cost components are, however, considerably more variable. Discard coal is not traded at present and it was therefore necessary to impute a shadow price at which it might be purchased to produce LSC. There is scope for arguing that mining houses should not profit unduly from the sale of discard coal. It is presently regarded as a waste product, which, if anything, has a negative value because of the costs of disposing of it satisfactorily. It may therefore be possible to negotiate favourable terms for the use of discards which are suitable for LSC production.

Rand (1993)	*Brick-making equipment (4 tons/day)*	*Slab casting (2 tons/day)*
Capital costs	3300	2000
Coal discards (R10/ton)	7	7
Cement (R285/ton)	31	31
Labour (6 x R30/day)	45	90
Transport	16	16
Depreciation (3 years)	1	2
Production cost (R/ton)	100	146

TABLE 5.5 Preliminary cost estimates for Enertek low-smoke coals
Source: van Horen (1993b)

Labour and transport costs are also very variable. Both processes are fairly labour-intensive and are suitable for decentralised production, possibly at a community or cooperative level. This would have the important advantage of providing local people with income-earning opportunities and retaining expenditure flows within communities themselves. However, a disadvantage is that product quality may vary more widely and could deteriorate to the point where the product is no longer acceptable to users. This suggests that, if this option is to be followed, extension support may be required to ensure that small-scale manufacturers conform to product specifications within a reasonable range. The expertise which has been accumulated by the CSIR Enertek personnel responsible for this product's development is a valuable resource in this regard and they are already looking at the requirements for training and extension.

University of the Witwatersrand/United Carbon Producers (UCP) devolatilised coal

This product is produced in a completely different way to the Enertek reconstituted fuel. The two main ingredients here are waste coal of a larger size than that used in the Enertek process, and waste heat. The discard coal is exposed to temperatures of 500 to 600oC for about two hours. This has the effect of driving off, under controlled conditions, the harmful volatile compounds which are emitted during normal combustion.

The main cost components of this production process are the discard coal, and the heat applied in the devolatilisation process. The product will be economically viable only if these are by-products or waste products. Again, no detailed costing exercises have yet been performed, but it appears that this type of LSC can be produced at a cost which will make it competitive with normal coal. This is thought to be the case because waste heat is currently being used from UCP's industrial coke production process, while suitable discard coal can be accessed at a low price, possibly around R10 per ton. It may therefore be possible to produce this product at a price which will not require any external subsidy finance.

'Wundafuel' solid fuel blocks

A company based in Lesotho, Ecofuel (Lesotho) (Pty) Ltd, recently began producing and marketing waste coal briquettes. The product, called 'Wundafuel', is marketed commercially as a smokeless alternative to LPG and paraffin, although it is technically more of a substitute for coal and wood. The DMEA has recently incorporated this product into its research support programme, which originally included only the Enertek and Wits/UCP fuels described above.

At first sight it would appear that this fuel will be less affordable for poor households than conventional coal, since it retails at a far higher price. According to the manufacturer, Wundafuel currently retails at a price of R1.00 to R1.20 per kg, with output levels at approximately 120 - 150 tons per month (Roux 1993). With improved packaging, and if economies of scale can be achieved through expansion, the manufacturer estimates that these costs can be reduced to about 50c per kg, equivalent to R500 per ton. As noted earlier, conventional coal retails at about R160 to R320 per ton. Nonetheless, the product offers several advantages over conventional coal, such as lower smoke emissions, its ability to light within a few minutes, and the fact that it can burn on the ground, and therefore does not require a stove or brazier. If consumers place a high value on these advantages, the product may begin to replace normal coal at prevailing price levels. However, it is more probable that it will compete with more expensive fuels such as paraffin and LPG, and it appears from the marketing strategy being adopted that these are currently the main target market segments for the Wundafuel.

Interventions necessary for promoting the use of LSCs[1]

It was shown earlier that the use of coal by households causes significant health problems for the millions of people who are exposed to the pollution caused by it. These health effects, in turn, carry major economic costs. It is therefore considered imperative that, in principle, energy policy-making should actively intervene in the household coal market, so as to encourage a shift away from conventional coal to energy sources which carry less serious environmental problems. An important component of this would be the development of low-smoke coal. Not only are there health and equity arguments for the substitution of coal, but these can also be reduced to strong economic arguments.

Legislation already exists which could be applied to enforce smokeless zones in townships, effectively making conventional coal use in households illegal. However, this legislation can only be applied once affordable alternative energy sources are available to effectively substitute bituminous coal.

