SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT

PROJECT FOR STATISTICS ON LIVING STANDARDS AND DEVELOPMENT

ENERGY POVERTY IN SOUTH AFRICA: WIDENING ACCESS TO BASIC ENERGY SERVICES

by

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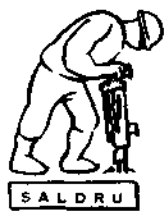

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During 1992 the World Bank approached the Southern Africa Labour and Development Research Unit (SALDRU), School of Economics, University of Cape Town, to coordinate a study in South Africa called the Project on Statistics for Living Standards and Development. This study was carried out during 1993, and consisted of two phases. The first of these was a situation analysis, consisting of a number of regional poverty profiles and cross-cutting studies on a national level. The second phase was a country wide household survey conducted in the latter half of 1993. The Project has been built on the Second Carnegie Inquiry into Poverty, which assessed the situation up to the mid 1980's.

Whilst preparation of these papers for the situation analysis, using common guidelines, involved much discussion and criticism amongst all those involved in the Project, the final paper remains the responsibility of its authors.

In the series of working papers on regional poverty and cross-cutting themes there are 13 papers:

Regional Poverty Profiles:	*Ciskei*
	Durban
	Eastern and Northern Transvaal
	Natal/Kwazulu
	OFS and Qwa-Qwa
	Port Elizabeth - Uitenhage
	PWV
	Transkei
	Western Cape
Cross-Cutting Studies:	*Energy*
	Nutrition
	Urbanisation & Housing
	Water Supply

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1 Introduction

1.1 The background and context of energy poverty in South Africa

The representation in government, for the first time in history, of the majority of South Africans will inevitably lead to greater redistributive investment and government expenditure directed at the basic needs of the poor. However, the state's capacity to finance and implement extensive welfare programmes will be limited due to inevitable resource constraints. Indeed, it seems unlikely that the state will be able to meet expectations for health care, education and housing within a short time because of the enormous backlogs, budget constraints and the absence of appropriately trained personnel. However, one area in which the state can deliver relatively quickly is basic energy services for the poor. The energy sector is dominated by a small number of powerful and well-established institutions, so that new national policies can be implemented effectively. In addition, the energy sector is able to raise large amounts of revenue from internal sources, and can potentially apply this revenue to finance the widening of access to energy services for the poor.

This report contains a description and analysis of the current energy consumption patterns of poor households in South Africa, and proposes a range of policies which can improve significantly the access of the poor to adequate and affordable energy services. It draws on the work of the *Energy Policy Research and Training Project*, a two-year policy research project involving some twenty person-years of effort, being conducted at the Energy for Development Research Centre (EDRC).

One of the characteristics of poverty is poor access to services such as energy. Poor households have generally been denied the benefits of affordable, versatile and safe energy sources. Very few of the urban poor and almost none of the rural poor can simply flick electric switches to meet any desired energy demand. Instead, most struggle to secure adequate energy to provide for their basic needs including cooking and heating. The absence of electricity also restricts production opportunities. Marginal communities very often pay more for fuel or spend more time collecting them. Their patterns of fuel use also result in a more severe impact on environment and health. In contrast, middle and upper income households, industry and commerce and nearly all farms outside the rural reserves have access to an energy carrier of choice, usually (but not exclusively) electricity. Energy for these sectors is cheap, by international comparison.

Inequality in access to energy is not a result of energy scarcity. South Africa has a great abundance of energy. It has the fifth largest reserves of coal in the world (DMEA 1992a). Coal mostly occurs in thick, shallow seams in the Eastern Transvaal, Northern Orange Free State and Northern Natal and mining costs are low. It forms the basis of South Africa's energy-intensive economy, contributing more than 80% of primary energy consumption, mostly for electricity generation and also liquid fuels production in the Sasol plants. The balance of national energy consumption derives from biomass (currently exploited for firewood on a non-sustainable basis), nuclear energy (from Africa's only nuclear power plant), hydro-electricity (from two small installations on the Orange River) and imported petroleum. Natural gas, off the southern coast, will make a further small contribution through the Mossgas process which converts it to petroleum products. South Africa is the third largest exporter of coal and one of the largest exporters of uranium in the world. Within the region there are large gas and hydro-electricity resources which await exploitation.

Inequalities in access, instead, are a direct consequence of political and economic policies which have served the interests of the enfranchised minority. Very little investment has gone into rural development. And in urban areas, black people were, until the 1980s, regarded as temporary visitors, there to sell their labour, but with no urban political rights and without permanent tenure. The bare minimum of urban services was provided and, with few exceptions, this did not include electricity.

Energy investments during the apartheid era were directed towards achieving greater energy security. A white minority government, facing the opprobrium of the world and a United Nations-led oil embargo spent many billions of rand on the Sasol and Mossgas synthetic petroleum fuel plants and building up a local nuclear capability through the Atomic Energy Corporation. South Africa continues to pay a premium on these fuels, which can be procured more cheaply on international markets. Indeed, South Africa has never become fully self-sufficient in either petroleum or nuclear fuels and in spite of international sanctions continued to import these fuels. The cost to the economy has been enormous and the opportunity for investment in more productive social infrastructure has been squandered.

The opportunity now exists for a radical new direction for energy investment. In a post-apartheid, post-sanctions era, energy policy will be governed by three principle concerns: equity, economic efficiency and sustainability. A democratically elected government will place greater emphasis on achieving equity in access to sufficient and affordable energy resources (in particular electricity). At the same time, energy should be provided cheaply to industry to boost its international competitiveness; and attention will increasingly have to be given to the long-term environmental sustainability of energy investments.

1.2 Methodology and data organisation

The methodology underpinning the research on which this report is based is that of Integrated Energy Planning (IEP). Essentially, this is an analytical and planning approach which takes a holistic view of energy systems, and which integrates both demand and supply side considerations in energy planning. Accordingly, it explicitly recognises that energy is used by households to provide a multitude of *services*, the principal ones being cooking, heating (space and water), lighting and entertainment. Each of these end-uses can usually be met in a variety of ways, of which some will be more cost-effective than others. In conventional economic analysis households are assumed to maximise utility, which is a function of all the goods and services enjoyed by the household. 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. The household is obviously constrained by various factors such as income, its existing appliance stock, and access to energy carriers. Thus the household's demand for energy would be expected to be a function of these and other variables.

The methodology used in this study has been to, as far as possible, approach energy use from the perspective of the consumer, concentrating on the end-uses, that is, the services required by the consumer. This has not been easy, given the fact that almost no primary data collection was carried out for the project. As a result there has been heavy reliance 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 (mostly 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. The data from these surveys has been collected by EDRC on the *Energy Policy Research and Training Project*, synthesised and entered into the most comprehensive household energy database currently available in South Africa. The development of this database has been extremely useful in evaluating the adequacy of the surveys conducted to date, especially in regard to their ability to furnish the data required for an IEP approach to household energy planning.

The process of aggregation in the database has two main effects, one favourable and the other unfavourable:

- the aggregation of data provides an overall view of household energy use across regions and facilitates generalisations; but
- the same aggregation process can result in problems where insufficient data exist to justify such generalisations, or where differentiation becomes hidden in averages.

Nonetheless, a large amount of data have been collected in recent years and does appear to justify its aggregation, provided any reservations are made explicit. The process of data collection, organisation and reporting are more fully described in Trollip (1993).

There is no doubt that useful data have been collected, however it is remarkable how many seemingly comprehensive surveys have failed to collect vital pieces of information. The inclusion of this additional information would often have greatly enhanced the usefulness of the

data far beyond the purposes for which they were initially collected. Space does not permit a comprehensive critique of the surveys, but two of the most often noted omissions 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. This most probably arises out a lack of understanding by the survey designers of the context within which they are working, and the assumption that, because the energy carriers being dealt with are commercial, the price can be established independently of the survey itself. There is thus a failure to understand the complexity of fuel marketing mechanisms in poor areas, and indeed the very way in which poor households use energy.

Another example of the shortcomings of many of the surveys is their failure 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. Admittedly these data items are not as easily collected as fuel prices, but are nonetheless vital for a complete understanding of a household's energy consumption behaviour. Some attempt, however rough, should at least be made to estimate the split of one energy carrier between different end-uses. Indeed, many surveys fail to even 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. This is an issue which must be flagged for future data collection efforts.

2 Energy consumption by the urban and rural poor

2.1 Characterising the "energy poor"

The energy consumption patterns of the urban and rural poor reflect their state of "energy poverty" - the situation in which the range of choices people face about how to satisfy their energy needs is constrained by structural conditions. Energy poverty frequently exists when people lack access to their preferred energy sources, which may differ from case to case. In other words, households have a *suppressed* demand for certain energy services: they would demand them if a market existed and if they were able to participate in such markets; however, for reasons of lack of access to suppliers, or lack of information, their demand remains unexpressed and consumption accordingly diverges from their theoretical demand.

A more simplistic and practical interpretation of energy poverty in the South African context is that it applies to those households which do not have access to the convenience of electricity. However, such an interpretation may be contradicted in two respects:

- households *with* an electricity connection may still face problems in securing adequate energy supplies, where for example, the electricity service is unreliable or too expensive for end-uses like space heating;
- conversely, households *without* electricity may be in a position to afford and utilise alternative sources of energy which are adequate and reliable, such as gas.

While acknowledging these problems with such a definition of energy

poverty, it may nevertheless be useful as a working definition for purposes of the present discussion. It is important, however, to be explicit about the effects of constrained choices in energy use: these have multiple economic, social, environmental and health dimensions which will be made explicit in the subsequent sections. Moreover, it must be stressed that the relationships between poverty, energy use and energy poverty *per se* are very complex and not adequately understood through simplistic analyses such as that suggested above. These relationships may become more apparent during the analysis of data which follows.

Less than 40% of all households have access to the national electricity grid, and given that the average number of people in unelectrified households is generally higher than those in electrified dwellings, the percentage of people with electricity is probably even lower. In absolute terms, roughly 23 million people live in unelectrified houses. The largest portion of these are in rural areas, where only about 10% of dwellings have electricity. In urban areas, on the other hand, about 55% of dwellings are electrified. Clearly, however, these figures are highly aggregated and serve to mask significant inter- and intra-regional differentiation. Some of these patterns will become apparent in subsequent sections.

Numerous factors influence the energy consumption patterns of households in South Africa. A first and obvious distinction can be drawn between those with electricity and those without. Other important determining factors, most of which apply even to electrified households, include income levels, income stability, the relative availability of labour to collect or purchase fuel, proximity to coal fields, availability of free or cheap supplies of fuelwood, climatic conditions, dwelling structure and thermal performance. Clearly all of these, and other less-easily quantified factors such as social preferences, will

affect consumption patterns. A comprehensive theory of household energy demand would have to model the relationships between these variables, energy consumption and energy demand.

However, for the purpose of classifying energy consumption in the present study, the data have been organised along the following lines:

- according to house category (refer below), and
- within each of the DBSA development regions.

The house categories used, in turn, differentiate between urban and rural areas. The dwelling categories are shown in Figure 2.1.

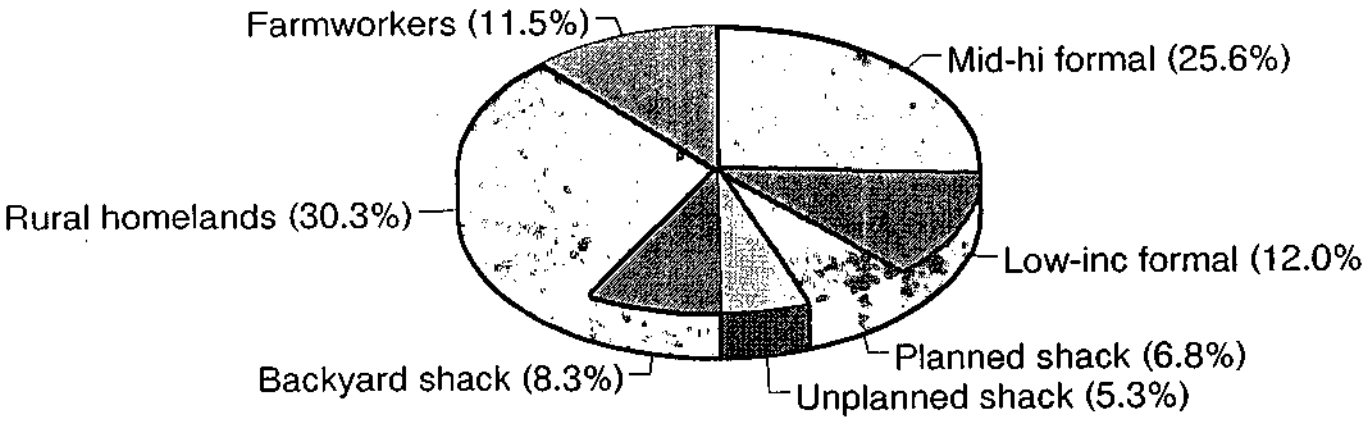

Figure 2.1 Categorisation of South African dwellings
(EPRET database 1993)

The largest category comprises rural households - these will be described and analysed further in section 2.3 below. Included in the urban population is a group of relatively well-served, better-off

households, which by and large coincides with white residential areas. Most of these areas are fully electrified and those households rely almost exclusively on electricity for their energy needs. The remaining 33% constitute the focus of the next section, namely those urban households suffering to a greater or lesser extent from energy poverty.

2.2 Energy consumption by urban households

The major concentrations of poor urban households are in the metropolitan areas of Pretoria-Witwatersrand-Vereeniging (PWV), the Durban Functional Region (DFR) and Pietermaritzburg, Cape Town, Port Elizabeth and East London. It is estimated that these areas account for roughly two-thirds of the urban poor. These 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, more than the other three urban metropoles combined. It is set to grow to one and a half times its present size by 2010 with most of the growth being in the low-income informal sector. The climate in the PWV area is temperate, and in the winter months temperatures dip below 0°C, thus making domestic space heating a necessity. There are roughly 300 000 poor households in the Durban area, 300 000 in Port Elizabeth and East London combined, and nearly 120 000 in the Cape Town area. The DFR has a subtropical coastal climate while the Cape urban centres have temperate coastal climates.

The rest of 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 "white" towns. 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 80km away. This category accounts for about 350 000 dwellings.

The categorisation of urban households in the above-mentioned manner was to some extent prompted by the fact that certain of the more recent in-depth studies of energy use in low-income households have categorised users according to similar dwelling type definitions (Golding & Hoets 1992, UPE 1992). 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 use patterns.

2.2.1 Current energy consumption patterns in urban centres

This section will describe and analyse the data which have been collected in a number of household studies in the four main metropolitan regions mentioned above, as well as data from a number of surveys in smaller urban areas.

Figure 2.2 gives an overall idea of the use of different energy carriers in the main urban areas of South Africa. It is apparent from the figure that over-riding factors in the determination of household energy use patterns are such variables as climate, proximity to coal fields, and access to electricity. The following sections discuss variations in all of these factors and in fuel use in the main urban centres.

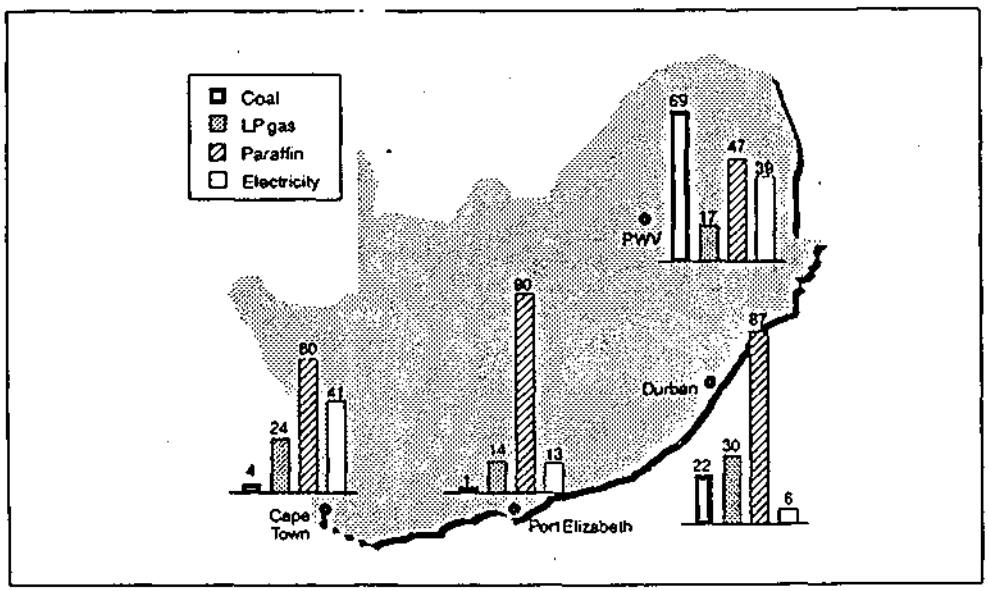

Figure 2.2 Variations in percentage of households using various energy carriers *(EPRET database 1993)*

2.2.1. The Pretoria-Witwatersrand-Vereeniging (PWV) region

Current energy consumption patterns

The PWV region contains about 40% of all low-income urban households in South Africa. The overriding energy consumption characteristic of these households is their high use of coal. Over 80% of non-electrified households rely heavily on coal, and consume an average of 115 to 160kg per month. This results in the highest average monthly delivered energy consumption of poor households in the country. This is particularly true of the unelectrified households, all of which are consuming in excess of 4 000 MJ per month on average.

As stated earlier this high use of coal has to do primarily with the fuel's relative cheapness resulting from the proximity of the Eastern Transvaal coalfields. In addition to this, when used in a stove coal is a fuel that provides multiple utility, that is, it can simultaneously supply three services: cooking, water heating and space heating. The value of this multiple utility is most clearly demonstrated by the fact that a large number of electrified households in the PWV continue to use coal. However, the adverse effects that this fuel has on the household and outdoor environment must be weighed against these advantages (refer section 2.4).

The ownership and use of coal stoves is therefore an important parameter in determining energy consumption, but has tended to be overlooked, particularly by surveys of electrified households. Nonetheless, some data are available, as are records of total coal stove sales, and these help to give an indication of their ubiquity in the PWV region. According to sales figures quoted in Dickson and Baldwin (1990), in the period 1980-90 almost one million solid fuel burning

stoves were sold in South Africa. Although these statistics include wood-burning stoves, it can be assumed that most are coal burners. Golding and Hoets (1992) found that an average of 69% of all households in four PWV townships had coal stoves. Unfortunately they did not provide a breakdown of how many electrified households had coal stoves.

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 (Dickson and 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 above services. Figure 2.3 graphically shows the important role that coal plays in PWV low-income households' energy economies. The wood is primarily used for kindling coal fires.

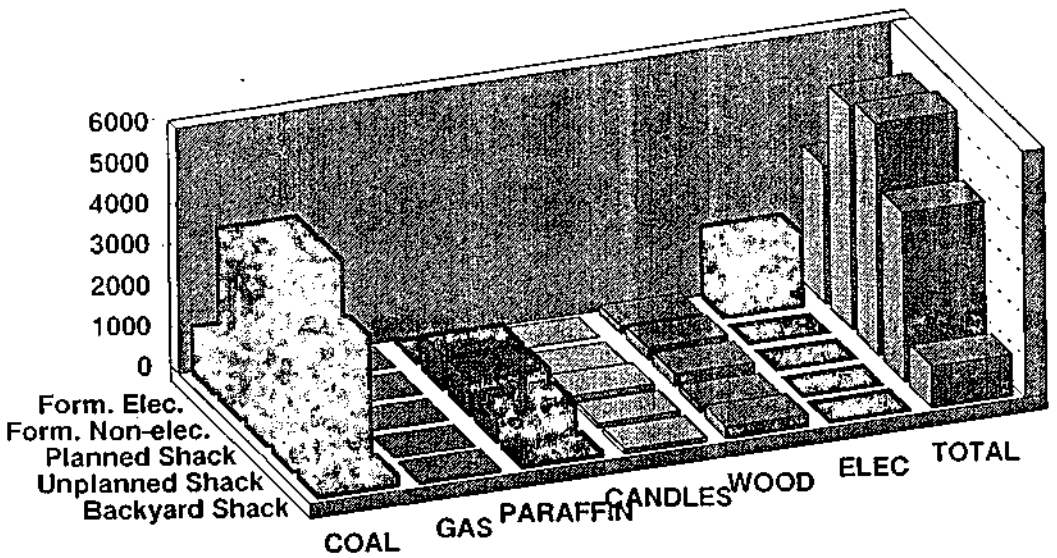

Figure 2.3 Monthly household delivered energy consumption (in MJ) in the PWV *(EPRET database 1993)*

It can be seen from Figure 2.3 that paraffin is also an important fuel, particularly in non-electrified households. It is significant to note how paraffin consumption decreases in electrified households. This would tend to indicate the importance of paraffin for illumination, although 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 water boiling or reheating of food. Its other very important characteristic is that it can be bought in small quantities, thus suiting itself ideally to the erratic and low cash flows of poor households.

A surprising feature of energy consumption in the PWV, and indeed

throughout the country, is the low consumption of what is a very convenient and efficient fuel, liquified petroleum gas (LPG). There are several reasons for this. Firstly, it is generally more expensive than alternatives such as paraffin, and, secondly, it can only be purchased in fixed quantities (depending on the size of the gas container) which generally require a relatively large cash outlay. Thirdly, gas containers are inconvenient and difficult to transport, especially where depots are far from peoples' homes or transport routes. Fourthly, the costs of gas appliances tend to be higher than those of paraffin equivalents, although obviously coal and electric appliances are usually even more costly. Finally, there are frequently negative perceptions regarding its safety.

A marketing survey conducted by Eskom in 31 townships in the PWV found that average monthly electricity consumption per household was 426kWh per month (Van Gass 1991). Another survey covering seven electrified communities and representing 190 000 households found that average household consumption ranged from 380kWh to 676kWh per month (Berrisford and 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 be equivalent to 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 borne out by the findings of the Palmer Development Group (1993) in their survey of ten townships nationwide. They found that Kagiso had an average monthly household consumption of 730kWh (summer 500kWh; winter 900kWh)

compared to the 390kWh (summer 320kWh; winter 500kWh) found in Alexandra, where prepayment meters were being used. The Alexandra residents had access to electricity for the past four years, and had their credit meters replaced with the prepayment type.

Energy expenditure patterns

The distinct lack of sufficiently disaggregated data on energy expenditure by poor households greatly limits analysis of this important area. However, certain surveys have dealt with energy expenditure patterns, the most comprehensive in the PWV region being Golding and 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 income and expenditure data available, it was not possible to generate the graph with reference to the housing categories shown in Figure 2.1. Thus it is not possible to draw firm conclusions as to the effects of using different energy carriers on energy expenditure as a percentage of income. This is an additional area which has been earmarked for future study by EDRC.

The first and probably 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, with high standard deviations. What is probably more important about this feature is the extent to which it differs from the next category: those with incomes of between R400 and R800 per month, who are spending between 10% and 15% of their income on energy.

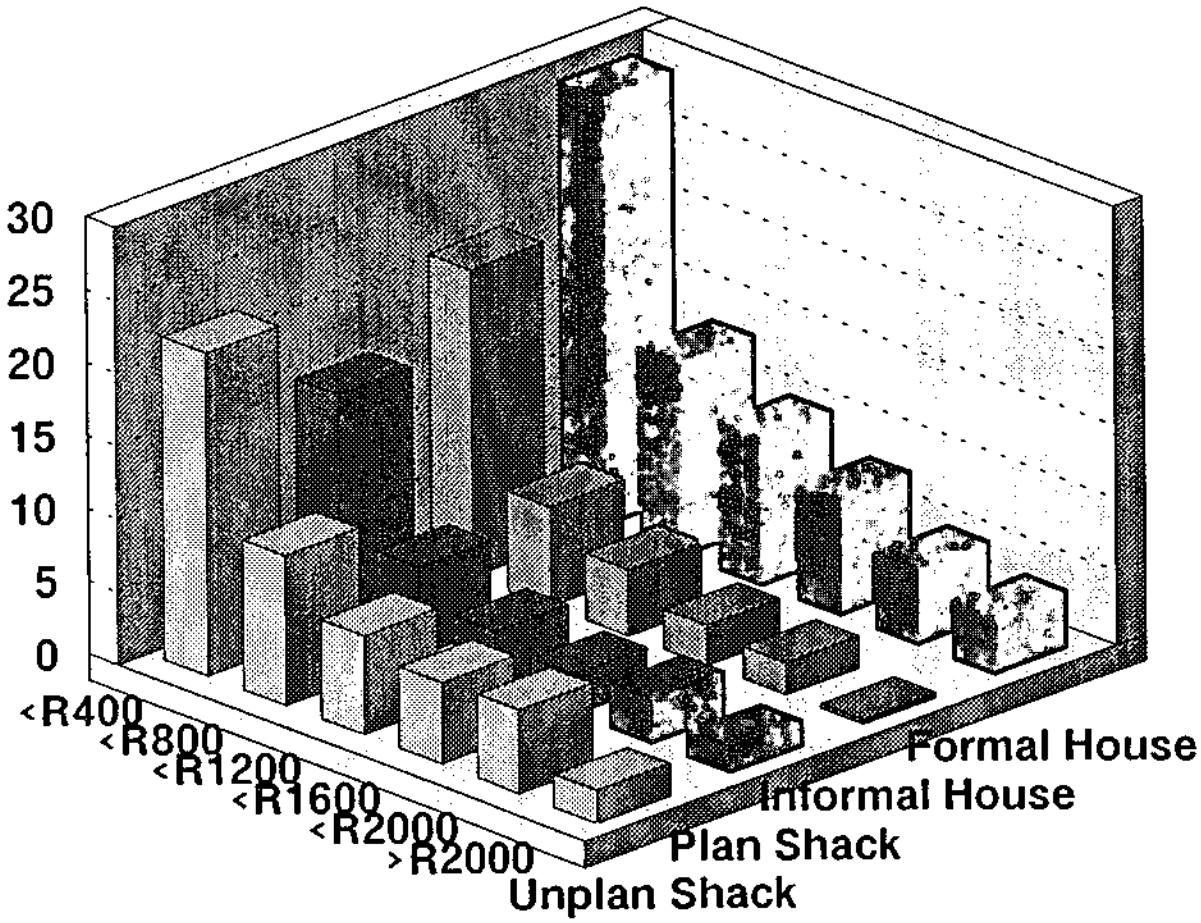

Figure 2.4 Percentage of income being expended on energy in PWV households *(EPRET database 1993)*

There are two implications of the above data. First, the high standard deviations of the lowest income category's energy expenditure percentages highlight an issue regarding the survey methods employed. 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. The same question put to better-off households

could present similar problems. However, despite this unreliability, it is evident that poor households are spending substantially more in relative terms on energy than the rest of the population.

The second important characteristic which is indicated by this relatively high energy expenditure is that there appears to be a certain level of energy consumption required to sustain a minimum standard of living. Consumption below this level would constitute a state of energy deprivation, and would conceivably prejudice the household's welfare. Unfortunately the data-set 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 conducted countrywide, and it is hoped that further analysis of this complete data-set will be able to throw light on this and other important issues.

The absolute amounts of energy expenditure reported in a number of studies is also interesting. Based on the data collected in the EPRET database, the absolute amounts being spent on energy by PWV households range from R32 per month in the case of backyard shacks, to R86 in the case of planned shacks, with an average of R56 across all categories. The largest items of energy expenditure are for coal and paraffin. Unelectrified households are reported to be spending between R23 and R33 per month on coal and R27 to R33 per month on paraffin. Electrified households spend around R60 per month, which represents 76% of their energy budgets. This expenditure data should be treated with a certain degree of circumspection, because of its aggregated nature - nonetheless, it does give some idea of the orders of magnitude of energy expenditure.

2.2.1.2 The Durban Functional Region (DFR) and Pietermaritzburg

Energy consumption patterns

The DFR metropolitan area enjoys a sub-tropical climate, thus resulting in a much reduced need for space heating. This factor, in combination with greater distance from the coalfields, results in much lower coal consumption. In the Pietermaritzburg region, however, coal use is higher because of the greater need for space heating during winter, and possibly also because of the closer proximity to the coalfields of Northern Natal. In aggregate, coal is the most important energy carrier, on a delivered energy basis, for two dwelling categories: formal non-electrified houses and planned shacks. This relates particularly to households in the Edenvale/Imbali complex outside Pietermaritzburg. These household categories consume an average of 60kg and 40kg of coal per month respectively, representing 50% and 40% of their gross monthly energy requirements. This is roughly a quarter to a third of their PWV counterparts' coal consumption. In the case of unplanned shacks, paraffin is the most significant source of energy, while for backyard shacks wood plays a proportionately larger role. Significantly, paraffin consumption for all dwelling categories is very similar to that of the equivalent PWV households. In households in the DFR area, paraffin is the dominant fuel.

It is interesting to note that in South Africa as a whole, LPG enjoys the highest penetration in this region, with around 30% of unelectrified households using it, although in energy terms it only contributes around 14% of their gross consumption. Unfortunately no detailed analysis of LPG use in the DFR area has been conducted by any of the surveys available, but it may be related to the proximity of the two

oil refineries, Sapref and Genref.

For electricity, Berrisford and Bluff (1991) reported that coastal area consumption levels were of the order of 300 to 400kWh per month. The Palmer Development Group (1993b) found median monthly consumption levels in Umlazi to be 500kWh (summer 600kWh; winter 750kWh), although they noted that the accuracy of the data was questionable. It is significant that the median consumption in newly-electrified areas with prepayment meters was much lower at 150kWh. In Sobantu near Pietermaritzburg, the mean consumption was 365kWh (summer 320kWh; winter 450kWh) 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 500kWh.

