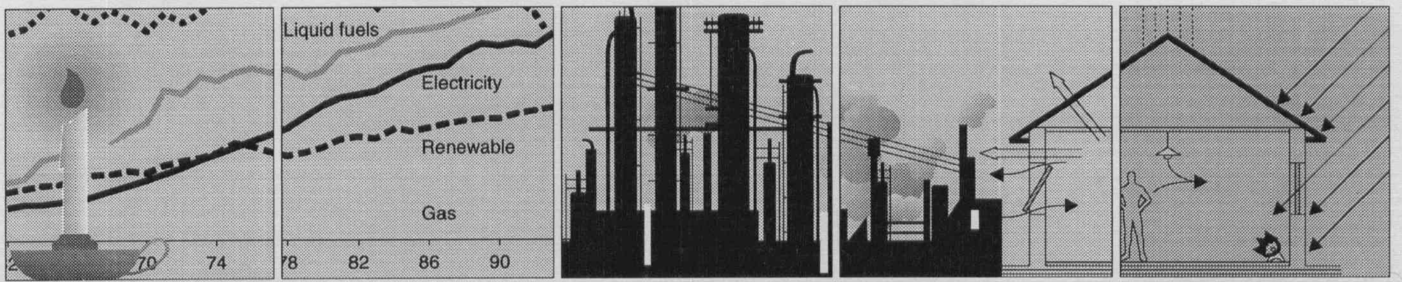
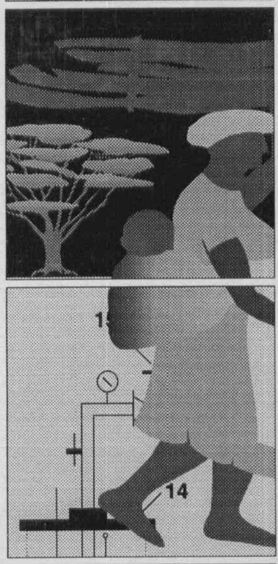
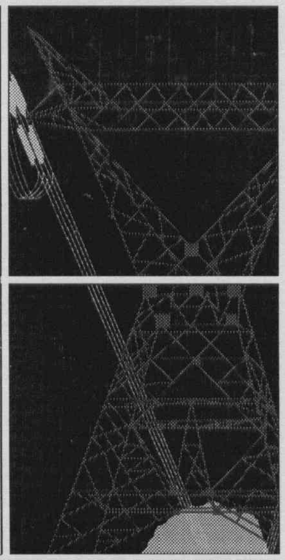
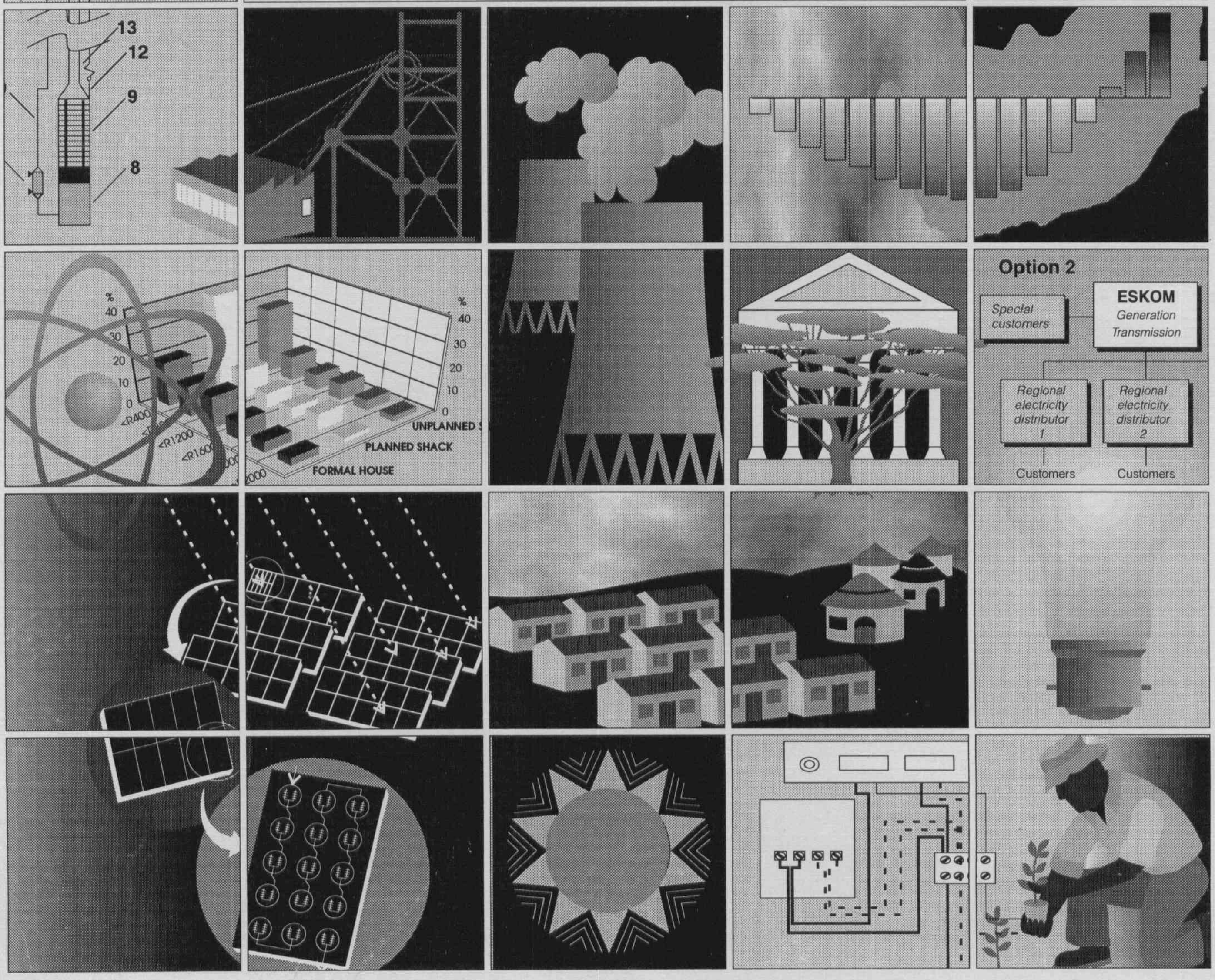




Energy efficiency in South Africa's low-income urban household sector: a review

NISA MAMMON





EDRC REPORT SERIES

ENERGY & DEVELOPMENT RESEARCH CENTRE
University of Cape Town

Energy efficiency in South Africa's low-income urban household sector: a review

Nisa Mammon

This report was prepared as part of the project entitled: "Energy efficiency, equity and the environment: improving access to energy services for the urban poor of South Africa". The project is funded by the International Development Research Centre and Eskom whose support is gratefully acknowledged.

Report No.2

November 1995

EXECUTIVE SUMMARY

1. Introduction

The challenge faced by policy makers and planners in the energy sector to address the energy-related needs of South Africa's urban and rural poor along with other development needs, is one which can be incorporated into various other development programmes proposed for this sector. This can happen if an integrated approach to energy planning is adopted. Energy efficiency is an important component of this challenge since many opportunities exist to introduce efficiency at the outset of certain development programmes, for example, the government's housing and electrification programmes.

The purpose of this paper is to assess whether the literature and information compiled to date on energy efficiency in South Africa is sufficient to address the energy-related needs of the ***urban poor household*** *sector*. The rationale for focusing on this sector is firstly, that the majority of South Africans in this sector reside in urban areas and spend a large proportion of their income on energy services. Secondly, urban areas contain a mix of land uses, all of which utilise energy in some form or another. The infrastructure is already in place to provide energy services for land uses other than residential and can facilitate the provision of energy services to poor urban households. Thirdly, two main developments are converging to present a unique opportunity to ensure that energy efficiency concerns are adequately addressed in urban areas. These are:

- the large-scale electrification programme in South Africa under which it is proposed to connect 2.5 million houses between 1994 and the year 2000, supplying electricity to between 400 000 and 450 000 households annually (Davis 1995); and
- the RDP's goal to facilitate the construction of a million new homes over the same period (ANC 1994: 22), thus presenting a crucial opportunity to ensure that new dwellings take account of thermal performance criteria, which can have a significant impact on energy consumption.

2. Household energy end-use and consumption patterns among the urban poor in S.A.

2.1 Cooking

Thorne (1995: 60) provided the following table to indicate the usage of different fuels for cooking by urban households.

	electricity	wood	coal	gas	paraffin	dung
Urban households	42	23	25	8	44	-

Percentage of urban households using different fuels for cooking
Source: Hofmeyer (1994); Moller (1985); Uken and Sinclair (1991) in Thorne (1995: 60)

The author measured the efficiency of cooking as the ratio of utilised to delivered energy, the former defined as the energy which 'goes into cooking, boiling, simmering and frying' (1995: 60). Electricity is said to be the most efficient in the conversion of delivered to utilised energy. Solid fuels are the least efficient. The greatest efficiencies are achieved through the use of commercial fuels i.e. electricity, gas and paraffin. The author points out, however, that while electricity is the most efficient in the final transformation, when the entire transformation process from primary to utilised energy is considered, it is not the most efficient. While electricity provides the highest efficiencies, the wood fire has the lowest life-cycle cost. Cooking with dung, coal, low-smoke coal or wood in a stove also has low life-cycle costs (Thorne 1995).

Paraffin appears to be utilised mainly out of necessity because it is cheap and obtainable in small quantities. If households therefore have access to safer and more convenient as well as directly accessible fuels for cooking, they would naturally refrain from using paraffin or use it in conjunction with other fuels and out of choice, not necessity.

At the macro scale (external to the household), the literature on end-use patterns among the urban poor in South Africa is mostly quantitative and in this form generally serves adequately to inform national policy and decision making on the provision and planning of energy services for the urban poor for cooking activities. The literature also informs suppliers of ways and means of achieving energy efficiency in their provision of energy services. However, as pointed out by Ross (1993) who is referred to in Williams (1994: 26) 'household income and fuel efficiency are not the only criteria by which fuel use decisions are made'. For example, among other factors, the gender and status of the person doing the activity is also an important consideration.

It is not unusual for women and children of neighbouring households in less formal urban locations to gather or purchase fuel (wood/coal) together. Large fires are often made outside and cooking takes place communally, resulting in fuel savings. However, open-fire communal cooking does not feature in the literature on end-use patterns.

A further omission from the literature is the question of low income urban peoples' own initiatives to embark on domestic energy efficient programmes. For example, it is not known to what extent households in this sector are aware of the efficiencies of different fuel and appliance combinations for cooking, nor to what degree efficiency influences the decision-making of households when this end-use is planned for in the long to medium term.

2.2 Space heating

According to the research utilised by Williams (1994: 31) there are two fuels which dominate the provision of space heating services: paraffin and coal are used by 42% and 39% of households respectively on a national basis.

Space heating would not be such a major consideration for low income urban households in terms of fuel usage had they resided in dwelling structures where insulation is adequate and their thermal performance is properly matched with human comfort given the climatic conditions within which they are located.

While information on the improvement of the thermal performance of housing is abundant, it is restricted to the micro scale (specific to the dwelling structure). There are many other considerations at a larger scale which require attention in order to improve energy efficiency and thermal comfort. These include factors such as orientation of the dwelling structure to wind, sun and other natural conditions.

2.3 Water heating

Williams (1994: 30) quotes Uken and Sinclair (1991) as having found that paraffin is the most frequently used water heating fuel. It is utilised by at least 45% of low income households.

Williams (1994: 30) further indicates that water heating is 'very often provided by the same appliance-energy carrier combination as is used for cooking'. The same can be said for space heating. There is therefore a significant degree of correlation between the energy carriers used for the provision of these three end-uses.

It is difficult to separate out water-and-space heating and cooking services since a single appliance/fuel combination can meet three services simultaneously. In fact, this undermines the basic end-use approach. For example, the costs and efficiencies of coal stoves are low on average for all three services because coal provides multiple utility. The most efficient way of heating water is through the utilisation of solar energy i.e. heating water by utilising the long wavelength radiation of the sun. There are many benefits to be derived from using this source.

Abundant information is available on the technology and know-how of introducing domestic solar water heating to end-users on a large scale. While the cost of solar water heaters is said to be high and the payback periods long, savings in the long term can benefit domestic users.

The literature regarding solar water heating usually omits to discuss the use of incentives to encourage use of this technology For example, reducing the up front cost can make it more affordable for users. Another aspect which requires some focus is the lack of knowledge among poor urban households about this energy source.

2.4 Lighting

The basic fuels used for lighting by poor urban households are paraffin, candles, LPG and electricity. Paraffin and candles are believed to be the most common fuels for lighting. Williams (1994: 33) records Uken and Sinclair (1991) as stating that 34% and 31% of households use paraffin and candles respectively.

Thorne (1995: 82) states that even though 'lighting uses little energy in absolute terms, amongst the poor it is a service that constitutes a considerable proportion of the energy bill, and where these households are electrified, of the electricity bill.' He also states that 'despite the low energy intensity of lighting, it is an energy service in which significant household energy and economic efficiency advances can be made.'

Electric lighting provides a superior source of lighting and is among the cheapest options for the provision of thisservice. It follows, therefore, that electrification and access to electricity by the urban poor will improve access to proper lighting for this sector. Electric lighting is, however, constrained by entry costs of house-wiring and those of luminaires as well. This raises questions about the capacity of the urban poor to afford this source of lighting when it becomes available.

Household lighting is seen separately from other sources of lighting, for example, street lighting. As a 'free' public utility, this form of lighting is hardly mentioned in the literature on energy efficiency. Yet it acts as a source of lighting to occupants of backyard shacks in urban areas.

2.5 Refrigeration

Electricity is the main fuel for refrigeration. It is an important service in poor households largely because it enables them to make bulk purchases of perishable goods which provides an opportunity to extend the value of their meagre incomes. However, the entrance barrier to refrigeration is high given the high capital cost of the appliance and the lack of access to credit among poor urban households.

Access to refrigeration through one refrigerator per household, is not the only way of addressing the storage of perishables. Innovative ways need to be found to provide easy and convenient access to acquiring perishables.

3. Supply-side energy efficiency interventions

Supply-side energy efficiency interventions are at present mainly geared towards electrified households. These interventions are therefore inappropriate for a large proportion of the urban poor household sector and undertaken mainly to suite the supplier's purpose. Eskom, for example, essentially adopted its Demand Side Management Programme as a means of reducing the demand on the electricity load at peak times (Eskom 1995: 16) and not to improve end-use efficiency.

Local authorities in South Africa utilise DSM in a very limited way through ripple control of hot water storage geysers. Their motivation is somewhat similar to that of Eskom's, which is to reduce the demand on the electricity load at peak time.