It is possible that some of the LSC prototypes may be produced on a commercial basis, either for the low-income market, or for other more wealthy market segments. Clearly, the ideal situation is one in which LSCs can be sold at prices which are competitive with normal coal, and where this is the case, these producers should be encouraged by the state to do so. This can be done by providing private sector manufacturers with a stable and transparent policy environment. This will entail, for example, making explicit, the government's policy towards conventional and LSCs, by indicating that LSC will be supported through further research, that

1. This section is drawn extensively from van Horen (1993b).

legislation may be applied to ensure that conventional coal is replaced by preferred alternatives, and so on. This clarity and stability in the policy environment is a prerequisite for the private sector to invest in the development of low-smoke fuels which are potentially commercially viable.

Should LSCs be marketed by private sector producers, be they small-scale enterprises, or formal sector organisations, it may be necessary for the DMEA to monitor the operation of this market so as to maintain the technical production standards at reasonable levels, and to ensure that unacceptable profiteering does not occur at the expense of poor households.

It is possible that some form of financial subsidy will be required to make LSCs affordable to households. There are two main sources of finance which present themselves as possible options. Firstly, production costs could be subsidised directly from the fiscus. Possible justifications for this option follow.

- Many of the benefits of reduced health problems would accrue to society as a whole, or the state in particular. To the extent that air pollution is reduced and respiratory and other illnesses become less prevalent than they would otherwise have been, the public health care service will be relieved of some of its burden. In other words, expenditure on LSC would avoid or prevent additional health care expenditure by the state. The effect on the fiscus of the subsidy outflow would therefore be countered by a reduced outflow on health care expenditure.
- Precedents exist in South Africa for direct state support of fuel prices, such as the support for the Atomic Energy Corporation's enriched uranium production facilities, and the Sasol and Mossgas synthetic fuel production processes. While the economic and social benefits resulting from those projects are questionable, the benefits resulting from LSC subsidisation are, in principle, uncontroversial.

A major disadvantage of this financing option is that it will impose an additional burden on the state's resources in the short-term.

The second option, which is more attractive from a theoretical micro-economic perspective, would entail the internalising of negative environmental externalities. In other words, a levy would be imposed on the price of conventional coal, so as to more fully reflect the true environmental and health costs associated with its use. At the same time, this would raise additional revenue for the state, which could then be applied to cross-subsidise the production costs of LSC. Such an approach should not, however, be confused as a general revenue-raising fiscal mechanism. The determination of this levy amount is beyond the scope of the present discussion, but it appears from the preliminary cost estimates which are available for the Enertek and UCP fuels, that it would not have to be very significant to shift the price advantage in favour of LSCs.

A question which arises, is whether the levy should be applied only on coal sales to households, or on sales to other local consumers, primarily Eskom, Sasol, and industrial users, or indeed, also on export sales of coal. Clearly, these could have negative downstream effects on the prices of electricity, synthetic petroleum fuels and exported coal. On the other hand, the impact on coal prices would be much smaller if spread over the higher volume of *all* coal sales. For instance, if the financing requirement for LSC subsidisation amounted to, say, R60 per ton, a very cautious estimate, then an annual subsidy would have to be in the region of R180 million, to completely replace conventional coal usage by households, currently thought to be about 3 million tons per annum.

If this is spread over total local coal consumption for 1991 of about 132 million tons, then the price increase would amount to about R1.36 per ton, equivalent to a 4.1% increase in average local ex-mine prices (Minerals Bureau 1992). If the financing requirement is spread over total coal sales, including exports, the increase would be around R1 per ton, or 3.0% of domestic prices, and 1.2% of export prices. The effect of this on export revenue is equivalent to a similar fluctuation of approximately 1% in the Rand:Dollar exchange rate.

At a macro-economic level, the advantage of this second option is that it has a smaller impact on government expenditure. Negative macro-economic impacts may result in the short-term, if a levy is imposed on coal sales to export and non-household local consumers, in the form of slightly higher electricity and synfuel production costs, and reduced margins on export sales.

It is clear that it will take some time before LSCs are widely available for household use. Consequently, it is proposed that the DMEA should continue to support research efforts in this area, with a view to facilitating and expediting their development. In many respects, this process is already under way, and includes a number of important areas of research and development.