Figure 2.5 shows the monthly household consumption profiles for the region. The vertical axis is the same as for other regions so as to allow easy comparisons. Thus it can be seen that DFR/Pietermaritzburg households consume markedly less energy on a delivered basis than do those in the PWV. However, given the complete lack of data on energy consumption by particular end-use, it is impossible to analyse this phenomenon in detail, other than to suggest that the low price of coal is a major contributor to the high energy consumption in the PWV.

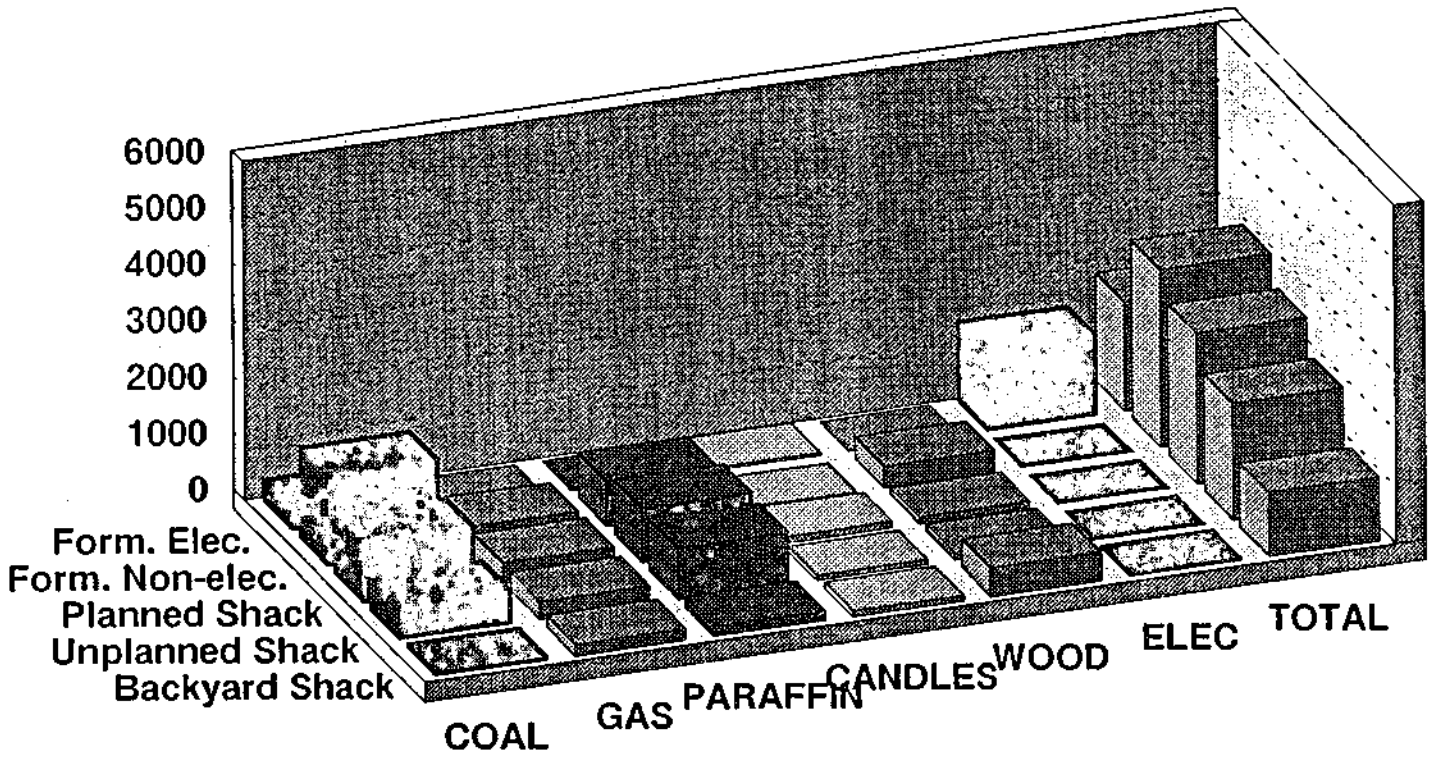

Figure 2.5: Monthly household delivered energy consumption (in MJ) in the DFR/Pietermaritzburg region *(EPRET database 1993)*

Energy expenditure patterns

Energy expenditure as a percentage of income for DFR households shows very similar characteristics to those found in the PWV. Again, it is apparent from Figure 2.6 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.

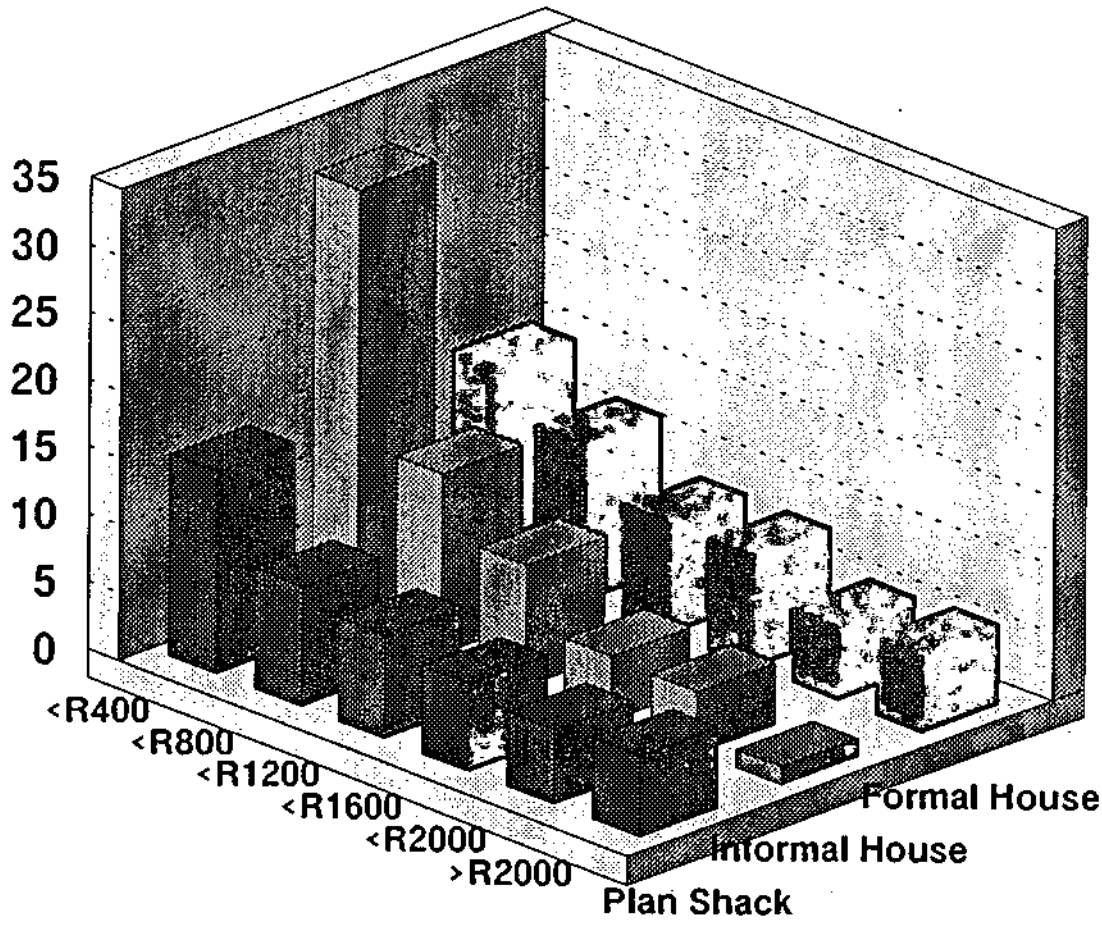

Figure 2.6 Percentage of income being expended on energy in DFR/Pietermaritzburg households *(Synthesised from Golding and Hoets 1992, and checked against DRA 1989)*

The absolute amounts being spent on energy in these Natal urban centres are very similar to those in the PWV, with the average amount across all housing categories being R60 per month, based on the EPRET database. Paraffin is the most significant of the energy carriers, representing around 40% of a household's energy budget.

This is of course not the case for electrified households which spend an average of R60 per month on electricity, accounting for 88% of their total energy expenditure.

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

2.2.1.3 The Cape Town metropolitan region

Energy consumption patterns

The Cape Town metropolitan region experiences a temperate Mediterranean climate, that is, 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 DFR/Pietermaritzburg consumption figures brings them into line with those of the Cape Town region. Low income households in the Western Cape 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 2.7 shows the delivered energy consumption levels for this region.

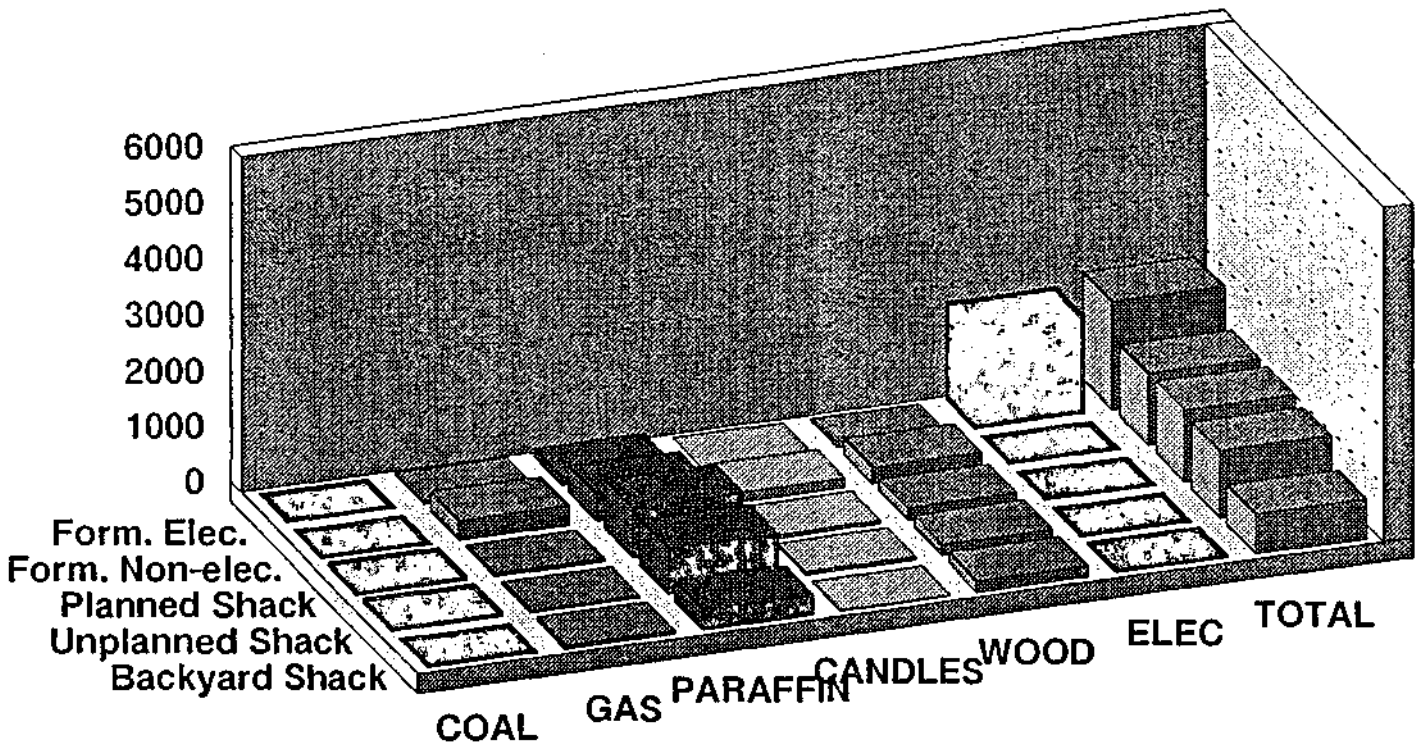

Figure 2.7 Monthly household delivered energy consumption (in MJ) in the Cape Town metropolitan region *(EPRET database 1993)*

It is interesting to note that LPG is also used quite extensively in Cape Town, with formal non-electrified households using about seven kilograms per month, and planned and unplanned shacks both using around five kilograms per month. 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 is a problem 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 is very low.

Thorne and Theron (1993) found that annual mean monthly electricity consumption levels for Langa and Guguletu households were 497kWh (summer 411 kWh; winter 508kWh) and 523kWh (summer 453kWh; winter 538kWh) respectively. The first households in these areas were electrified in the 1960s, and the electrification levels are 73% and 89% respectively. In both areas 85% of the households were found to be in arrears, with the average outstanding amount 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 access to electricity for longer than five years had average consumption levels of 450kWh per month. Those that had been connected for between two and five years, consumed an average of just over 300kWh, while those with less than two years of access consumed around 240kWh per month. The increase in the first year of connection was found to be about 60%, from 162kWh in the first month to 259kWh in the twelfth month.

The study by Thorne and Theron 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, with an annual average of 599kWh (summer 490kWh; winter 596kWh) 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, including the credit-metered households. It was found that the summer means for

Khayelitsha increased from 154kWh to 248kWh per month, while the winter means had increased from 210kWh to 290kWh per month. The average annual consumption had increased from 200kWh to 244kWh 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.

This longitudinal study produced other important findings. From Phase 1 to Phase 2 of the study, the percentage of households found to be dependent on 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 daily for cooking consumed an average of 445kWh, while those making daily use of hot plates consumed 323kWh per month. Interestingly, those using gas stoves on a daily basis consumed 307kWh per month, thus indicating that hot plates do not contribute significantly to electricity consumption.

A further phase of this survey is being completed. This third phase 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 questionable. Thus more

surveys of this type are necessary to provide insights into the complex variables that determine electricity, and indeed, all energy consumption patterns.

Energy expenditure patterns

Unfortunately no *recent* data stratified by income category is available on energy expenditure for this region. As Figure 2.8 illustrates, in 1983 households with incomes of less than R200 per month were spending 38% of their income on energy, while those with incomes between R200 and R400 were spending 21% on energy (1983 Rands, Eberhard (1984)). This figure dropped to 13% for the next category between R400 and R600, thus showing the same trends found in the PWV and DFR areas. Unfortunately this data cannot be presented for each house category as in other regions.

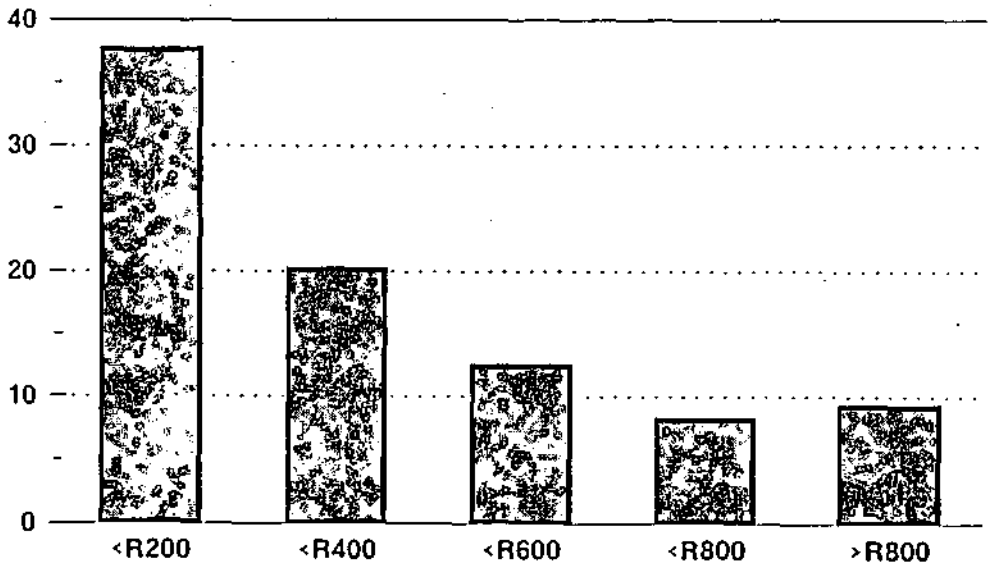

Figure 2.8 Percentage of income expended on energy in Cape Town metropolitan region in 1983 *(Eberhard 1983)*

Another important feature of Eberhard's findings is that those households using electricity spent significantly less than those using other energy carriers, with the ratio in one area being R25 to R65. 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 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. An even more recent survey of low-income electrified households in the Cape Town area (Thorne and Theron 1993) found that energy expenditure levels were between 8% and 17% of monthly household income in electrified households.

Once again, these expenditure figures should all be treated with circumspection, particularly because they were drawn from different samples and income categories. Data aggregation serves to mask differentiation between poor and better-off households. While the percentage expenditure on energy reported here is comparatively low, very poor families almost certainly still spend similar proportions of their income on energy to their PWV and DFR counterparts. This is an example of how aggregated data could mislead one into believing that the poor in the Cape Town region are better-off energy-wise than poor people elsewhere in South Africa. Further investigation of income and energy expenditure links is needed before such a conclusion could be drawn.

2.2.1.4 The Port Elizabeth and East London region

Energy consumption patterns

Port Elizabeth and East London will be considered together, as they fall into the same climatic regime, and the socio-economic profiles of low-income households are similar. The only detailed energy-related survey conducted in this region was that carried out by the University of Port Elizabeth (UPE, 1992). Despite the vast amount of data contained in this report, it concentrates on the percentage penetration of various energy carriers, and lacks information on the actual consumption (in kg, litres, or MJ) of energy carriers 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 is not even 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.

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

Figure 2.9 shows the monthly delivered energy consumption profiles typical of households in these metropolitan areas. What is immediately evident from this data is the low consumption of delivered energy compared to the PWV and DFR metropolitan areas. This is probably

attributable to three factors. First, in comparison to the PWV, the climate is obviously much milder, with this region enjoying higher average winter temperatures. The second reason, which probably has a greater influence on consumption levels is the generally lower incomes of households in Port Elizabeth and East London, when compared to the former two regions. Thirdly, coal prices are relatively high in this region, especially compared to the PWV.

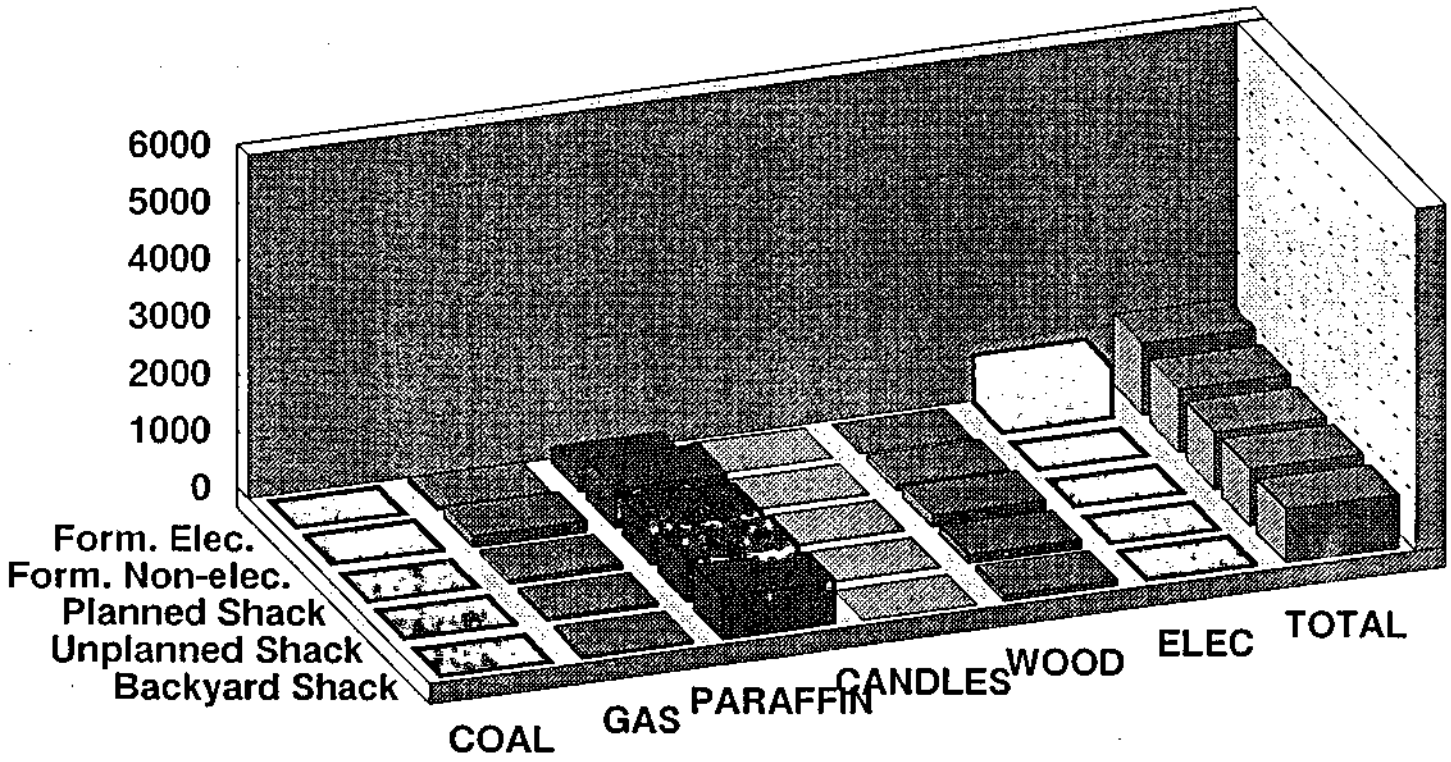

Figure 2.9 Monthly household delivered energy consumption (in MJ) in the Port Elizabeth/East London region *(EPRET database 1993)*

Paraffin is far and away the dominant energy source for unelectrified households in these two metropolitan areas, providing for at least 70% of domestic energy requirements. No other energy carriers feature prominently, except obviously for electricity in unelectrified households. Again, LPG does not enjoy a high level of penetration. Questions asked about preferences among the various energy carriers had LPG ranking 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.

Energy Expenditure Patterns

Unfortunately, the data available for these areas are 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 the UPE (1992) 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. Households in East London showed an average energy expenditure over the whole sample of 5% of income, that is R46 per month, while Port Elizabeth had a mean of 6.7%, or R56 per month. These levels of expenditure, while seemingly low compared to the percentages reported for the PWV and Natal urban regions, are actually not inconsistent with those results when the lowest income bracket is excluded from the other regions' data (refer Figures 2.4 and 2.6). The sample in PE/EL included some households with high incomes (over R2 000 per month) which skewed the averages.

This was one of the few surveys that considered both summer and winter energy expenditure. Over the whole Port Elizabeth sample it was found that winter energy expenditure hardly rose at all, while in East London an increase of 11.5% over summer expenditure levels was recorded. That the fluctuations between summer and winter expenditure are insignificant is not surprising given the relatively moderate winters experienced in this region. However, this finding should not be generalised across the country, since the harsher winters of the PWV region are likely to be reflected in considerably

higher energy expenditure levels.

2.2.1.5 Energy consumption and expenditure patterns in secondary urban areas

The energy use patterns of the smaller urban areas such as Kimberley and Bloemfontein and small towns will be dealt with in this section. Unfortunately the data available for these areas is very patchy. The areas to be considered fall mainly into Development Regions B (Northern Cape), C (Orange Free State), F (Eastern Transvaal), G (Northern Transvaal) and J (Western Transvaal), although some small towns in the other Development Regions will be included. Rather than give a comprehensive analysis of their energy use patterns, this section concentrates on those aspects which may be of particular interest, and which 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 and 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 consumed 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.

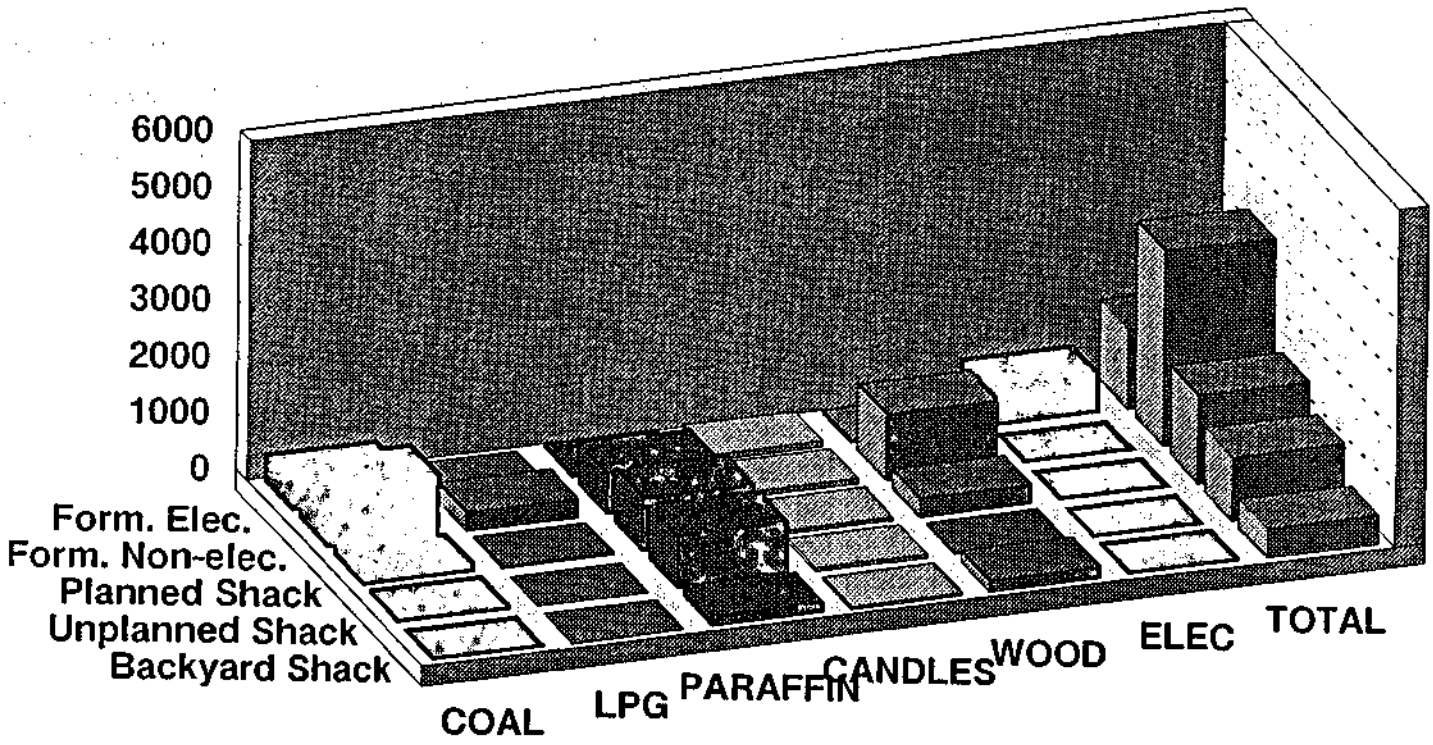

Figure 2.10 Monthly delivered energy consumption in MJ - Kimberley
(EPRET Database 1993)

Because of coal's higher price - around 40c per kg as compared to between 20c and 30c per kilogram 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 in the four metropolitan regions already discussed. The Palmer Development Group (1993b) found mean electricity consumption levels of 570kWh (summer 330kWh; winter 530kWh) 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 even with the occasional snowfall, thus showing the need for space heating. This is borne out by the fact that 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 in this area, with 21% of households using it for cooking, although none use it for heating. The median expenditure on energy as a percentage of income across the whole community was 7%, with the high income group spending 8% of their median income of R696 per month, middle income group spending 7% of R276 and the lowest income group spending 7% of R199. The two lowest groups' expenditure seems extremely low, but this could possibly be attributed to the fact that 40% of them use fuelwood, much of which could be collected at no cash cost.

A number of studies have been conducted in the Orange Free State. 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.