4. Redefining IEP

From an energy efficiency and end-user perspective, the determinants upon which IEP are based should include considerations which examine the urban poor household sector's energy needs in an all-inclusive way. This is significant in two ways. Firstly, research will be based on the needs of this sector and not on demand which has an economic implication. Needs are defined as the energy requirements expressed by the target group itself. This is distinguished from demand which is inferred from data collected from a survey where the representivity of the sample is determined outside the user community and from a research perspective. Secondly, energy considerations will not only focus on the household itself but on other energy-related aspects, for example, transportation.

An unresolved question related to energy efficiency is that concerned with the strategies households themselves employ to conserve energy sources. This has a direct bearing on the extent to which households themselves are involved in energy research, policy and decision-making. Qualitative research would include participatory planning methodologies which, by definition, include the household itself. The list of IEP determinants should not be seen as conclusive and should be extended to include, among others, scale, transportation energy, participation and qualitative criteria.

5. Recommendations

This report recommends that future research should focus on the following:

5.1 Revision of IEP and DSM

It is important to revise and adapt the determinants upon which IEP and DSM as a component thereof, are based, so as to create a methodology for micro-scale energy project planning which should incorporate qualitative as well as quantitative analyses.

5.2 Energy efficiency and electrification

The preparation and/or planning for the implementation of the national electrification programme should be complemented by research work on the provision of other services as well. Research should also be conducted on the provision of safe and convenient access to fuels other than electricity so as to widen its choice and encourage the efficient use of energy sources.

5.3 Energy efficiency and transportation

Access to energy efficient transportation by low-income urban households and energy efficiency in the transportation sector should be given attention to in future research on the urban poor's household energy needs.

5.4 Thermal performance and integrated design

Attention should be given to the improvement of thermal performance and energy efficiency in the provision of low cost housing with a particular focus on the following areas:

- facilitative policies and legislation to entrench thermal design in the provision of housing;
- new housing developments should form targeted models where thermal design can be introduced, monitored and evaluated;
- broader (than the dwelling's structure) planning issues like the siting of local urban areas on land which is generally suitable for urban development. These and other concerns

mentioned in chapter three of this paper must be considered at the very outset of the planning process; and

- the sensitivities of low-cost housing design to the natural elements prevailing in local areas.

5.5 Appliances

Research on appropriate appliance labelling, standards, retooling and financing should continue.

5.6 Energy efficiency funding

Funding should be prioritised so that effective energy efficiency programmes can be considered for implementation and research conducted into appropriate energy efficiency/DSM interventions.

5.7 Education

Education on energy efficiency is imperative for suppliers and users. Suppliers need to understand the energy needs of low-income households from an end-use perspective as much as end-users need to learn about the various options available to them to conserve energy.

5.8 Energy efficiency in southern Africa

Important lessons can be learned from South Africa's regional counterparts especially while the climate is right for regional cooperation in the energy sector.

5.9 Coordination

Research should focus on the coordination and integration of direct and indirect services provided in the household sector and the application of DSM interventions should be expanded with a view to formulating a coordinated DSM programme.

Contents

List of figures

List of tables

CHAPTER ONE

Introduction

1.1. Background

This report forms part of a wider study entitled 'Energy Efficiency, Equity and the Environment: Improving access to energy services for the urban poor of South Africa (E4). The objectives of this study are threefold:

- to improve access to energy services by poor communities of urban townships and to increase the affordability of such services by improving household end-use efficiency;
- to mitigate the potentially adverse environmental effects which may result from increased generation of coal- and nuclear-based electricity generation; and
- to reduce the local environmental and health risks resulting from the use of fuels such as wood, coal, gas and paraffin.

The specific aims of the E4 project are to:

- develop a demand-side management (DSM) strategy for application to poor urban households which would include programmes to be delivered by utilities, government and energy distributors; and
- encourage an improved capacity to develop, plan and analyse energy efficiency programmes for application in disadvantaged and poor communities.

1.2. Energy services in South Africa

Prior to the shift to democracy in South Africa and the Government of National Unity's introduction of the Reconstruction and Development Programme (RDP) as the driving force behind this transformation process, energy planning and the provision of energy services in South and southern Africa was fraught with severe problems. This necessitated a re-assessment of the regional energy situation in southern Africa as a whole.

Despite the availability of a large energy resource base, various factors contributed to the general decline related to the energy crisis in the southern African region. The oil crisis in the early 1970s led to increased debt in southern Africa. The recession in South Africa in the 1980s was largely due to investments sunk in the expansion of its domestic energy activities. Under apartheid rule, South Africa was actively engaging in military attacks on energy installations in southern Africa.

South African apartheid energy planning also contributed to environmental degradation. In its quest for energy self-reliance, it embarked on massive development of its coal resources for electricity generation and the production of synthetic fuel for transportation. The environmental impact of these large investments had far-reaching implications for the country.

Energy services in South Africa were also managed in a centralised and inappropriate way, allowing very little or no input from energy end-users. Utilities were essentially supply oriented with no consideration given to managing energy demand.

Thus the provision of energy services and planning in South Africa needs to be reviewed and examined from a different perspective. Already changes are being considered to shift energy planning from a centralised, supply oriented approach to an integrated, demand oriented, efficient and affordable one. These changes should be approached with a new energy imperative which incorporates principles of efficiency, coordination, cost-effectiveness, social equity and environmental sustainability.

Ultimately the impact of the provision of energy services and planning is experienced at the scale of the household, the community, commerce and industry and all other operations for which access to energy resources is essential. Their input is therefore essential in the planning of energy services. The group for which access to energy sources is most difficult and unaffordable, is that of South Africa's urban and rural poor household sector. This sector forms the focus of this paper.

1.3. Energy planning principles

The principles of ***equity, sustainability and efficiency*** should form the foundation upon which energy planning is built. Ideally, the goal of energy planning should be 'to create a sustainable energy economy which increases access to the energy sources available to meet growing demand at an affordable price, without detrimental environmental, social, financial and economic impacts' (Williams 1994: 4). ***Equity*** refers to equality of access to energy sources for all. ***Sustainability*** points to the ongoing supply of affordable energy in a manner that least disturbs the natural environment. ***Efficiency*** refers to the optimal usage derived from the supply of energy sources at the least financial cost to the user community and the supplier.

As an approach to the supply and usage of household fuels, *energy efficiency* should incorporate all these principles.

1.4. Purpose and focus of the study

The main objectives of this study are to:

- review the work produced to date on energy efficiency in the urban household sector of South Africa; and
- determine whether this is sufficient to understand current patterns of energy usage among poor urban households.

Demand side management (DSM) is the tool employed by suppliers of electricity to reduce the demand on their load at peak time. A demand side management plan is 'a supply authority management scheme, which is end-user informed' (Thorne 1995: 96). The purpose of this paper is therefore to assess whether the literature and information compiled to date on energy efficiency in South Africa is sufficient to inform a demand side management plan (DSMP) for the country. It focuses specifically on ***poor urban households***. The rationale for this is that the majority of South Africans reside in urban areas.

The DBSA estimates that in 1993, 48% and 65% of South Africa's total population was respectively urbanised and functionally urbanised (Development Bank of Southern Africa 1994). Functional urbanisation is defined to include people living in areas adjacent to formal towns (e.g. informal settlements) or in settlements where more than 5000 people reside but have not yet attained town status. If appropriate energy usage is not encouraged and high levels of pollution and health problems persist, the urban environment will undoubtedly be affected even further. Also, urban areas contain a mix of land uses, all of which utilise energy in some form or another. This raises further concerns regarding environmental degradation.

Two main developments are converging to present a unique opportunity to ensure that energy efficiency concerns are adequately addressed in urban areas. Firstly, under an ambitious electrification programme it is proposed to connect 2.5 million houses between 1994 and the year 2000, supplying electricity to between 400 000 and 450 000 households annually (Davis 1995).. Secondly, the RDP aims to facilitate the construction of a million new homes over the same period (ANC 1994) thus presenting a crucial opportunity to ensure that new dwellings take account of thermal performance criteria, which can have a significant impact on energy consumption. By contrast, the standard form of low-cost housing built during the apartheid years, the so-called `51/9 matchbox houses' usually lacked even basic insulation devices such as ceilings (Thorne 1994).

Williams (1994: 2) states that an important characteristic of urban poverty in South Africa is a lack of access to suitable and affordable energy carriers. 'Lack of access to electricity, arguably the most convenient energy carrier for domestic use, is probably the clearest defining characteristic of the focus group. Despite the well developed national grid which generates 52% of the total electricity on the African continent, and currently has a surplus of generating capacity, only about 40% of South African homes have access to electricity' (Williams 1994). The large majority of the urban poor are said to rely upon expensive and less convenient energy sources such as wood, coal and paraffin. A significant proportion of this sector's income is therefore spent on energy.

At the end of 1994 the number of houses, including formal institutions, in urban areas in South Africa was estimated at 4 696 000 of which 68% were electrified. Of this total, 714 000 houses were classified as informal housing of which 31% were electrified and 147 000 were classified as informal backyard dwellings of which 25% were electrified (Davis 1995). Urban electrification levels are low in informal areas where the majority of the poor reside.

1.5. Methodology

This paper adapts the methodology of *integrated energy planning (IEP)* to review and assess the literature and information available on the urban household sector and, at the same time, to critically assess the effectiveness of IEP for adequately evaluating household energy demand at the micro or local scale.

The rationale for IEP is clearly stated by Eberhard (1994: 2). In a nutshell, it is an approach which compels energy subsectors 'to adapt to demand induced by the market, both in terms of supplying sufficient energy and by minimising costs'. An important aspect of this approach is least-cost energy planning which requires cost and benefit analyses of different energy service options.

IEP must, however, be integrated with the economic, environmental, political, social and spatial sectors through which changes in society are usually effected. For example, the supply of energy requires very large investments, and 'sectoral decisions can have a major impact on key macro-economic variables for many years ahead' (Eberhard 1994). IEP can also address environmental concerns in energy production and usage such as global warming and deforestation if these are incorporated into the IEP process. The political process which defines the legal and institutional framework within which energy planning is managed, is a further element for consideration within IEP.

The components of IEP are described in more detail by Eberhard (1994) and will be adapted in accordance with the purpose of this paper. The energy demand analysis component of IEP is discussed in detail because of its integral place in formulating a DSM programme.

Eberhard (1994: 12) states that 'demand analysis requires an understanding of the relationship between energy demand and various variables at two different levels of data:

- macro-economic and demographic data as used in national economic planning; and
- sector and subsector data for each end-use, consumption sector and fuel, including fuel price.'

Other important data include the cost of alternative fuels, their availability, connection or access charges, reliability of supply, uniformity of quality, convenience of use, technical and economic characteristics of energy using equipment and appliances, availability of credit, income, rate of urbanisation, social preferences, acceptability and knowledge of potential users.

Demand analysis also needs to consider why consumers shift from one fuel to another and why multiple fuel use is often common among poor urban households. Demand analysis based on the factors discussed here becomes an important input to policy analysis and formulation.

1.6. Structure of the paper

Chapter two assesses the literature from an end-user perspective. It provides an overview of household energy end-use patterns among the focus group of this study. It also investigates the demand and supply of energy resources in terms of meeting current and future demand.

Chapter three scans the current energy efficiency strategies employed by suppliers and looks at their motivation for having introduced these. It also looks at other stakeholders' involvement with energy efficiency.

Chapter four establishes whether the literature adequately covers and understands current energy demand and future projections among the poor urban household sector from an end-user and energy efficiency point of view.

Chapter five concludes the paper by summarising and assessing the literature in terms of the principles of efficiency, equity and sustainability. It further attempts to identify the gaps in the literature in informing a DSMP. Some recommendations are made on further studies to be commissioned on energy efficiency in the urban household sector.

CHAPTER TWO

Household energy end-use and consumption patterns among the urban poor in South Africa

2.1. Introduction

This chapter reviews the literature and information available on energy end-use and consumption patterns among the urban poor in South Africa's household sector paying particular attention to the question of efficiency in the consumption and usage of energy sources and services. In responding to the energy needs of poor urban households, it is necessary to consider the availability, accessibility and affordability of energy sources.

The following graphs indicate the monthly household income distribution profiles for low-income households located in the major metropolitan areas (Figure 2.1) and the percentage use patterns of different energy carriers in these areas of South Africa (Figure 2.2)..

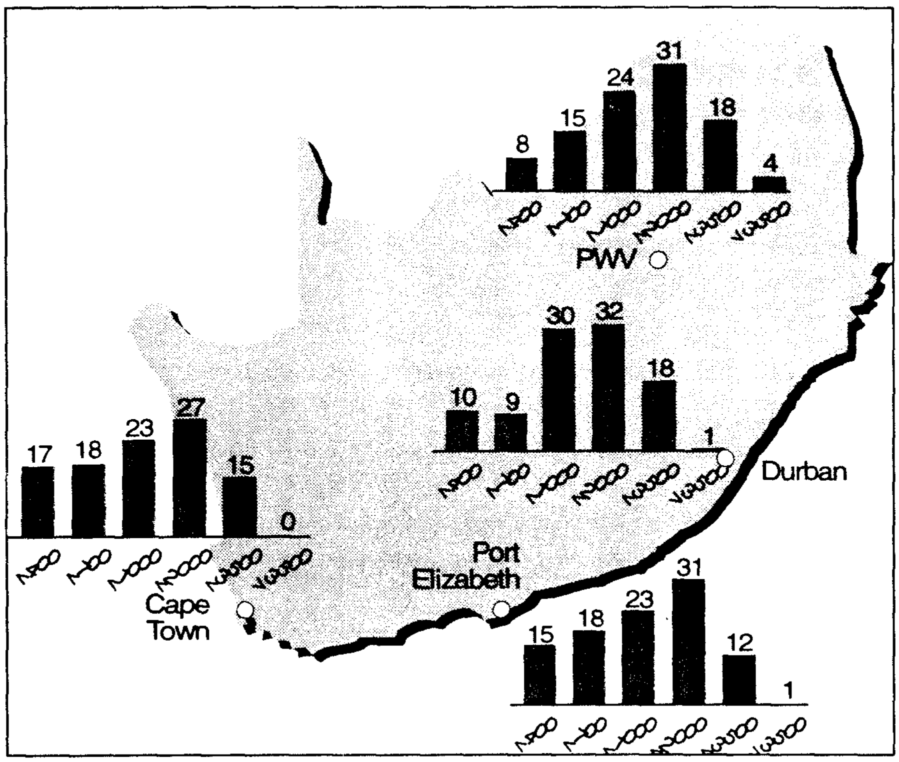


Figure 2.1 Monthly household income distribution profiles for the major metropolitan areas (Rands per month)
Source: Adapted from Markinor cited in Williams (1994: 3)

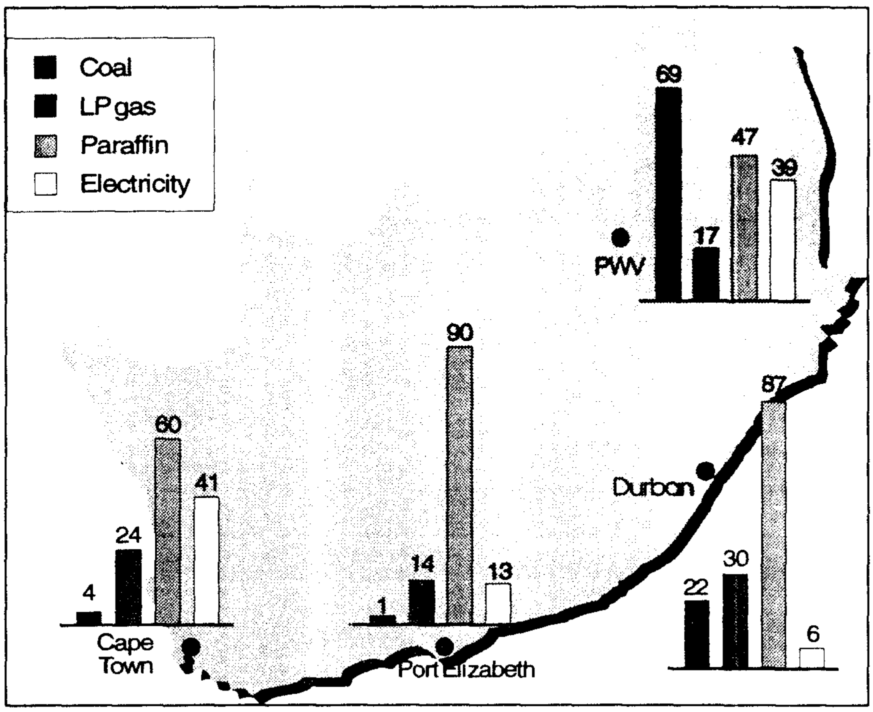


Figure 2.2 Percentage usage patterns of different energy carriers in different regions
Source: Adapted from EPRET database used in Williams (1994: 11)

It can be clearly observed that the high percentage of paraffin usage by end-users in the poor urban household sector throughout the country is related to the availability, accessibility and affordability of this fuel. It may also be a consequence of the fact that many homes in the low income urban sector of South Africa are not electrified as yet and where this is the case, multiple fuel usage is not uncommon. This is indicated by the sum of the various percentage uses in the regions where totals exceed 100. Also, electricity often requires the usage of an appliance which is not always affordable for low income households.