- Further enhancement of the technical characteristics of the various prototype products, so as to optimise the balance between the emissions, the ignitability, and the length of time for which the fuels burn.
- Also necessary before mass production can begin, is a better understanding of the social acceptability of the low-smoke fuels in relation to alternatives.
- Once the technical and social acceptability of the fuels are established, it will be necessary to evaluate different financing and pricing mechanisms. In particular, it will be important to understand the current system of coal distribution and marketing, so that LSCs may be distributed most effectively by existing actors in the distribution chain.

CHAPTER SIX

Summary of policy proposals and institutional issues

A substantial body of research has been conducted over the past fifteen years into household energy consumption patterns in developing countries. The results of this work have tended to indicate a correlation between household income levels and the types and quantities of energy carriers used in the household. Based on these findings, researchers developed the notion of a 'fuel/income ladder' to explain shifts in energy use. The energy ladder is based loosely on an economic theory of household decision making which holds that, as household incomes increase, households will switch from reliance on relatively inefficient, dirty or inconvenient 'traditional' energy carriers to the use of efficient, clean 'modern' energy carriers (Hosier and Kipondya 1993)

However, as research has advanced, the complexity of the fuel/income relationship has been revealed, and a new understanding of fuel switching phenomena is emerging. It appears that all is not as simple as the energy ladder theory suggests. Researchers are finding that relative fuel prices do not consistently constrain household fuel choices. Low-income households tend to use different energy carriers for different purposes, and decisions are made within, and are changed by, social contexts (Ross 1993). A deeper understanding of fuel switching processes has only recently begun to emerge in this country, and criticism of the oft-cited, but very problematic linear 'transition' model of fuel switching is growing.

The integrated energy planning process initiated by the EPRET programme has attempted to take this emergent understanding of the complexity of energy-related decision making into account. In adopting this approach, we have had carefully to examine the energy-related data available to us, a process which has led to the conclusion that the current longitudinal, cross-sectional and micro-scale energy-use data available in South Africa leave much to be desired. There is substantial scope for the deepening of our understanding of the determinants which influence energy use patterns in South African low-income urban households. Development of knowledge in this area will be essential if future household energy policies are to make any significant impact, and on a more pragmatic level, if the planning of organisations such as Eskom is to be based on sound assumptions.

Despite the above constraints, the EPRET team has been able to identify a number of policy interventions which are felt to be consistent with the emergent understanding of low-income household energy use behaviour. They have been laid out in greater detail elsewhere in this and other papers of the EPRET series, and are briefly summarised below. Following on this summary, are some proposals of overarching interventions which would serve to draw them into a cohesive whole.

6.1 IEP-based policy proposals

Electrification

As has become evident through the EPRET programme, an extensive electrification drive will spearhead the effort to widen access for the urban poor to affordable energy. For the ESI to be able to achieve the rates of connection envisaged, around 500 000 per annum over a decade, it will require substantial and fundamental restructuring and rationalisation. An important aspect of the rationalisation will be the introduction of a single national flat-rate tariff. The introduction of this measure will allow the ESI to generate revenue which will cover a substantial portion of the capital outlay required for the programme in a relatively short time. It will also have a significant effect on balancing the equity situation as regards electricity supply to domestic consumers.

Further funding requirements of the electrification programme will be met in part from the substantial resources that the ESI itself has at its disposal. In addition, a number of other recommendations have been made, including the establishment of an Electrification Fund. This would act as a channel for funds, and as further finance is required, would seek this from either national or international sources. An example of this is a financial instrument that has already been used by Eskom, namely the Electrification Participation Note. This has been able to attract substantial funds from South African institutional investors.

In the short to medium term it is envisaged that the centre of national electrification planning will be the proposed national Energy Policy Council (EPC) (Steyn 1993). The EPC will include representatives of all stakeholder groupings, including consumers, labour, regional government, and the relevant state departments. The long term goal is, however, that electricity supply will become the domain of special public corporations that will cover large geographical areas.

At the local level, it is envisaged that the majority of the electrification projects to be undertaken will be defined in an agreement to be negotiated between the community involved, and the distribution authority responsible for the project. The negotiation process will deal with aspects such as the level of supply and service to the particular community, and will include details such as overhead or underground cabling, the type of metering to be installed, the involvement of community labour, and other similar issues. The main issue that will *not* be negotiable from community to community is the tariff structure, as this will be set nationally.