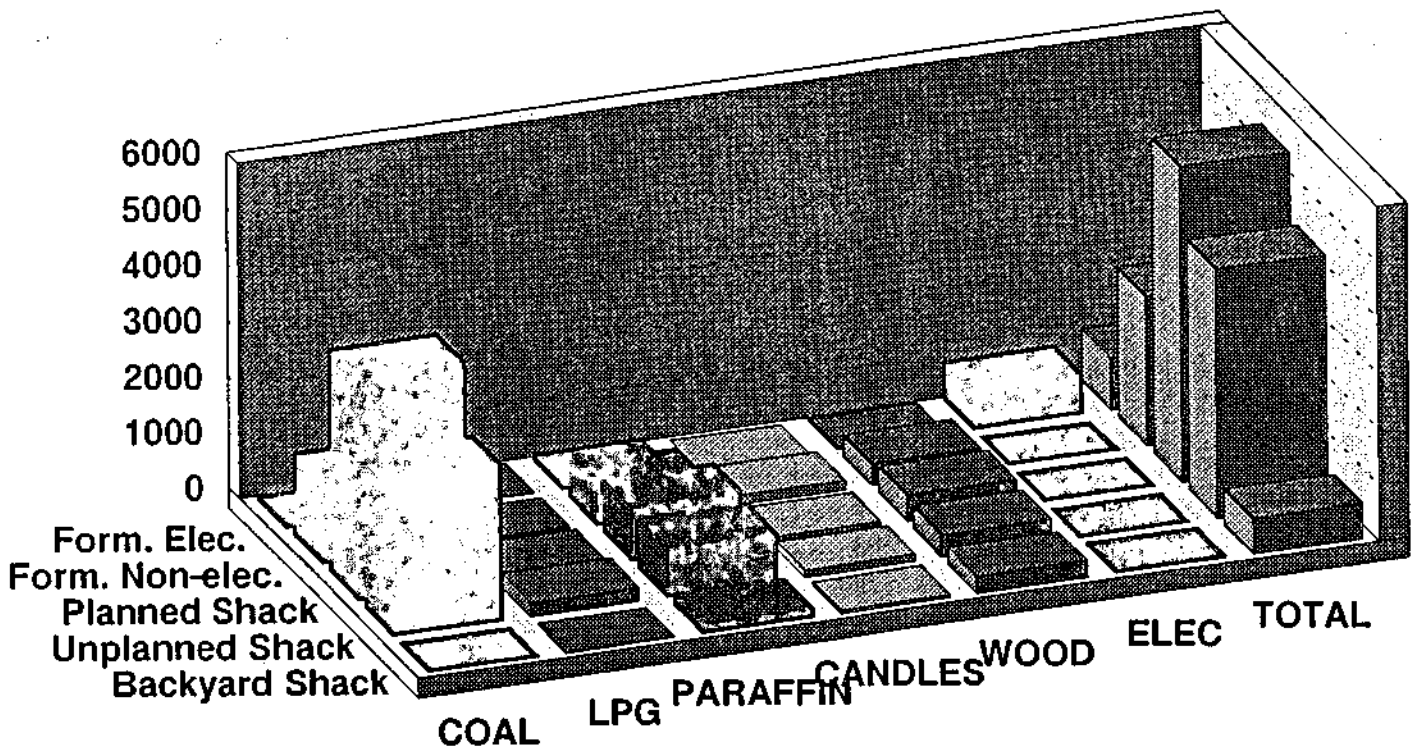

Figure 2.11 Monthly delivered energy consumption in MJ - Orange Free State *(EPRET Database 1993)*

Simon and Norval (1987) conducted a survey of Botshabelo and Mangaung outside Bloemfontein which bears out findings reported 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

400kWh; winter 800kWh) in those households with credit metering, and 230kWh (summer 175kWh; winter 300kWh) in those with prepayment meters. Also of interest is that average consumption was 1 000 to 1 200kWh 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 into Region J. Dickson and 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 resulting from 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 and 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. 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 to 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. This phenomenon is found in many of the surveys dealing with electrified areas, and reliability of supply is often commented on by interviewees. Likewise, 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 and 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 was paraffin, being used by 77% of households. Almost 100% of informal households used it, and 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 of a gas sales point to the township. Of the electrified households, 96% claimed to be paying for the service, and according to the Palmer Development Group (1993b) mean consumption was 570kWh (summer 420kWh; winter 750kWh) 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 an enormous 34% 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 20km outside Pietersburg. Paraffin was found to be used by 95% of households, with coal ranking quite highly at 50%. Although consumption levels of individual energy carriers were not reported, Viljoen did give delivered energy consumption of what he called "fuel groups" (defined as having more than half of their delivered energy provided by any one energy carrier). It was found that the coal group, which comprised 39% of the survey sample, had a gross monthly consumption of 6 600 MJ, which although high, follows the trends found elsewhere.

Possibly of greater interest in this case, is that the paraffin group, which also constituted 39% of the sample had 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 product depot close by. Thus the majority of the population buy their paraffin

directly from the depot, 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).

2.2.2 Poor households' survival strategies

Having physically located and described the energy use patterns of the focus group, it is important to look at 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. Some important work has recently been done by researchers such as van Gass (1993), Ross (1993) and Annecke (1993), to understand and describe poor households' survival strategies, paying particular attention to energy questions.

It is probably true to say that the majority of poor 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 classified as living in the informal planned, unplanned and backyard shacks. Given its predicament, informal society evolves strategies aimed at accessing services and benefits. These can to some degree diminish its dependence on the formal sector, but these local systems can be extremely vulnerable to outside interventions.

The strategies developed by the poor households are prompted to a large extent by the nature of their incomes, which usually consist of

multiple sources each characterised by its size, predictability and periodicity. Space does not allow for 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 are the extremely short cash flow cycles, involving small income amounts. These result in households having to meet needs as and when the cash is available, and generally results in income being spread 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.

To conclude, the study's focus group can only be broadly characterised by its extreme diversity and the complexity of their energy use patterns and coping mechanisms to deal with energy poverty. As a result a variety of strategies will be required if any success is to be achieved in widening access to energy sources for this group of people. This report also presents some of these strategies in section 5.

2.3 Energy consumption by rural households

The rural population comprises commercial (essentially white) farmers, the workers on these farms and their families, and rural households in

the homelands, outside proclaimed towns, residing in dense and scattered settlements. The first category have enjoyed favoured and sometimes subsidised access to infrastructural support, including electricity. The remaining households can largely be classified as the rural poor. Farmworker wages are generally low and in the homelands, few rural dwellers derive sufficient income from farming activity and rely mainly on remittances from migrant workers or on pensions. Homelands essentially have a residential character with virtually no sustainable economic base.

The table below summarises the estimated number of households in these categories in 1990. Despite natural population growth, the number of rural households is unlikely to grow significantly, largely because of urbanisation.

Table 2.1 Number of rural households
(EPRET database 1993)

Farmworker households	879 000
Rural homelands	2 162 000
RURAL TOTAL	3 041 000

More precisely, the rural poor are those households with incomes below the Minimum Living Level (MLL) which in 1992 was estimated to be approximately R850 per month. This can be verified from Figure 2.16. Approximately a third of South Africa's population can be classified as poor according to this definition.

Rural poverty is more complex than the above discussion suggests. Poorer households generally do not have secure access to sufficient cash incomes to meet their basic needs and commitments either in

total or at the time when it is needed. The unreliability and periodicity of income places severe pressures on survival. Consequently, households have to depend on a range of informal mechanisms of support such as production for home consumption, emergency savings, informal enterprise, social network reciprocity and exchange relationships and strategies for restructuring the household demographically to obtain a more economic configuration. Coping with poverty requires access to resources in addition to cash, such as land, household labour, and social contact networks. Bekker et al (1992) identify households which are deficient in two or more necessary assets in addition to formal cash incomes as the primary group vulnerable to rural poverty.

Data on energy consumption patterns of rural households are still limited. Although more than 7 500 households have been surveyed in recent years, little attention has been given to sampling techniques and sample sizes have been inadequate. It is not possible, therefore, to give a statistically representative picture of energy use, even on a regional basis. Instead, a small number of the better studies have been selected as a basis for understanding the factors which influence energy use in rural areas. The studies cover areas in the homelands of Bophuthatswana (Eberhard and Dickson 1987), Gazankulu (Griffin et al. 1992), KwaZulu (May 1993) and Ciskei and Transkei (Eberhard 1986). Data is also presented for "coloured reserves" in Namaqualand (Borchers et al 1990) and for farmworkers (Hofmeyr 1993). The latter study has attempted to collate all data on farmworkers and provides a national picture of energy use patterns. Data from this study is discussed separately.

2.3.1 Homelands and reserves

Percentage of households using different fuels

Multiple fuel use is a clear characteristic feature among rural poor households in the homelands and the "coloured reserves". This is probably a survival strategy of low income people, shifting from one fuel to the other depending on the required end-uses, in order to make ends meet within their tight budget constraints. The percentage of rural households using different fuels in the study areas identified above is presented here in Figure 2.12 to illustrate this behaviour. This figure shows that at least eight different fuels are being combined in diverse ways to meet energy needs.

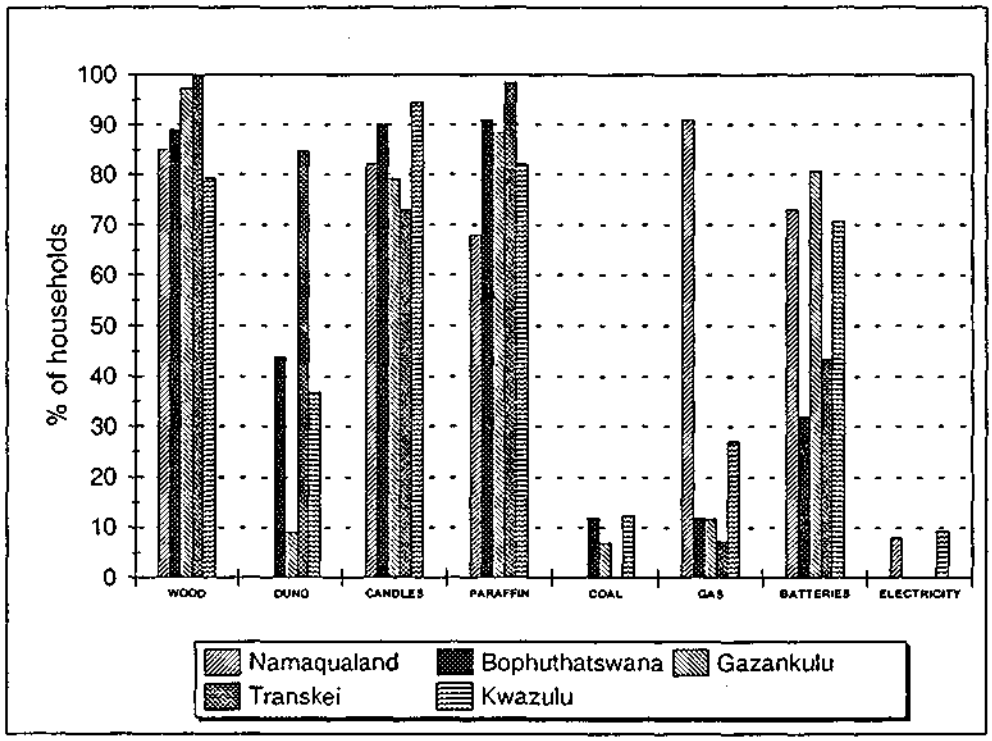

Figure 2.12 Percentage of households using different fuels in different rural areas *(EPRET database 1993)*

It is evident that the most widely used fuels are fuelwood, candles, paraffin and to a lesser extent, dry-cell batteries. More than 70% of households use these fuels. This shows that these needs are basic

and that rural poor households are constrained to resort to these fuels due to poverty and inadequate access to other more convenient energy carriers. For an area like Transkei/Ciskei, fuelwood and paraffin is used by almost all households. Any decrease in the supply of such resources would obviously have an immediate impact on the lives of the people.

The use of fuels such as dung, crop residues and LPG is significant in particular areas and, like coal, their use is regionally specific. Dung and crop wastes are used extensively in Transkei particularly in areas of fuelwood scarcity. On the other hand, for a dry place like the coloured reserves in Namaqualand, LPG is used extensively probably because of higher incomes and also partly because of poor availability of biomass resources. A few households use petrol or diesel generators or lead-acid batteries. Very few use coal due to the higher price of the fuel in areas far away from coal fields.

Dahl and Horvei (1993) estimate that less than 4% of rural households in homelands have access to electricity. Only two out of the five regions under discussion have some access to electricity and, even for those two areas (KwaZulu and Namaqualand), the percentage of households using electricity is under 10% (Figure 2.12).

Energy consumption patterns

The overall energy consumption (expressed in equivalent energy units) is presented in Figure 2.13 and this gives a vivid picture of how *intensively* the various fuels are utilised in the poor rural households of the five study areas. Figure 2.14 also indicates the overall percentage energy contribution by the major fuels in all the South African homelands and self-governing territories (EPRET database 1993). It is clear that fuelwood is by far the dominant fuel, followed by

dung and paraffin and coal. It should be appreciated however, that paraffin burns much more efficiently than fuelwood and thus contributes a higher proportion of useful energy than is indicated here.

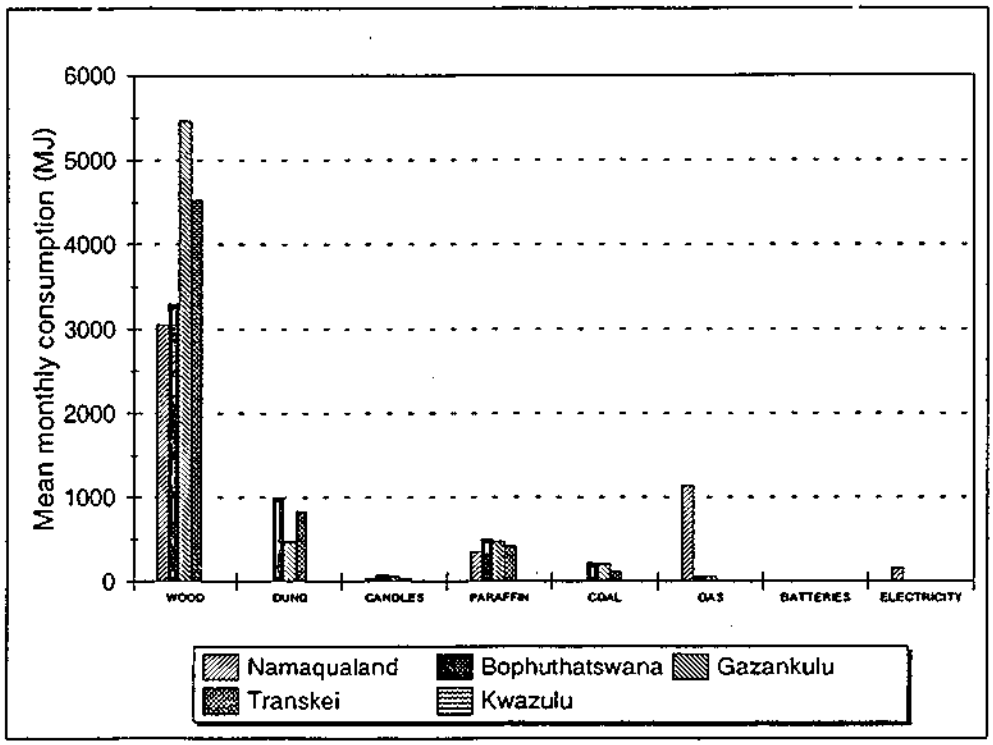

Figure 2.13 Mean monthly energy consumption per household (MJ)

There is considerable variation in the energy contribution by each fuel in the different study areas. While in Gazankulu and Transkei/Ciskei households consume a monthly average of 5 500 and 4 500MJ of fuelwood respectively, those in Namaqualand and Bophuthatswana consume 3 060 and 3 300MJ respectively. This occurrence is a consequence of smaller natural woodland resources in the latter areas due to very dry conditions, in comparison to the former where

fuelwood availability is higher.

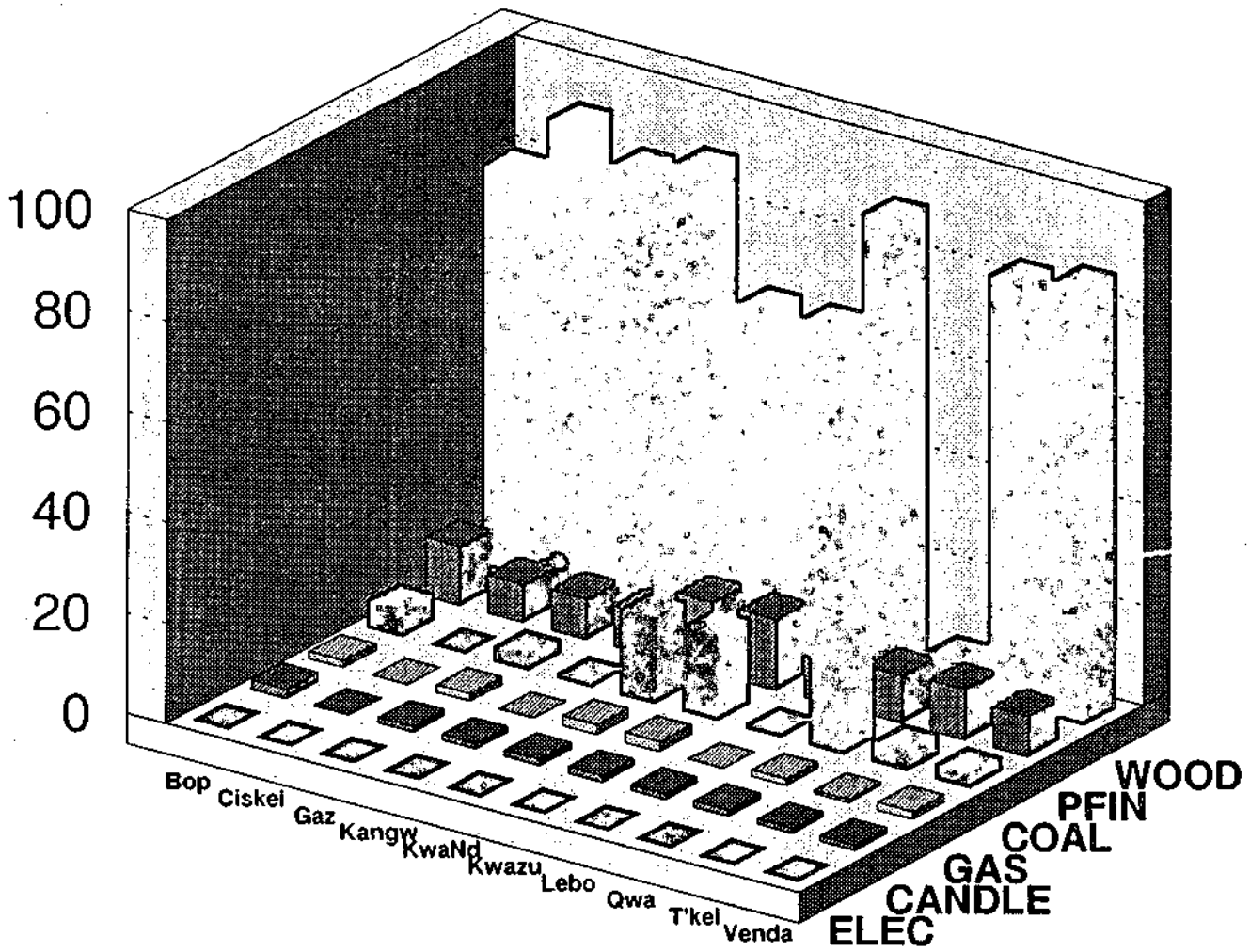

Figure 2.14 Percentage energy contribution by major household fuels in the homelands and the self-governing states

From both Figures 2.13 and 2.14 it can be inferred that paraffin is very commonly used with a remarkable consistency of consumption in most rural areas. This seems to indicate that there is a basic minimum quantity of paraffin required for some *essential needs* beyond which it is not a preferred fuel. Figure 2.14 indicates that in QwaQwa coal consumption is reasonably intensive and it has almost replaced fuelwood. This is a function of closer proximity to the coal fields as well as high population density (Figure 2.15) and the lack of wood resources. This substitution of coal for wood is further observed in

KwaNdebele and KwaZulu (Figure 2.14).

Reference	Homeland/SGT
1	Bophuthatswana
2	Ciskei
3	Gazankulu
4	Kangwane
5	KwaNdebele
6	KwaZulu
7	Lebowa
8	Qwa Qwa
9	Transkei
10	Venda

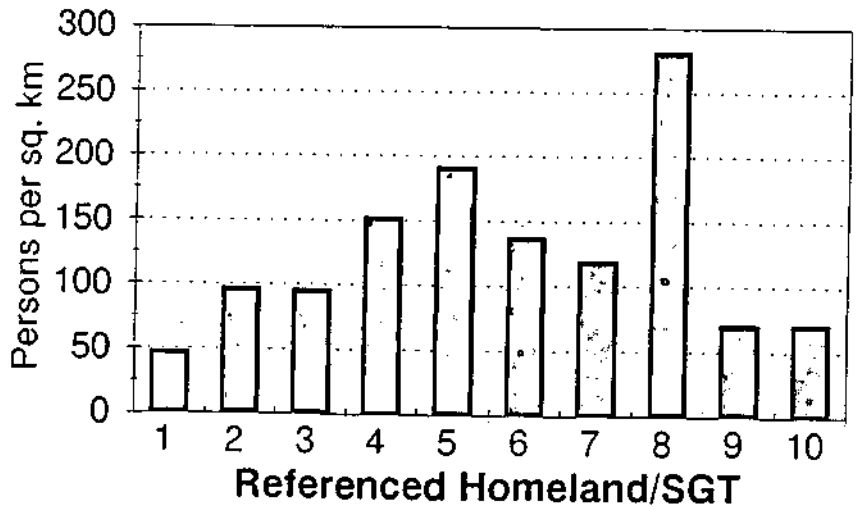

Figure 2.15 Population densities in the homelands and self-governing states *(DBSA 1990)*

LPG consumption is significant only in Namaqualand. Energy contributions by crop residues, dry cell and lead-acid batteries are very insignificant in all rural households.

Energy expenditure and income

Figure 2.16 depicts a general observation that poorer rural households bear greater burdens in terms of energy expenditure. This holds for three of the areas, namely Bophuthatswana, Gazankulu and KwaZulu, but not for the coloured reserves in Namaqualand. Even though both Namaqualand and KwaZulu have comparatively higher monthly incomes, households in Namaqualand have less access to free wood resources and are therefore constrained to depend on more expensive commercial fuels resulting in higher energy expenditure. It can be seen in this figure that, even though the actual energy expenditure is lower for lower-income areas, the percentage of monthly household income spent on energy is higher. Overall, rural households spend between R35 and R100 on energy and this constitutes about 8-14% of their monthly income.

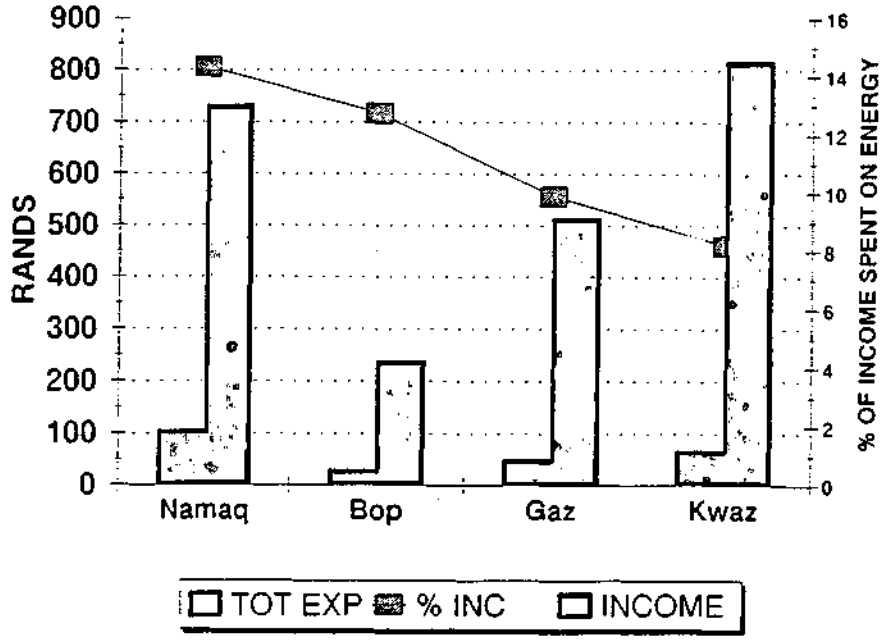

Figure 2.16 Mean monthly energy expenditure and income of rural households

Energy expenditure in rural households is heavily dependent on geographic location. What is more interesting is the fact that fuelwood is not always a free resource. In many areas it has to be trucked in and paid for. It is also interesting to note that, even though the energy contribution by fuelwood in Transkei/Ciskei is less than that in Gazankulu, expenditure on fuelwood is higher. In Figure 2.17, as much as 40-60% of the energy expenditure in Transkei/Ciskei results from the purchase of fuelwood, while this is generally lower than a third in Gazankulu as shown in Figure 2.18. This figure also gives an indication of the importance of dry-cell batteries to the rural households in Gazankulu in terms of cost (18-51% of energy expenditure) even though the energy derived from them is very small. The comparatively lower percentages of households using dry-cell batteries in Transkei and Bophuthatswana (Figure 2.12) seem to indicate the extreme poverty of these areas.

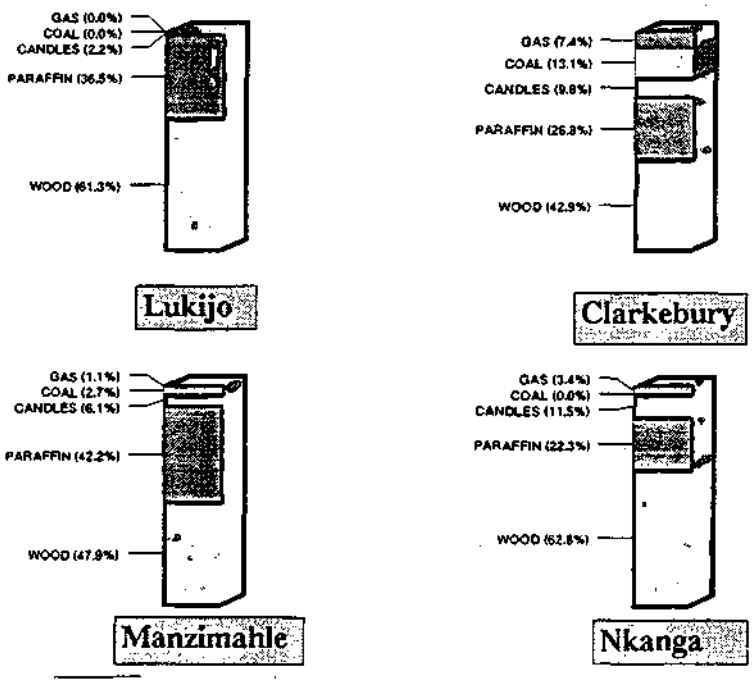

Figure 2.17 Fuel expenditure in rural Transkei/Ciskei households (rands)

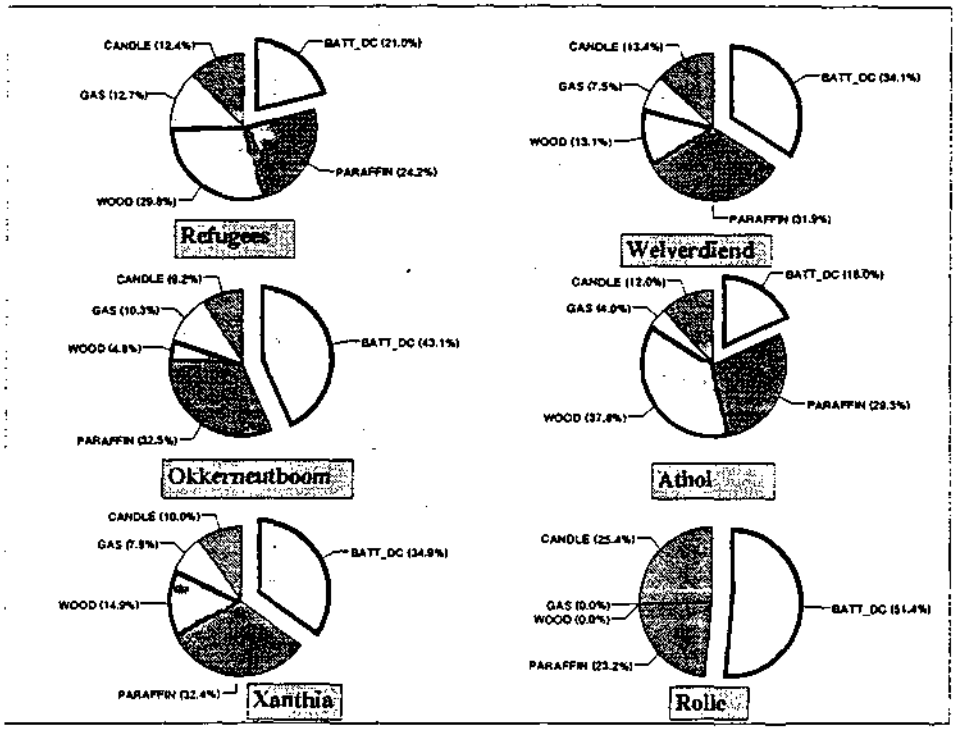

Figure 2.18 Fuel expenditure in rural Gazankulu households

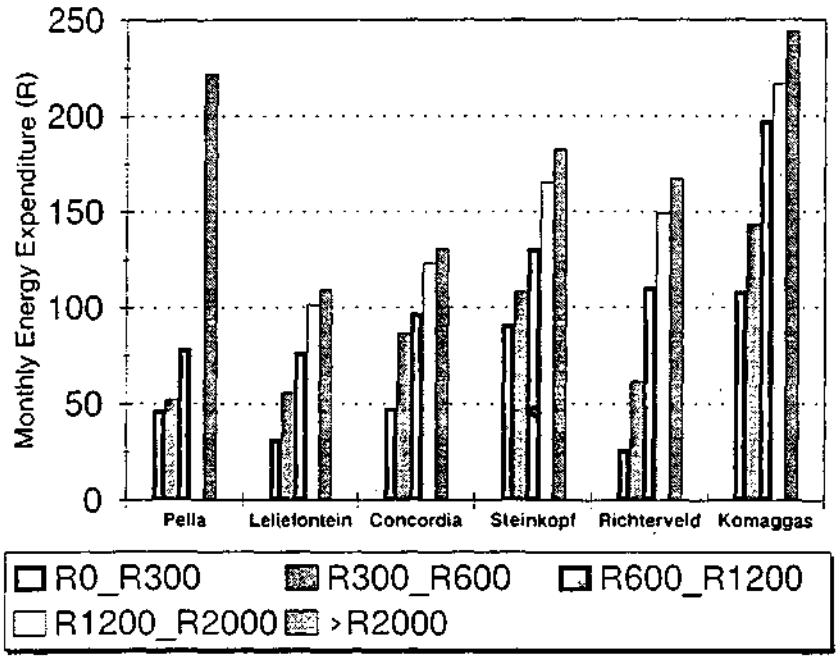

Figure 2.19 Monthly energy expenditure of different income groups in the *coloured reserves* in Namaqualand

Figure 2.19 above gives a clear indication of a transition from free or cheap but time-consuming fuels to commercial, quicker and convenient fuels with increasing incomes in all the coloured reserves in the Namaqualand study. Furthermore, Figures 2.20 and 2.21 demonstrate how energy expenditure rises as household income improves. It is evident in Figure 2.22 that the fact still remains that the poorer households are in Namaqualand, the more *burdensome* their energy expenditure becomes.