The high percentage of use of coal in the Gauteng region is a direct result of the proximity of the coal mines to urban households in this area. Again, availability, accessibility and affordability influence the usage of this fuel. In the Gauteng region which contains 40% of all low-income urban households in the country, a high percentage of household income is spent on energy by the poorest category (households with an average monthly income of less than R400). It is said that in this category between 15% and 40% of total household income is spent on energy (Williams 1994: 14).

Figure 2.3 indicates the daily demand curve on the day of peak electricity demand on the national grid in 1992 which is a major informant of Eskom's Residential Demand-side Management Programme. According to the graph, peak demand occurred at 18h00 on a cold day, coinciding with the peak demand of domestic users. As stated earlier, the country's electrification programme is likely to impact significantly on this situation if appropriate steps are not taken to intervene.

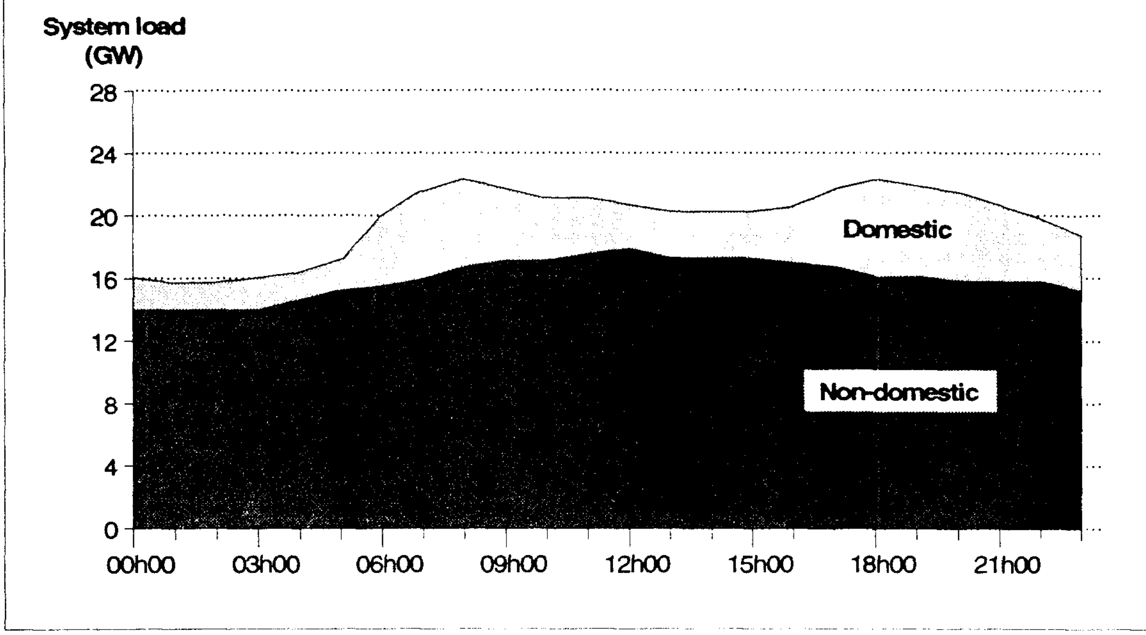


Figure 2.3 South African electricity system demand on day of peak demand (1992)
Source: Berrisford and Bluff (1991) in Eberhard and Trollip (1994)

Table 2.1 indicates the price ranges for fuels in urban areas of South Africa.

Fuel	*Units*	*Urban*	
		min	*max*
wood	c/kg	30	123
paraffin	c/litre	108	162
gas	c/kg	180	317
electricity	c/kWh	15	25
coal	c/kg	20	49
candles	c/candle	9	42

Table 2.1 Price ranges for fuels in urban areas of South Africa - 1992
Source: Trollip (1994)

A lack of access to fuels and money to acquire fuels for various end-uses present major problems to poor urban households. The cost of electricity and coal is relatively low in South Africa. Once the entry cost of electricity is overcome, it becomes more affordable. Access to other inexpensive fuels such as paraffin should also be maintained.

Thorne and Theron (1993) contend that a lack of access to fuels such as electricity, is a barrier to energy and economic efficiency. In Khayelitsha (a township in metropolitan Cape Town) non-electrified households spend nearly twice as much money on energy services as those who have access to electricity.

2.2. Household energy consumption patterns

Figure 2.4 shows an estimate of the contribution of various fuels to household energy services used by the urban and rural poor in the country in 1990. It must be borne in mind that the data presented by this figure reflects energy supplied to different consumers. Using supply-side data in energy planning presents the problem of focusing on large energy users, energy supply subsectors and supply-side institutions which essentially diminishes the importance of small energy end users.

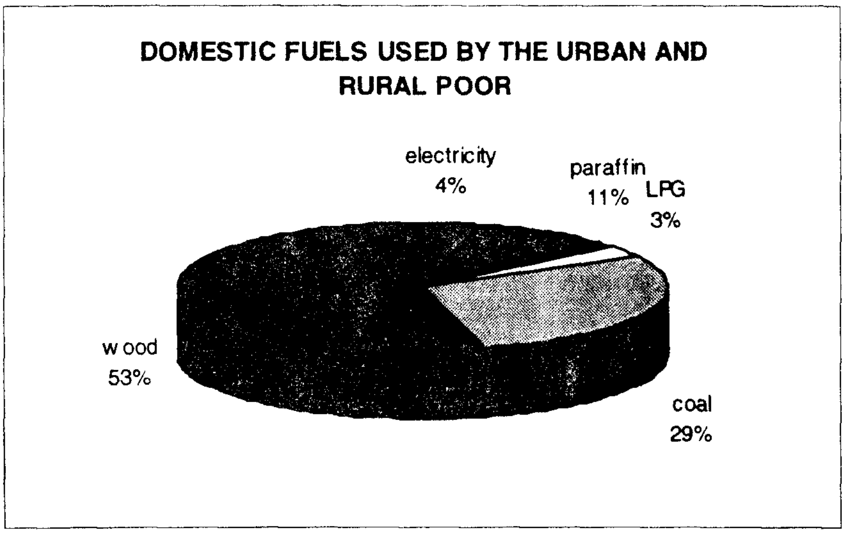


Figure 2.4 Domestic fuels used by the urban and rural poor
Source: Trollip (1994)

The studies completed by Trollip (1994), Williams (1994), Afrane-Okese (1995) and Thorne (1995) provide the most up to date analyses of data and information on household energy end-use patterns among the urban poor South Africa. These studies draw on some 200 research papers and surveys conducted by various organizations in the energy sector including Gervais (1987); Markinor (1988); DRA (1989); Uken and Sinclair (1991); the Palmer Development Group (1992; 1993a; 1993b). Other work drawn on includes that of the DMEA (1992); Eskom (1993); Ross (1993); Annecke (1993) and various others.

In addition to these studies, Nel (1992) prepared a report for the former National Energy Council which provided a synthesis of thirty-four energy efficiency related research projects in all sectors (with the exception of transportation energy) in South Africa. Roughly a quarter of these focused on the domestic sector. The synthesis was compared with the international research experience on energy efficiency.

The contents of these studies therefore provide a comprehensive summary of the data and information available on energy end-use patterns in low income households in South Africa. The bibliography provides a list of studies and surveys available on end-use patterns among low income households in South Africa which were used to prepare this paper. The surveys and studies utilised by Afrane-Okese (1995) and Trollip (1994) are available directly from these sources and are not listed in the bibliography.

An important contribution to the understanding of household energy end-use and policy issues pertaining to these was made by the now disbanded National Electrification Forum (NELF) whose Working Group for the End-use of Energy and the Environment published a series of working papers in 1994. The content of these is briefly discussed in chapter 3.

Trollip (1994) utilised around 170 studies which dealt with energy in low-income households. These provided the quantitative input for his analysis which aimed to inform and build integrated energy planning as a methodology for the provision of energy services in the low-income household sector of South Africa.

Williams' (1994) study aimed to address the question of the reliance of the urban poor in South Africa on expensive and less convenient (than electricity) energy sources such as wood, coal, paraffin, candles and batteries. He showed that poor urban households spend a significant proportion of their income on energy.

In 1992, the South African Department of Mineral and Energy Affairs (DMEA) commissioned the Energy for Development Research Centre (EDRC) 'to establish a National Domestic Energy Use Database (NDEUD) system' (Afrane-Okese 1995: 3). The need for this system which was first assembled as part of the South African Energy Policy Research and Training Project (Trollip 1994) arose out of the recognition that there is a lack of comprehensive data and information to inform policy making around energy services for low-income households in the country.

In his study entitled *Domestic energy use analysis to facilitate development strategy*, Afrane-Okese (1995) drew extensively on the data collected for the NDEUD system. The purpose of his study was 'to provide a comprehensive collection of all research on low-income household energy usage that has been done in South Africa in a consistent format'. The study utilised the *long-range energy alternatives planning* (LEAP) model which requires that energy demand data be arranged in a hierarchical format based on four levels namely: climatic zone, dwelling types, end-uses and devices used.

For the purpose of this study, three climatic zones were identified to construct energy use profiles for low-income households at the national scale. These include: temperate, hot-humid and hot-dry (refer to Figure 2.5). The temperate zone includes the Western Cape, Eastern Cape and Gauteng. The hot-humid zone includes Border, Transkei, Kwazulu/Natal and the Eastern Transvaal Lowveld and the hot-dry zone the Orange Free State, Northern Cape, Western and Northern Transvaal and the Karoo. It is clear from this description that urban households are mainly located in the *temperate climatic zone*. This study focused on urban and rural areas. The data therefore reflects fuel usage patterns for both.

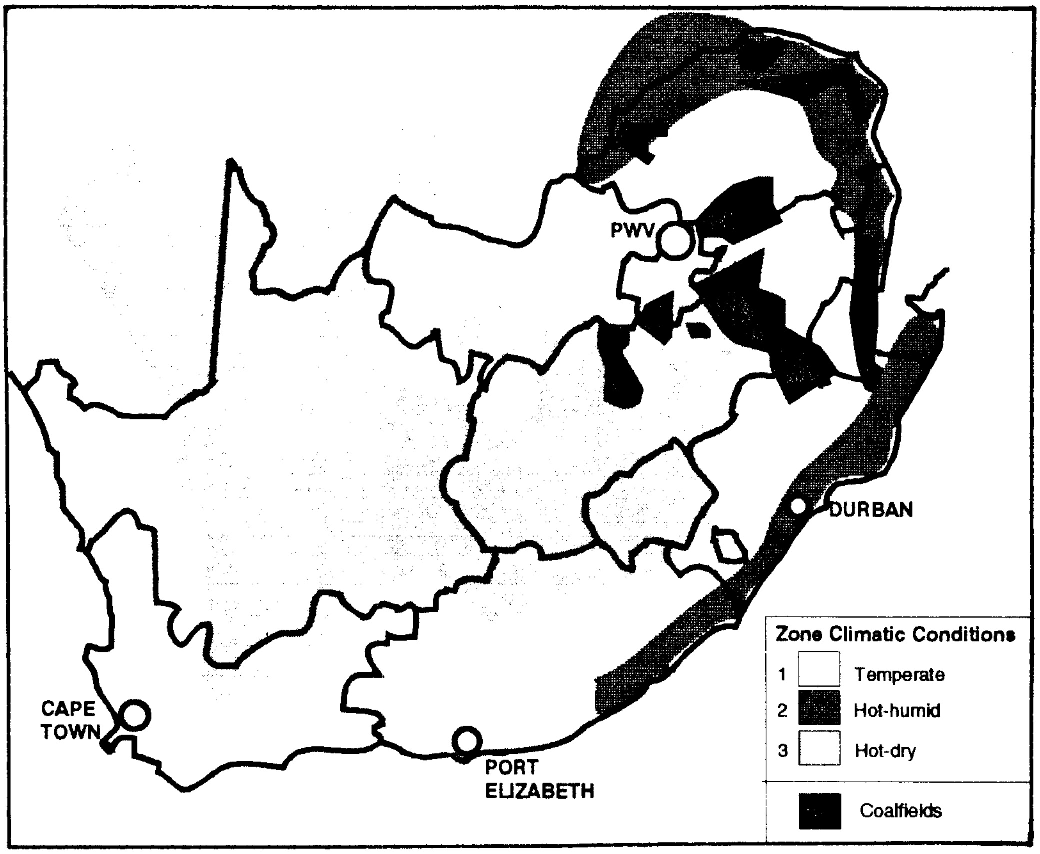


Figure 2.5 Climatic zones in South Africa

While Thorne's (1995) work focused mainly on electricity, he examined energy efficiency and conservation policy options which would reduce the demand for energy and economic resources for household energy services.

What follows is a summary of the abovementioned studies insofar as they focus on energy end-use patterns among low income or poor urban households in South Africa. This is important to determine whether there is an adequate overview and analysis of end-use patterns in order to inform energy efficiency measures.