The negotiating process around electrification is of paramount importance in ensuring the successful outcome of the projects under negotiation, and the subsequent good relations between the community and the supply authority. It is also imperative that the most important end-users of energy in the domestic context, women, be included in this negotiation process. This process of negotiation around an issue of importance to the whole community could play an important role in creating greater social cohesion in communities that have become fractured by continual social tensions, the results of years of apartheid rule and disempowerment. We therefore propose that the ESI treat this negotiating process with the seriousness that it deserves, and do not seek to short-circuit it, even if this does result in annual connection rate targets not being met.

Low-smoke coal

There is no doubt that multiple fuel use is a characteristic of low-income South African households. A particularly important example of this can be found in the PWV area, where electrified households continue to make extensive use of coal. This phenomenon brings with it appalling air pollution problems which need to be addressed. Attention is already being given to this problem, and research has been initiated into the development of low-smoke alternatives to the bituminous coal usually used by domestic consumers.

The continuation of this work should be given the highest priority, and every effort should be made to bring suitable products into the market-place as soon as possible. If further research and development of these fuels is required, support must be given as a matter of urgency by the state. The success of the penetration of these fuels in the market intervention will require a thorough investigation of the current coal marketing chain, so as to determine the best manner in which to stimulate the use of these low-smoke fuels. Support should then be given to prospective marketers to successfully enter the market, particularly if it is found that small-scale, labour-intensive production of the fuels is a viable proposition. Finally, a high-profile, national media campaign should be mobilised to promote the use of these clean fuels.

Paraffin
As has become apparent in this study, paraffin is an important source of energy for low-income households, and in particular the poorest. It is therefore vital that this fuel be made more accessible and affordable to them. A restructuring of the current paraffin price is proposed, whereby it will become more attractive for the oil companies to efficiently take the product further down the distribution chain, this in turn facilitating better control of the regulated price. In this manner, low-income households will be able to purchase the paraffin nearer their homes at or close to the controlled price. Measures will have to be introduced to prevent this initiative being abused by operators of diesel-powered vehicles.

In addition to this intervention, the problems of paraffin poisoning need to be addressed. It is proposed that current research into the production of low-cost childproof bottle closures be continued, and that the oil companies assist in the funding of this work. Initiatives to reduce or remove the unpleasant odours associated with paraffin should also be pursued. However, every effort should be made not to pass any costs of improvements on to the already beleaguered consumers.

LPG
This is an efficient and clean fuel which is not as widely accessible to the poor as it should be. Problems of affordability are to some extent responsible for this, but its distribution could also be improved. A number of interventions are therefore proposed. First, the oil companies should investigate the possibility of introducing smaller canisters, the cost of which would be more in line with the types of cashflow experienced by low-income households. Second, they should consider the possibilities of marketing LPG appliances at lower cost, and could recover the discounted amount through a marginal increase in the LPG price. Finally, a concerted consumer education exercise is required to teach people how to use LPG safely, and to allay the fears that exist about its explosive potential.

6.2 Institutional requirements

South Africa is on the brink of a new era in which democracy will become a reality for the majority of its hitherto disenfranchised citizens. It is felt that as all the current initiatives in the housing and service sectors come to fruition, these will also present an opportunity to reinforce this process of democratisation by putting in place community-based structures, thereby empowering the communities, and allowing them to take greater control over their lives.

For the above energy policy proposals to be effectively implemented, institutional support will be required at various levels. The first and most important of these is at the level of the affected communities themselves. As outlined above, through the negotiating processes that will accompany the electrification drive in each community, an awareness of energy-related matters will be engendered in the community. It is felt that this should not be lost, and that the one way of maintaining and nurturing this would be through the establishment of an energy centre in each community.

These centres should be constituted in such a manner as to be representative of all parties interested in household energy matters. It is therefore envisaged that 'ownership' of the centres should be tri-partite, with the community, the state and the energy service sector involved. Before implementing this concept, it is proposed that an evaluation of the currently operational Eskom energy centres should be conducted. This would serve to highlight the shortcomings and strengths of these centres, before further ones are established. If this evaluation turns out to be positive, careful thought should then be given to the location of the centres, and the way in which they should be linked to community-based development initiatives such as small-scale industry centres, building material cooperatives and community centres.

An important role of the centres would be the education of energy consumers in various aspects of energy. These would include the efficient use of energy, the demand-side management options available to them, allaying fears about various energy carriers, the safe handling of fuels and in helping them to achieve the best mix of energy carriers. For these efforts to meet with success it would be important for strong contacts to be made and fostered with women's groups where they exist in a community. This contact would serve a dual purpose, as it would not only allow a flow of information to end-users, but would also provide them with a more efficient line of communication to the energy suppliers and policy makers.