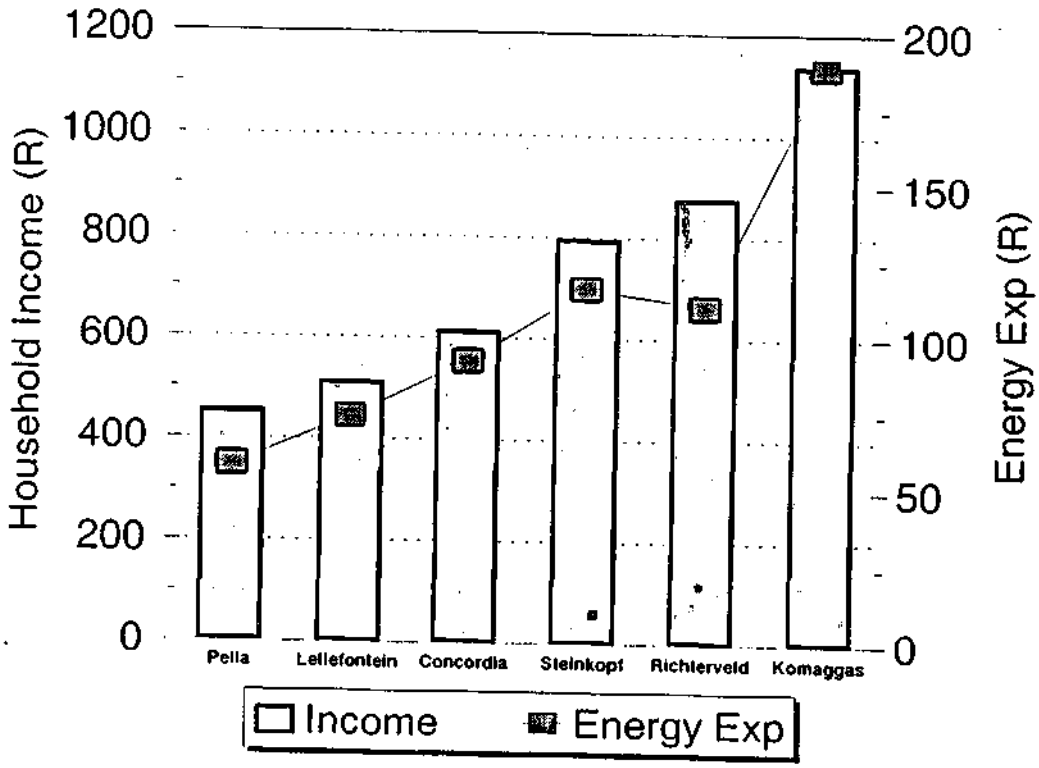

Figure 2.20 Mean monthly income & energy expenditure in rural Namaqualand households

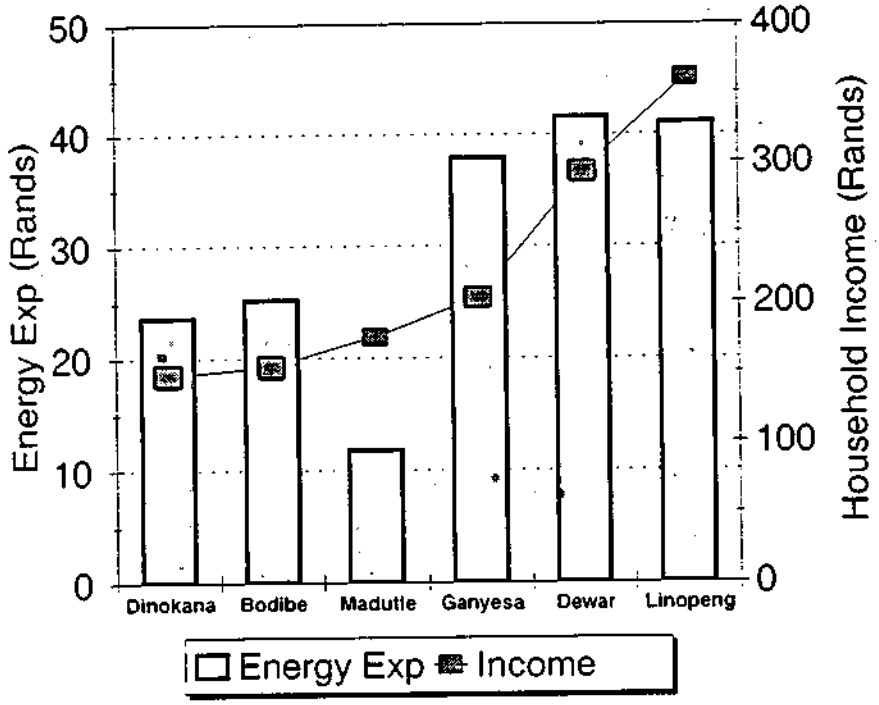

Figure 2.21 Mean monthly income & energy expenditure in rural Bophuthatswana households

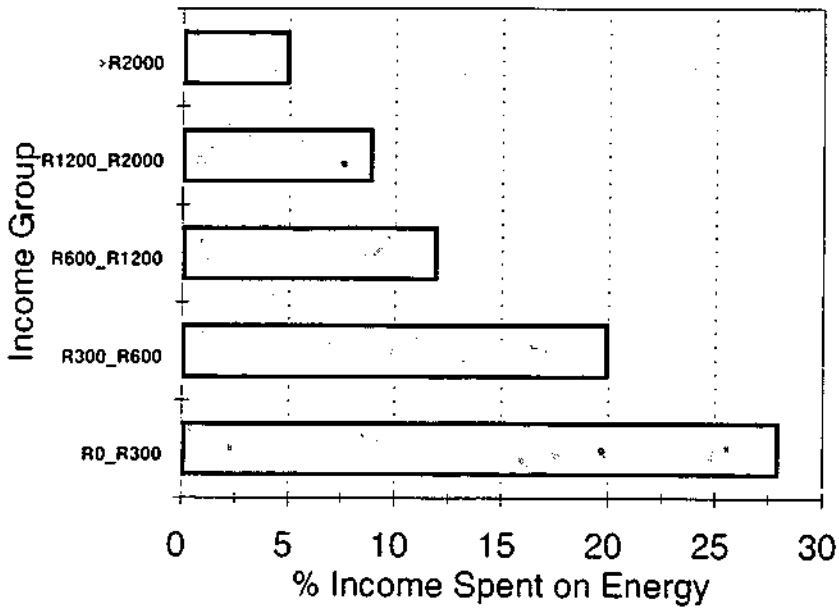

Figure 2.22 Percentage of income spent on energy by different income groupings in rural Namaqualand

Other forms of energy costs to the rural poor households in terms of time spent on fuelwood collection, safety and health hazards associated with fuel use are discussed in section 2.4.

2.3.2 Farmworker households

There is a considerable amount of information on energy use in farmworker households, but this has not been properly collated into regionally representative data due to varying research methodologies of the studies available. Furthermore, the accuracy of the information in the various studies is difficult to gauge since, in most cases, it was farmers who provided the information on the behalf of the farmworkers, and this could easily distort the real picture. Nevertheless, as part of a study by Hofmeyr (1993), an effort was made to pull together useful data from the other studies to provide some indications of the energy use patterns of farmworker households. The results of this effort are presented in Tables 2.2 and 2.3.

Percentage of households using different fuels

The overriding factors influencing energy use patterns of farmworkers are poverty and the isolation from energy services besides those provided by the farmers. Since commercial farms are mostly in remote areas, farmworkers are far removed from energy service centres and their poverty is characterised by low wages, very little access to educational and health services, insecurity of employment and tenure, and relationships of extreme dependence on the farm owners.

Multiple fuel use is common among farmworkers, although not as widespread as in the homelands. Fuelwood use can be seen from Table 2.2 to be relatively consistent between different studies and fuelwood is, by a significant margin, the main energy source for

farmworker households for cooking and heating in all the regions. This is not surprising since worker homes are often situated on farms with natural woodlands or woodlots. Fuelwood is generally free, in most cases, and can be used without commercial appliances.

Table 2.2 Percentage of farmworker households using different fuels for cooking and heating

Report	Sample		Percentage of households					
Source	*Size*	*Region*	*Fuelwd*	*Farm waste*	*Coal*	*Paraf*	*LPG*	*Elect*
Moller	299	NE-Tvl / Natal	88	34	17	42	2	2
Eberhard	382	National	97	4	5	19	9	4
Lieberman	45	National	88	8	8	25	-	6
Jooste & Nortje	530	W-OFS	86	59	8	9	1	0
Lieberman & Dingley	200	E-OFS /S-Tvl / N-Cape /Natal-cst	88	9	8	25	-	8
Tobich & Dingley	100	W/ N/ E-Cape W/ E-Natal/ S&E Tvl	73	0	14	-	-	-
Gandar	948	Transvaal/ Natal	96	4	0	-	-	-
Weighted Average			91	20	6	21	4	3

Table 2.3 Percentage of farmworker households using different fuels for lighting

Report	Sample		Lighting as end-use (% of households)				
Author	*Size*	*Region*	*Candles*	*Paraffin*	*LPG*	*Elec*	*Fuelwood*
Moller	299	NE-Tvl/ Natal	90	67	2	10	5
Eberhard	382	National	14	65	3	14	-
Lieberman	45	National	46	37	-	25	-
Jooste & Nortje	530	W-OFS	91	68	-	0	5
Lieberman & Dingley	200	E-OFS/ S-Tvl N-Cape/ Natal-cst	56	37	-	35	-
Tobich & Dingley	100	W/ N/ E-Cape W/ E-Natal/ S&C-Tvl	25			22	6
Gandar	948	W/ E-Tvl/ Natal	96	0	-	27	-
Weighted Average			*75*	*62*	*3*	*18*	*5*

The use of agricultural residues for cooking and heating is inefficient and unpopular. Apart from the farms of the North-Eastern Transvaal, Natal and Western Orange Free State where fuelwood resources on the farms seem to be insufficient, the use of agricultural residues is very insignificant (Table 2.2). The extent to which it is used is likely to depend on the waste produced by the farming activity and the availability of fuelwood.

Among the commercial fuels, paraffin is the most commonly used among farmworkers. The fact that paraffin can be obtained in small quantities with little cash outlay, almost certainly affects the extent to which it is used. The use of coal and LPG are insignificant. Accessibility to distribution depots seems to be a major factor

influencing the use of coal, in addition to the proximity to coal fields. For LPG, the main constraints are the capital outlay required for gas cylinders and appliances and the difficulties associated with the refilling process. Candles are widely used for lighting in areas where electricity is not available or cannot be afforded.

In terms of accessibility to electricity, farmworkers are better off than homeland dwellers since most farms are electrified. Table 2.4 gives a rough indication of farms and farmworker households connected to the electricity grid.

Table 2.4 Percentage of farms and farmworker households connected to the grid

Source	Sample		Eskom electricity provision	
	Size	*Region*	*Farms (%)*	*Worker households (%)*
Moller (1985)	299	NE-Tvl/ Natal	-	10
Eberhard (1986)	382	National	57	14
Lieberman (1988)	45	National	71	25
Lieberman & Dingley (1989)	200	E-OFS/ S-Tvl /N-Tvl-cst N-Cape	69	35
Tobich & Dingley (1989)	100	W/ N/ E-Cape/S&C-Tvl W/ E-Natal	77	23
Gandar (1991)	948	W/ E-Tvl/ Natal	-	27
Eskom (1992)	-	National	-	21
Weighted Average			68	22

Access to electricity does not mean that it is used for all energy services, as is shown in Table 2.5. This is because farmworkers are frequently unable to afford simple electrical appliances and the higher electricity consumption which results. Based on a study of electrified

farms by Hofmeyr (1993), it is shown in Table 2.6 that the percentage of farmworker households which are electrified does not vary much from region to region except in South-Western Cape where farmers are known for their "progressive" attitude toward farmworker needs.

Table 2.5 Fuel use in electrified and non-electrified farmworker households *(Lieberman 1987:28)*

Energy carrier	Non-electrified	Electrified
Fuelwood	91	85
Paraffin	62	25
Coal	7	8
Agric (Farm) waste	25	10
Candles	63	29
Batteries (all type)	15	13

Table 2.6 Percentage electrification of farmworker houses according to region *(Hofmeyr 1993:20)*

Region	Percentage electrified
SW-Cape	71
W-Cape	32
N-Cape	11
E-Cape	26
OFS	26
Natal	15
E-Transvaal	22
N-Transvaal	27
W-Transvaal	26
Weighted Average	32

Energy Consumption

It is not easy to gauge the amount of electricity consumed by worker households because there is often no individual metering, and also the use of communal facilities is a common phenomenon. However, estimates made by Hofmeyr (1993) give some indications in Table 2.7. Regional variations in the ownership of electrical appliances correspond with electricity consumption. The Western Cape and Orange Free State (OFS), where a wider range of electrical appliances are used, have higher electricity consumption by workers than the Northern Cape and Natal where very few appliances are used. This illustrates how poverty constrains the use of electricity even when it is accessible.

Table 2.7 Electricity consumption per farmworker household *(Hofmeyr 1993:25)*

Development Region	Consumption (kWh/month)
SW-Cape	310
W-Cape	260
N-Cape	110
E-Cape	189
OFS	226
Natal	140
E-Transvaal	204
N-Transvaal	189
W-Transvaal	153
Weighted Average	*203*

Apart from the cost of appliances, there are some restrictions by farmers which affect the extent to which worker households consume electricity. Some of these restrictions are on the type of appliances households are permitted to use, the number of hours per day that workers can have access to electricity, and the number of free electricity units available to workers.

Compared to the rural homelands, fuelwood consumption by farmworker households is generally higher: over 800kg/capita/year (Hofmeyr 1993:34), which is about 6800MJ per household of six people. This is because fuelwood is more readily available to workers on commercial farms than to other rural dwellers in the homelands (Table 2.8); about 90% of farmers provide workers with fuelwood .

Table 2.8 Availability of fuelwood to farmworkers and homeland dwellers *(Moller 1986)*

Fuelwood accessibility	Rural (%)	"White" Farms (%)
Collected nearby	45	90
Collected 30 min away	10	1
Bought	45	9

Candles, paraffin, coal and LPG are consumed by farmworkers in lesser quantities than rural homeland dwellers.

Energy expenditure and income

On average, farmers pay over 80% of the cost of electricity used by workers, although about a third of the workers contribute to the cost of electricity. The two regions where workers contribute most and least to the cost of electricity, Western Cape and Northern Cape respectively, are also the regions with the highest and lowest consumption of electricity respectively. This shows how electricity demand by farmworkers is suppressed by poverty. In general, about 2-4% of workers' income is spent on electricity but where special appliances like geysers are permitted, this rises to about 8%. Extension of electricity to the dwellings of workers is generally related to their income levels (Table 2.9).

Table 2.9 Percentage electrification of farmworker households and farmworker household income *(Hofmeyr 1993:21)*

Household income (R)	Percentage electrified
60 - 150	10
160 - 200	20
210 - 300	25
320 - 400	26
420 - 500	48
520 - 650	54
700 - 980	66
1000 - 2000	87

About a third of all farmers attach some cost to the fuelwood supplied to workers and, on the average, this is about R15 per month. However, it must be appreciated that it costs fuelwood users a lot more in terms of time and energy required for the use and collection of fuelwood.

The total energy expenditure by farmworker households is estimated by Gandar (1991:13) as R270 per annum. This is far below that spent by rural homeland dwellers generally. It must be noted, however, that in spite of better access to electricity and fuelwood availability, farmworkers still spend about two-thirds of their total energy expenditure on paraffin and candles.

2.3.3 Energy end-uses among farmworkers and homeland dwellers

The end-uses of the various fuels among farmworkers and the rural homeland dwellers do not differ much. The major difference is that there are some farmworker households with electric appliances like stoves, fridges, radios, kettles and, in very few cases, geysers. Candle use for lighting is also lower among farmworkers since candles are displaced by electricity in most cases.

Cooking is the most important task for which wood is used. In the Natal/KwaZulu study by May (1993:52), even the 3.2% of the people who did not use wood for cooking had wood as a back-up energy source. Other important end-uses for wood are water heating, space heating and in some cases, cooking and the brewing of beer for traditional feasts. End-uses of coal are similar to those of wood (May 1993:62) except that it is not used as extensively. Almost all the households who use coal in the Natal/KwaZulu study also use wood to start their coal fire. Coal is usually left to burn for the whole day in order to save not only on wood but also on matches.

Dung is generally not a preferred fuel because it is smoky, dirty and unsuitable for intensive cooking (May 1993:60). Its preferred use is for the smearing of floors. However, it is used for cooking, heating and the starting of coal fires and as a substitute for wood in households where incomes are so low that other substitutes cannot be afforded. About one-fifth of the households sampled in the KwaZulu study use dung for these applications. Dung use is thus an indicator of poverty even though research has not as yet established an exact correlation. Dung use is also an indicator of high livestock densities, which can have subsequent overgrazing impacts on the environment such as in the Ganyesa area in Gazankulu (Eberhard & Dickson 1991:9).

Candles are ubiquitous as the main source of lighting in the rural homeland households since electricity is generally not available. However, higher income households prefer paraffin for lighting or a combination of the two. Paraffin is also commonly used for quick heating and cooking. LPG has almost the same end-uses as paraffin but it is preferred by those who can afford the up-front cost of appliance, cylinder and fuel purchase. The basic end-use for dry-cell and lead-acid batteries is entertainment and sometimes lighting.

2.3.4 Summary of salient points

From the above discussion, a conclusion can be drawn that the issue of rural energy poverty has been grossly neglected even though it engulfs a third of the South African population. Generally, rural households have very low access to electricity but farmworkers are better off than homeland dwellers in this regard. The rural poor are thus forced to depend on more expensive and inconvenient fuels.

The discussion makes it clear that the provision only of a traditional source of fuel like fuelwood to the rural poor cannot be a solution since its use is still laborious and inconvenient for many applications. Neither is the extension of the electricity grid to all rural areas a complete solution unless the rural poor are empowered financially to utilise the energy services supplied. Their incomes need to be improved in order to be better equipped to purchase required appliances and also enjoy the benefits of discounts realised through bulk purchases of fuel.

2.4 Environmental, health and social effects of current energy use

The reliance of a large number of households on inconvenient and

dirty fuels causes impacts which are felt in many dimensions: both social and natural. It is clear that the general environmental conditions experienced by the poor are more degraded than those of the wealthy, and this is particularly true of the impact energy-related uses. This section describes some data related to the impact of environmental, health and social of energy use by poor urban and rural households. These fall into three broad categories: air pollution from fuel combustion, paraffin poisoning and burns from fires, and the effects of fuelwood scarcity.

2.4.1 Air pollution exposures

The mixture of fuels used by poor households in urban areas has a range of impacts on their indoor air environment. The most serious of these is caused by the combustion of coal, which is used by the majority of households in the PWV complex, and wood which is used by almost all rural households.

Air pollution exposures from coal combustion

South African coal is of varying quality, but generally the highest grades are exported, leaving the poorer quality for domestic users. The average sulphur content of coal, about 1%, is fairly low by world standards, but ash content is especially high at up to 40% (CSIR 1991). The consequence is that domestic combustion of coal emits a number of pollutants which have a serious impact on air quality in those homes, particularly as many have no chimneys or are poorly ventilated. The most serious of these pollutants is particulate matter, in terms of both the extent of its emission and the ambient levels which occur in homes.

Pollution studies in South Africa have historically measured ambient

levels of pollutants at fixed monitoring stations. Only recently have some pollution and health studies utilised the Total Exposure Assessment (TEA) approach, which recognises that the health effects suffered by people are a function of both the concentration of pollutants in the air and the duration of exposure (Smith 1988). The response therefore is to measure the personal exposures of study participants to the pollutants under examination and simultaneously to gather information regarding their movement patterns. In this way, the data include a mixture of both indoor and outdoor concentrations. A recent study of school children aged eight to 12 years in the Vaal Triangle, south of Johannesburg, indicated that the median time spent indoors was about 75%, which is slightly less than the 80 to 90% spent indoors by boys in the USA (Terblanche et al 1992a).

The first personal exposure studies in South Africa were conducted in 1991. They formed part of an ongoing longitudinal study, called the Vaal Triangle Air Pollution Health Study (VAPS), which aimed to assess whether South Africa's air pollution control programme adequately protects human health (ibid). In one component of the project, a group of 45 black children, aged eight to 12, and living in and near Sebokeng in the PWV area, carried personal exposure monitors to collect data on exposures to air pollution caused by coal combustion. The results indicated extremely high levels of exposure to Total Suspended Particulates (TSPs), with 12-hour levels exceeding the USA EPA 24-hour standard of 260μgm^{-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. Average concentrations on a summer weekend day were 387μgm^{-3} and 620μgm^{-3} for electrified and non-electrified areas respectively. As expected, increased coal consumption in winter was reflected in higher exposure levels. Average concentrations on a winter weekday were 1 168 μgm^{-3} in electrified areas and 1 363 μgm^{-3} in non-electrified areas. This

relatively small difference between electrified and non-electrified areas was an important finding and was attributed to the close spatial proximity of electrified, partially electrified and non-electrified areas, and to the high background levels caused by low-level coal burning in areas where dispersal conditions are unfavourable. The implication is that only full electrification, or put differently, the complete substitution of bituminous coal by cleaner energy sources, occurring on a wide scale in urban areas, will have the effect of reducing people's particulate exposures to acceptable levels.

Interesting comparisons can be made with other components of the VAPS study, which recorded the exposure levels of white children in primary schools in the PWV area. These revealed levels of TSPs well below those experienced by black school children: 63% of exposures exceeded the EPA 24-hour standard, and the median level on a winter school day was 310μgm^{-3} (ibid). These children came from homes which were fully electrified, which again suggests that background pollution levels are very high. This comparison is presented graphically in Figure 2.23.

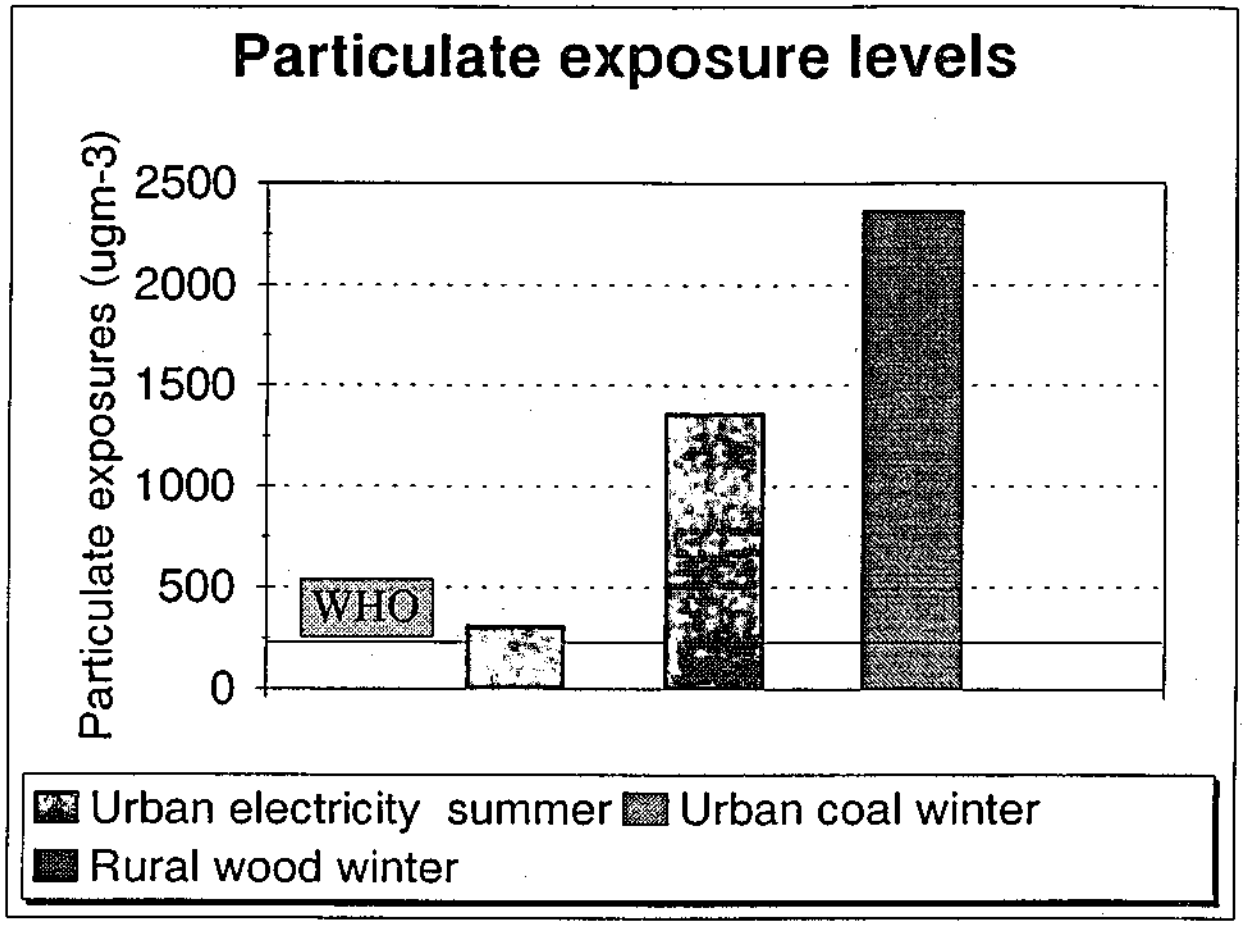

Figure 2.23 Average concentrations of particulates in PWV residential areas compared to EPA and WHO standards *(Van Horen et al 1993)*

This project concentrated on only one aspect of the indoor air environment: exposures of children in PWV areas to particulate matter. This probably represents the most serious energy-related hazard to the *urban* poor in South Africa. Nonetheless, 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. Further, while non-electrified households in other urban centres use a range of different fuels, such as paraffin, gas and

wood, to satisfy their basic energy needs, the impact of these fuels on indoor air quality has not yet been measured in South Africa.

The effects of such high particulate concentrations on the exposed population's health are serious. Their significance is emphasised by the fact that acute respiratory infections (ARI) constitute the second-most important cause of death in South African children, after gastro-related illnesses; and in the Cape Town urban area, ARI is reported to be the leading cause of infant mortality (Von Schirnding 1991). Significant difficulties exist, however, in attempting to establish 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 latency periods of health outcomes; 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 eight 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, gas or electricity (ibid). Coal 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.

The problems of *outdoor* air pollution have been fairly well documented in South African urban areas, particularly in Soweto and other townships in the Transvaal. The earliest monitoring of air quality in South Africa commenced in 1955, but this was based mostly in city

centres. Although some surveys were done in Soweto in the 1970s, these were intermittent, and a more comprehensive picture of air pollution emerged in the 1980s when various monitoring programmes were established in Soweto (Turner et al 1984). The scope of these programmes has 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 view of air quality in townships.

Soweto's air quality has been studied more widely than that of any other township in South Africa, partly because its air is so heavily polluted, and partly because electrification was expected to bring about substantial improvements. For various reasons, coal continues to be used on a large scale in Soweto and, consequently, air pollution problems remain serious. Eskom commenced its monitoring programme in Soweto in June 1983. Results from the first few months of operation showed that concentrations of TSPs frequently exceeded 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.

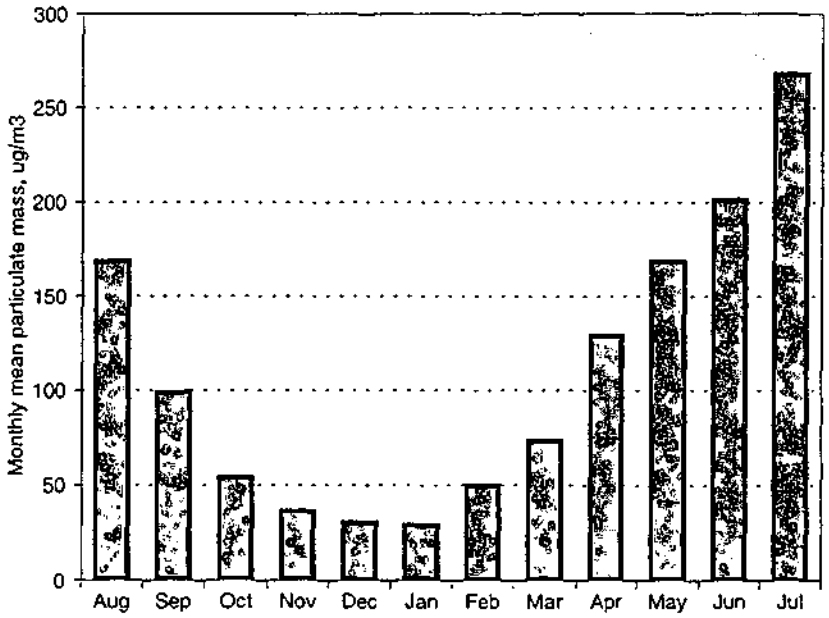

Figure 2.24 Monthly mean fine particulate concentrations in Soweto, August 1990 to July 1991 (Turner and Lynch 1992)

Measurements carried out from August 1990 to July 1991 by Eskom again revealed that concentrations of particulates were unacceptably high. The mean annual concentration of fine particulate matter (FPM) over this period was 112µgm^{-3}, more than double the US standard of 50µgm-3 (Turner and 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 2.24 and 2.25, strong seasonal and diurnal fluctuations in concentrations occur, which suggests that particulate pollution is closely related to household coal use patterns, as well as to the dust created by vehicles travelling on unpaved roads.