2.2.1 Cooking

Afrane-Okese contended that in the three climatic zones identified, the majority of low income households do not cook with electricity. It is further observed that there is a direct relationship between formal dwelling types and the use of electricity for cooking. The 'more formalised the dwelling type in each climatic region, the more households tend to use electricity for cooking' (Afrane-Okese 1995).

In the three climatic zones, wood is used more extensively for cooking than any other fuel. Wood usage for cooking is quite high in these three climatic zones among all dwelling types with at least 80% of households using wood. Backyard shacks appear to use more wood for cooking than other housing types. It must be borne in mind that Afrane-Okese focused on rural and urban areas.

Nationally, wood is said to be used by 23% of urban households for cooking and coal by 25% for the same end-use (Uken and Sinclair 1991 cited in Williams 1994). According to Afrane-Okese (1995: 15), in the temperate and hot humid zones about 50% of households in formal and unplanned shacks use coal for cooking.

Area specific end-use patterns for cooking are recorded in Williams (1994) from various studies (Uken and Sinclair 1991; Kessel 1988 and so on). The use of multiple fuels for the same activity (end-use) is more distinct at this scale. For example, while it was found that between 55% and 70% of Soweto and Pretoria households were using electricity for cooking, 63% of electrified households use coal for cooking in the PWV area.

Paraffin is also used widely for cooking among poor urban households. In the temperate and hot humid zones, the use of paraffin for cooking is very prominent among planned and unplanned shacks. Over 70% of these households use this fuel. According to Uken and Sinclair cited in Williams (1994: 28), paraffin is the principal energy source for cooking among poor urban households in South Africa.

LPG is not said to be an important fuel for cooking except in the Western Cape where it is used by non-electrified households in the order of 7 kg per month, with planned and unplanned shacks both using about 5 kg per month (Williams 1994).

Thorne (1995: 60) provides the following table to indicate the usage of different fuels for cooking by urban households.

	electricity	wood	coal	gas	paraffin	dung
Urban households	42	23	25	8	44	-

Table 2.2 Percentage of urban households using different fuels for cooking
Source: Hofmeyer (1994); Moller (1985); Uken and Sinclair (1991)
in Thorne (1995: 60)

Thorne (1995) measured the efficiency of cooking as the ratio of utilised to delivered energy, the former defined as the energy which 'goes into cooking, boiling, simmering and frying'. Electricity is said to be the most efficient in the conversion of delivered to utilised energy. Solid fuels are the least efficient. The greatest efficiencies are achieved through the use of commercial fuels i.e. electricity, gas and paraffin. The author points out that while electricity is the most efficient in the final transformation, when the entire transformation process from primary to utilised energy is considered, it is not the most efficient. While electricity provides the highest efficiencies, the wood fire has the lowest life-cycle cost. Cooking with dung, coal, low-smoke coal or wood in a stove also has low life-cycle costs.

2.2.1.1 *Energy efficiency and cooking*

The literature reveals that many households are reluctant to utilise LPG not only for cooking but other end purposes as well mainly because of their perception that this fuel carries a high degree of danger. The Government of National Unity's RDP also intends to construct a million houses in the next five years. The proposed housing programme provides an opportunity to change this perception of the potential occupants of new dwellings and to encourage them to utlise LPG for cooking and other end-uses. In addition to electrification, gas cylinders can also be provided for in the planning and construction of new houses. In this way, new households (in the urban poor sector of South Africa) will be left with a choice of fuel usage for different activities.

While paraffin appears to be widely used for cooking, it appears from the literature that it is utilised mainly out of necessity because it is cheap and can be obtained in small quantities. If households therefore have access to safer and more convenient as well as directly accessible fuels for cooking, they would naturally refrain from using paraffin or use it in conjunction with other fuels and out of choice, not necessity.

At the macro scale, the literature on end-use patterns among the urban poor in South Africa is mostly quantitative and in this form generally serves adequately to inform national policy and decision making on the provision and planning of energy services for cooking for the urban poor. The literature is also able to inform suppliers of ways and means of achieving energy efficiency in their provision of energy services. However, as pointed out by Ross (1993) who is referred to in Williams (1994: 26) 'household income and fuel efficiency are not the only criteria by which fuel use decisions are made'. There is a myriad of other end-use considerations of a more qualitative nature at the micro scale that need to be understood in order to provide an energy efficient service to the urban poor and to inform a *demand-side management programme* (DSMP) from an end-user perspective.

In relation to cooking, for example, household size plays an important role in determining consumption patterns of various fuels. Consideration should be given to the number of people (the core household, lodgers, occupants of a backyard shack or outbuilding located on the same erf as the main dwelling) constituting 'the household' when cooking arrangements are decided. Other considerations include the use of extra energy for preparing food for large feasts, funerals etc.

The gender and status of the person doing the activity is also important to consider. It is not unusual for women and children of neighbouring households in less formal urban locations to gather or purchase fuel (wood/coal) together and engage in the activity at the same time. Large fires are often made outside and cooking takes place communally, resulting in fuel savings. The social benefits of such an arrangement are noted as well.

From an urban planning point of view, this type of arrangement can be encouraged through the design of local areas in which proper outdoor facilities are provided to accommodate it. The provision of proper facilities to accommodate outdoor communal cooking will also obviate the problem of carbon monoxide emissions from the constant burning of fuels. Such an area could be located close to playlots and public open spaces designated for extra-mural use by children (during the day and early evening) so that adult supervision (usually by women) can take place at the same time as engaging in the activity of cooking.

Open-fire communal cooking does not feature in the literature on end-use patterns. In fact, wood is not considered to be a commonly used fuel in urban areas in the studies reviewed on end-use patterns. Yet, while it may not be a frequent occurrence, wood is used in this way especially in low-income informal urban settlements. This observation was made by field-workers in Vrygrond, an informal settlement in Cape Town (Cape Town City Council 1994).

The literature has also failed to examine initiatives by low income urban peoples' to embark on domestic energy efficient programmes. Very real attempts by households in this sector to conserve energy and utilise it in an economically and environmentally efficient manner may be contributing towards achieving energy efficiency. Little is known, for example, about the extent to which households in this sector are aware of the efficiency of different fuel and appliance combinations for cooking, nor the degree to which energy efficiency influences the decision-making of households when this end-use is planned for in the medium to long term.

2.2.2 Space heating

According to the research utilised by Williams (1994) there are two fuels which dominate the space heating service provision. These include paraffin and coal used by 42% and 39% of households respectively on a national basis.

The regional differences for space heating among low-income households are as follows. Coal is used by 48% of households in the Gauteng area and by 85% in Bloemfontein. In the Western

Cape, 72% households use paraffin for space heating. In the Durban Functional Region, the need for space heating is somewhat less with only 53% of households needing to utilise fuel for this end purpose. Of these, 27% use wood and the rest use paraffin. In Port Elizabeth and East London, space heating does not appear to be a high priority among low income households because of the more favourable climatic conditions prevailing in the winter season.

Thorne (1995) argues that improved thermal comfort of households can be achieved through design characteristics of a dwelling's structure. It is well known, however, that the urban poor largely reside in structures which can barely be termed habitable in terms of human comfort and thermal performance.

Various problems are being experienced with current space heating practices in South Africa. Thorne (1995) cites Surtees (1993) as stating that Eskom has found that for the past two years, the national peak electricity demand coincided with the domestic peak on cold days in winter. Electrical space heating therefore contributes increasingly to peak electricity demand as indicated by Figure 2.3 above.

Thorne (1995: 77) further points out that the use of solid fuels for space heating is often inefficient because of incomplete combustion and the release of high levels of pollution inside the dwelling which impacts negatively on the health of low-income coal-using urban households. Pollution monitoring undertaken in several historically black residential areas by the CSIR and MRC has found that peoples' exposures to indoor air pollution, especially particulate matter, exceed US and WHO health standards by a factor of five to six during winter, and two to three during summer (Terblanche et al 1992: 15).

2.2.2.1 Energy efficiency and space heating

Space heating would not be such a major consideration for low income urban households in terms of fuel usage if they resided in dwellings with adequate insulation and their thermal performance was properly matched with human comfort with reference to the climatic conditions within which they are located. Should the thermal performance of the dwelling be improved, access to electricity to operate heat pumps, for example, would simply be a bonus. Additional space heating may then easily be regarded as a luxury.

Households could decide whether they require additional space heating bearing in mind the additional costs involved. The usage of less efficient fuels would be minimised since additional space heating would not necessarily be required and if so, certainly not as frequently as would be the case in structures which perform poorly in terms of thermal comfort.

Sellick (1993: 2) acknowledges that 'a dwelling which is built without adequate or no insulation, will experience poor thermal performance. This has a number of detrimental effects on the occupants which are exposed to hot and cold temperature extremes and inefficient and costly space heating to ward off the cold.' Others, including Holm (1994), Van Wyk & Rousseau (1992) and Thorne (1995) have attempted to address the issue of poorly performing low income housing in terms of thermal comfort and energy-efficient low-cost housing design.

Holm's work (1994) focuses on passive thermal design in low cost housing. Passive design refers to the construction of buildings in harmony with the local climate to ensure indoor thermal comfort with minimal dependence on artificial heating or cooling. His report distinguishes three categories of improved passive thermal design, namely informal retrofit, formal retrofit and new formal, mainly in the Highveld region of South Africa.

Van Wyk & Rousseau discuss, inter alia, energy efficient design with respect to building materials, orientation, windows, ventilation, number of occupants of a dwelling, roofing, insulation and flooring.

Thorne states that the South African Building Regulations and the Minimum Agreement Norms and Technical Advisory Guide (MANTAG) include thermal performance and lighting criteria for dwellings. The National Building Research Institute (NBRI) embarked on an experimental housing project in the Western Cape known as the Cape Low Energy Experiment Project (CLEEP) which focused on the improved thermal performance of housing for (low) middle income occupants. However, only limited implementation of these principles has been effected in the case of low cost housing for the urban poor even though sufficient technical information is available on improving the thermal performance of a dwelling unit.

In fact, the urban building process in South Africa around the development of informal or self-made housing does not have very good building practices where, among other things, thermal performance is concerned. Even in formal township layouts, sun and wind directions which should inform the orientation of the dwelling, are hardly considered.

While information on the improvement of the thermal performance of housing is abundant, it is restricted to the micro scale. There are many other considerations at a larger scale which require attention in order to improve energy efficiency and thermal comfort where space heating as an end-use, is concerned. These have to do with the siting of a local area for habitation by the urban poor. The urban poor reside mainly on the city's edge typified by an urban fabric which is mostly unacceptable in term of basic human comfort. The term 'urban fabric' defines the environment in which household dwelling structures are located, for example, informal urban settlements or shack developments. Edge conditions of a city, especially in South Africa, often result in the marginalisation of the poor. The South African city's apartheid history which prevented, through group areas and other legislation, the location of this sector close to urban opportunities, intensified such marginalisation.

The economic disadvantage of locations away from urban opportunities, necessitates a trade-off between access and pricing. This hinders efficiency because people are willing to pay dearly for energy services and products from the informal economy which is expensive. These services would otherwise be more easily accessible and cheaper to obtain within the formal urban economy.

Also, in these circumstances, the poor often find themselves in spaces on the city's periphery which would (under normal circumstances) have been declared unsuitable for urban development unless appropriate interventions (like land fill) were commissioned to make these suitable. Informal urban settlements such as Crossroads in the Cape are often located on wetlands or land with high water tables and have inadequate drainage services to overcome such problems. This, together with wind leaks and damp penetration, increases the need for space heating.

The predominance of macro scale determinants informing the urban building process prevents this process from responding to the natural conditions prevailing in certain local areas. Macro scale determinants can only be stated broadly and therefore often fail to inform site specific conditions (i.e. conditions specific to a local area or large piece of vacant land to be developed) which informants at a micro scale are able to do. A good example of this is the insistence in the literature upon understanding the development of local areas and dwelling structures in terms of six (cold interior, temperate interior, hot interior, temperate coastal, subtropical coastal and arid interior) or three broad climatic zones (temperate, hot-humid and hot-dry) prevailing in South Africa. The development of local urban areas is dependent not only on climatic conditions but on many other natural elements as well. These are likely to differ from area to area within the same climatic zone and include micro-climate considerations and those of geology, hydrology, local vegetation and landscape requirements. If these were to be carefully considered in the urban building process, not only will thermal efficiency improve but development would take place in response to and with respect for the prevailing environmental conditions within which local areas are located.

Future studies on the improvement of thermal performance and energy efficiency in the provision of low cost housing need to focus also on broader planning issues like the siting of local urban areas on land which is generally suitable for urban development. These and other concerns mentioned earlier must be considered at the very outset of the planning process.

The RDP's proposed housing programme provides an opportunity for low income housing to be perceived differently from just the provision of a dwelling unit or shelter. It provides an opportunity to create living environments where the emphasis is on meeting basic needs as well as providing access to all urban services, including energy services.

2.2.3 Water Heating

Afrane-Okese's study (1995: 16) reveals that wood and paraffin are the most common sources of energy among low-income households in the case of water heating. Around 50% of urban households in all dwelling types use wood for this purpose. In the three climatic zones identified in this study, wood usage for water heating decreases in formal households as the use of electricity increases. This may be due to the installation of geysers in formal housing. Williams (1994: 30) quotes Uken and Sinclair (1991) as having found that paraffin is the most frequently used water heating fuel, which is used by at least 45% of low income households.

Williams (1994: 30) further indicates that water heating is 'very often provided by the same appliance-energy carrier combination as is used for cooking'. The same can be said for space heating. There is therefore a significant degree of correlation between the energy carriers used for the provision of these three end-uses.

Afrane-Okese (1995) reports that about 20% of all households are said to use coal for water heating. The mix of energy sources used for water heating does not differ widely between climatic zones. This does not, however, mean that the quantity of energy used is the same in each zone.

2.2.3.1 *Energy efficiency and water heating*

It is difficult to separate out water-and-space heating and cooking services since one option can meet three services simultaneously. In fact, this undermines the basic end-use approach. For example, the costs and efficiencies of coal stoves are low on average for all three services because coal provides multiple utility.

The most efficient way of heating water is through the utilisation of solar energy i.e. heating water by utilising the long wavelength radiation of the sun. The benefits to be derived from this source include:

- a reduction in the cost of water heating;
- a reduction in the indoor use of coal, wood or hydrocarbon fuels and thus indoor and urban air pollution;
- a reduction in household expenditure on energy services;
- enhancing the quality of life of households and communities; and
- reducing peak load demand on the national electricity grid.

As is the case with thermal performance of low-cost housing, abundant information is available on the technology and know-how of introducing domestic solar water heating to end-users on a large scale. While the cost of solar water heaters is said to be quite high and the payback periods quite long, savings in the long term can benefit domestic end-users.

The literature on solar water heating fails to address the question of introducing incentives to encourage use of this technology by reducing, for example, the up front cost thus making it more affordable. Another aspect which requires some focus is the lack of knowledge among poor urban households about this energy source.