This improvement in information flow would greatly accelerate the learning process that energy policy makers will have to go through in coming to grips with the complexities of energy-related decision making processes in poor households. The information that could be gathered through the centres would greatly facilitate the improvement of the longitudinal energy database, thereby allowing energy planners to respond more efficiently to the energy needs of communities, and furthermore, allow greater sensitivity and flexibility in answering the specific energy problems of a particular community. On a national scale it would greatly facilitate a truly integrated approach to planning of the rational use of the nation's energy resources.

With regard to institutional support at the regional and national levels, it is proposed that the embryonic initiatives to develop national integrated energy planning capacity should be fostered, and the lead should be taken by the Department of Mineral and Energy Affairs. The national Energy Policy Council mentioned earlier, will provide a forum for the formulation of a nationally integrated energy plan. At the regional and local levels, similar fora should be constituted to allow full coordination and integration of development planning at these levels. The energy centres would play an important role in this process, by allowing the actual end-users of energy the maximum possible opportunity to engage in and inform this planning.

The proposed future organisation and functions of the DMEA in the context of an IEP future are discussed in more detail in Steyn (1993) and Theron (1993). Suffice it to say here that integrated energy planning must be given the highest priority, and that for it to be truly meaningful and successful, the fullest community, local and regional involvement in the planning process must be secured.

REFERENCES

AMEU 1993. Elektrisiteit vir al hoe meer mense... *AMEU news*, No 21. June 1993.

Annecke, W 1993. Fuel for thought. *Journal of energy in Southern Africa.* 4(2) May 1993.

Berrisford, A J & Bluff, E 1991. Electricity load profiles of developing communities. SAIEE workshop on the electrification of developing communities, Johannesburg, 11-12 November 1991.

Berrisford, A J & Surtees, R M 1992. Electrical demand characteristics of low income and developing urban communities. Eskom report No. TRR/EA/92/LR005.

Beute, N 1993. Domestic utilisation of electrical grid energy in South Africa. Ph D thesis submitted to the P U Ch E. Potchefstroom.

Chambers, R 1983. Rural development - putting the last first. New York: Longmans.

De Wet, B, Van Schalkwyk, D, Van der Spuy, J, Du Plessis, J, & Du Toit, N (Forthcoming). Paraffin (kerosene) poisoning in childhood: is prevention affordable in South Africa? To be published in *South African medical journal*.

Dickson, B J & Baldwin, S A 1990. The development of low-cost fuel-efficient wood burning stoves appropriate for underdeveloped areas of SA. Energy Research Institute, Report No GEN 136. Cape Town.

DMEA 1988. Discard and unsold duff coal in South Africa 1988. Pretoria: Department of Mineral and Energy Affairs.

DMEA 1992. The development of the electricity distribution industry in the Republic of South Africa. Report to the Minister of Mineral and Energy Affairs, May 1992.

DRA 1989. Edendale-Imbali Complex electrification survey. Survey conducted for Eskom Power Marketing , Western Natal. Durban.

Eberhard, A A 1984. Energy and poverty in urban and peri-urban areas around Cape Town. Carnegie Conference Paper No. 155. University of Cape Town.

Eberhard, A A & Dickson, B J 1987. Energy consumption patterns and alternative energy supply strategies for underdeveloped areas in Bophutatswana. Energy Research Institute Report No INO73, University of Cape Town.

Eberhard, A A 1992. EPRET Paper No. 2. Integrated energy planning: A methodology for policy analysis and research. EDRC, University of Cape Town.

Eberhard, A A 1986. Energy consumption patterns in underdeveloped areas in South Africa. Energy Research Institute, University of Cape Town.

Energy for Development Research Centre (EDRC) 1993. Initial investigation into the macro-economic effects of future strategies in the energy sector. Report for MERG. EDRC, University of Cape Town.

Eskom 1993a. 1992 *Annual report.* Eskom, Johannesburg.

Eskom 1993b. The increase in potential and expectations due to the increase in Eskom's area supply. Electrification Fact Sheet REF 93/5.5, July 1993. Eskom, Johannesburg.