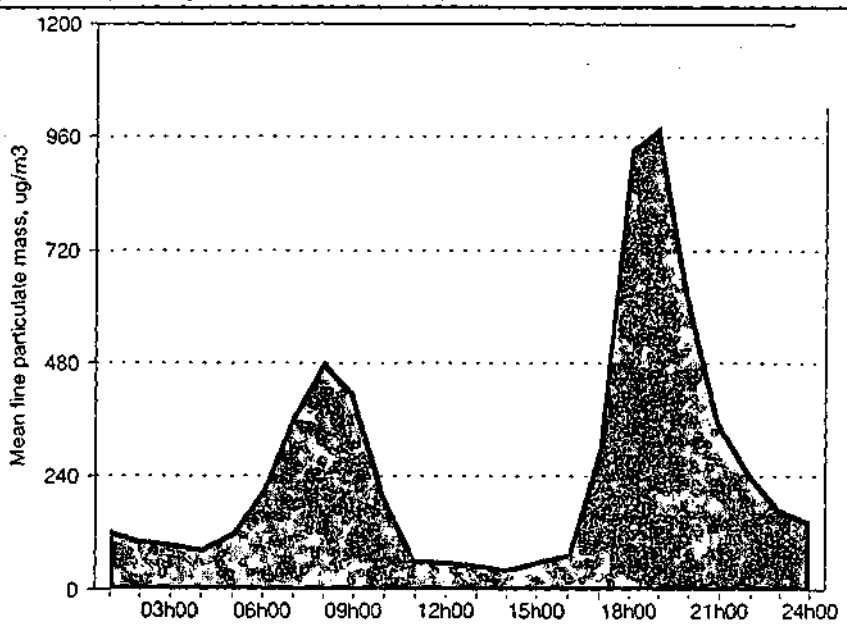

Figure 2.25 Diurnal distribution of mean fine particulate concentrations in Soweto, July 1991 *(Turner and Lynch 1992)*

Levels of gaseous pollutants were also monitored, and it was found that SO_2 levels followed similar cyclical profiles - winter levels far higher than those in summer, and strong morning and evening peaks. The measurements recorded were mostly within the health guidelines, although guidelines were occasionally exceeded during winter. While NO_x levels were higher than those of SO_2, they were well within the government's health guidelines. The diurnal and seasonal distribution of NO_x suggested that the bulk of this pollutant is derived from the extensive vehicular traffic in the township.

Air pollution exposures from wood combustion

Anecdotal evidence suggests that levels of air pollution in many rural homes can reach exceptionally high levels, especially where these dwellings are designed for maximum heat retention, and have no chimneys and few, if any, windows. The impacts of these pollution levels on the health of the people inhabiting such dwellings, are likely to be significant. Furthermore, the poor quality and scale of health services in many rural areas, exacerbates these adverse health

impacts.

In spite of the seriousness of the problem in rural areas, pollution monitoring and control efforts have, until recently, almost entirely neglected rural households. The first and only study in South Africa to-date to measure the levels of pollution encountered in rural homes, has been conducted by the CSIR and MRC in parallel to a similar study in Sebokeng/Lekoa (referred to above). The rural study utilised both personal monitors for particulates, worn by 17 children, and fixed monitors which measured concentrations of sulphur dioxide, nitrogen dioxide, carbon monoxide, total volatile organic compounds and total suspended particulates (CSIR 1992:1).

The results of the study indicated that exposures of the children to total suspended particulates (TSPs) exceeded safety guidelines in all cases (ibid). Personal exposures over 12 hours varied between 1 044μgm^{-3} and 8 330μgm^{-3}, with a mean of 2 367μgm^{-3}. By comparison, the 24-hour level above which negative health effects have been observed by the WHO is 180μgm^{-3}. The fixed monitors located in the cooking areas reported average TSP concentrations over a 12-hour period of 1 558μgm^{-3}, while those in sleeping areas averaged 734μgm^{-3} over the same period. These exposures are far in excess of those measured in any of the urban studies previously conducted in South Africa.

The study also found that maximum hourly levels of gaseous pollutants were well above health guidelines during cooking periods. The average maximum hourly level of sulphur dioxide was 7 852μgm^{-3}, more than ten times the Department of National Health and Population Development hourly guideline of 780μgm^{-3}. Likewise, maximum hourly carbon monoxide concentrations averaging 80.41ppm were more than double the WHO standards of 35ppm (ibid).

The extreme levels of pollution measured in this study, have important implications for health and energy policy interventions. Given that approximately 40% of the South African population relies to a large extent on fuelwood for their energy needs, and with the high indoor pollution concentrations which frequently result, improvement of the rural indoor air environment must rank as a high national development priority. The fact that most rural households are economically among the poorest in South Africa and have been denied their fundamental political rights for most of this century are primary reasons for the lack of priority accorded thus far to research and appropriate interventions in the field of rural indoor air pollution. The seriousness of the problem demands that appropriate interventions be made to alleviate these conditions. In the first instance, a systematic national research programme is required to identify where the most serious risks occur, and what their effects are on health and the environment. Moreover, developmental interventions are required to provide for households' basic energy needs in a sustainable and affordable manner.

2.4.2 Paraffin poisoning, burns and fires

Further threats to the safety of household members, in the form of poisoning, burns and fires, are also posed by reliance of the poor on fuels such as paraffin, gas, coal and candles. The project referred to in the previous section also recorded safety data from 2 124 people in low-income households and found that 6.5% of the people surveyed had suffered poisoning from drinking paraffin, and that some people were reported to have died from the same cause (Terblanche et al 1992b:68-69). It was reported that South African data showed that paraffin poisoning represented a major cause of hospital admissions. In another survey conducted among over 1 600 unelectrified households in the Eastern Cape, 3.1% of households reported having suffered illness due to the drinking of paraffin (IPR n.d.:75, 161, 237,

322, 386). Furthermore, death had resulted from paraffin poisoning in ten households (ibid:76, 162, 237, 322).

In a study conducted by the Medical Research Council, patient data from six major hospitals in the Cape Peninsula were examined to determine the incidence and treatment cost of paraffin poisoning, and to identify high risk areas (De Wet et al forthcoming:1-14). A total of 436 children (63% male), and mostly between the ages of 12 and 36 months were treated for paraffin poisoning during 1990, at an estimated direct cost of about R112 000. According to the authors' estimates of the costs of producing one-litre child-resistant containers, the same amount of money would have been sufficient to provide 95% of *all* households in the eight highest risk residential areas with those containers. Alternatively, if all low- and high-risk areas were taken into account (that is, areas where at least one child poisoning incident occurred), then the direct treatment costs could have provided about 40% coverage. It should be noted that the above estimate represents an absolute minimum cost of paraffin poisoning, having taken into account only the *direct costs* of medical care, while omitting the costs relating to travel expenses to and from hospitals, time taken off work by parents, and pain and suffering by the patients. Moreover, the research indicated that poisoning rates were highest in summer months, when children are most likely to mistake paraffin for water or lemonade. From a policy perspective, it is clear that relatively low-cost interventions in the provision of child-resistant containers or bottle tops, could have a major impact on the rate of paraffin poisoning.

In addition to the risks of poisoning, the use of paraffin and candles presents a real fire hazard, especially in high density informal settlements where shelters are often constructed with wood and cardboard. Fires from accidents with paraffin, candles and even coal stoves have caused numerous deaths as well as the destruction of the

sparse possessions of inhabitants of informal settlements. In South Africa as a whole, burns are one of the top four causes of injury mortality in children under fourteen (Lerer 1993). In a study of all burn deaths admitted to the Salt River State Mortuary in Cape Town from January 1990 to December 1991, of the 358 burn fatalities identified, residential fires accounted for 75% of childhood fatalities with 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 child deaths. It is clear from this report that the use of non-electric fuels such as paraffin and candles are implicated in a high percentage of accidents resulting in burns and death.

2.4.3 Effects of fuelwood scarcity in rural areas

The dependence on fuelwood in rural areas has two dimensions: the *social* impacts associated with women's time spent collecting wood, and the effects on existing wood supplies.

Social impacts of wood scarcity

The responsibility for collection of fuelwood, the preparation of meals and a myriad of other tasks usually rests with women. Their social position in many rural communities, where little opportunity exists for expression of their needs, is one reason why the increased domestic burden caused by wood scarcity has had to be carried in much the same way as their other household responsibilities: without much hope for improvement in their load.

The effects of increasing scarcity of fuelwood is felt in many ways by rural households:

(1) *More time* is spent in the collection process. In Gandar's study conducted in the Mahlabatini district of Kwazulu, the average time taken to collect one headload of wood varied from about 2.5 hours in the valley lowveld areas where wood supplies were more abundant, to 4.5 hours in the high grassland areas (1984:3). Households required between two and three headloads per week, so that total time spent gathering fuelwood varied from 6.75 hours to just over nine hours. These are merely averages, and in one extreme case, he encountered a group of women who spent 9.5 hours walking a total of 19km to collect headloads weighing 40kg each (ibid:4). The people interviewed were certain that the distances they travelled to collect wood had increased; this perception was most emphatic among older women who could remember when wood supplies were closer to their homes. Similar results were found in Eberhard's study of six rural villages: average distances walked were from six to nine kilometres, two to three times per week, requiring 2.6 to 6.2 hours each time (1986:33-34). Bembridge and Tarlton (1990:89) reported similar results from a study in an area of Ciskei.

It is clear from these and other studies that women spend considerable amounts of time collecting fuelwood. Unfortunately, no longitudinal studies have been undertaken to measure trends in these variables in particular communities, although an indication has been obtained from the perceptions of the people themselves. In the majority of cases, it has been reported, especially by older women, that the time required for collecting wood has increased, as wood has become more scarce. In many respects, this is a very unproductive use of time. If fuel collection is included as part of food preparation, then in many cases, households spend more time preparing

food than growing it; clearly, not a productive situation (Gandar 1984:5).

On the other hand, it has been argued that the time spent collecting wood is relevant only insofar as it relates to the *availability of labour* (Leach and Mearns 1988:17). If surplus labour is abundant, then it may not matter that collection of fuelwood takes longer and longer; conversely, even if wood is abundant, a scarcity of labour may pose a very serious problem. Once again, this observation widens the analytical focus, from a concern only with an energy issue (availability of fuelwood), to a concern with broader developmental issues (labour availability). The division of labour between men and women is therefore also an important determining factor in households' coping strategies.

It is difficult to make generalisations regarding the availability of labour in South Africa's rural areas: the specifics vary considerably from one area to another. Nonetheless, the high degree of male absenteeism in many places which act as sending areas for the migrant labour system, means that, in general, women carry out most domestic responsibilities. This includes fetching water, and tending of fields and other agricultural work which may otherwise have been done by men. As a consequence, it is frequently the case that women's labour time is fully utilised, and therefore increased time spent collecting wood is not easily accommodated with surplus labour.

As the time required for food preparation increases, less time and energy is available for more fulfilling and productive tasks. These include farming, child-minding, home crafts, education, socialising and simple leisure time.

2) As the length of wood-collecting journeys increases, so women attempt to economise on time, by collecting *larger headloads* of fuelwood in order that fewer trips can be made. Again, no studies have been made of individual communities comparing changes in the size of headloads over time, but comparisons between communities with different wood availability supports the view that headloads increase in size as distance travelled increases. Bembridge and Tarlton, for example, found a large headload of 33kg being carried by a small, old woman who they estimated could not have weighed more than 40kg herself (1990:89). Table 2.10 below summarises the average number of headloads per week, the average mass of all headloads and the heaviest headload measured in a number of studies.

Table 2.10 Comparison of average mass of headloads, average collection trips per week per household, and heaviest bundles observed in various studies

Area and Study	Average mass of headload	Average trips per week	Heaviest headload
Amatola Basin, Ciskei (Bembridge and Tarlton 1990)	24 kg	5.1	36 kg
Mahlabatini, Kwazulu (Gandar 1983)	38 kg	2.3	-
Gazankulu (Liengme 1983)	30 kg	3.5	67 kg
Malefiloane, Lesotho Jozanna's Nek, Transkei Mashunka, Kwazulu (Best 1979)	21 kg 15 kg 21 kg	4.4 3.6 3.4	32 kg 34 kg 40 kg

While some variations from the trend occur, this data supports the argument that households making fewer (and normally longer) trips to collect fuelwood, carry heavier loads. This is (literally) a burden borne by women, and imposes extra stresses on their physical well-being; in extreme cases it is not impossible that spinal damage may occur (Gandar 1982:151). By any standards, carrying a headload of these sizes over long distances and rough terrain is a physically strenuous activity.

3) Researchers have identified several *coping strategies* adopted by households when faced with scarce wood supplies. Often these involve economising in domestic activities, such as improving the efficiency of fireplaces or cooking with more than one pot at a time. Sometimes, however, the responses are likely to decrease the overall welfare of the household. In some cases, fewer meals may be cooked, food may be cooked for shorter times, or it may be cooked in bulk and stored until a later meal; the lack of refrigerators in most rural homes means that food which has been stored for a few days may have become unfit for consumption (Eberhard 1986:38, Bembridge and Tarlton 1990:92).

Less time may also be spent on socially necessary functions, including recreation, spending time with children, family and friends, and cultural activities. The pressure on traditional social structures, caused by many other factors, may also be further increased for this reason.

4) Where households are unable to compensate for increasing scarcity in the ways described above, they may be forced to spend more of their incomes on *commercialised fuels*, including wood being sold by vendors. One of the striking

findings of Eberhard's study of six rural villages around the country, was the extent to which fuelwood had been commoditised (1986:35). In five of the villages, almost half of the households surveyed purchased some of their wood requirements. In a survey conducted for Eskom of three rural areas being evaluated for electrification planning purposes, Gandar (1989) found that in all three areas, expenditure on energy accounted for a high proportion of monthly income: from 15% to 17% (1989:13,26,39). From 68% to 86% of wood users purchased *all* their wood, and accordingly, expenditure on wood made up a large portion of the monthly energy budget. The commoditisation of fuelwood has also been reported by McClintock (1988:44) in a study of the Upper Tugela Location in Kwazulu, and by Eberhard and Dickson (1991:ii) in a study of two areas in Bophuthatswana.

In summary therefore, wood scarcity, coupled with unavailability of labour to collect it, imposes heavy financial burdens on already impoverished households. These costs are accompanied by a restricted set of choices regarding energy sources, especially in more remote areas where the prevailing costs of electricity, gas and even paraffin may be far beyond their financial means.

Effect of wood scarcity on the natural environment

It is not clear from the data which have been collected in South Africa, what the major driving forces behind fuelwood scarcity are. As will be described below, fuelwood scarcity does occur in many areas, and is, in fact, increasing in many parts of rural South Africa. As to the underlying *causes* of these scarcities, the experience in Africa and elsewhere suggests that the clearing of agricultural land carries

primary responsibility. However, it is not certain that this is the case in South Africa. Apart from the expansion of agricultural land, other possible causes of scarcity in South Africa include the collection of fuelwood, overgrazing by goats and other livestock, land clearing for settlement, and the multiplicity of other uses of wood for rural dwellers (construction material, medicinal uses and so on). Unfortunately the data in South Africa is insufficient to quantify the respective impact of each of these causes on fuelwood scarcity. Nonetheless, it does appear as though nearly all potentially arable land has already been utilised for agricultural purposes in the homeland areas to which the rural poor have historically been confined, and therefore that relatively little land clearing is still occurring in rural areas for agricultural purposes. This suggests that other processes such as fuelwood collection and overgrazing may be more important contributors to deforestation in South Africa than is the case elsewhere on the subcontinent.

Little doubt exists that fuelwood is becoming increasingly scarce in many rural areas. Beginning with a study of energy consumption in rural villages by Best in 1979, numerous studies have found situations of energy scarcity in areas relying primarily on biomass. Best's study included three rural villages: Malefiloane near Mokhotlong, Lesotho, Jozanna's Nek near Sterkspruit in the Transkei and Mashunka near Tugela Ferry in Kwazulu (1979:5). Only in the latter area were fuelwood supplies abundant, and consequently annual wood consumption in the areas of scarcity was considerably lower, with women in these villages remembering that wood has become scarcer and that standing trees have become smaller (ibid:25,71). In this paper, Best made the explicit point that firewood consumption cannot be singled out exclusively as the major cause of fuel scarcity: "the forces of agriculture, veld burning, overgrazing and settlement play dominant roles along with firewood collection" (ibid:71).

A study by Gandar in the Mahlabatini District of Kwazulu found that in spite of a large increase in population density during the period 1956 to 1975, the density of wood cover in part of the study area had increased by 38% due to shrub encroachment in rangeland (n.d.:4.5). The number of tall trees, however, had decreased by 50%, partly as a result of clearing land for farming. The other major reasons for the cutting of live trees were their use in the construction of huts and kraals, and their use in bush fencing. Gandar noted that during that period, the amount of dead wood available was certainly adequate to meet firewood demand. His observation was that people were prepared to walk long distances to gather dead wood before resorting to cutting down living trees for firewood.

These observations were consistent with the findings of a study by Liengme in a well-wooded rural area in Gazankulu (1983:245). Her results indicated that, while firewood was the major use for wood collected in the area, most of the live wood which was cut was intended for building purposes. Further, wood supply was adequate for the needs of the inhabitants at that stage, although it was expected that a combination of factors would threaten the sustainability of supply: population increases, fuel gathering for adjacent towns, escalating demand for agricultural land and wasteful harvesting methods (ibid:255).

In all of these studies, fuelwood collection was not seen as the primary cause of wood scarcity. This finding, however, was not confirmed in a study by Eberhard (1986), which included surveys of six rural villages (in addition to five peri-urban areas). In all rural areas of this study, respondents reported that wood was becoming increasingly scarce. The focus of the study on energy consumption patterns meant that other causes of wood consumption, such as for building or land clearing were not explicitly addressed. The fact that green wood was

observed in headloads of fuelwood (ibid:40), however, suggests that in these cases fuel use was at least partially contributing to fuel scarcity.

A study by Griffin et al (1992) from the Wits Rural Facility of six rural settlements in Gazankulu including one camp of refugees from Mozambique found that wood was the main source of energy in all 424 households surveyed. While some of the settlements appeared to have sufficient supplies of wood available in the vicinity, a demand-supply modelling exercise indicated that, even in the best-case scenarios, present consumption patterns of fuelwood would not be sustainable in the long-term (ibid:126). Many households were forced to use dung (against their preferences) or to purchase wood from vendors, even though income levels were extremely low. Again, it was not possible to apportion wood collection between energy and other needs, although measurements of the quantities of wood in buildings and other structures such as fences, indicated that a considerable quantity of wood stayed out of the cooking fire (ibid:69).

A study by Aron et al (1991:89) was the first to attempt to provide an aggregated picture of national wood consumption and supply. The study utilised a conventional gap analysis based on per capita wood consumption data which had been collected in a number of studies in the past decade. These average consumption rates were extrapolated across the total rural population in the homelands, to estimate total fuelwood consumption for 1980. Based on projected population growth rates for the ensuing 20 years, estimates were made of consumption in 2000. An estimate of the annual sustainable fuelwood supply in the homelands was also made, which yielded a slight overall surplus of fuelwood in 1980, but a large deficit by 2000. Although the study acknowledged the criticisms normally addressed at such analyses of fuelwood gaps, it nevertheless stated that natural woodland in the

homelands would be entirely denuded by 2020 "if demand were to remain at constant levels" (ibid:96), which it clearly would not. In spite of the usual limitations of this kind of calculation, the study served at least two important purposes: it was the first attempt to provide an overall picture of the national fuelwood situation, thereby opening the way for improved data collection exercises in the future. Secondly, its dire conclusions have made a strong impact on energy and development planners and agents, even if they have tended to focus excessively on the projection of complete deforestation by 2020.

The Department of Mineral and Energy Affairs has subsequently established a large project, the Biomass Initiative, the first phase of which entails a national research and data collection effort. This will include the use of satellite imagery to assess the severity of deforestation in various rural areas, with a view to subsequent development interventions. While the Landsat imagery being utilised is capable of producing high resolution images, it is also important that sufficient field studies are done to corroborate the results obtained. Research by Lane (1988:ii) showed that maps of ground cover prepared from remote sensing equipment revealed very little change in the area of woody vegetation, even though field studies indicated considerable qualitative degradation of vegetation structure. The remote sensing equipment used (aerial photographs, Landsat and SPOT satellite images) was unable to show up the more subtle forms of degradation, such as lower canopy height, and was argued to be most useful for identifying broad land-use types and settlements around which a high impact on vegetation are most likely to occur (1988:66).

Traditionally, discussions of fuelwood scarcity and deforestation have also addressed the use of *dung and crop residues* for energy needs. The conventional view was that the burning of dung and crop residues

represents a loss of fertilizer and nutrient value for the soil. In terms of the "energy ladder" formulation of household fuel use, dung and crop residues are inferior to wood and commercial fuels, with lower cost but also lower convenience (Smith 1988:30). While this energy ladder concept may have some intuitive appeal, it cannot account for all the social and economic complexities entailed in domestic fuel use. In particular, it is not merely income level which determines whether people will use commercial fuels such as paraffin and gas, but the *availability* of various energy sources. A large-scale study of dung use in the homelands by Bembridge et al (1992:51) found that the quantity of dung used was greatest for those households with the most cattle - these are also likely to be the wealthiest households. In other words, availability of dung was the key determinant of its use as a fuel, contrary to the view implied in the conventional energy ladder concept, which is that only the poorest households would use dung.

In other cases, it certainly is true that people resort to using dung and crop residues only when other preferred options are constrained. This may be the case when fuelwood is so scarce as to require lengthy collection periods, when it has become commoditised and is therefore beyond the means of cash-strapped households, or where people are unable to afford, or have no access to paraffin and other commercial fuels. Such people are faced with the unfortunate situation of being unable to meet their energy needs from freely available wood, or from commercial fuels, and therefore have little choice but to use dung or crop residues. The point is, however, that the *relative availability* of various energy sources is the key determinant in peoples' energy mixes, and that this does not bear any fixed relation to variables such as income level.

Bembridge et al (1992:49-52) found that dung was widely used for various domestic purposes in the homelands, with fuel accounting for

86% of the quantity used, followed in order of importance by floor cleaning, manure, plastering, decorating and medicinal purposes. Per capita use of dung for fuel varied widely between areas, and averaged 408kg per annum. Similarly, Eberhard (1986:45) found that a high proportion of households in the six rural villages surveyed, used dung and crop residues to supplement their fuel needs. Mean per capita consumption of dung was lower than in the study quoted above, ranging from 53 to 231kg per annum. In one village, dung provided approximately 21% of total energy value of all fuels (ibid:55). This was considered to be a symptom of increasing fuelwood scarcity (ibid:111). The environmental effect of this, however, was considered to be negligible. An estimation of total national annual dung production (from cattle, sheep, goats, pigs and chicken) showed that dung consumption for cooking and heating was less than 1% of total dung production (ibid:46-47). Dung was usually collected from the area closest to the home, and was still used extensively as a fertilizer in the fields. Gandar (1984:7) also found that domestic use accounted for only about 1% of total livestock dung production in the Mahlabatini area.

The assumption that combustion of dung and crop residues will lead to a decline in soil fertility is therefore probably an exaggeration giving rise to unwarranted alarm. Dung which is dry enough to be burnt at the fireplace, has generally lost most of its nitrogen and is therefore not particularly effective as a fertilizer anyway (Foley 1988:7). The analysis by Bembridge et al suggests that the effect on agricultural production of removing dung for domestic purposes is not significant (1992:67). In reality, the problem of declining soil fertility is frequently related to causes of instability in agricultural systems, such as increasing population densities, which place greater pressure on available agricultural land, thereby shortening the fallow period during which soil fertility is renewed. In South Africa, over-use of land is a result also of the state's resettlement policies carried out in the past.

It would therefore be simplistic and misleading to link poor soil fertility or low agricultural productivity with household energy use patterns when, in fact, they are more directly linked to the political, social and economic forces which have shaped the rural environment.

Several conclusions can be drawn from the preceding discussion. Firstly, no generalisations as to the *causes* of fuel scarcity can be supported with reliable data. In some international studies, it has been found that wood scarcity is caused primarily by competition for land from agriculture, and by cutting of wood for use in household construction. In other areas, wood supplies *have* been denuded by the collection of wood for energy needs. At the same time, few studies have attempted to assess the effect on biomass supplies of grazing by livestock. In summary, therefore, the causes of wood scarcity, and deforestation where this results, require specific investigation because of the variability of environmental, demographic, economic and social factors which influence the rate of wood consumption in any particular area.

A second conclusion is that wood resources are under increasing pressure in many areas in South Africa, for a variety of reasons, and as a consequence wood scarcity is an increasing phenomenon. In some cases, the scale of the problem is so severe that woodlands have become completely denuded. This most frequently occurs when large scale resettlements of people were engineered in terms of apartheid legislation, resulting in very high population densities without the provision of basic services (such as water or electricity), and without local economies which could support these populations. The Thornhill area in the Eastern Cape is an instance of an area where about 40 000 people were resettled from the Herschel district in 1976/77 (Daniel 1984:6). Daniel's personal observations were that within a few years, a previously "good cover of thorn trees and bush"

was reduced to a reddish patch of bare soil, with hardly a tree to be seen.

Thirdly, as the above example demonstrates, it is necessary to look beyond mere calculations of wood consumption and supply, to the complex array of political-economic and social factors which influence human-environment relationships. These range from questions of high population densities brought about by forced resettlements of large communities, to those of income-poverty, as well as poverty of choices available to people. By implication then, in order to derive solutions to environmental problems of woodland denudation, strategies are required which grapple with issues of equity, poverty, and basic needs - in short, developmental solutions are required. Narrowly defined solutions to environmental problems, located in either the environmental or energy spheres are unlikely to succeed in the long-term.

Finally, increasing scarcity of wood resources has numerous effects on the natural and social environments. Many of these combine to further entrench the burdens of poverty already borne by those affected.

2.5 Summary of salient points

A number of salient features emerge from the previous sections; these are important both to understand the characteristics of energy use by poor households, and to inform policies which seek to improve household access to energy services:

- multiple fuel use is common, even in households with electricity connections;
- coal is cheap and commonly used in the PWV region, but insignificant in most other areas;
- wood is the dominant fuel for cooking and heating in almost all rural areas; and is also used as kindling for coal in urban areas in PWV;
- paraffin is used by almost all unelectrified households;
- gas use is relatively low and is income elastic (that is, it is used in better-off households);
- wood and coal cause very high levels of pollution, which have severe health impacts;
- paraffin poisoning is common in infants, especially between 12 and 36 months; similarly, burns and fires are common in unelectrified households;
- candles and batteries (for lighting and media) are much more expensive than electricity would be if people had the choice;
- electricity is not the cheapest source for heating in many areas, especially where coal and wood are available;
- energy use and expenditure patterns are highly variable across space and time;
- the size, predictability and periodicity of income for the poorest households is highly variable and has a major impact on fuel purchasing patterns;
- generally, expenditure on energy poses a large burden on poor

households;

- particularly where households face fuel and resource scarcities, they have developed complex coping mechanisms or survival strategies;
- questions about data reliability cannot be ignored - these have been noted during the previous analysis of data;
- there has been no effective state intervention to date aimed at improving access to adequate energy services for poor households.

3 Key issues in urban energy use

This section explores a number of key themes in the urban energy sector: issues which affect the understanding of the problems and which influence the policy interventions which may be suggested.

3.1 The links between urbanisation and energy use

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.

Moving to the city opens up greater scope than exists in their rural homes for the poor to meet these needs. However, life is still harsh, and although opportunities may be created for the new urbanites, so too are constraints. As noted earlier, 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, and for some, open the door to social and material advancement.

Satisfying their energy needs is just one of the many challenges the urban poor face. 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.

Some of the general patterns which have emerged in South African urban areas are not dissimilar to those found in many developing countries. For individual households multiple fuel use is common, more so than in rural areas, 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 fuel prices, household incomes and access to different energy sources change.

This last phenomenon, described variously as fuel transition, fuel switching and interfuel substitution is of central concern to urban energy planners. It is through a better understanding of the energy choice and use process that the most effective policy can be formulated to provide the optimum response to the energy needs of poor urban households. Internationally there is still limited understanding of the process, although recent efforts have gone some way towards answering some of the key questions (Leach, 1992). This lack of knowledge is severely hindering effective energy policy formulation in most developing countries, and South Africa is no exception.

The conventional view of the "fuel transition" is closely tied to a *modernisation theory* of development, in which "traditional" (or primitive) households use "traditional fuels" such as wood, dung and

candles. As they are exposed to the "modernising" processes of development, often coinciding with their urbanisation, they begin to switch to the so-called "transitional fuels": paraffin, gas, and coal. Ultimately when they are "fully modernised" they abandon these fuels and move to the top rung of the energy ladder, namely electricity.

While such a model of fuel use may be intuitive, it is also simplistic and misleading. The choices people make about how to meet their energy services are more complex than suggested by their "stage of modernisation" and are influenced by a much wider array of structural and social factors. Moreover, the energy ladder concept does not easily cater for multiple fuel use, especially not from the top and bottom "rungs" as occur, for example, in some electrified households which continue to use coal and even wood for heating. The deterministic nature of the fuel transition theory also does not adequately explain the intricate and complex social relationships which have developed in many poor urban areas around the use of energy carriers and appliances. Similarly, an understanding of the constraints on improved access to energy services must be accompanied by an analysis of the structural conditions which influence households' actions in the energy sphere: for example, the variability of income flows, the lack of political power which hinders peoples' attempts to secure better services, and the internal power dynamics in households where women as the main energy users carry much less power in the decisions around how to obtain and use those energy services. In South Africa, these questions are very relevant to the current patterns of energy use in poor households, and must therefore be implicit in policy deliberations.