2.2.4 Lighting

The basic fuels used for lighting by poor urban households are paraffin, candles, LPG and electricity. Paraffin and candles are believed to be the most common fuels for this purpose. Williams (1994: 33) records Uken and Sinclair (1991) as stating that 34% and 31% of households use paraffin and candles respectively, for lighting.

Thorne (1995: 82) states that even though 'lighting uses little energy in absolute terms, amongst the poor it is a service that constitutes a considerable proportion of the energy bill, and where these households are electrified, of the electricity bill.' He also states that 'despite the low energy intensity of lighting, it is an energy service in which significant household energy and economic efficiency advances can be made.'

2.2.4.1 *Energy efficiency and lighting*

Electricity provides a superior source of lighting and is among the cheapest options for the provision of this service. It follows clearly therefore that electrification and access to electricity by the urban poor will no doubt improve access to proper lighting for this sector.

Electric lighting is, however, tied to entry costs of house-wiring and those of luminaires as well. This raises questions about the capacity of the urban poor to afford this source of lighting when it becomes available.

The national electrification programme should therefore not be seen in isolation from other economic factors faced by low-income urban inhabitants. The provision of housing and electrification can provide tremendous economic opportunities for a large number of people, (as well as improving the thermal performance of dwellings) and attempts should be made to provide as many jobs as possible through employing labour-intensive methods.

Household lighting is usually viewed separately from other sources of lighting at a bigger scale. Street lighting as a 'free' public utility is hardly mentioned in the literature on energy efficiency. Yet it acts as a source of lighting to occupants of backyard shacks in urban areas.

Highmast lighting also illuminates backyards and/or backyard shacks where streetfront lighting fails to reach. Household safety and visits to ablution facilities which are most often located outside of the backyard dwelling, can be enhanced through street lighting.

This separation of household lighting services from street lighting is an indication of fragmentation in the urban building process. When self-made homes are constructed in areas where urban infrastructure (the provision of roads, services, public facilities) is adequately supplied, administered and supported, self-made home builders respond positively to that which is already in place. In other words, they make full use of the utilities surrounding them in order to save on building costs.

Candle usage as an important source of lighting is underestimated in the literature. Afrane-Okese (1995: 17) admits that there are 'data gaps on candle use, since most surveys ignore candles as one of the basic fuels for low-income households'.

2.2.5 Refrigeration

Electricity is the main fuel for refrigeration in the three climatic zones distinguished by Afrane-Okese (1995: 17). At least 35% of households in formal houses, planned and unplanned shacks rely on this energy source for refrigeration. Williams (1994: 34) quotes Golding and Hoets (1992) as having found that out of 11 townships surveyed, an average of 83% of electrified households had refrigerators which were also found to be the most common electrical appliance available in the sample surveyed. LPG is utilised by at least 25% of formal houses and unplanned shacks for this end-use.

Refrigeration is an important service in poor households largely because it enables them to make bulk purchases of perishable goods and therefore extend the value of their meagre incomes. It must, however, be remembered that the entrance barrier to refrigeration is high given the high capital cost of the appliance and the lack of access to credit among poor urban households. Electric AC refrigerators have the lowest operating costs according to Cowan et al (1992) cited in Thorne (1995).

2.2.5.1 Energy efficiency and refrigeration

Refrigeration is important for the storage of bulk purchases andperishables. It is not so much the cost and availability of the source of energy to fuel this appliance that is important as the fact that the entry cost to acquire it is extremely high. Low-income households do not have easy access to credit.

Access to refrigeration through ownership of one refrigerator per household, is not the only way of addressing the storage of perishables. Innovative ways need to be found to provide easy and convenient access to acquiring perishables. Low-income urban households living in informal urban settlements, for example, can obtain daily supplies of fresh fruit and vegetables from informal dealers located at strategic points in these areas. It is not known whether purchase prices are higher in these areas but the time and cost of transportation to get to the closest shopping centre can offset higher prices.

2.2.6 Television, radio and hi-fi (media)

Television, radio and hi-fi consume only small amounts of energy. They are, however, important in that they provide poor urban households with recreational and educational opportunities. Williams (1994: 33) contends that the poor attach a high value to accessing these services. Dry cell and vehicle batteries are most often used for this end-use. Research on battery use is scattered and there is no information available on a national scale.

Percentages of battery usage are available for some regions. On average, 21% of households in the PWV and 30% in the Durban Functional Region (DFR) use them. Their usage was found to be the highest in formal non-electrified townships, 59% of which use them.

2.3. Energy demand projections

The most recent work on demand projections for low income households is presented by Trollip (1994) and Afrane-Okese (1995). As stated earlier, Trollip's work extracts information and attempts to draw together 170 studies completed over the last five or so years on energy related end-use and consumption patterns. This information is evaluated in terms of the determinants of IEP.

Afrane-Okese (1995) estimates demand projections for the period 1993 to 2010 for the three climatic zones identified in his study and which were explained earlier in this paper. He uses a scenario approach to determine these projections. The scenarios include a Base Case Scenario, an Energy Efficiency (EF) Scenario, an Electrification (EL) Scenario and a Combined (CO) Scenario. It is pointed out that these scenarios are quite crude and were done mainly for illustrative purposes.

The Base Case Scenario assumes that there are no direct major development interventions in energy supply options for low-income households. The EF scenario introduces energy efficiency policy interventions into the Base Case. The EL scenario contemplates possible fuel/appliance switches among low-income households resulting from the proposed major electrification drive. The CO scenario is a combination of the electrification and energy efficiency interventions.

2.3.1 Low-income household electricity demand

Figure 2.6 presented by Afrane-Okese (1995: 35) provides the national electricity demand projections in terms of climatic zones/regions for low-income households from 1993 to 2010 based on the four scenarios described above. From the Base Case perspective, low-income household demand for electricity increases from 28.8 million GJ in 1993 to about 39.4 million GJ in

2010 indicating an increase of 10 million GJ over a period of 17 years. Figure 2.6 further demonstrates that energy efficiency measures in low-income households could lower the electricity demand growth in such a way that the increase in demand over this period would only be about 6.7 million GJ.

In terms of the EL scenario, the demand for electricity increases by 45 million GJ by 2010, at an annual growth rate of 9%. The CO scenario, however, illustrates this increase to be only 28.5 million GJ (a 35% reduction compared to the EL scenario) at an annual demand growth rate of 6%. It is evident that the simultaneous introduction of successful energy efficiency measures into the electrification programme will no doubt decrease the demand for electricity significantly.

2.3.2 National Energy demand projections for different fuels

Afrane-Okese (1995: 36-7) compares the national energy demand projections for each fuel as well as for all fuels combined in Figure 2.7.

The figure indicates that for LPG and paraffin, the energy efficiency measures introduced are not adequate to effect any visible reduction in demand over the period 1993 to 2010. However, the electrification programme seems to result in a reasonable reduction in demand for LPG and paraffin. It also demonstrates the wisdom in combining energy efficiency measures and electrification in terms of other fuel usage like those of LPG and paraffin.

As far as coal usage is concerned, efficiency measures alone do not seem to result in immediate negative growth in demand over the given period. Electrification alone would result in immediate negative growth in demand and a combination of the two would decrease demand much further.

Figure 2.8 illustrates 'that alternative policy options seem to offer some solutions. If fuel switching and appliance switching follow the trends assumed under the Electrification Scenario, it could be expected that electrification alone can lower the growth of the national energy demand significantly' (Afrane-Okese 1995). The Efficiency Scenario contributes to a significant decrease in national energy demand over the period 1993 to 2010.

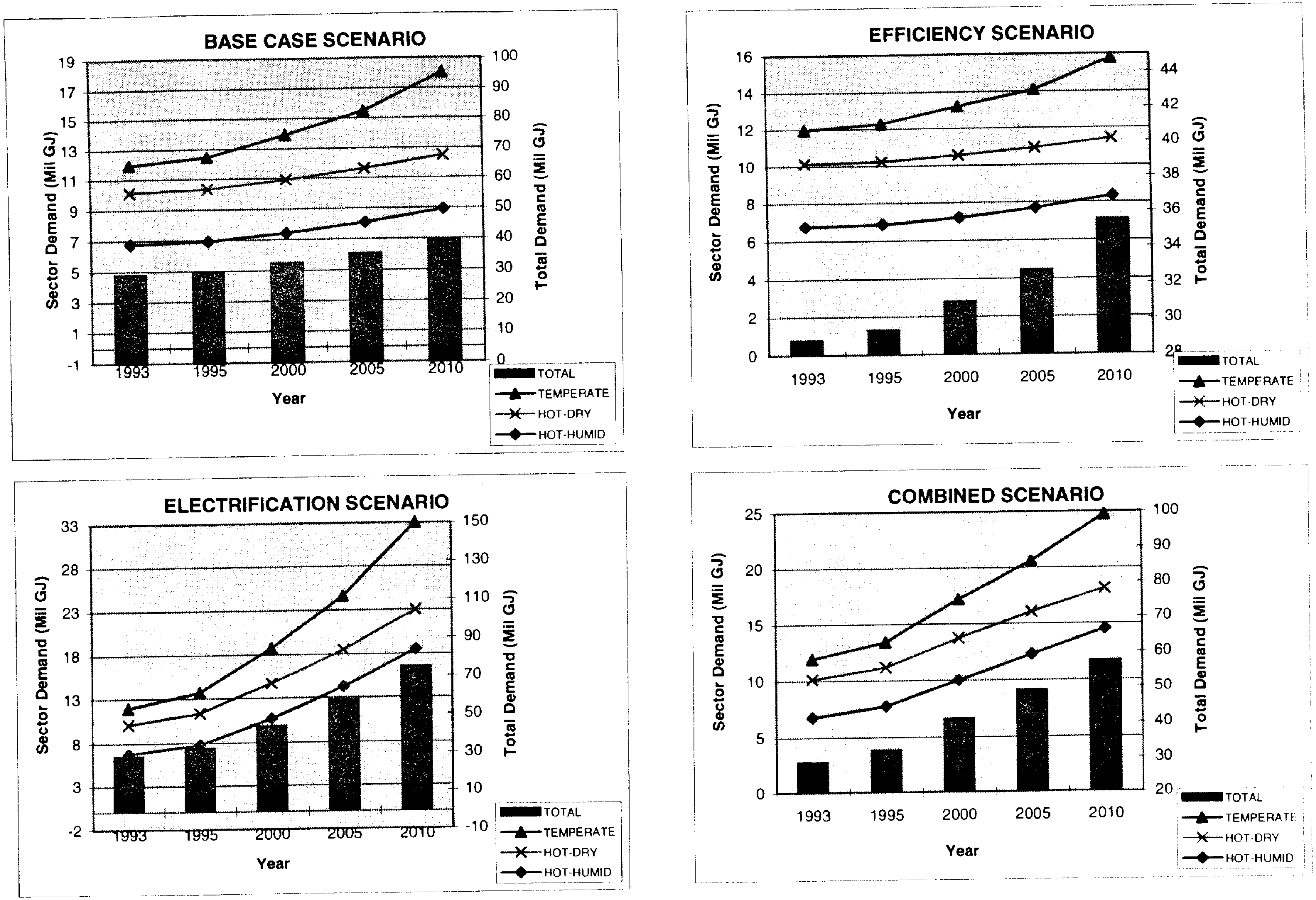


Figure 2.6 Electricity demand projections: sector by year
Source: Afrane-Okese (1995: 35)

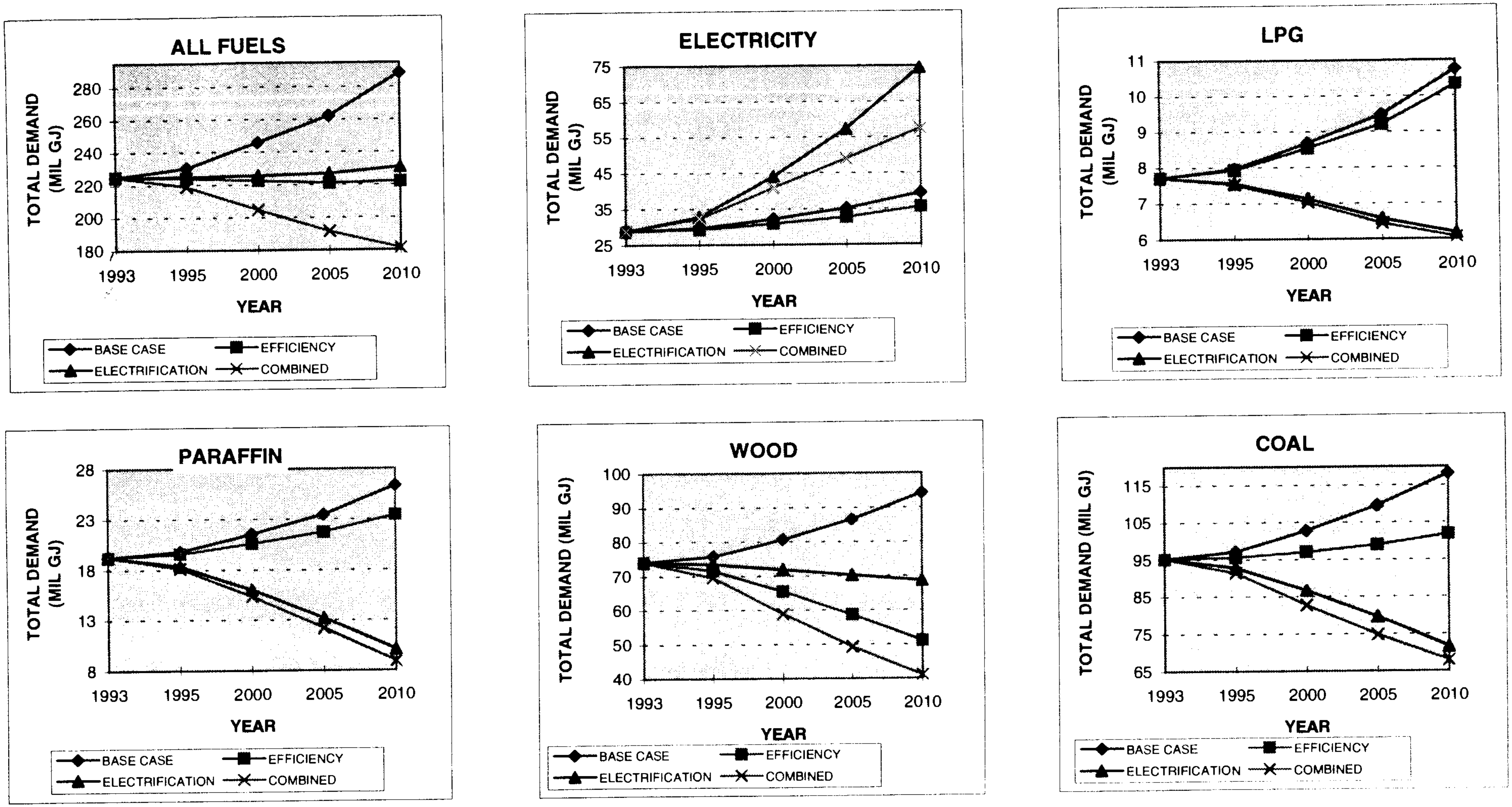


Figure 2.7 Total demand projections for different fuels, all climatic sectors by year
Source: Afrane-Okese (1995: 36)