Fitzgerald, K B, Barnes, D & McGranahan, G 1990. Interfuel substitution and changes in the way households use energy: the case of cooking and lighting behavior in urban Java. Energy Series Paper No 29, World Bank, Washington.

Gervais, J S 1987. An analysis of the Soweto Electrification Project. LHA Management Consultants.

Golding, A P & Hoets, P A 1992. Energy usage in urban black households in selected formal and informal townships of South Africa.

Hosier, R H & Kipondya, W 1993. Urban household energy use in Tanzania. *Energy policy*, 21 (5) May 1993.

Kessel, A 1988. Black squatter market: technical report. Markinor (Pty) Ltd. Job No. 88/286/AK.

Lane, I 1991. The present and future national electricity demand. P.U. for C. H. E.

Leach, G 1992. The energy transition. *Energy policy*, 20 (2) February 1992.

Lerer, L (Forthcoming). The epidemiology of fatal childhood burns. *South African medical journal*.

LHA 1987. The supply of fuel to the black domestic market in the PWV. Pretoria: LHA Management Consultants.

Ligoff, D 1992. Small customer demand-side management - project proposal. Eskom National Pricing Policy, Johannesburg.

Macroplan 1992. Feasibility study for the electrification of houses in Khayelitsha Town 1 Village 1, 2 and 3 (P Block) and Village 4 (Y Block) and in Town 2 Village 4C; Survey results on energy needs and perceptions.

McGregor, G A G 1993. EPRET paper 14b. Hydrocarbon fuels. Cape Town: EDRC, University of Cape Town.

Minerals Bureau 1990. South Africa's mineral Industry 1990. Johannesburg: Minerals Bureau, DMEA.

Nadel S, Geller, H & Ledbetter, M 1991. A review of electricity conservation programs for developing countries. American Council for an Energy-Efficient Economy.

Palmer Development Group 1992. A survey of the cost structure and distribution of three selected transitional fuels in two selected Transvaal areas. Report to the DMEA.

Palmer Development Group 1993a. Cost and distribution of transitional fuels in the Transvaal. Report to the DMEA (Draft).

Palmer Development Group 1993b. Electricity consumption rates in selected South African townships - phase 2 (Draft Document). Prepared for the DMEA.

Poyer, D A & Williams, M 1993. Residential energy demand: additional empirical evidence by minority household type. *Energy economics,* April 1993.

Ross, F 1993. Transforming transition: Exploring transition theories in the light of fuel use in a squatter settlement. *Journal of energy in Southern Africa.* 4 (2) May 1993.

Ross, F 1993. Personal communication.

Rossouw, A M M & van Wyk, M J 1993. A socio-economic survey of energy consumption patterns in the Eastern Cape: a database. Institute for Planning Research, Report No. 48. Port Elizabeth.

Roux, F 1993. Personal communications. Ecofuel (Lesotho) (Pty) Ltd. Maseru.

Sathaye, J & Tyler, S 1991. Transitions in household energy use in urban China, India, the Philippines, Thailand, and Hong Kong. *Annu. rev. energy environ.* 16: 295 - 335.

Simon, E A & Norval, R D (1987). Ondersoek na verbruik van en besteding aan water en energiebehoeftes in Botshabelo and Mangaung. READ Consultants, Bloemfontein.

Sithole, J S, Turner, C R, Lynch, E, Rorich, R and Annegarn, H J 1991. Air pollution exposures in coal burning residential areas of South Africa. Durban: National Association for Clean Air.

Steyn G 1992. A framework for discussing the future of the electricity distribution industry in South Africa. Report to the Local Government Policy and Planning Research Project, October 1992.

Steyn, G 1993. EPRET paper 14. The electricity distribution sector. EDRC, University of Cape Town.

Steyn, G & Pickering, M 1993. A policy option for the electricity supply industry in South Africa. AMEU Conference 1993.

Tait, H 1993. Personal communications. Project manager: coal utilisation: agglomeration. Pretoria: CSIR Enertek.

Terblanche, A P S, Opperman, L, Nel, C M E, Reinach, S G, Tosen, G & Cadman, A 1992a. Preliminary results of exposure measurements and health effects of the Vaal Triangle Air Pollution Health Study. *South African medical journal*. 81.

Terblanche, A P S, Nel, C M E & Opperman, L 1992b. Health and safety aspects of domestic fuels. Report to the National Energy Council. Medical Research Council. Pretoria.

Theron, P, Eberhard, A A & Dingley, C 1992. The provision of electricity in urban areas of South Africa: towards a new policy framework. *Urban forum*. 2(2).