It is apparent that in the South African context, urbanisation is also accompanied by broad changes in fuel use:

- The potential for electrification of urban settlements is obviously more favourable than in dispersed rural settlements, because of the lower costs of electrifying them and their closer proximity to the centres of political power and decision-making.
- Access to commercial fuels such as paraffin, gas and coal is generally much easier in urban areas and these tend to play an increasing role in household energy budgets.
- Fuelwood use tends to continue in newly-urbanised households where wood is available although its use by second-generation urbanites is generally negligible.
- While urban households generally have a wider choice of fuels than in rural areas this also comes at a cost, because households have to pay for these fuels. In rural areas on the other hand, fuelwood is normally free. Consequently, poor urban households may be further stressed by having to lay out cash for what was previously a free service (in terms of cash cost, since the opportunity cost of labour time is generally not monetised in rural areas). This is often mirrored in other service areas such as water and sanitation, and refuse removal.

3.2 Urban housing policy developments

It is widely acknowledged that South Africa faces an enormous problem 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 which will also have to be satisfied 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.

Although it is beyond the scope of this study to provide a full analysis of current and expected housing policy developments, there are several important energy-related issues to address. Firstly, it is likely that there will be considerable interventions in the housing sector after the first stage of the transition to democracy, and this presents a unique opportunity to ensure that energy questions are given sufficient priority. For instance, energy efficiency concerns, which can have a very positive effect on households at the micro scale as well as on the macro-economy, can be given real emphasis in the planning and design of housing structures. Such simple measures as maximising solar insolation in cold areas by facing houses towards the north and using energy-efficient materials for ceiling insulation can significantly reduce household energy expenditures at minimal or zero initial investment. In essence therefore, the anticipated housing developments in coming years, even where these involve only site-and-service schemes, present an important "window of opportunity" which should be fully exploited.

Secondly, the spatial form of urban development also has energy implications. The typical pattern of sprawling residential settlements is much less efficient from an energy perspective than denser, vertical development. The heating requirements of medium-rise buildings, for example, can be more effectively met than for an equivalent number of often poorly constructed free-standing houses.

Thirdly, the historical pattern of urban development has concentrated the industrial and commercial bases in and near racially-defined white areas, while townships have a predominantly residential character. The implication of this for energy sources such as paraffin, gas, coal and candles is that they are generally "imported" to those areas from neighbouring white areas. The effect is threefold:

- The prices faced by end-users are often far higher because of the additional mark-ups of intermediaries and the additional transport costs.
- Most of the revenues from the sale of those fuels is exported from poor townships to the commercial base.
- Service standards and appliance availability is generally inferior to the conditions in urban centres. This is obviously exacerbated by current conditions of extreme violence.

In the case of electricity supply, the absence of an industrial and commercial base in townships means that their load profiles are dominated by residential peaks in mornings and evenings, with negative cost implications. This issue will be touched upon again in the electrification policy section. It should be clear that in all of these cases, urban planning and development can have a significant impact on the energy services of the poor, and these issues should therefore be given the appropriate attention.

A final area in which housing and urban policy will affect energy use is the institutional and financing one. The issue of who has responsibility for service provision (including, for example, electricity), and who has access to the financial bases which currently electrified areas represent, is an area of key debate in the National Electricity Forum and Local Government Negotiating Forum, and will determine

whether local, regional or special-purpose authorities can access the revenue bases from electricity trading. This will, in turn, affect the provision of other municipal services. This debate is also addressed in more detail in the section on electrification policies. Likewise, the financing and subsidy arrangements which may apply to housing and land development, may also include a component for energy services (specifically electrification), although as suggested later, the electricity sector may be able to rely on its own (internal) sources of finance for electrification and should possibly not divert resources away from other areas of social demand.

3.3 Energy and small-scale enterprises

The informal sector of the economy currently acts, by default, as a massive safety net for those unable to gain employment in the formal sector of the economy. A large portion of the 40%-plus unemployed workforce are engaged in some kind of income-earning activity which sustains them and their dependents. However, even though the total number of people in South Africa supported by the informal economy is considerable, relatively little of this activity results in any *value-added* in manufacturing or other activities. Much of the income generated in this sector is derived from the distribution and retailing of consumable goods which are purchased from larger retail outlets and resold in townships closer to peoples' homes.

Recent research carried out under the Industrial Strategy Project (ISP) has emphasised the weakness of the small-scale *manufacturing* sector in South Africa, both in terms of its size and the incomes it offers to participants (Joffe et al 1993:20). One of the key contributory factors in the underdevelopment of this sector, was found to be the absence of infrastructure (ibid:21). An essential component of this infrastructural support is *adequate energy supplies.* It can safely be suggested that

the absence of adequate, reliable and affordable energy acts as one of the constraints on the development of a small-scale manufacturing industry in South Africa. In most micro-enterprises, the preferred and required source of energy is electricity; the low level of access to electricity in the poor urban and rural areas is therefore a serious hindrance to the development of value-added capacity.

Very little South African data exists regarding current energy-use by small-scale enterprises, or regarding the extent to which a lack of electricity constrains their growth. Nonetheless, the general consensus from local and international studies of the role of electricity in informal sector activity, is that electricity is a necessary but not sufficient condition for the growth of small enterprises. Other constraints include lack of access to credit, low skills levels, low buying power from potential consumers, and various planning and legislative hindrances. Clearly, therefore, the single act of electrifying households, and of small businesses operating in or separately from households, will be insufficient to bring about huge growth of small-scale enterprises. Likewise, electricity alone will not result in massive productivity gains or the development of higher value-added enterprises such as small manufacturers.

Although the multiplier effect of electricity provision to the small-scale enterprise sector has not been estimated, it can be postulated that there will be more significant spin-offs than from electrification for domestic purposes only. Higher turnover and savings in small businesses generally mean that they are better able to afford large appliances such as fridges, freezers, stoves and other electrical goods, whereas households frequently struggle to afford new appliances and to get credit for their purchase. For instance, a review by Fakira of the available studies reporting on energy-use by micro-enterprises found that refrigerators are the most common electrical appliance used

(1992:47), whereas relatively few newly electrified households purchase fridges in the first few years after connection because of their cost and the need for other appliances (irons, kettles, etc). It appears, therefore, that the economic multipliers from electrification of micro-enterprises are greater than from domestic electrification.

The current and future electrification programme must therefore seek to maximise the opportunities for small-scale enterprises, especially those involved in manufacturing and value-added activities, to get access to the electricity grid. In urban areas, this will have technical implications, such as ensuring that the load requirements of machinery, welding equipment and the like can be carried by the distribution and reticulation system. A narrow focus by distribution authorities on the installation of readyboards (and nothing else) into peoples' homes would deny these enterprises the opportunities they need to grow and develop. Small-scale enterprises in *rural areas* generally take a different form, and have different needs. A possibility may be to concentrate resources in village-based community centres which have access to electricity, communications systems and other services and which serve important functions as social centres. In doing so, two benefits may accrue:

- The opportunities for people to engage in small income-earning activities will be facilitated; for example, electric cooling, heating and cooking equipment will allow households to trade in food and beverages. This can reduce household poverty in the short-term, especially insofar as their income levels may rise from such trade.
- Simultaneously, access to electricity or other energy supplies may facilitate the growth of value-added manufacturing and other activities. From a national economic perspective, this is desirable as a small-scale

manufacturing sector can play an important role in providing employment and as a basis for the development of medium-scale manufacturing concerns.

Given the significance of the informal sector it is important that policy-making acknowledges this sector's key role. In the energy sector, this may be assisted by ensuring their representation on the relevant stakeholder bodies at national and lower levels. In practice, the informal sector, is almost by definition, less visible and under-represented than its economic contribution warrants, so that proper representation and accountability may be difficult to achieve. Nonetheless, organisations such as NAFCOC (National African Federation of Chambers of Commerce) and FABCOS (Foundation for African Business and Consumer Services) may be better able to articulate the energy needs of small-scale enterprises than anyone else at present. In addition to their involvement in decision-making in the energy sector, they should also participate in other arenas such as the granting of credit to small businesses.

From the electricity utility's point of view, another reason for encouraging the growth of small-scale enterprises, particularly those involved in manufacturing, is that their electricity consumption pattern generally has a far better load factor than those of households. A stronger base of small businesses located in residential areas of supply (specifically townships) can thus improve the overall load factor considerably, thereby bringing down the real supply costs, as happens in historically white areas where there is good mix of residential and industrial or commercial electricity consumers.

4 Issues affecting energy use by rural households

4.1 A framework for rural development and energy service provision

Rural energy policies need to be located within a broader rural development policy framework in order to understand constraints and opportunities. In this paper, we devote some space to exploring a likely rural development framework for service provision as little as been published elsewhere.

Constraints on rural development

Development policies in rural areas face enormous constraints. The ability of a poorly performing national economy to deal adequately with redistributive demands is limited and hard decisions have to be made between competing social investments. The rural poor are the most marginalised and politically under-represented social formation. The inevitable result is that their concerns slip off the bottom of the political agenda and that macro-economic investment decisions favour the organised urban constituencies rather than rural communities. Rural communities are also generally unable to pay the full cost of services because of relatively high costs associated with distribution to dispersed settlements, their low incomes and the limited local economic base.

In addition to these economic constraints, there are severe institutional problems. A large inefficient, often conservative and sometimes corrupt bureaucracy exists in homeland administrations. It is essentially urban-oriented and ineffective in promoting or supporting rural

development. These institutions cannot be transformed overnight. Local government structures (tribal authorities) are weak and deficient. They suffer from problems of illegitimacy, poor capacity and inadequate finance. There are no institutions which undertake rural development planning.

There are also severe land constraints. The racial division of rural land has defined and determined the rural economy. The population density in "black, small-scale" farmland is nearly 80 times that of "white, commercial" farming. Possibilities for land redistribution will possibly be constrained by the privatisation of state-held land and by a proposed Bill of Rights which includes clauses entrenching property rights.

We need to understand the function of land. Is it for productive agriculture, subsistence or merely a place to live? Who are farmers and who just live there? One estimate is that nearly a third of rural households have access to neither arable or grazing land rights and that a further 56% operate below subsistence level. This means that only 230 000 (or 13%) of rural households in homeland areas can be considered small farmers, and just a fraction commercial farmers (Bembridge, 1986).

The different functions of land are mirrored in demographic movements. Household population growth is higher in rural areas than in urban areas. However, natural increases in the rural population will be offset by urbanisation and current rural population levels will more or less stabilise at around 14 to 16 million (two million households in homelands and about one million farmworker families in "white" farming areas). Over the next 20 years, the rural population will decline from 40% to 25% of the total population. At the same time there is significant backward and forward movement of households between

urban and rural areas. Links with rural areas are maintained for a number of reasons, including the desire to maintain a degree of social security by retaining rights to rural land and resources through being seen to be utilise land entitlements. Cultural links are also sometimes significant and urban violence has also contributed to re-migration. On the other hand the drought has led to a large (in many cases temporary) move to the cities. This perspective needs to be qualified by the fact that many rural households no longer have access to farming land.

These demographic shifts have a number of important rural development policy implications. New land rights and shifting tenure and land-use patterns will fundamentally affect the potential for marginal urban households to retain a level of rural social-security. On the other hand, improved security and access to urban land and housing will diminish this dependence on rural land.

There are also implications for decisions on investment in services such as energy supply. Infrastructure of service provision is usually expensive and is designed to last many years. It is thus critical to understand demographic shifts. Services can be provided much more cheaply and effectively in urban areas. Should investment in service provision be concentrated only or mainly in urban areas, or even rural towns? A counter argument is that it is still critical to invest in services and basic needs provision in rural areas for welfare and population development reasons. Both urban and rural development scenarios are bleak and we cannot ignore rural areas. Investment in basic needs fulfilment can create opportunities for local income generation, employment, skills enhancement and capacity building.

The previous discussion raises the question as to whether investment

in rural services and energy supply in the homelands should primarily be conceived as simply welfare and basic needs provision or whether services should also, importantly, support *production*. Are services for consumption or production? Does one support basic needs provision (within fiscal limits) and simply hope that there might be some productivity gains, or do we target services for production more specifically and extensively?

The resolution to this debate depends very much on one's perception or understanding of the essential character of underdeveloped rural areas. Are homelands simply "poverty-stricken retirement villages" and "disadvantaged consumer communities"? Or are there a large enough group of farmers where significant productivity gains could be made?

Underdeveloped rural areas originally facilitated social reproduction through subsistence land use by households left behind by migrant workers. Today, this welfare mechanism functions only partially through exploitation of rural natural resources (such as water, energy and a portion of food requirements), but increasingly through budgetary transfers - both public (from state pensions and services) and private (through migrant remittances). The average state welfare expenditure for the homelands is 42% of Gross Geographical Product, compared with 12% for South Africa as a whole and 13% for an "average" developing country (Mbongwa and Muller, 1992).

Homeland areas cannot sustain their existing population through indigenous economic activity; they will remain dependent on financial transfers until a more appropriate distribution of population and economic activity is achieved between them, "white" rural areas and towns.

Thinking and planning beyond homeland boundaries

Some of the above dilemmas begin to be resolved when there is convergence in thinking, policy formulation and planning between historically black and white rural areas. The challenges of greater agricultural productivity (including in historically white areas), land rationalisation and de-population in homeland areas, densification of previously white agricultural land, reversal of the decline of platteland towns and the distribution of existing support services including energy become possible when we start formulating a common and new vision of rural areas. We need to think in terms of regions - a different conception of development space from homelands, which were a creation of colonial conquest and apartheid.

In the transition, the potential to effect these changes will be greatest along the borders of the old homelands, and, indeed, in some isolated cases, is already beginning.

An integrated rural development strategy is thus proposed, which straddles the old divides and which ensures coordinated planning and mobilisation of development resources. This involves both spatial planning and the co-ordination of development activities and projects over time. Linkages are created between different institutions, government departments and similar sectoral programmes in order to maximise benefits.

An effective rural development policy would necessarily involve land reform, strategies to improve rural incomes, services to support production and basic needs, and the establishment of viable local rural government.

Land redistribution and new land tenure systems

Rural land is a productive asset. It is an important asset for coping with poverty and is used for residence and subsistence or partial subsistence. It can also be used for small-scale industry, forestry, and nature conservation which promotes tourism.

Given the skewed patterns of land ownership and access, land reform (in terms of redistribution and tenure) is fundamental to a rural development strategy. Redistribution is not simply about reclaiming land from forced removals. There is the bigger issue of equity. Various schemes have been advanced to achieve this, such as the World Bank voucher system for emergent farmers and land taxes to encourage productive use with the threat of loss of land for unproductive use. Ownership of under-utilised or speculative land would be reviewed. Farm sub-division will facilitate redistribution of previously "white" land. This will unlock much underutilised land - especially in DBSA development regions E and F.

There is a need to evolve flexible systems for land tenure. As the market economy grows, flexibility is required for individual choice. The market has to develop - but there needs to be protection for the dispossessed. There also has to be recognition of the value of partial subsistence production for local survival and consumption. We need to support emergent farmers but not at the expense of the other value of land which contributes to subsistence. A legal system is required to back local tenure and arbitrate around potential conflicts.

The rights of farm workers to land on commercial farms also needs consideration, both for partial subsistence and greater security of tenure. An additional option is the creation of farm worker villages.

Improving rural incomes

Greater access to cash incomes will enable the poor to make use of some of the more productive and effective poverty coping strategies discussed earlier. In the longer term real and sustained increases in rural incomes will only be possible if a viable rural economy is established. Strategies for improving rural incomes will involve agricultural development, sustainable management and harvesting of natural resources, targeted welfare transfers, public works programmes and small enterprise development. An important component in most of these programmes is the provision of adequate and affordable energy services.

Investments in production and service provision

Failure to build on productive rural opportunities will mean a continued, and potentially long-term, drain on an urban and industrial, productive economy to support a primarily welfare rural economy. There has been so little support for small-scale agriculture that much potential remains untapped. New policies, including energy supply, in support of small-scale agriculture are imperative.

Whether emphasis should be given to investment in energy for either consumption or production will depend on the primary character of the area and its production potential. Many rural areas will remain primarily residential in character. On the other hand, consideration should be given to potentially productive areas such as the wetter eastern seaboard.

Energy is an essential input into production. And energy services are needed for the provision of basic services, particularly for cooking food

and providing heat.

Government, Non-Governmental Organisations (NGOs), Community-Based Organisations (CBOs) and private sector roles in rural development service provision

In the absence of integrated rural development institutions and effective regional and local rural government, NGOs and CBOs have played a critical role in service provision and development. CBOs can be considered either as the starting point of new legitimate local government charged with the responsibility of providing services, or as a crucial component of civil society committed to pressuring and monitoring performance of the state. Either way, CBOs have an important potential function in ensuring participatory development planning and links between policy-making and local needs and preferences.

NGOs have a critical role in service provision where rural government is absent and where new models of effective and accountable service provision are necessary. In the medium to long term, NGOs should strive to integrate service provision within accountable regional and local government.

The state should retain ultimate public responsibility for particular services such as electricity. The level of the state at which these services are provided is discussed below. Fuelwood might be provided by either the state or privately, while hydrocarbon fuels (such as coal, LPG and paraffin) have been traditionally supplied by private companies.

The provision of services involves various functions divided between

different levels of government and other institutions. Appropriate functions of central or *national* government are policy formulation, central revenue collection and national resource allocation. It is at this level that overall macro-economic choices between different areas of state spending are made. Integrated development planning should occur at *regional* and district level to promote co-ordination, integrated resource planning and effective convergence between developed and underdeveloped rural areas. Rural *local* government should primarily represent the interests, needs and priorities of local consumers to regional and central government and to regional utilities. Poor communities also need to know the parameters of what can be asked for. Local community involvement and interaction is possible around the implementation of projects affecting them. The transformation of rural local government will be extremely difficult. One approach may be to offer accountable tribal authorities ex-officio status in elected rural government.

Rural local government might be supplemented by village development committees, NGOs and CBOs in service provision and development.

Operational and economic efficiency criteria may determine that services are often best provided by special purpose regional authorities, guided by regional and central development planning, with inter-regional financial transfers. Our proposals for a rationalised regional electricity distributors fall into this category.

Some of the risks and problems associated with service provision arrangements are urban domination, delimitation of regions, financial transfers, equity expectations, insufficient resources and loss of legitimacy or absence of accountability.

4.2 The role of energy in rural development

Based on the preceding discussion of a rural development framework it is important that energy provision to rural households be coupled with service provision aimed at enhancing productive activity. Consequently, the most effective mode of energy provision in remote rural areas may be to couple investments in domestic energy with communal and productive energy services. In practice, this may mean that rural clinics and schools are connected to the electricity grid first and that households be connected subsequently. Likewise, efforts in the petroleum sector should concentrate first on meeting the needs of small-scale farmers for fuel for their agricultural activities, and on the basis of, for example, improved distribution networks for diesel, extend this to include better distribution of paraffin and gas for household demand.

It will also be apparent that some transfers from wealthier urban areas to rural areas will be required, if a degree of horizontal equity is to be achieved in energy provision. In the case of electricity, for example, tariffs will have to contain an element of urban-to-rural cross-subsidy if electricity is to be affordable to the rural poor. Even so, electricity use will probably meet only a portion of rural energy needs; the bigger focus will be on fuelwood issues. Again, transfers will have to be made to rural areas to enhance the supply of fuelwood. Some of these issues will be considered in more detail in the following section which deals with policy issues.

5 Policy interventions

This section outlines a number of possible policy options which, it is argued, could have a significant impact on the level of access to adequate energy services for the urban and rural poor in South Africa. Although the sections considered coincide with the major supply sectors, it must be stressed that different fuels may be used for different end-uses; so, for example, electricity in rural areas may be used for lighting, radio and television, while wood will continue to be used for cooking and heating.

5.1 Electrification

A widespread and sustained electrification programme will be at the centre of attempts to address household energy poverty in coming years. 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. Moreover, electricity is a highly politicised service, with high expectations of future service levels held by millions of presently unconnected households.

The rate of connection of new households has increased dramatically since 1991, with a total of about 200 000 households being electrified in 1992. Of these, about 160 000 were made by Eskom, and the remainder by Durban, Port Elizabeth and other municipal utilities. While this represents a significant increase in the rate of connection of black residential areas, it will have a small impact on the backlog of unelectrified houses, especially in the context of rapid new household formation due to urbanisation and population growth. Consequently, if an electrification programme is to be stepped up and sustained for

long enough to electrify the bulk of households in South Africa, attention will have to be given to several problematic aspects of the electricity supply industry. These include the governance and structure of the industry, the electricity pricing system and financing arrangements. Each of these is discussed below.

5.1.1 Governance and structure of the electricity supply industry (ESI)

The current structure of the South African electricity supply industry acts as a major constraint on rapid and widespread electrification of urban and rural households. The historical and currently prevailing system of local government allocates the legal responsibility for electricity distribution to local authorities, which, given the highly fragmented nature of local government in South Africa, means that there are over 600 local authorities with legal supply rights, of which about 430 have exercised their rights (DMEA 1992b:14). The racial differentiation of local government means that black local authorities (BLAs), in addition to their political illegitimacy, generally lack the technical, financial and institutional capacity to electrify new areas or 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, with profitable returns from well-diversified residential and commercial customers bases (Steyn 1992:5).

One highly visible consequence of the fragmented electricity distribution industry (EDI) is the multiplicity of tariffs applicable to domestic consumers. Households in wealthy residential areas pay tariffs which are (often 8c/kWh or 30%) lower than those applied to consumers in newly connected townships - a situation which, on the face of it, appears to be highly regressive and is therefore politically

unpopular. There are several reasons for these tariff discrepancies. Firstly, new customers are generally paying off the capital connection costs through their tariffs, which accounts for a difference of roughly 6c/kWh. Secondly, because black residential areas generally lack the well-diversified customer bases of white towns, their load ratios are less favourable and therefore require more expensive distribution networks. Thirdly, there is no regulation of the distribution industry as a whole, so that all 430 distributors can set their tariffs at whichever levels they choose. In many cases, white local authorities generate surpluses on their electricity trading accounts, parts of which are applied to reduce property rates for other municipal services.

It is widely agreed that the present structure of the EDI will be unable to deliver electricity to the majority of the country's people, and that in the long-term, restructuring is required. In the interim, several important processes are under way. Firstly, an emergent trend is that Eskom is negotiating the take-over of the supply rights of larger local authorities, such as Khayelitsha and Soweto, and that it will make new connections itself or manage existing customers, as the case may be. Although these arrangements are likely to change as clarity emerges over the future structure of local government and the EDI in a democratic dispensation, in the meantime electrification is at least proceeding on this basis. Secondly, the future structure of the EDI is likely to be determined by fundamental debates taking place at national level. Most fundamentally, national constitutional negotiations are likely to establish principles regarding the powers and functions of national, regional and local tiers of government. Simultaneously, the respective working groups of the National Electricity Forum and the Local Government Negotiating Forum are specifically concerned with the structure of the EDI and the responsibilities for service provision.

Many possible models exist regarding the structure of the EDI, such

as a single vertically-integrated electricity utility, a single horizontally-integrated distribution authority, a small number (say 5 to 10) of regional distributors, and the retention of electricity service provision in democratic local government structures. Whilst it is not intended to pre-empt this debate, it is clear that *efficiency* can be enhanced by rationalising and aggregating the large number of distributors into a smaller number. Similarly, it is imperative from an *equity* perspective that the resources and needs of (respectively) wealthy and poor supply areas be consolidated. A high degree of regional autonomy and devolution of power from the centre may frustrate these goals, unless a national regulator is established and granted the power to direct the operations of regional electricity utilities. Moreover, horizontal equity (that is among comparable customers in different regions) 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 EDI in the long-term, such as the need to ensure the financial viability of the EDI 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 to avoid duplication of infrastructures or unproductive competition for resources. Many of these issues will be influenced by another crucial aspect of the future EDI: the nature and form of regulation. Whilst 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.

Guiding principles for the ESI

The current system of governance over the EDI involves a maze of

Guiding principles for the ESI

The current system of governance over the EDI involves a maze of local authorities, the Provincial Administrators, the Electricity Control Board, Eskom's Electricity Council and the Minister for Public Enterprises (Steyn 1993:10). It is widely recognised within the local electricity industry, as well as from international experience, that the system of governance and structure of the industry must be overhauled. Steyn and Pickering (1993:2-8) have proposed a number of principles to inform the future governance and structure of the ESI:

- 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).
- Governance must seek to maintain a *stable environment*, especially to facilitate access to low-cost finance.
- 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 division of the system of governance between federal and state levels can result in large inefficiencies such as in Argentina and the USA. The independent regulator should be composed of "technical experts" and should pro-actively mediate the relationship

between government and public utilities.

- *Planning* for capital investment, electrification and operations should be co-ordinated centrally.
- *Generation and distribution* functions should be *separated*, because of their increasingly divergent natures and the need to ensure that a "focus on the core business" can be retained.
- Distributors should be *larger* than *metropolitan areas* for three main 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.

The effect of these principles is that utilities will operate at arms-length from government, which has primary responsibility for setting policy, and that the relationship between government/policy-making and utility operations will be regulated and mediated by an independent national regulator. This kind of framework is conducive to more efficient and equitable development in the ESI.

5.1.2 Electricity tariffs

As in the case of the system of governance and structure of the ESI, the issue of electricity tariffs is currently receiving a considerable amount of attention from the National Electricity Forum and other key players. In addition, the issue of electricity tariffs is highly politicised because of (inter alia) perceived inequalities in tariff levels and service boycotts. Consequently, the process of revising pricing policy must acknowledge its politicised nature in the short-term, while attempting to ensure the long-term financial viability of electricity utilities.

Important short-term or interim goals in deriving tariff policies include

the following (Pickering 1993:1):

- minimising public conflict over tariffs;
- facilitating electrification at a rapid rate; and
- making tariffs affordable to the poor.

In the longer term, two additional goals become important:

- maintaining the financial viability of supply authorities, in order to sustain their ability to keep electrifying alongside their other responsibilities; and
- encouraging the conservation of electricity through the efficient use of the resource.

Clearly there are numerous possible tariff structures for domestic consumers, all of which have particular advantages. However, when evaluated against the above objectives, the options become more limited. Consequently, it is proposed that the system of domestic tariffs be rationalised so that there is a *single, national flat rate tariff*. This will have to be coupled with a mechanism to facilitate financial transfers between distributors in order to avoid large deficits and surpluses. In the longer term, the single flat rate tariff could be supplemented by a Time of Use (TOU) tariff for those consumers in a position to benefit by, for example, shifting their electricity consumption out of peak times.

This kind of tariff structure will have several advantages over the current diversity of tariffs in place:

- It will minimise potential conflict over tariff differences because all consumers will be paying exactly the same unit price.
- The flat rate for all consumption levels contains an

inherently progressive cross-subsidy from high-level (generally wealthier) consumers to low-level consumers (often the poorest) because real costs follow a declining curve.

- A single flat rate tariff is easy to understand.
- Whilst the incentive to conserve electricity will not be as large as if the tariff increased at higher consumption levels, it is an improvement on current tariffs, many of which are lower at higher consumption levels.
- The administrative costs will be almost as low as is conceivably possible in a billing system, and is compatible with the prepayment technology currently in use.
- The tariff can be set at a level which meets the overall revenue requirements of the industry.

Figure 5.1 shows the inherent cross-subsidy in a flat rate tariff, assuming relatively stable marginal costs and a fixed cost component in respect of monthly service and administration costs.

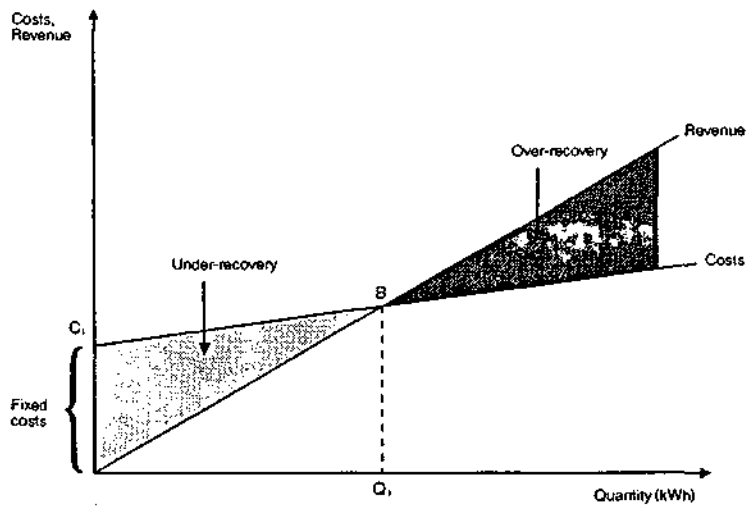

Figure 5.1 Revenue and cost curves for proposed flat rate tariff compared to real costs

It is apparent from the figure that provided the under-recoveries from low-level customers are balanced by over-recoveries, the supply authority will be financially viable in the short-term. The positive distributional effect is also evident. In the long-term, the authority may have a higher revenue requirement if it is to finance further investment (for example due to additional capacity expansion).

The Time of Use tariff is a particularly important tool in Demand-Side Management strategies to manage the pattern of energy demand more efficiently. Household energy use corresponds to the main domestic activities associated with cooking and space heating in the mornings and evenings. The result is that daily domestic electricity use is very uneven with high peaks at these times and relatively low loads in between. In order to satisfy these peak demands, the electricity system requires a more expensive mixture of generation and transmission equipment, thus providing an important reason to attempt to manage energy use more efficiently. 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, 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 1993:635). This peaky demand profile (as shown in Figure 5.2) is therefore an important reason why Time of Use and other demand-side management strategies can provide incentives to use electricity more efficiently and outside of periods of peak demand.