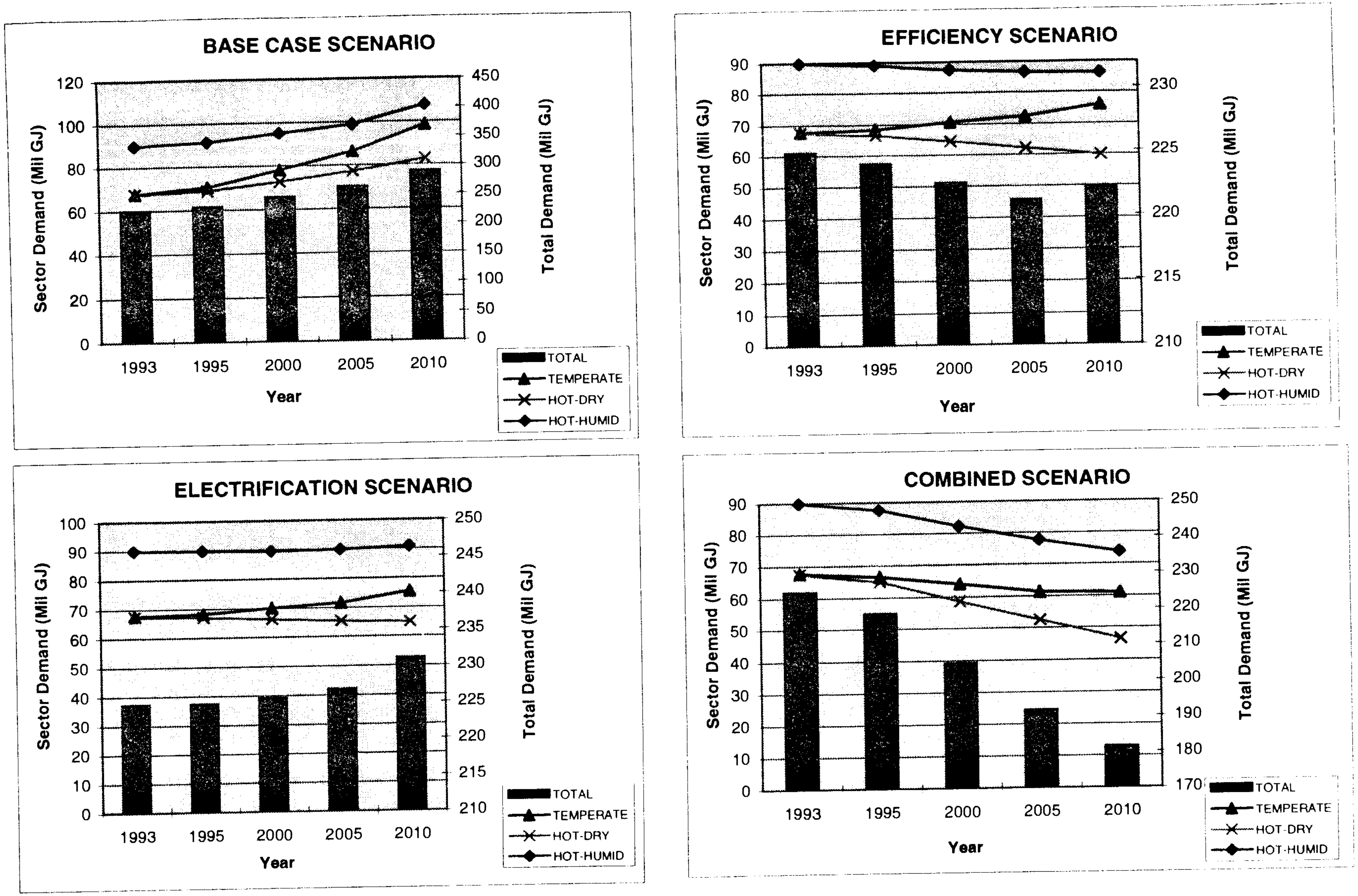


Figure 2.8 Energy demand projections: sector by year, all fuels
Source: Afrane-Okese (1995: 34)

CHAPTER THREE

SUPPLY-SIDE ENERGY EFFICIENCY INTERVENTIONS

3.1. Introduction

This chapter reviews the current practices of energy suppliers with respect to energy efficiency and demand-side management. Suppliers' application and policy-makers' contribution to energy efficiency measures are also examined.

3.2. Eskom's IEP and RDSMP

Eskom, the largest supplier of electricity to residential households in South Africa, defines *integrated electricity planning* (IEP) as a 'process which aims to reduce the cost of electricity by selecting an optimal mix of demand-side and supply-side programmes with which to satisfy customers' needs' (Eskom 1994). Eskom employs Residential Demand Side Management Programmes (RDSMP) as a tool of IEP. Demand side management was defined in chapter one of this paper as 'a supply authority management scheme, which is end-user informed' (Thorne 1995: 96).

The objectives of Eskom's RDSM include the following (Ligoff 1993: 2):

- optimising the utilisation of surplus capacity;
- sustaining the decrease in the real price of electricity in the long term;
- increasing electricity's competitiveness in the small customer energy market;
- contributing towards the national economy; and
- contributing towards environmental conservation and awareness.

Eskom essentially adopted DSMP as a means of reducing the demand on the electricity load at peak time (Eskom 1995: 16). Its current RDSM programmes are outlined below.

- Time-of-use tariffs (TOU)

This is a time-differentiated pricing structure which can be used to extract the desired market response from small customers or residential households.

- Water heating load management

Water heating typically constitutes about 40% of a domestic load (Ligoff 1993: 17). This end-use is often seen as having the greatest potential for load shifting since electric water heaters do not have to be switched on at the time of use.

Eskom has four sub-programmes associated with water heating load management. These include:

- Promotion of appropriate hot water usage

The intention of this programme is to promote appropriate water heating systems which are available in the country at the moment such as efficient shower heads and so on.

- New geyser design

New geysers are to be designed and marketed to take into account TOU tariffs, extended ripple control switching and solar heater adaptation.

- Solar water heating

This programme is aimed at developing and marketing cost-effective solar water heating in conjunction with electric water heating systems.

- Heat pumps

The intention of this programme is to develop and test cost-effective heat pumps and to market these as efficient water heating systems.

- Appliance labeling

This programmes aims to create an awareness among customers of the relative running costs of appliances. Eskom intends to rate appliances in terms of their relative energy efficiency. Initial appliances targeted include fridges and freezes.

- Thermal efficiency

Eskom's load research has shown that the demand of low-income communities is particularly sensitive to changes in temperature with space heating constituting a major component of the after diversity maximum demand (ADMD). This contributes directly to both morning and evening peaks.

- Efficient lighting

This programme of Eskom's intends to promote the use of compact fluorescent lights as well as other efficient lighting sources.

- Combined DSM programmes

Figure 3.1 provides an indication of the impact on a domestic load profile given the combined DSM programmes.

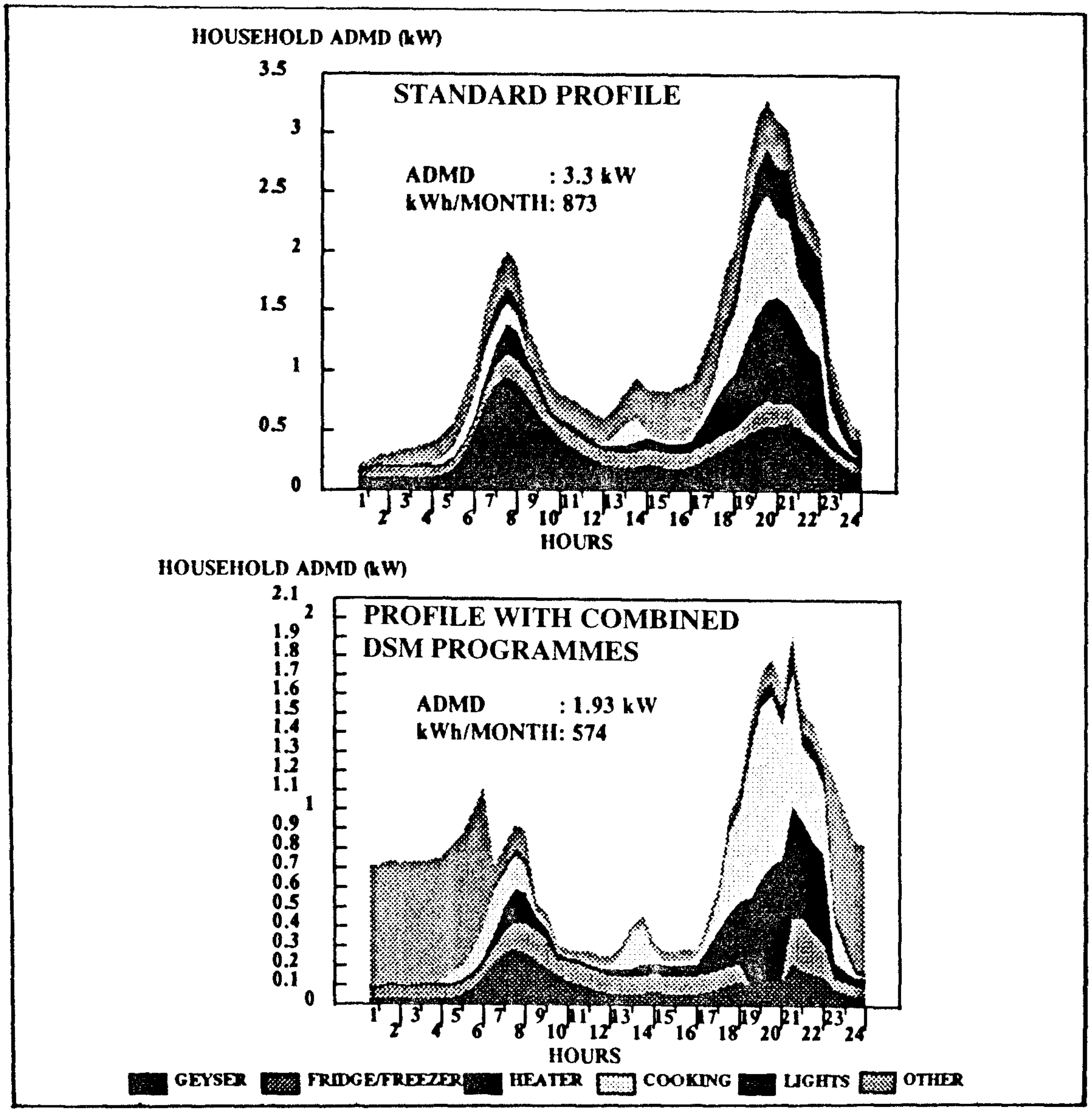


Figure 3.1 Impact on a domestic load profile in response to the combined DSM programmes
Source : Liggoff 1993

3.2.1 Eskom's energy efficiency funding

Eskom's five year funding commitment of R238 683 000 to research between the years 1994 and 1998 includes an allocation of R2 million (2.2%) to energy management systems where the focus is on energy efficiency and conservation (Eskom 1993). In the current year (1995) an amount of R630 000 has been allocated to the thermal performance of dwellings and adequate and affordable energy services for the urban poor (Eskom TRI 1995).

3.3. Local authorities' application of DSM

Local authorities in South Africa utilise DSM in a very limited way. Their motivation is somewhat similar to that of Eskom's, that is to reduce the demand on the electricity load at peak time.

- Ripple Control

This involves the direct control of hot water geysers by switching them off at peak times. This measure is popular with municipalities because of the direct economic benefits the municipality derives through the improvement in load factor and the reduction of the purchase cost of power from Eskom (Anderssen and van der Merwe 1989: 88).

- Tariffs

Time-of-use tariffs are mainly utilised by municipalities in South Africa to affect demand. Where tariffs are used, they are based on marginal cost, time-of-use and time-of-day. Others are specifically designed to alter the load shape of the municipal supplier. According to Anderssen and van der Merwe, the use of tariffs is rarely employed to 'influence user behaviour and to improve load factor' (1989: 90).

- Communication

In some instances there is an attempt by municipalities to communicate with customers about the most efficient way of using electrical energy. This usually takes the form of a newsletter accompanying the customers' electricity account. The account itself, however, does not explain in any great detail to the customer how electricity is utilised and how savings could be made. Electricity accounts are generally set up to suit the needs of accounting departments within municipalities rather than the customers they serve.

- Load shedding relays

Municipalities are known to discourage their customers from the simultaneous use of stoves and hot water cylinders. These are often also communicated in a newsletter which is often not the most effective means of communication. The effectiveness of this strategy has neither been measured nor documented by municipalities.

- Pumped storage scheme

Anderssen and van der Merwe (1989: 93) report that the Cape Town City Council operates a successful pumped storage scheme at Steenbras which ensures a very high Eskom load factor.

3.3.1 Energy efficiency funding - local authorities

Figures 3.2 and 3.3 represent the typical format of the expenditure accounts of two of the largest local authorities' electrical engineering departments in South Africa, namely Cape Town and Johannesburg. Funding towards energy efficiency programmes is not specified and if included in the category 'other' in the case of Cape Town, constitutes only a minute percentage of this department's expenditure.