Theron, P 1992. EPRET paper 3. The development context for energy planning in South Africa. Cape Town: EDRC, University of Cape Town.

Theron, P 1993. EPRET paper 20. Energy institutions. EDRC, University of Cape Town.

Thorne, S 1993. EPRET paper 15. Energy efficiency and conservation. EDRC, University of Cape Town.

Thorne, S & Theron, P 1993. Analysis of new electrification schemes in the Western Cape. Cape Town: EDRC, University of Cape Town.

Thorne, S & van Gass, M 1993. Paper presented to World Housing Congress, Cape Town, April 1993.

Tosen, G R, Turner, C R & Terblanche, A P S 1991. Outdoor air pollution monitoring — the first year of VAPS. Durban: National Association for Clean Air.

Trollip, H L 1993. EPRET paper 5. South African energy database. Cape Town: EDRC,

Turner, C R, Annegarn, H J, Snyman G, Rorich, R, Wells, R B, Turner, S & Page, K 1984. Air pollution monitoring in Soweto. 6th International Conference on Air Pollution. Pretoria.

Turner, C R & Lynch, E C 1992. Township air quality — a problem with a solution. Johannesburg: Eskom Engineering Investigations.

Uken, E-A & Sinclair, D 1991. The effective use of energy in newly-urbanised homes. Cape Technikon, Ref No NE 14/6/5.

Van Gass, I 1991. Profile of the domestic electricity market in the PWV area. Eskom internal marketing report. Johannesburg.

Van Gass, M 1993. Some observations related to domestic energy requirements based on fieldwork done in informal settlements in the Cape Town metropolitan area. Internal working paper prepared for EPRET.

Van Horen, C 1993a. EPRET paper 16. Household energy and environment. Cape Town: EDRC.

Van Horen, C 1993b. EPRET paper 18. Financing and economic implications of household energy policies. Cape Town: EDRC.

Van Horen, C, Williams, A T, Trollip, H L, Thom, C & Eberhard, A A 1993. Energy poverty in South Africa: widening access to basic energy services. Report for The SALDRU World Bank project: Statistics on living standards and development. Cape town: EDRC, University of Cape Town.

Viljoen, R P 1990. Energy use in the low-income dwellings in the winter rainfall area. Energy Research Institute. Report No. GEN 138. University of Cape Town.

Viljoen, R P 1992. Mmotong energy study. Pretoria: DMEA, Energy Branch.

Wilson, F & Ramphele, M 1989 *Uprooting poverty — The South African challenge*. Cape Town: David Philip.

PROJECT DESCRIPTION

A major two year research project was launched by the Energy for Development Research Centre in April 1992. It aims to investigate policy options for widening access to basic energy services for the urban and rural poor in South Africa. Research papers are being produced in the following areas:

Background papers
Research outline
Integrated energy planning: a methodology for policy analysis and research
Development context for energy planning in South Africa
Background on South African energy system

Energy demand analysis
Energy demand in underdeveloped urban and rural areas

Rural areas
Energy for rural development: an introduction and overview
Energy and small-scale agriculture
Rural household energy supply options
Afforestation and woodland management
Remote area power generation options

Urban areas
Household energy supply in formal and informal urban settlements
Energy and informal sector production

Ancillary sector
Energy and mass transportation*

Key supply sector
Electricity distribution sector*

Cross-sectorial studies
Energy efficiency and conservation*
Energy and environment*
Southern Africa linkages*
Investment requirements and financing mechanisms*
Pricing policy*
Institutional analysis*

Policy options
A concluding document will draw together key policy conclusions
** The scope of these studies is restricted to energy issues concerning the urban and rural poor.*

EDRC

The Energy for Development Research Centre is located at the University of Cape Town. Its objectives are to study energy related problems of developing areas in Southern Africa, and possible ways to address them.

EDRC seeks to achieve its objectives by:

- undertaking research projects;
- running a specialist postgraduate programme to support research projects and to train personnel to contribute to this field;
- transferring relevant information to user groups by offering consulting services and running workshops, and through publishing books, journal papers, reports, leaflets and design and user manuals.

Energy for Development Research Centre
Energy Research Institute
University of Cape Town
Private Bag
Rondebosch 7700
South Africa

Contact persons: Dr Anton Eberhard / Paul Theron
Tel: (021) 650 3230 *Fax:* (021) 650 2830