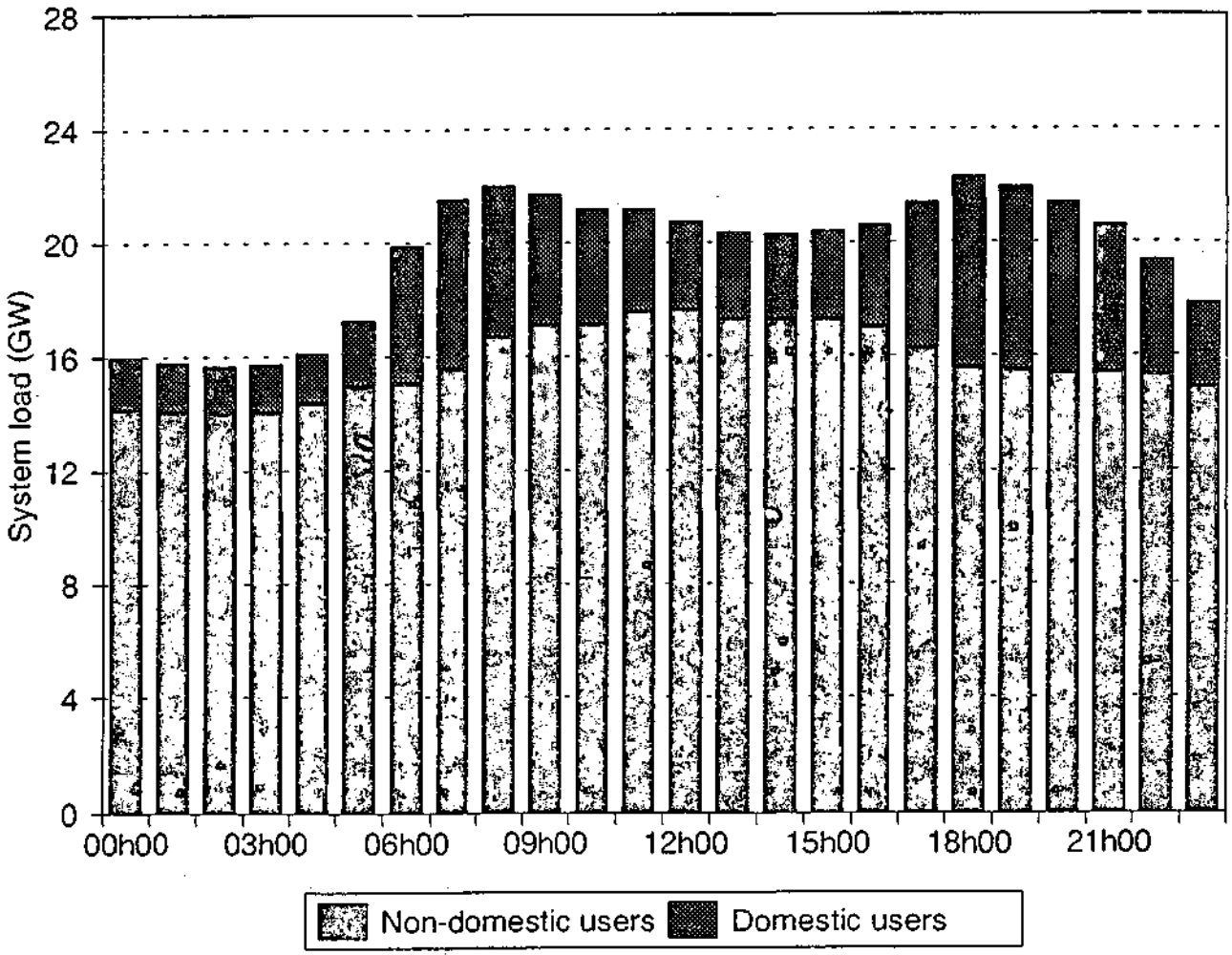

Figure 5.2 Profile of electricity demand on day of maximum demand
(Van Horen et al 1993)

A system of Time of Use tariffs should present benefits to households with large electricity needs (for example geysers, stoves, heated swimming pools) in that their electricity costs can be reduced by shifting these tasks to off-peak periods, and is obviously also advantageous from the utility and national perspectives insofar as the price system will more accurately reflect the real resource costs of providing electricity.

5.1.3 The financing of electrification

The ability to finance a national electrification programme is critical to its long-term success. Moreover, it is important that available sources of finance be utilised in such a manner as to deliver the maximum benefits to *all* low-income electricity consumers *over time*.

There are several specific issues that must be addressed in relation to the financing of electrification:

- the approximate *amount* of finance required for a national electrification programme;
- the *current sources* of finance in the electricity supply industry;
- ways of mobilising *additional sources* of finance be maximised, especially from the private sector; and
- if *grant finance* becomes available (for example from government or foreign donors), this must be allocated among all poor households in the most *equitable* manner.

The amount of finance required

Finance is required for two kinds of expenditure by electricity

distributors. The first and largest requirement is for the capital connection costs, which, although varying widely from case to case, are currently in the region of R3 000 per dwelling. Secondly, finance is needed to meet the shortfall between revenue derived from electricity sales based on a flat rate tariff, and the associated costs, for all levels of consumption which are below the break-even level (refer to Figure 5.2). Under Eskom's S1-tariff, for instance, the assumed break-even level is 350kWh/month. Clearly, many other factors will influence the total amount of financing required (such as monthly fixed service costs), but an order-of-magnitude estimate of the total costs of electrifying about 85% of all households within 15 years, would be R10 to R20 billion.

Current sources of finance in the ESI

There are several major sources of finance in the ESI at present. These are divided between Eskom and other distributors:

- Eskom raises loan finance on local and international capital and money markets (total debts of R28 billion in 1992) (Eskom 1993);
- Eskom generates surpluses from its operations (retained surplus of R1.4 billion in 1992) (ibid);
- many municipal distributors generate surpluses on the trading of electricity (total of R0.9 billion in 1988/89) (EDRC 1993:26);
- some municipal distributors raise loan finance from own sources, external capital markets or other sources (such as DBSA loans of 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 enough under the present structure of the distribution industry, because many local authority distributors other than Eskom, lack the capacity (as well as financial and political integrity) to raise sufficient funds to finance electrification. This problem could be alleviated in both the short- and long-term, by the establishment of an Electrification Fund.

Establish an Electrification Fund to raise and disburse bulk finance

It is proposed that an Electrification Fund be established as soon as possible under the auspices of the National Electricity Forum (Van Horen 1993). Subsequently this should come under the control of an Energy Policy Council (similar to the former National Energy Council). An Electrification Fund would have two main objectives:

- the *raising of bulk loan finance* for electrification;
- the *allocation of grant finance* to benefit all poor electricity consumers (across time) as equitably as possible.

Accordingly, there should be a Loan Fund and a Grant Fund to fulfil these two objectives. To illustrate how an Electrification Fund might operate, it is depicted graphically in Figure 5.3 and described briefly below.

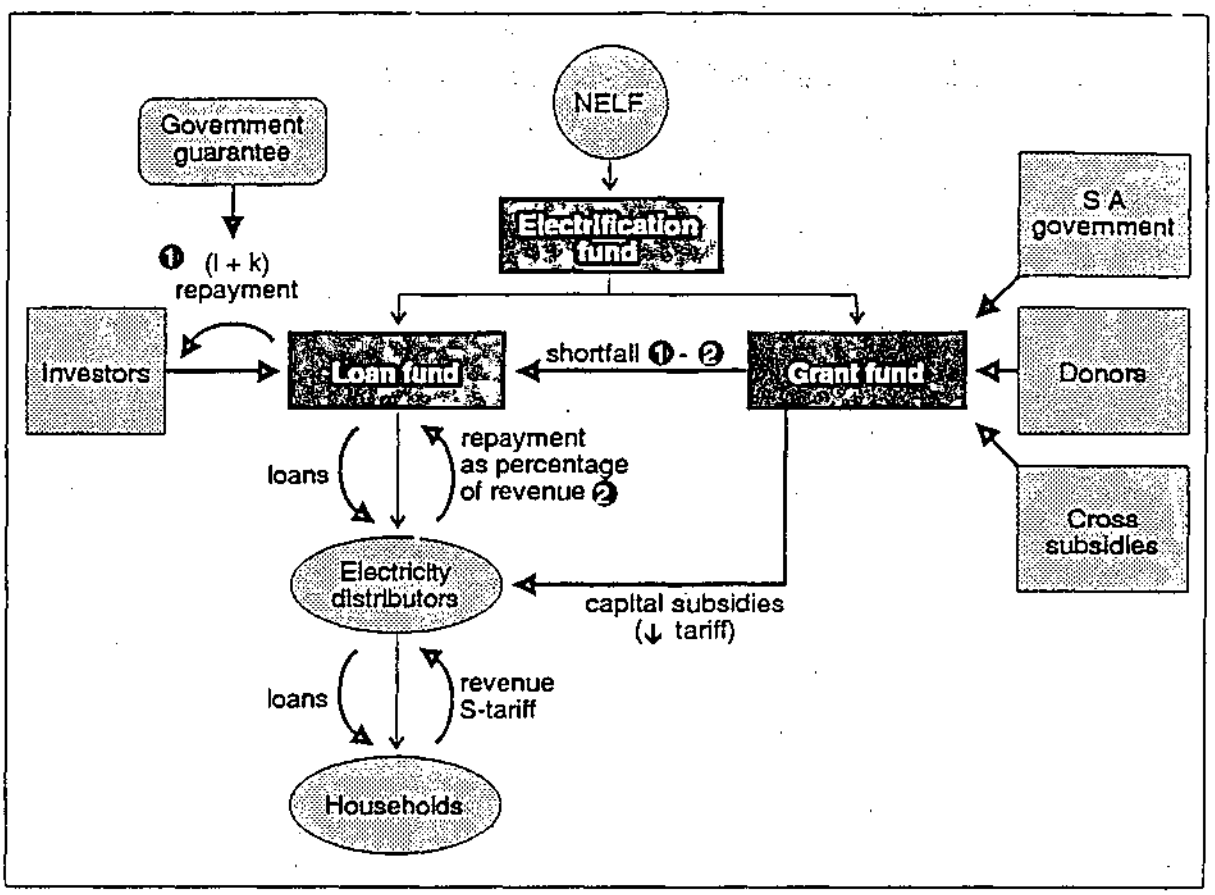

Figure 5.3 Proposed structure and operation of an Electrification Fund *(Van Horen 1993)*

- Firstly, an injection of seed finance into the Grant Fund is required, to provide a capital base to act as a loan guarantee fund. The amount could be in the order of R500 million to R1 billion.
- This 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 which can 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 through the fund.

- Thirdly, the Loan Fund would then on-lend to distributors to finance their electrification projects. These loans would be repaid to the Loan Fund by distributors as they recover their costs from subsequent 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, eight to 12%). Any shortfalls between this minimum and the actual return from electrification would be met from the Grant Fund and guaranteed by government so as to lower investors' risk further. The effect of this is that low-level consumers (generally the poorest) would be subsidised from this fund.

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

Grant finance to be allocated to households through the Electrification Fund

It is suggested that the guiding principle for the equitable allocation of subsidy finance, is that it should be applied to reduce the capital connection costs of all poor households; that is, all poor households, including both those who have been electrified in the recent past, as well as those to be electrified under the programme in the future. The Grant Fund can be utilised to achieve this objective:

- If the Grant Fund has sufficient resources to meet current and anticipated shortfalls in the Loan Fund, then any additional amounts could be allocated to benefit both current and future low-income consumers. The benefit would be passed on immediately to existing customers through a proportionate reduction of tariffs. The portion allocated to future customers would be held in trust in the interim and later disbursed to reduce their connection costs on a pro-rata basis.
- These allocations would be made to distributors in proportion to the number of new connections they had made, to reduce the 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.

The funding arrangements proposed here, and specifically the establishment of an Electrification Fund, have several important advantages:

- leverage effects and economies of scale can be maximised by concentrating the bulk financing function in one central point;
- joint management by the fund of loan and grant finance would achieve synergies such as through the simultaneous use of the Grant Fund as loan guarantee fund to generate further income and to attract further capital;
- subsidy finance can be allocated as equitably as possible over time, rather than benefiting only those lucky enough to be electrified at the right time - while

subsidy finance is available;

- the impact on price levels will be much smoother than if tariffs were reduced and increased according to the amount and cost of subsidy and loan finance available in any particular year;
- finally, this kind of financing arrangement is not dependent upon any specific structure of the EDI, and, on the other hand, will not constrain the future restructuring of the EDI.

Many other complexities have to be considered in establishing an Electrification Fund; however, there are no major impediments to the establishment of such a fund in the immediate future. It is possible, for example, that the high levels of expertise and experience in existing institutions (such as Eskom's Treasury Department) could be engaged on an agency basis to manage the detailed operations of the fund. This could facilitate the more rapid electrification of South African households.

5.2 Enhancing fuelwood security in rural areas

Within the context of the proposed rural development framework in section 4.1 above, energy services for consumption and welfare support are an essential component of rural development. Rural households are an important target for policies aimed at widening access to basic energy services. Poor rural households are located mainly in the homelands, but also in commercial farming areas. The discussion below is relevant to both homelands and commercial farming areas; conditions specific to farm-workers and their families are discussed separately below.

Rural energy problems are very much more difficult to address than

urban household energy issues. Households are more diffusely settled and the costs of infrastructure to distribute energy supplies is very much more expensive. The average length of electricity grid line per household connection will be longer. Other fuels such as coal, gas and paraffin have to be transported further distances and convenient transport is not always available. Thus electrification, although it may be desirable, will not always be the most cost-effective option. Another preferred energy carrier, bottled gas or LPG, is seldom available and difficult to transport. Rural households are also generally poorer than urban households and are less likely to be able to afford connection charges, delivery costs or new appliances.

On the other hand, many rural areas still have access to natural woodland and, in a few cases, fuelwood from plantations and woodlots. Fuelwood from natural woodland is generally free to harvest, but bears a heavy social cost in time and effort for collection. In those areas where woodland is most scarce, rural households have also to pay for the transport of fuelwood from other areas of surplus.

A contemporary analysis of the "fuelwood problem"

When devising appropriate energy policies for poor rural households it makes sense to start with the most commonly and widely used fuel, namely fuelwood. However, simple notions of desperate fuelwood scarcities and apparently obvious solutions of large-scale afforestation and dissemination of fuel-efficient stoves are being re-examined. As noted in section 2.4, it is no longer "obvious" that fuelwood gathering is the major cause of deforestation. Major reviews of studies in developing countries (such as Leach and Mearns, 1988) and local research in Southern Africa, for example in Botswana (ERL, 1985), Zimbabwe (Du Toit et al, 1984) and Zambia (ETC, 1987), indicate that agricultural practices and land clearing, rather than fuelwood collection,

are the major causes of deforestation. No equivalent studies have been undertaken in South Africa, but it could be argued that increasing population pressure on scarce land resources (aggravated by the homeland policy) has resulted in inadequate land for crops and grazing, overstocking, and the erosion of woody biomass resources as well as the soil. As rural people depend largely on arable and pastoral production for their subsistence it is often the woody biomass component of the system that is first placed under threat. Traditional management systems begin to collapse and deforestation and environmental degradation accelerate.

If this is true, then there are clear policy implications which turn previous simplistic proposals and plans for rural energy supply on their head. A new, contemporary paradigm is emerging which takes a fresh look at problems of supply and demand of fuelwood. Effective policies cannot be produced by energy or even forestry ministries *in isolation*, but have to be developed within the framework of agricultural and rural development policy, taking into account macro-policy issues such as population, land distribution, tenure and rights, and land management issues. A highly integrated and multi-disciplinary approach is required which not only incorporates a range of government departments, but which starts with rural people and begins to understand their responses to fuelwood scarcities.

A statement by the regional co-ordinator of the SADC Energy Sector indicates the way forward:

> The best way to ensure future woodfuel supplies, and simultaneously to prevent environmental degradation, is to improve the management of woody biomass within existing production systems based upon the innovations and responses already occurring among smallholder-

> farmers. For this operation to succeed at a national or even at a regional level, new relationships have to be developed between ministries responsible for energy, forestry, rural development, environment and agriculture ... These new relationships can be used to develop research and extension networks that will support woody biomass production by local farmers. This, of course, requires that strategies go beyond energy and forestry projects and are incorporated into as many other development schemes as possible (Munslow et al, 1988:i).

This new paradigm has great relevance for developing appropriate and effective policies to alleviate fuelwood scarcities in South Africa. We need to understand better the reasons for pressure on woody biomass resources in the homelands. There is also the associated question of the extent to which *commercial* agriculture has destroyed, and continues to destroy, woody-biomass resources. This is no longer an academic question, easily dismissed in the face of the economic value of agricultural output and the fact that commercial farmers have relied, in any case, on commercial fuels rather than biomass. Subsidies are being phased out for marginal commercial agriculture, and poor rural households, who rely on biomass for their primary energy needs, increasingly stake demands for access to this land outside the so-called homelands. The first policy implications of a new approach to the fuelwood issue may well be macro-policies for appropriate land redistribution. At the same time, we cannot ignore the imperatives of rural development in the underdeveloped "homeland" areas.

The new fuelwood paradigm requires not only an integrated development planning approach, it also encourages us to build on the responses rural people themselves make to fuelwood scarcities, that

is, managing natural woodland, planting trees, conserving fuelwood and switching to other fuels.

A proposed method for developing a fuelwood programme

The first step in designing a fuelwood strategy is to develop a clear statement of the linkages of such a programme with national and regional economic and social objectives, and also the linkages with other energy policy initiatives. The principal objective in the present analysis is to promote greater equity through widening access to basic energy services for the poor. This will include a focus on fuelwood for cooking in rural areas, but will also involve promotion of fuel-switching to paraffin and LPG and the provision of electricity in some areas for specific end-uses. Fuelwood strategies will be a central component of rural energy policy, but full account has to be taken of these complementary fuel strategies.

Secondly, it is necessary to construct fuelwood energy balances at a national and regional level in order to identify areas of greatest need in terms of both meeting basic energy needs of the poor and in protecting the environment. The construction of fuelwood balances requires regional estimates of both fuelwood production and consumption. Experience has shown that *supply data* is subject to much greater uncertainties than *demand data*. Remote sensing tools should be used for an initial assessment of biomass resources, followed up with selective ground verification. On the demand side, comprehensive demographic data on settlements, households and mobility variables is required along with a selected number of field studies of fuelwood and other household energy expenditure and consumption in a range of characteristic bioclimatic zones and settlement types. Table 5.1 gives a first approximation of areas of greatest fuelwood deficits. The current Biomass Initiative of the

Department of Mineral and Energy Affairs has a large data collection component and will enable this table to be refined.

Table 5.1 Estimated fuelwood supply and demand in homelands, 1990 *(Aron et al 1991)*

Homeland	Sustainable supply (Mt pa)	Estimated demand (Mt pa)	Deficit/(surplus) (Mt pa)
Bophuthatswana	552	603	51
Ciskei	256	175	(81)
Gazankulu	634	375	(259)
KaNgwane	130	125	(5)
Kwandebele	44	207	163
KwaZulu	475	2511	2036
Lebowa	794	1436	642
QwaQwa	0	56	56
Transkei	875	2311	1436
Venda	475	505	30
Total	4235	8304	4069

This stage aims only to gain an overall regional picture of fuelwood scarcity. Experience elsewhere in Africa has indicated that wood deficit areas are likely in "fuelsheds" close to metropolitan centres, low-rainfall areas with low biomass productivity and, paradoxically, highly productive agricultural areas with fertile soils, adequate rainfall and high population density - because of extensive clearing of woodland for agriculture (Hosier, 1990). Some rough indicators of fuelwood scarcity are: women walk longer distances; crop residues and/or dung are used in addition to wood; men assist with fuelwood collection;

carts and vehicles are used for collection; fuelwood is bought; and fewer meals are cooked.

The third step is the more detailed disaggregated demand and supply analyses of identified problem areas. Responding to reality implies grappling with detail. More thorough and disaggregated assessments need to be made of biomass resources and productivity and detailed studies need to be made of the energy consumption patterns of particular communities.

On the supply side, we need to find out what biomass resources are available locally, including state-controlled land and forests and what access there is to these resources. In terms of natural woodland and on-farm trees we need to find out about relevant indigenous knowledge and practices in natural resource management. Are there competing demands for wood products for construction, fodder, environment protection, shade, food, cultural or medicinal purposes which influence the effective supply of fuelwood? Is there competing commercial demand from urban fuelwood markets? And to what extent does the natural environment (climate, topography and soils) constrain biomass production?

To better understand biomass management practices, information is also needed on the land tenure, control of common resources, land distribution, and more broadly, the nature and extent of local institutions. Ideally, we need to understand overall livelihood strategies - the entire production and consumption system, both on- and off-farm. What is the dominant production form and how significant are external factors such as labour migration?

On the demand side, we need detailed information on demographic trends, social differentiation, income, household decision-making and

expenditure patterns, and current use of wood and other fuels.

This may seem to require an intimidating array of data. Techniques have been developed, however, to gather relevant data rapidly with the minimum of resources. Rapid Rural Appraisal (RRA) techniques usually involve a multi-disciplinary team going into the area of study for a brief period. The key characteristics of RRA techniques are that they are "iterative, innovative, interactive, informal, in the field and involving" (Molnar, 1987).

Based on this data and interactive meetings with affected communities a set of policy interventions are then developed, incorporating, where appropriate, local initiatives.

In analysing critical ingredients to successful projects, Leach and Mearns (1988) emphasise the importance of spelling out the relationship between the project participants and clarifying whose knowledge and resources will be employed. It is also recommended that projects start small, possibly as pilot projects and that there is flexible commitment over a long period. Indirect, low cost, multi-purpose projects with multiple, not necessarily measurable, products have also tended to be successful.

Munslow et al (1988:150) remark:

> It is one thing to have a clear idea about the strategy to pursue but quite another to be able to put it into practice. What are the absolutely essential ingredients needed to ensure success? There appear to be three: agents on the ground who are well-versed in this new approach; a genuine commitment towards ensuring popular participation; and integrating the efforts of the separate

institutions.

This may require the establishment of new, decentralised structures and extension services. But extension workers will need training in how best to use the farmer's knowledge, technical skills and practices. While there is a central role for the state in initiating overall and regional planning exercises, it will also make a great deal of sense to involve NGOs who are often best placed to understand local opportunities and constraints and who are able to secure population participation.

Growing and managing trees

There is growing consensus that large-scale state managed woodlots have not been successful in meeting fuelwood needs and that approaches should focus more on integrating trees into farming systems, for example, through agroforestry approaches. There also appear to be distinct economic and productivity advantages to on-farm tree growing as opposed to dedicated plantations. Agroforestry is still in its infancy in South Africa and there is a great need for more co-ordinated research into viable local systems.

The new paradigm advocates a shift away from institution-led forestry initiatives, often based on one fast growing species, to building on initiatives by small-holder farmers in managing woody-biomass.

An approach which appears promising insofar as wood supply may be increased, is the establishment of a network of nurseries to disseminate small trees to rural people. Assuming that such a programme aims to disseminate 40 million trees per year, this could be achieved through 4 000 nurseries each producing 10 000 plants per year; a provisional estimate of this cost is about R100 million

including the set-up costs, and about R80 million per annum thereafter (Gandar 1993). Although this appears to be a large sum, it can be put into perspective as follows:

- The utility derived by tree growers and beneficiaries is not simply an increased supply of fuelwood. As noted earlier, people value trees for a number of reasons of which fuel is only one. Trees provide fruit, fodder, shade, building materials and medicines as well as fuel. Consequently, this expenditure would contribute to a range of other social goals, and should be seen as part of broader development processes. In practical terms, this means that this amount should come out of the budgets of a number of government ministries: not only energy, but also forestry, agriculture, environment and rural development.
- Compared to other subsidies and flows of capital in the energy sector, for example, electrification costs and subsidies to the Atomic Energy Corporation and the synfuels industry, these amounts are not very significant.

Despite the problems, there is great potential to improve land management practices which can boost production and improve woody-biomass output. Best practice, discovered from local wood-users, is a starting point in managing natural woodland resources. The establishment of Resource Management Areas may facilitate better management of and control over existing wood resources.

Fuelwood conservation

Rural households are already conserving fuelwood, through using it more efficiently in carefully made fires, shielded from the convective

losses induced by wind. For example, only the ends of sticks and logs are exposed to the fire and quickly withdrawn and extinguished when the cooking or heating task is complete; fires are often made indoors, in specially constructed cooking shelters or behind wind shields. These simple measures can improve the cooking efficiency (that is the proportion of the energy value of the fuelwood which is translated into heat for cooking) from less than five per cent to more than 15 per cent. They can also be more effective than many so-called fuel-efficient wood-burning stoves, although the health risks associated with smoke-filled rooms has been shown to be serious (refer to section 2.4). Stoves, at the very least, can provide a cleaner, more healthy indoor environment.

Conventional approaches to the fuelwood crisis have always focused on fuel-efficient stoves which have aimed to improve the poor efficiency of open fires and thus to conserve scarce fuelwood resources. But there has been growing scepticism of this approach, reflected in Foley and Moss's influential 1983 review of improved cookstoves. "How much wood could a woodstove save if a woodstove could save wood?" they asked - intimating that many so-called efficient stoves were less efficient than a well protected open wood-fire. That was certainly the case for many of the early design efforts, characterised by every volunteer aid-worker, committed to the notion of appropriate technology, trying her or his hand at constructing a new fuel-efficient stove. Stoves cannot substitute for one of the valued properties of an open fire - its social focus - and many do not have the same power output possibilities, or efficiencies in space heating and lighting.

Nevertheless, there has been a serious international effort at developing improved stoves (Joseph, 1987). Some have been successful, such as the Kenyan *jiko*. Within South Africa, the main

wood (and coal) stove manufacturers produce large, expensive, up-market devices, more appropriate for urban areas or high-income farms. Laboratory test have shown these to be inefficient, sometimes less efficient, than a carefully made fire (Dickson and Baldwin 1990). Stove manufacturers have periodically produced lower cost designs but these have not been proved to be more efficient and have not achieved wide-spread sales. A well-funded multi-year project at the University of Cape Town resulted in a lower cost, more fuel-efficient stove, but although a trial batch manufactured by one of the largest stove producers were well received, no investment has been made for larger production runs (ibid). The barrier to successful production and dissemination of improved stoves is not the absence of a market. There appears to be sufficient evidence from rural development NGOs that many rural households would like stoves. Neither is the barrier one of design. The international literature and local research experience, have clearly defined the basic elements of a fuel-efficient stove design. One key barrier is production. Improved stoves will never make an impact unless they are produced and sold in large numbers. South Africa, unlike many poorer developing countries, has a well developed manufacturing sector which can produce robust, well-finished stoves at costs much lower than is possible by the informal sector. (This partly explains the weakness of the informal sector in manufacturing). However, large stove manufacturers are removed from this low-income rural market, are unsure of its extent and have little experience of appropriate marketing channels in remote rural areas. An appropriate policy intervention by government would be assistance to stove manufacturers to explore and understand this new market. Assistance could also be provided in technology transfer through funds being made available for manufacturers to employ experienced stove researchers to assist with production design.

A parallel intervention could be the promotion, by rural development

NGOs, of user-built mud-clay brick stoves. Experience with *Lorena* type mud-stoves, or lighter weight ceramic stoves has been mixed. They are subject to cracking and their lifetime can be as short as 18 months. Although cheap to build, there are potentially high hidden costs involved in training and dissemination. If these stoves are to be effective, then they need to be built according to well defined design principles and dimensions. There has been some interesting experience in the Clerkesbury area of Transkei where a number of stoves were built using locally made bricks and with a metal to overcome cracking problems. These stoves were well-received.

As with tree-growing programmes, an indirect approach incorporating multiple needs may be the most fruitful. Fuel-efficiency may not be the primary concern of the user and smoke removal from the kitchen may be much more important. It is vital that the stove design is pleasing, durable and low-cost, in addition to being fuel-efficient.

Fuel substitution

In parallel with the foresters who responded to the fuelwood "crisis", engineers (particularly those converted to the notion of appropriate technology) sought to substitute renewable energy technologies in the form of solar cookers and biogas digestors. But nowhere in Africa have these technologies made any impact and numbers produced and disseminated can be counted in tens rather than the tens of thousands required. An analysis of the reasons for the failure of these projects in the region may be found in Eberhard (1991).

Substitution of paraffin for fuelwood occurs, especially where there are fuelwood scarcities and since there is a remarkably extensive paraffin distribution network, even to the remotest rural area. Paraffin stoves

are also widely available in rural trading stores. Paraffin is used primarily for short cooking tasks or for heating water quickly, and for lighting. However, for meals which need to be cooked slowly over long periods, paraffin is a less suitable source of energy than wood. There would thus appear to be some limitations on massive substitution of paraffin for wood in rural areas, in addition to the major barrier which is cost both for the fuel and for paraffin appliances. Other fuels such as LPG and electricity still have very limited distribution networks in rural areas.

Fuel-switching away from fuelwood is much more of an option within the context of urbanisation, driven not so much by fuelwood price increases due to greater scarcity (which experience elsewhere in Africa shows does not necessarily occur), but by the availability of other fuels and the desire to improve living standards.