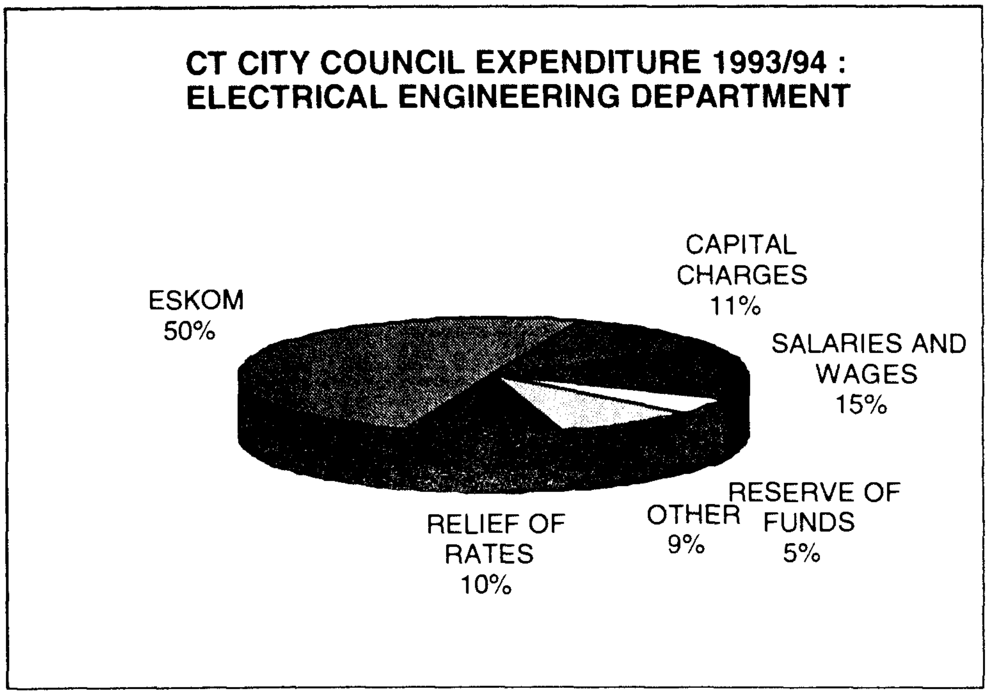


Figure 3.2 Cape Town City Council Electrical Engineer's Department expenditure (1993/1994)
Source: Cape Town City Council Electrical Engineer's Department's Annual Report (1993/94)

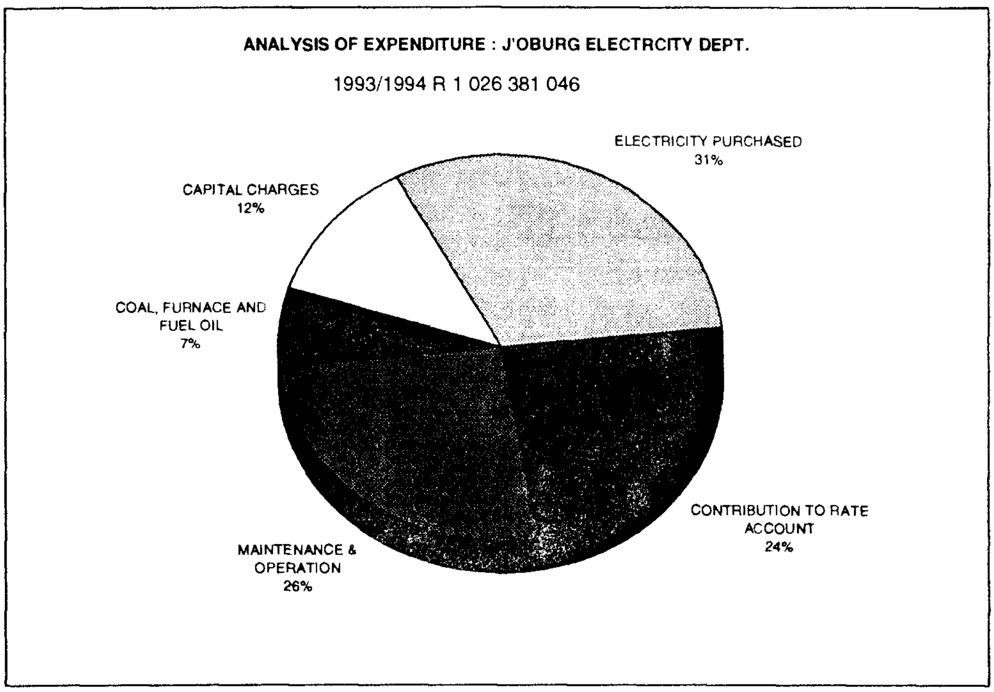


Figure 3.3 Johannesburg City Electrical Engineer's Department expenditure
Source: Johannesburg City Electrical Engineer's Annual Report (1993/94)

There is no indication in the literature surveyed that local authorities take account of thermal comfort when they construct housing developments for low-income households.

3.4. DMEA, energy efficiency and funding

The Department of Mineral and Energy Affairs' Energy for Development directorate supports policy research projects on energy efficiency to inform its policy making. For example, it introduced a manual containing guidelines for housing boards which contain thermal comfort considerations. Some of its other work on energy efficiency in the urban household sector is incorporated into the major studies reviewed in chapter 2 and listed in the bibliography.

There is currently very little explicitly stated national policy on energy in housing development including considerations about thermal performance. Minimum standards through regulation governing planning and development of formal housing are generally applied.

This department is, however, largely responsible for providing funding for research in the area of energy efficiency in the low income urban household sector. Figure 3.4 indicates that the budgetary allocation for this department is R716 374 000 for this year. It forms roughly 0.2% of the total government expenditure account for the current financial year.

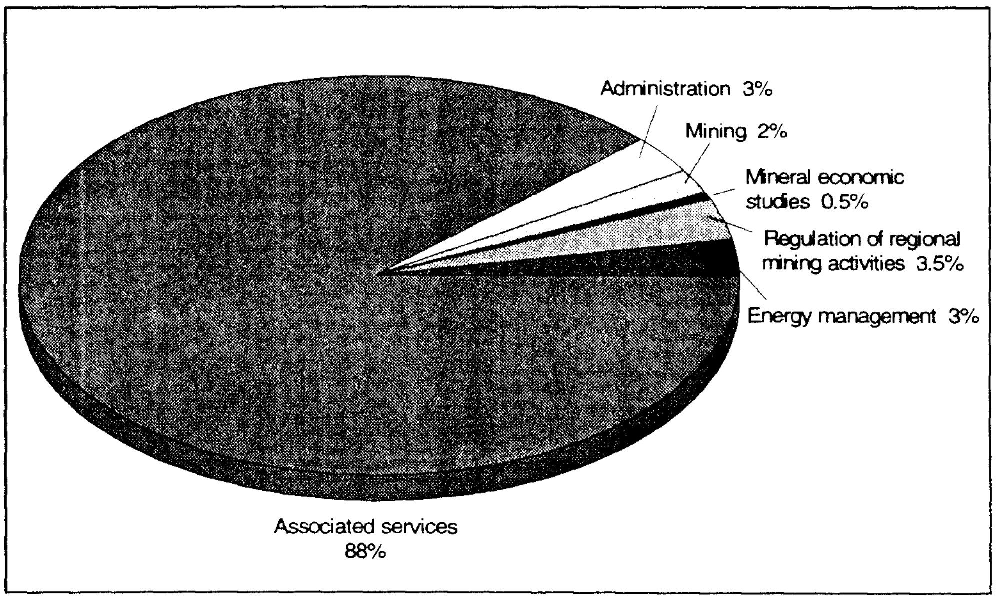


Figure 3.4 Department of Mineral and Energy Affairs budget allocation - 1995/96
Source: Department of Finance (March 1995)

The most noticeable feature about the DMEA's budget is its huge allocation to 'associated services' which is undefined in the public information available on budgetary allocations for the current fiscal year. The DMEA, however, confirmed that 68% of the 88% allocated to this category goes towards nuclear energy. It was further confirmed that of the 68%, R311 million is a direct subsidy to the Atomic Energy Corporation (AEC).

Only 3% of the DMEA's budget is allocated to energy management which refers to the department's research funding commitment to ensure the optimal utilisation of energy sources. Figure 3.5 depicts the breakdown of the department's expenditure on energy management, the largest share of which goes towards electricity (34.5%). This portion is allocated to research into electricity and gas (8.54%), energy efficiency and coal (25.58%), energy and environment (65.86%).

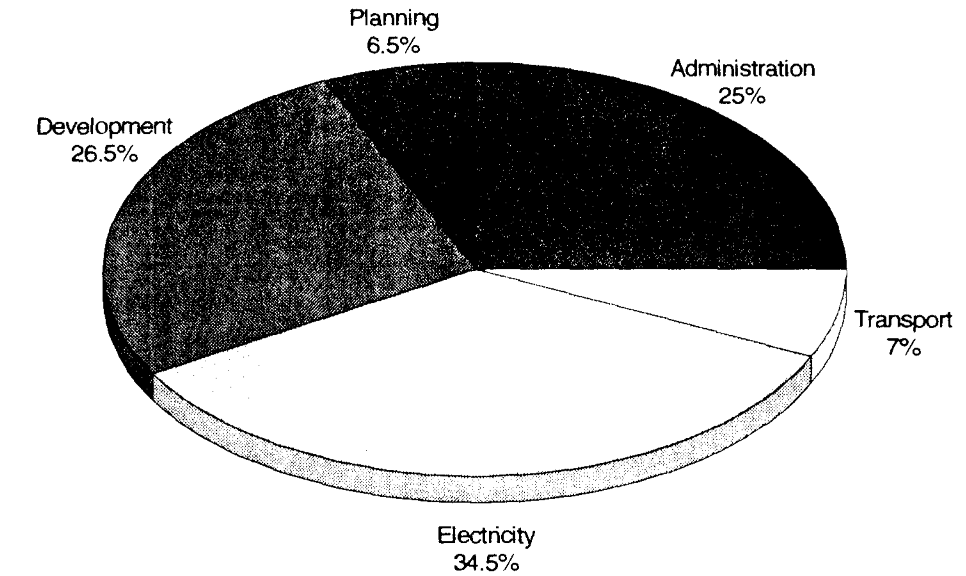


Figure 3.5 Breakdown of DMEA energy expenditure for 1995/6

Source: DMEA (1995)

3.4.1 Energy policy white paper (Energy Policy Discussion Document)

This purpose of this document is to provide a systematic framework for government, energy suppliers, users and other stakeholders to participate in dialogue around a new energy policy directive for South Africa.

The document covers energy efficiency in the following areas:

- the development of an energy efficiency agency within the Department of Mineral and Energy Affairs;
- the promotion of energy efficiency by the state through the development of knowledge and information on sectors and applications where energy is used inefficiently;
- the introduction of energy efficiency into state buildings and facilities;
- the establishment of a national programme aimed at improving the thermal performance of low-cost housing;
- the improvement of appliance energy efficiency through the application of minimum standards, establishing appliance norms and labeling and introducing import barriers based on appliance performance standards and norms; and
- the control of hot water geyser systems.

The areas considered in the Energy Policy Discussion Document no doubt cover a wide range of issues pertinent to energy efficiency. These will be evaluated in the following chapter.

3.5. The National Electrification Forum (NELF)

NELF was a forum of non-statutory and statutory stakeholders investigating a range of policy issues with a view to increasing the rate of electrification of the household sector.

NELF's working group for the end-use of energy and the environment produced a number of working documents in 1994 to consider the provision of domestic energy services, particularly electricity, to end-users. The focus of this group was the satisfaction of domestic energy service needs at lowest life cycle cost.

The reports produced by this working group included the following.

3.5.1 The use of energy and equipment

This study investigated the use of equipment, including characteristics and affordability, the mix of energy carriers and the consumption, cost, availability and affordability of energy to users.

The policy issues identified include gender considerations, the importance of energy for thermal applications, the unraveling of the benefits and disadvantages of each of the multiplicity of fuels used by households and addressing the problems associated with the acquisition of appliances.

3.5.2 Domestic electrical appliances

The electrical appliance manufacturing industry's output for 1993 amounted to R2.1 billion. Equipment of completely built up units worth R700 million and component parts worth R500 million were imported for this period. Exports represented R75 million. It is estimated that approximately 15% of total appliance sales were a direct result of new electrification programmes (Basson 1994). This will, however, change over time.

Two salient points mentioned in this work are firstly, the lack of consumer knowledge among new and potential consumers about electricity usage, appliance availability, prices and quality differences and secondly, first time affordability, high life cycle costs and cost of credit.

3.5.3 Passive/thermal design and heating of dwellings

Concern was expressed about the poor thermal performance of dwellings occupied by low income households. The life cycle cost of heating a dwelling with poor thermal performance is much higher than one with good thermal performance. Thermal performance of existing low-income dwellings can be considerably improved through retrofitting measures.

The existing use of specific energy carriers for space heating, especially coal in the inland urban areas of the country, leads to unhealthy environmental conditions inside and outside the dwelling. It is estimated that the health costs associated with the use of this energy carrier for all end purposes, including loss of productivity, is very high.

Health costs can be reduced significantly through passive thermal design and retrofitting.

3.5.4 Demand profiles and their influence on electrification strategy

Basson (1994) outlines the nature of township electricity demand profiles and studies associated with these. The present impact of these profiles is quantified and future projections are made based on growth estimates of the various sub-sectors within the South African domestic customer base.

The impact of end-uses on the demand profile and the potential for some DSM initiatives within the domestic sector are also evaluated.

3.5.5 Energy and environment interface

This report summarises 'the environmental impacts of electrification and details a holistic environmental management approach which may be adopted in a national programme such as electrification' (Basson 1994). Important national impacts of electrification are identified along with weaknesses and gaps in the current processes associated with the provision of this service.

Integrated environmental management (IEM) was evaluated and said to be inappropriate for electrification. It was therefore concluded in this work that 'subject to the implementation of appropriate management systems, electrification will result in net positive or neutral local, regional and global environmental impacts' (Basson 1994).

3.6. The National Electricity Regulator

The National Electricity Regulator (formerly known as the Electricity Control Board) which was established in 1995, represents a wide spectrum of stakeholders and implements public policy for the electricity sector by issuing licenses for the distribution, transmission and generation of electricity in South Africa. It has the power and mechanisms to determine conditions of supply and set tariffs.

It does not, however, engage in any energy efficiency measures at this stage and requires a clear policy directive on energy efficiency to be provided by government (Steyn 1995: personal communication).

The Electricity and Eskom Acts are the main pieces of legislation governing electricity generation and distribution in South Africa. Energy efficiency is not at all mentioned in either of these governing measures.

3.7. Oil and coal companies

Thorne (1995: 49) points out that oil and coal companies have very limited interest in promoting energy efficiency measures, especially in the household sector since their direct interest lies in increased sales. In any event, the household sector makes a minute contribution of these companies' sales.

3.8. Mortgage lenders

There is no explicit commitment from mortgage lenders to provide low-income housing borrowers with incentives to consider the thermal comfort of their dwellings at the point of construction or in retrofitting measures in the case of already existing mortgage holders.

It is estimated that R7.5 billion per annum will be required to construct 300 000 homes in order to address the backlog in the provision of housing in the country (de Blanche 1993). This size of this potential market may well lead mortgage lenders to consider thermal comfort as part of the financial package offered to low-income housing borrowers.

3.9. Builders

Thorne (1995) points out that a survey of 121 building contractors revealed that 70% seldom or never take energy efficiency into account in the design of structures. Figure 3.6 points out the respondents' reasons for this.