5.3 Paraffin and gas interventions

Paraffin and gas will continue to be major fuels for domestic use in coming years, notwithstanding the shift to electricity which will follow from the electrification programme. Both fuels are supplied by the major petroleum companies, with variable distribution arrangements coming into play further down the chain, particularly in the case of paraffin. The capacity of the petroleum industry and its distributors to supply these products is well developed, and is not constrained by foreign exchange shortages or lack of refining capacity. Rather, the main problems with paraffin and gas consumption at present include the following:

- there are very high increases in price between the wholesale and retail levels;
- households in remoter areas often face difficulty in

procuring these fuels, especially since both products are fairly heavy and difficult to transport; and

- there are significant safety concerns about the use of paraffin and gas.

A range of policies have been proposed to deal with these issues.

5.3.1 Affordability to households of paraffin and gas

A major advantage of paraffin and gas as domestic fuels is that the barriers to entry for household use are insignificant compared to electricity and coal. The appliance costs (mainly for stoves, but also for heaters and lamps) are generally low enough for households to be able to afford their purchase, either in cash or through credit arrangements from retail dealers. Moreover, in the case of paraffin, households are usually able to purchase fuel in small quantities to suit their budgets. The relative absence of financing constraints on the appliance and fuel purchase is one reason why paraffin use is so widespread.

This is not to suggest, however, that real savings cannot still be made in the distribution cost structure. This is particularly the case where retailers extract excessive mark-ups from consumers, or where the distribution chain has an inefficient structure (refer to Figure 5.4). Significantly, the low mark-up in Mmotong township was attributed to the fact that it was very close to an oil company depot, that is, the intermediaries' mark-ups were largely eliminated.

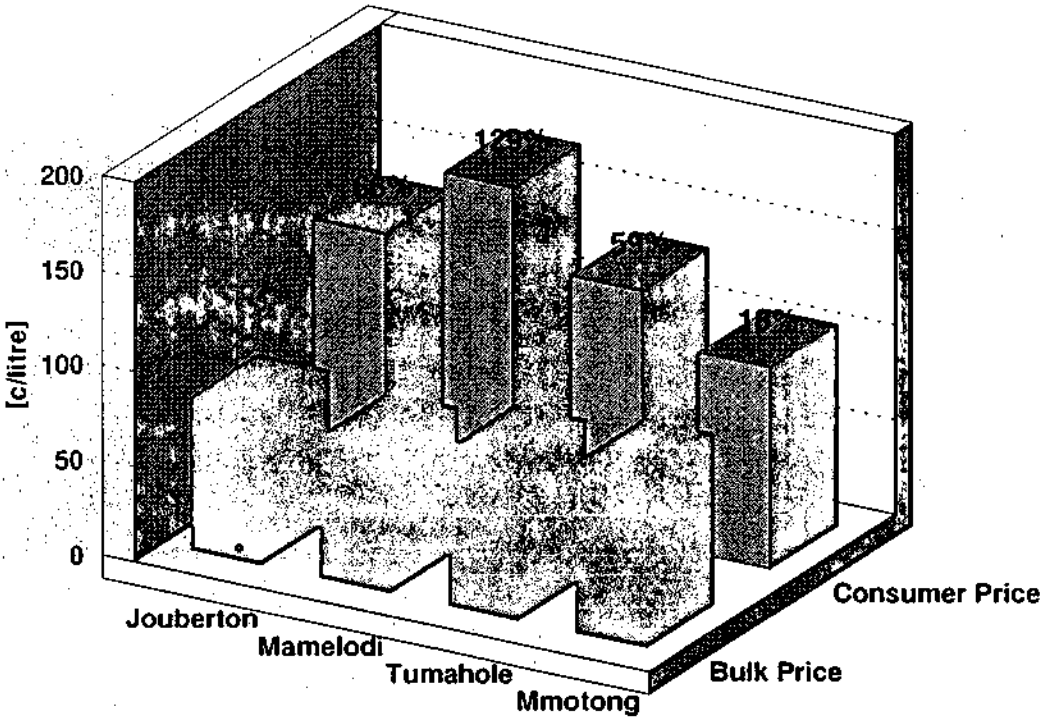

Figure 5.4 Paraffin prices at wholesale and retail levels in selected townships

Dealing firstly with paraffin, households purchase the product from a number of possible outlets. The most common, particularly in urban areas, are informal spaza shops and formal trading stores. Retailers are allowed a mark-up of 33.3% on the wholesale price, although retail prices are not monitored and often far exceed these levels. These mark-ups accrue to a very large number of retailers, many of whom trade in small volumes, and earn their incomes from this on-selling.

The previous stage in the distribution chain involves the intermediaries between the oil companies and marketers. Oil companies distribute their products (not just paraffin) to their depots, of which there are about 178 around the country, via the Durban/Reef pipeline, and/or by road and rail transport (EDRC 1993:59). Depots represent the wholesale level, at which prices are regulated by government. Included

in the regulated price is a component called the *service differential*, amounting to 9.7 cents/litre in April 1993, which is intended to finance the distribution costs related to delivery of paraffin from oil company depots to retailers. The service differential for paraffin is intended to be sufficient to remunerate both the oil companies for their costs and the "routers" who subsequently distribute the products to final retailers. These routers are therefore remunerated by a portion of the service differential (6.2 cents/litre), supplemented by discounts they may receive from oil companies reducing their wholesale margins. It appears that this distribution arrangement is relatively successful in maintaining a very wide distribution network for paraffin, although the mark-ups by the intermediaries and retailers mean that the prices paid by end-users are very high. Some of the policy proposals centre around this service differential arrangement - these will be described below.

A similar situation exists with the financing of LPG distribution. Although the gas price is not regulated by government in the same way, the same level of service differential is allowed for transport, handling and storage costs (9.7 cents/litre). This is also split between oil companies and other private sector distributors.

There are two possible interventions to improve the access to and affordability of paraffin and gas for poor households.

Increase the service differential

The motivation for this proposal is that an increased service differential will provide oil companies with sufficient incentive to distribute their products further down the marketing chain to the final retailers, thereby eliminating the excessive mark-ups currently extracted by intermediaries and routers. This would mean that the service

differential increase would be offset by a bigger decrease in the retailer or router margin, so that the price paid by the end-user would be lower. Essentially, the same distribution arrangements would then prevail as for petrol, where oil companies distribute their product directly to service stations (the retailers).

The socio-economic adjustments under this kind of arrangement would entail a financial shift away from the current intermediaries, in the form of reduced margins, with the benefits then being passed on to consumers through lower prices. The role currently played by routers would then be spread between them and oil companies entering the distribution sector, although the latter would be better placed to provide the transport and distribution service to retailers because they also have the benefit of their wholesale margins to make their involvement viable. While the effect of extending the oil companies' involvement further down the distribution chain may be to squeeze out some of the routers, or at least to reduce their profitability, any negative effects on their livelihoods could be offset by absorbing them and their operations into the oil companies.

In this way, by having better control over the distribution chain, it is more likely that the "regulated" 33.3% mark-up from wholesale to retail level can be achieved and managed.

Encourage bulk purchase by co-operatives and micro-enterprises

The intention in encouraging *bulk* purchases by end-users is to be able to buy directly from oil companies, at or near to the wholesale price, without having to finance the profits of the intermediaries. Within this overall policy suggestion, there may be several alternatives. Firstly, service station operators may be provided with finance from oil companies to install bulk tanks for paraffin and gas (as for petrol and

diesel), which would then be able to supply households and small-scale enterprises directly. Secondly, co-operatives could be established to buy the bulk quantities of IP and LPG. These would require fairly extensive support regarding the technical, marketing, administrative and financial services they would have to perform. This support would be significant if taken in isolation of any other similar initiatives. However, it may be possible to dovetail these kinds of co-operatives with others which may be established around building materials, agricultural produce, and so on. In this case, the extension support which would be required would benefit a number of aspects of community involvement. In the case of paraffin and gas co-operatives, it would be necessary for the oil companies to be involved, at least to ensure that technical and safety standards are adhered to, and they may therefore also be able to play a bigger role in financing the extension support services required for these co-operatives.

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. It is conceivable that viable small-scale enterprises could be established with the support of oil company and development finance institutions (such as the SBDC and DBSA) along similar lines to community-based co-operatives.

5.3.2 Health and safety aspects of paraffin and gas

Paraffin and gas are associated with significant real and perceived health and safety problems. Poisoning from accidental ingestion of paraffin by infants, and burns and fires from both gas and paraffin flames, and even explosions of gas containers are not uncommon occurrences. To the extent that paraffin and gas continue to be used by households, they will face certain risks, especially those mentioned.

However, these risks can be significantly reduced through a combination of education and publicity around safe use practices, and specific interventions such as the prevention of paraffin poisoning through the use of appropriate containers and lids.

Child-resistant paraffin containers and lids

As noted earlier, paraffin poisoning is a relatively common incident in paraffin-using households with children, especially those in which there are infants between 12 and 36 months of age. 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, is 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-resistant lids* for *existing containers*.
- Production and use of *containers* to match the child-resistant lids.
- In the long-term, possible *legislation* to tighten up safety regulations.

In principle, the responsibility for financing these interventions lies in the first place with the private sector players whose products are concerned (mainly the oil companies) and secondly with the government which has overall responsibility for maintenance of public health. It can be expected that a real expenditure saving will accrue to the government in the form of reduced health care for poisoning

victims once policy interventions begin to have an effect. Nonetheless, an argument for government intervention cannot rest upon an assumption that it will realise a direct saving on health care expenditure.

Firstly, *education and publicity programmes* (such as posters) 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 who produce paraffin. Experience with some posters to date has been disappointing because of ambiguity of designs used; this highlights the importance of careful design and involvement of communities in the process.

The most significant impact may be derived from *child-resistant lids* (or closures). The Medical Research Council (MRC) is centrally involved in research into the kinds of lids which might be used on the existing containers in which people store their paraffin. These containers include, commonly, used bottles from soft and alcoholic beverages. It is expected that lids will be designed so as to be produced at low cost (of around R1 each). It is possible that the lid manufacture process may be suitable for decentralised production by small-scale enterprises located in townships. It is probable that in practice there will be a need for both mass-production plants and these smaller micro-enterprise based processes. From the initial research conducted by the MRC, it appears that communities will respond favourably to this kind of intervention, and that they would be willing to pay the full price of such a lid if it is in the region quoted. 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, establishment costs

would have to be financed for manufacturers, so that institutions such as the SBDC, DBSA and the government should assist producers to gain access to the necessary finance.

A subsequent phase may involve the design and production of containers, which should probably fit the lids produced during in the first phase. This is an area, however, which requires further research into the acceptability of various container designs and the willingness of households to pay for them. Obviously this option will be more costly than the first. Similar financing and pricing arrangements will probably apply to this stage.

5.4 Low-smoke coal

An important part of an Integrated Energy Plan for South African households is the development of low-smoke coals, with a view to replacing conventional bituminous coals. This is particularly necessary in the light of the high levels of pollution which result from household coal combustion, and which have adverse effects on the health of millions of people who rely on coal for cooking and heating.

The prime motivation for the development of low-smoke coal (LSC), is therefore to alleviate the negative environmental and health impacts of coal combustion. At this stage, LSC has not yet been produced in South Africa on a commercial basis, 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 policies.

5.4.1 Current status of low-smoke coal

There are three kinds of LSC which are of possible interest. Each has different technical properties, cost structures and institutional characteristics, which are described briefly below.

(i) Enertek reconstituted coal briquettes

This fuel is produced by binding coal discards with cement to form briquettes, in the ratio of 100kg of coal to 15kg of cement and 21kg of water (Tait 1993). The cement acts as a binding agent and reduces the amount of particulates emitted upon combustion. Many households manufacture their own briquettes in this manner, although Enertek has attempted to optimise the product's performance through testing and further development. For example, the addition of a small amount of lime to the product may reduce sulphur emissions (although at a fairly significant cost). The three main components of the fuel's cost are the cost of coal discards from mining houses, the cost of cement, and labour costs. Distribution costs must also be considered, and will depend mainly on the distance from the point of production to the point of sale.

No detailed costings have yet been undertaken for this fuel. Enertek's preliminary estimates suggest that the production costs will be higher than the *wholesale costs* of conventional coal. However, it is entirely feasible that this product could be available more cheaply than the *retail prices* of coal. There are two main processes to make this kind of fuel. The first uses equipment similar to that used for brick-making, while the second is more labour-intensive, using large slabs. Some illustrative (and very preliminary) cost estimates are shown in Table 5.2. By comparison, conventional coal prices for households in the

PWV are in the region of R50/ton at the wholesale purchase level (that is, ex-mine), and in a wide range from R160 to R320/ton at the retail level (Palmer Development Group 1993:26,61).

Table 5.2 Preliminary cost estimates for Enertek low-smoke coals

(R 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

Of the cost components, cement prices are essentially fixed. While the quantity of cement used could be reduced, this would decrease the product's technical performance and therefore its acceptability. The other main cost components are, however, considerably more variable. Discard coal is not traded at present and it is 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 has, if anything, a negative value because of the costs of disposing of it safely. It may therefore be possible to negotiate

favourable terms for the use of discards which are suitable for LSCs.

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 co-operative 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 could be utilised for training and extension work.

The preliminary costings shown in the table above suggest that this type of LSC may have an important role to play. Some financing options will be explored below.

(ii) Wits/UCP devolatilised coal

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

The main cost components of the production process are the discard coal and the heat which is applied to the fuel. The product will be

economically viable only if both of these are by-products or waste products. Again, no detailed costing exercises have yet been performed, but it appears that this kind of LSC can be produced at a cost which will make it competitive with normal coal. This is because waste heat is utilised from UCP's industrial char production process, while suitable discard coal can be accessed at a low price (possibly around R10/ton) from mining houses. It may therefore be possible to produce this kind of LSC at a price which will not require any external subsidy finance.

(iii) "Wundafuel" solid fuel blocks

A private company based in Lesotho, called Ecofuel (Lesotho) (Pty) Ltd, recently began to produce and market a solid fuel which also uses waste coal and binds it into small coal briquettes. The product, called "Wundafuel", is marketed commercially as a smokeless alternative to gas and paraffin, although it is technically a closer 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.

From a narrow cost perspective, 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 retails at a price of R1.00 to R1.20 per kilogram, with output levels at approximately 120 to 150 tons per month (Roux 1993). With improved packaging, and if economies of scale can be achieved through expansion into a number of plants around the country, the manufacturer estimates that these costs can be reduced to about R0.50 per kilogram, 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 its lower smoke emissions, its ability to light

within a few minutes, and the fact that it can burn on the ground (like wood) and therefore does not require an appliance. Consequently, 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 gas - these are currently the main target market segments of Wundafuel.

5.4.2 Policy proposals

It would be premature to make detailed policy proposals regarding the pricing and financing arrangements which are required to promote the use of low-smoke fuels in households which currently use coal. Further technical, economic and social research is required before financing and pricing mechanisms can be designed. Nonetheless, various financing policy proposals, at the level of principle, are presented below.

(i) Intervention is essential to mitigate economic costs imposed by coal use

Research into the use of coal by households suggests that the pollution levels which result cause significant health problems for the millions of people who are exposed on a long-term basis. These health effects, in turn, carry major economic costs, such as the direct expenditure on health care services by affected households and the state, and loss of time for productive activity due to illness and absence from work or informal income-earning activities. Other indirect costs are imposed by pollution from coal use, such as lower quality of life for inhabitants of polluted environments, as well as the contribution to global and regional environmental problems such as global warming and acid rain. While these links may be less direct, it is clear that on

the whole, coal combustion by households carries huge costs, many of which are borne either by households themselves, the state, or society at large. On this basis, therefore, it is considered imperative that, *in principle, energy policy-making actively intervenes in the household coal market*, so as to encourage a shift away from conventional coal, to energy sources which have less serious environmental problems. An important component of this is 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.

(ii) ***Legislation may be appropriate once alternatives are available***

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 alternative energy sources are available for use by households, which do not impose any additional financial burdens on them.

It is therefore proposed, that as a matter of principle, *air pollution legislation could be implemented in townships*, to eliminate the use of conventional coal, but that this should be done *only* once households have *access to affordable alternatives* such as low-smoke coal (or electricity). This means that low-smoke coal should be priced so as to be more-or-less competitive with conventional coal prices. The implications of this will be made explicit shortly.

(iii) ***Encourage those low-smoke coals which may be commercially viable***

It is possible that some of the low-smoke coal prototypes may be

produced on a commercial basis, either for the target market of this discussion, or for other more wealthy market segments. Clearly, the ideal situation is one in which low-smoke coals 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 low-smoke coals by indicating that low-smoke coal will be supported through further research, that 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 Department of Mineral and Energy Affairs 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.

(iv) Two potential sources of subsidy finance

Working on an assumption that some form of financial subsidy will be required to make LSC more attractive to households, there are two main sources of finance which present themselves as theoretical options. Firstly, production costs could be subsidised *directly from the fiscus*. There are several possible justifications for this option:

- 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 low-smoke coal 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.

- The state has a responsibility to improve the material living conditions of the vast numbers of people suffering from preventable health problems. In principle, therefore, it is necessary for the state to actively intervene in the domestic coal market, and this may best take the form of direct subsidisation of LSC.
- Indirect economic benefits should accrue to society as a whole and therefore also to the state, through an improvement in quality of life of a large number of people, which can be expected to cause a general increase in productivity of those people, having an impact on their income-earning activities.
- In the same way as economic benefits will result in the longer-term, so will political benefits follow, if the state is seen to be active in improving peoples' access to cleaner sources of energy.
- South African precedents exist 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 low-smoke coal subsidisation are,

in principle, uncontroversial. This is not to ignore the many other factors which require consideration to make state involvement effective.

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 low-smoke coal. 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 costs 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 local and exports sales. For instance, if the financing requirement for LSC subsidisation amounted to, say, R60/ton (a very cautious estimate), then an annual subsidy to completely replace conventional coal use (currently about 3 million tons per annum) would have to be in the region of R180 million. 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 FOR (that is, Free on Rail, or ex-mine) prices (DMEA 1992:26-27). 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 expenditures. There may be a negative macro-economic impact 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.

(v) Continued state support for low-smoke fuel development in short-term

It is clear that it will take some time before low-smoke coals are widely available for household use in South Africa. Consequently, it is proposed that the Department of Mineral and Energy Affairs should continue to support research efforts in this area with a view to facilitating and expediting the development of low-smoke fuels. 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 amount of pollution emitted, the ability to ignite easily and the length of time the fuels

burn.

- Also necessary before mass production can commence 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.
- Another important issue which will have a direct impact on the costs and financing requirements is the potential for *direct community and individual involvement* in LSC manufacture and marketing. It may be feasible, for example, for the state to support the establishment of labour-intensive co-operatives which could manufacture the briquette-type fuel at low cost. This would improve income-earning opportunities for poor communities and households and would simultaneously reduce the leakage of funds from townships. A range of methods of production may be feasible, and these should all be adequately investigated.

6 Conclusion

This report has provided an assessment of current patterns of energy use in poor urban and rural households in South Africa. It is evident from the data which exist that access to energy services is highly variable both across and within regions and that this differentiation is linked to the deeper political and economic divisions entrenched by apartheid. The majority of the country's poor black households lack access to electricity, whereas almost all white households, even those on rural farms, are connected to the grid. As a result most unelectrified households rely on a mixture of fuels which include coal, wood, paraffin, gas, candles and batteries.

In rural areas, wood use dominates for heating and cooking purposes, with adverse impacts in terms of pollution exposures and the amount of time spent by women in the collection of fuelwood. In urban areas, fuel use is more variable, depending on access to electricity, coal, paraffin and so on. The colder townships in the PWV area tend to rely heavily on coal for cooking and heating and consume larger amounts of energy in absolute terms than other regions. Although coal is very cheap and easily affordable for most of these households, it has a severe impact on indoor and outdoor air environments in these areas, with adverse effects on the health of exposed populations. In most other urban areas, coal plays a much smaller part in household energy budgets and instead paraffin is the dominant fuel for cooking and heating. The use of paraffin and other fuels such as candles result in high risks to households of paraffin poisoning, burns and fires from accidents. These hazards are yet another aspect of poverty which serve to place additional strains on poor households.

While it is apparent that very large numbers of households face a situation which may be termed "energy poverty", it is also apparent

from an analysis of the policy options which exist that a significant impact can be made on alleviating this situation in a relatively short time. Chief among these policy options is an accelerated electrification programme, which, in turn, depends on three main conditions: the restructuring of the electricity industry; the rationalisation of existing tariffs and establishment of affordable and viable tariffs; and the establishment of appropriate financing arrangements. Provided these requirements are met, it will be possible to increase the percentage of the population with access to electricity from its current level of less than 40% to over 70% by the end of the decade and over 80% by 2010. This is a highly symbolic and visible area in which a democratic government can meet the aspirations of the newly-enfranchised.

At the same time as proposing an ambitious electrification programme, it is recognised that electricity, alone, will not be an adequate solution. Consequently, a range of other policies have been proposed which collectively can improve the economic, environmental and social conditions related to energy use by the poor. These proposals included the establishment of a national programme to replace conventional coal with low-smoke coal in households on the grounds that the impact on environment and health are currently so severe as to demand intervention. Other important components included a programme to improve the security of fuelwood supplies and to make paraffin and gas more widely available in townships and rural areas at lower prices.

Based on the combination of these policy options, it is possible to make rapid and visible gains in improving access to adequate energy services for the poor, in this way having a positive impact on the levels of impoverishment experienced by vast numbers of South Africans.

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Appendix

TABLES OF DATA

TABLE A1 Categorisation of South African dwellings, 1990

	Number of dwellings
Mid-to-high income	1 949 931
Formal electrified	395 419
Formal non-electrified	520 612
Planned informal	518 840
Unplanned informal	399 705
Backyard shack	634 582
Rural	3 185 897
TOTAL	7 604 897

TABLE A2 Monthly household energy consumption in the PWV, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack
Coal	1223	4258	4320	3100	324
Gas	5	20	20	20	69
Paraffin	115	863	879	718	148
Candles	5	10	144	114	124
Wood	210	306	306	168	306
Electricity	1800	0	0	0	45
Total	3358	5457	5668	4119	1016

TABLE A3 Energy expenditure as a percentage of household monthly income in the PWV

	Formal house	Informal house	Planned informal	Unplanned informal
R0 - R399	19.3	52.2	41.0	27.8
R400 - R799	13.9	16.0	12.2	10.7
R800 - R1199	14.1	10.4	6.8	6.9
R1200 - R1599	8.1	8.7	5.1	7.3
R1600 - R1999	4.7	0	7.3	4.7
R2000 +	3.5	0	1.9	2.5

TABLE A4 Monthly household energy consumption in the Durban/Pietermaritzburg region, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack
Coal	405	1620	1080	608	81
Gas	10	348	368	323	216
Paraffin	16	799	969	918	185
Candles	47	2	121	93	101
Wood	17	387	128	128	510
Electricity	1440	0	0	0	45
Total	1935	3156	2665	2069	1137

TABLE A5 Energy expenditure as a percentage of household monthly income in the Durban/Pietermaritzburg region

	Formal house	Informal house	Planned informal
R0 - R399	20.2	32.0	14.8
R400 - R799	11.4	13.3	8.9
R800 - R1199	8.8	9.0	7.5
R1200 - R1599	7.7	4.7	6.1
R1600 - R1999	5.6	4.5	5.6
R2000 +	4.6	1.3	6.1

TABLE A6 Monthly household energy consumption in the Cape Town region, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack

Coal.	1	0	81	81	12
Gas	44	355	230	230	66
Paraffin	135	740	879	810	370
Candles	1	171	58	58	23
Wood	5	295	213	213	204
Electricity	1756	0	0	0	45
Total	1942	1561	1461	1392	721

TABLE A7 Energy expenditure as a percentage of household monthly income in the Cape Town region

	Households
R0 - R199	37.8
R200 - R399	20.4
R400 - R599	12.6
R600 - R799	8.4
R800 +	9.4

TABLE A8 Monthly household energy consumption in the Port Elizabeth/East London region, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack
Coal	0	55	5	27	0
Gas	79	207	89	63	45
Paraffin	271	710	674	736	763
Candles	1	17	23	16	5
Wood	0	109	216	171	102
Electricity	900	0	0	0	45
Total	1252	1098	1007	1013	960

TABLE A9 Monthly household energy consumption in Kimberley, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack
Coal	501	1086	173	76	24
Gas	0	343	44	0	15
Paraffin	76	749	951	952	185
Candles	104	97	65	65	47
Wood	54	1180	340	43	204
Electricity	684	0	0	0	45
Total	1418	3454	1573	1135	520

TABLE A10 Monthly household energy consumption in the

Orange Free State region, in delivered MJ

	Formal electrified	Formal non-electr	Planned informal	Unplanned informal	Backyard shack
Coal	49	1490	3993	2803	24
Gas	15	48	127	251	25
Paraffin	111	581	966	879	185
Candles	6	166	79	124	56
Wood	34	391	476	404	306
Electricity	720	0	0	0	45
Total	934	2676	5641	4460	641

TABLE A11 12 hour concentrations of Total Suspended Particulates in PWV residential areas compared to WHO guidelines

	TSP exposures (μgm^{-3})
Urban electricity users	310
Urban coal users	1363
Rural wood users	2367

TABLE A12 Monthly mean fine particulate concentrations in Soweto, August 1990 to July 1991.

	Particulates (μgm^{-3})
August 1990	170
September	100
October	55
November	37.5
December	31.5
January 1991	30
February	51
March	74.5
April	130
May	170
June	202.5
July	269

TABLE A13 Diurnal distribution of mean fine particulate concentrations in Soweto, July 1991

Time of day	Particulates (μgm^{-3})
01h00	127
03h00	100
06h00	211
09h00	418
12h00	62
15h00	62
18h00	933
21h00	356
24h00	147

TABLE A14 Average monthly household energy expenditure by different income groups at the *coloured reserves* at Namaqualand (Rands)

Settlement	R0-R300	R300-R600	R600-R1200	R1200-R2000	>R2000
Pella	47	52	79		222
Leliefontain	32	56	76	101	109
Concordia	48	87	97	123	131
Steinkopf	91	108	131	165	182
Richterveld	26	62	111	149	168
Komaggas	108	144	197	217	244
% income spent on energy	28	20	12	9	5

TABLE A15 Average monthly household income and expenditure on energy in the *coloured reserves* of Namaqualand

Settlement	Income (R)	Energy expenditure (R)	% income spent on energy
Leliefontein	456	58	13
Pella	513	74	14
Concordia	616	92	15
Steinkopf	798	116	15
Richterveld	878	111	13
Komaggas	1140	189	17

TABLE A16 Average monthly household fuel expenditure at four settlements in Transkei/Ciskei (Rands)

Settlement	Wood	Paraffin	Candles	Coal	LP Gas	Total
Lukijo	19	11	1	0	0	31
Clarkebury	21	13	5	6	4	49
Manzimahle	20	18	3	1	0	42
Nkanga	22	8	4	0	1	34

TABLE A17 Average monthly household expenditure on different fuels at six rural settlements in Gazankulu

Settlement	Average monthly household fuel expenditure (Rands)					Total energy expenditure	% income spent on energy
	Battery dry cell	Paraffin	Wood	Gas (LPG)	Candle		
Refugees	8	3	0	0	4	15	6
Welvediend	18	17	8	4	5	61	16
Okkemuet-boom	12	19	25	3	8	66	12
Athol	15	12	2	4	3	38	7
Xanthia	17	16	6	4	7	54	8
Rolle	14	17	21	9	9	73	10

TABLE A18 Average monthly household income and fuel expenditure at six rural settlements in Bophuthatswana

Settlement	Income (R)	Energy expenditure (R)
Dinokana	148	24
Bodibe	154	25
Madutle	175	12
Ganyesa	204	38
Dewar	294	42
Linopeng	361	41
Mean	239	31

TABLE A19 Mean monthly household income and fuel expenditure in rural areas of four regions in South Africa

Area	Income (R)	Fuel expenditure (R)	% income spent on fuels
Namaqualand	107	14	733
Bophuthatswana	31	13	238
Gazankulu	51	10	516
KwaZulu	67	8	818

TABLE A20 Percentage MJ (energy units) contributed by each fuel in the household sector of the ten homelands/self-governing states of South Africa

Homeland/SGT	Coal	Candle	LP Gas	Paraffin	Wood	Elec
Bophuthatswana	5	2	1	12	80	0
Ciskei	0	0	0	8	92	0
Gazankulu	3	1	2	8	86	0
KaNgwane	1	1	0	8	90	0
KwaNdebele	17	1	2	14	66	0
KwaZulu	17	1	2	14	66	0
Lebowa	1	1	0	8	90	0
QwaQwa	82	1	1	9	6	0
Transkei	4	1	1	10	84	0
Venda	3	1	2	8	86	0

TABLE A21 Percentage of households using different fuels in rural areas of five regions in South Africa

Area	Wood	Dung	Crop waste	Candl	Paraf	Coal	LP Gas	Petrol / Diesel	Battery (Dry cell)	Battery (lead-acid)	Elec
Namaqua-land	85			82	68		91	9	73		8
Bophutha-tswana	89	44	26	90	91	12	12		32		
Gazankulu	28	0	0	41	34	0	46	5	37	0	
Transkei / Ciskei	44	22	13	57	53		34		35		
KwaZulu	40	15	9	53	48	4	34		35	0	4

TABLE A22 Mean monthly energy consumption by all households in rural areas (MJ)

Area	Wood	Dung	Crop waste	Candl	Paraf	Coal	LP Gas	Petrol / Diesel	Elec	Total
Namaqua-land	3055			44	353		1142	32	162	4692
Bophutha-tswana	3300	1000		83	500	225	67		5200	5200
Gazankulu	5457	473		66	467	205	59	36		6968
Transkei / Ciskei	4526	835	137	40	422	114	20			6094