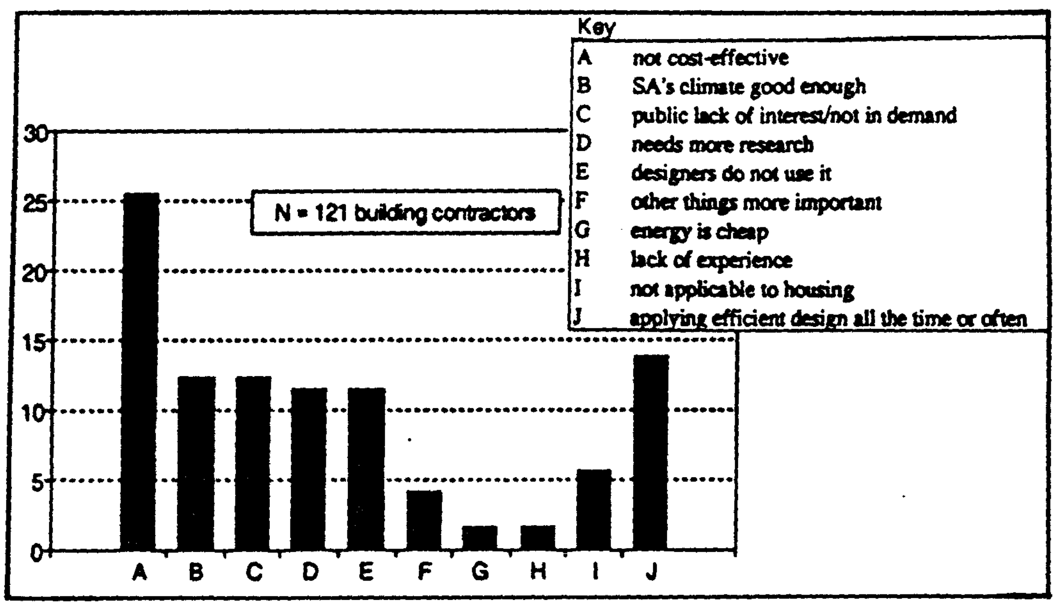


Figure 3.6 Builders' reasons for seldom or never using energy efficient design
Source: Lewis (1993)

CHAPTER FOUR

ANALYSIS OF ENERGY EFFICIENCY MEASURES

4.1. Introduction

It was stated earlier that *integrated energy planning* (IEP) demands that the energy sector be integrated with the social, economic, political, environmental and spatial sectors. It was also asserted that demand analysis requires an understanding of the relationship between energy demand and other variables so that it can adequately inform DSM practices.

Chapter three of this paper reviewed the management tools employed by suppliers and the contribution made by various stakeholders to energy efficiency practices in South Africa. This chapter critically analyses these practices in terms of their application to the focus group of this paper.

4.2. Redefining IEP

IEP may be a sound methodology or process within which energy policy planning and implementation takes place since it endeavours to incorporate those sectors mentioned above. However, when it is applied to the assessment and understanding of energy efficiency in the urban poor household sector, it is clear that the economic (including technology) and political sectors prevail. While the importance of these sectors is not to be denied, IEP would offer more if these were integrated with environmental, social and spatial considerations as well. In theory, IEP should consider all these sectors (Eberhard 1994). However, this does not happen in the practical application of IEP.

The fate of the energy needs of the poor in South Africa is largely determined by information and data sources which are predominantly based on economics and politics. Macro economics and national demographic data sources are the main informants of energy policy making. Energy end-use, fuel consumption patterns and energy efficiency in this sector are analysed in terms of these data sources and while there is a place for the use of such data, there is no indication of what real economic benefits there might be for the individual household in the urban poor sector i.e. micro economic effects.

Furthermore, at a broad level, IEP contains elements of the basic needs approach. However, from a political point of view the basic needs approach has been disparaged because it fails to address the unequal power and gender relations at the household level (Makan 1994: 5). Furthermore, it is argued that 'the tendency in research to look *at* households rather than *inside* them, ignores important intra-household dynamics such as gender and the implications they have on power and control over resources' (Moser 1993 cited in Makan 1994).

Where smaller scale local area research has been conducted such as the study in Cape Town by Thorne and Qangule (1994), the focus is on end-use and consumption patterns rather than sketching a holistic picture of energy as a component of the effective operation of a local urban area. In other words, the question of what should be done in order to overcome the development problems in this area or region and how should the energy input be arranged to contribute effectively to that process, remains unresolved.

As observed in chapter three of this paper, the DMEA's budgetary allocation is largely informed by macro-economics and politics. It was stated earlier that self-sufficiency and sustainability in energy resources has historically been a high priority for South Africa. The large discrepancy in the allocation of funding between the Atomic Energy Corporation, for example, and energy management which includes funding for research on energy efficiency and electricity, would be adjusted and re-prioritised if based on an approach true to integrated energy planning i.e. taking account of all sectors of development. Energy efficiency and the environment would then feature as a higher priority on the department's budget.

The political framework within which energy planning and service provision takes place, has until now, taken a top-down approach to commissioning research, ignoring the input and participation of marginalised groupings such as the poor and, especially, women (the main end-users in the household sector in general and especially in the urban poor household sector). The lack of qualitative research and decision-making bears testimony to this. Qualitative research as a more intimate and thorough methodology, would undoubtedly include micro scale determinants which are likely to be overlooked in quantitative research.

IEP therefore needs to be adapted to include two important criteria when it is utilised as a research methodology. These criteria are integration and scale and are directly linked. Integration requires that energy planning be part of an overall development plan for a local area or region taking into account the way in which elements of the same system can be linked in the most cost-effective and efficient way. For example, the principle of integration would ensure that the provision of housing includes the simultaneous provision of ancillary services such as electricity, other utility services, roads and so on. Scale has a quantitative and qualitative nature to it. The quantitative reigns at the macro or national level and the qualitative, mainly at the micro or local area level. Policy formulation and funding commitments at the national scale are largely based on quantitative criteria or projections. While there is some application of this at the micro scale for practical purposes, the delivery of qualitative products can only happen at this scale, for example, improved thermal comfort.

Energy planning would be more effective if the two scales are utilised in an interdependent way. Existing information and data sources on energy efficiency in the urban poor household sector covers mainly the macro scale. Primary research on energy efficiency therefore needs to focus on the micro scale.

4.2.1 IEP and modelling

The literature reviewed in this paper clearly emphasises that one of the most important macro determinants of a household's energy consumption is its geographical location. The studies mentioned above are therefore neatly categorised into climatic zones. The seasonal nature of fuel usage for different end purposes among the urban poor is, however, ignored in some of the work completed on energy end-use patterns among the urban poor in South Africa.

The data analysed by Afrane-Okese (1995: 16) on space heating, for example, shows that coal is used by a relatively small percentage of households in the three climatic zones identified in his study. This is not consistent with the known situation that coal is widely used in the Gauteng province. One of the reasons for this is that some of the data might have come from summer surveys but was treated in an 'all-year' fashion.

The problem associated with the analysis of data in this way, however, lies in the fact that modelling, in this case the LEAP model, as a technical analytical tool of IEP requires the categorisation of data in a specific way in order for it to be utilised effectively to determine user demand. Chapter two describes how data needs to be arranged so that it can neatly fit into the LEAP model. One aspect of this arrangement is the manipulation of data into three broad climatic zones (temperate, hot-humid and hot-dry).

Again, this raises the question of scale in assessing the focus group of this study. While the model enables the literature to undertake demand analysis at a broad national scale and in this way, inform energy policy at this level, it does not advance the argument for improving energy efficiency at the micro or household scale.

It is reiterated here that the predominance of macro scale determinants informing the urban building process prevents urban place-making from responding to the natural conditions prevailing in certain local areas. Macro scale determinants can only be stated broadly and therefore often fail to inform site specific conditions which informants at a micro scale are able to do and therefore contribute optimally to the thermal efficiency and comfort of the dwelling.

Seasonality needs to be considered in the provision and planning of energy services for the urban poor household sector in South Africa. In the planning and provision of energy services for the urban poor household sector, there is a need to adapt IEP in such a way so as to incorporate and bring together macro and micro elements or determinants into the process.

4.2.2 Determinants of DSM

The determinants of DSM were mentioned at the outset of this paper and are listed here again for ease of reference. They include the following (Eberhard 1994):

- macro economic data
- demographic data
- sector and subsector data for each end-use
- consumption sector and fuel
- fuel price
- cost of alternative fuels
- availability of fuels
- connection or access charges
- reliability of supply
- uniformity of quality
- convenience of use
- technical and economic characteristics of energy-using equipment and appliance
- availability of credit
- income
- rate of urbanisation
- social preferences
- acceptability
- knowledge of potential users

The literature on energy efficiency mirrors some of these criteria or determinants and DSM strategies employed by suppliers at the national level, are also well informed by them. The last three, however, i.e. social preferences, acceptability and knowledge of potential users, while in some instances documented (Thorne and Qangule 1994) are not widely used to inform analysis on energy end-use and consumption patterns among the urban poor household sector. In identifying the elements of a gender-sensitive planning approach, Makan (1994) recognises the need for a holistic approach which emphasises an in-depth understanding of energy end-users.

These three determinants have a qualitative touch and can be determined only at a smaller scale. For example, knowledge of users and acceptability of energy services or supply to the user, can only be thoroughly explored at a smaller local area or household scale. Hence, the importance of scale and qualitative research arises once more.

Williams (1994: 10) states that 'there are numerous determinants of energy demand some of which can be described as macro, that is, external to the household, while others act at the micro level, within the household itself.' These micro scale determinants are listed below.

- household size, including lodgers (concept of number eating from the same 'cooking pot')
- house structure, insulation, orientation, number of rooms
- tenurial rights
- water supply type
- household income, including patterns and reliability
- expenditure on all household requirements
- status (gender, age, education) of fuel and appliance user
- extraordinary energy use, feasts, funerals
- preferences, for example, dietary
- home-based productive activities
- health and safety considerations
- fuel prices, including alternatives
- availability and access to energy carriers
- reliability of supply and uniformity of quality
- cost of access to energy carrier, for example electricity connection fee
- appliances, source, cost, length of ownership
- technical and economic characteristics of appliance-fuel combination, convenience of use, multiple end-uses

From an energy efficiency and end-user perspective, the criteria listed above should include considerations which examine the urban poor household sector's energy needs in an all-inclusive way. This is significant in two ways. Firstly, research will be based on the needs of this sector and not on demand, which has an economic implication. Needs are defined as the energy requirements expressed by the target group itself. This is distinguished from demand which is inferred from data collected from a survey where the representavity of the sample is determined outside the user community and from a research perspective. Secondly, energy considerations will not only focus on the household itself but on other energy-related aspects as well. For example, end-users, especially in the low-income bracket, would take account not only of the end-uses focused upon in the literature i.e. cooking, space heating, water heating, lighting, refrigeration and media but would consider transportation as well.

In fact, transportation is an important aspect of any end-user's energy-related considerations and constitutes the means by which urban areas are connected to one another. It would constitute a very important energy consideration for any economically active householder in the focus group of this study if his/her livelihood depends on traveling/commuting between home and a place of work. It is important to note that the financial benefits of employment enable households to acquire access to other energy carriers necessary to run the household.

The structure and form of the South African city is not very conducive to efficient traveling and commuting (Boerne and Hatfield 1994), especially for the urban poor household sector who most often reside on the urban periphery and away from higher order urban opportunities like places of work, hospitals, tertiary educational institutions and so on. City structure is oriented to accommodate mainly road transportation and especially the private motor-car which in itself presents problems such as those of congestion and pollution. The private motor vehicle is not a very affordable commodity given its high entry-and-operating costs. Household energy needs and demand should therefore take into account transportation requirements.

An unresolved question related to energy efficiency which was mentioned earlier is that concerned with the strategies households themselves employ to conserve energy sources. This has a direct bearing on the extent to which households themselves are involved in energy research, policy and decision-making. Again, qualitative research would include participatory planning methodologies which include the household itself.

The list of determinants should therefore not be seen as conclusive and should be extended to include, among others, scale, transportation energy, participation and qualitative criteria.

4.2.3 Supplier-informed DSM

Current demand side management programmes are mostly suited to the needs of the supplier rather than the needs of the target group of this paper. Hence, it is referred to as a supplier-informed demand-side management tool.

Demand-side management programmes employed by utilities and distributors tend to focus on direct load control to reduce peak load. Eskom's focus, for example, is mainly on the utilisation of its surplus capacity and sustaining the decrease in the real price of electricity. Its RDSM programmes are focused on reducing peak demand especially in the domestic sector. Local authorities engage in demand side management practices for much the same reasons, that is, to reduce the demand on the electricity load at peak time. Improving thermal performance as a DSM tool, is an important and cheap option which can be incorporated into the country's housing and electrification programmes and from which benefits can be derived for suppliers and end-users alike, especially end-users in the urban poor household sector. While there are merits in the application of other tools such as solar water heating and appliance labeling, the question of this sector's ability to gain easy and affordable access to appliances, needs to be addressed and overcome.

Other than serving the direct interests of suppliers or distributors, energy efficiency measures employed by them are seldom based on end-users' energy needs. Hence, DSM is essentially a supplier-informed management tool. Suppliers of electricity are informed by electricity demand, not end-users' energy needs and multiple fuel considerations. Hence, their focus on technological and economic solutions to energy efficiency in the household sector.

So, what benefits are to be gained by the urban poor household as end-user other than active attempts on the part of distributors of electricity to improve the thermal performance of low-income urban households through retrofitting or supporting the thermal comfort of new housing developments? Many low-income urban households do not have access to electricity at all. If *efficiency* refers to the optimal usage derived from the supply of energy sources at the least financial cost to the user community and the supplier and *energy efficiency* incorporates the principles of sustainability, equity and efficiency defined earlier in this paper, then the application of supplier-informed energy efficiency interventions have not been very successful in the urban poor household sector.

Anderssen and van der Merwe (1989: 96) identify the possible factors which inhibit municipal distributors' application of effective DSM programmes. These include, among others, a 'top-down' regulatory climate. What is meant by this is that existing regulatory and governance measures on electricity distribution in South Africa, are very controlled and therefore limiting in terms of permitting local authorities to be creative about demand-side management practices. As stated in chapter three, energy efficiency is not catered for in the regulations governing electricity distribution, namely the Electricity and Eskom Acts.

The other important inhibiting factor mentioned by Anderssen and van der Merwe (1989: 97) is the fragmented nature of the South African electricity distribution system which is not conducive to DSM. The country has a large number of local authorities. The effort to persuade so many municipalities to adopt DSM as a management tool is quite an onerous task, especially if returns on their 'investment' cannot be guaranteed and/or measured in monetary terms. Incentives are therefore required to convince municipalities and smaller distributors about the merits of appropriate DSM programmes.

Again the question of demand analysis versus households' expressed energy needs is exposed. The economic culture of suppliers is to ensure a return on their 'investment'. Returns on DSM 'investments' cannot always be quantified and are at times more beneficial to the end-user than the supplier, for example, the promotion of multiple fuel usage. Investment in end-use efficiency infrastructure by local authorities, such as the provision and promotion of natural or coal gas piping to households, is not seen as a priority against electricity distributors' supply-side investments.

It is the business of local authorities to recover revenue, hence the emphasis on the sale of electricity! This practice needs to be re-evaluated against the principle of equitable and affordable access to energy services by the end-user, especially the urban poor household sector. Institutional and supply-side management arrangements need to develop their practices and re-prioritise their funding in accordance with the government's proposed electrification programme and other demand-side or needs-based informants. There are many benefits to be gained from certain DSM interventions by end-users and suppliers alike. Thermal efficiency is one such example.

The energy policy discussion process which culminates in an energy summit to be held on 20 and 21 November 1995 where relevant issues are to be placed on the national energy policy agenda, should be regarded as an important medium through which the promotion of energy efficiency practices in the urban poor household sector can be effected in such a way that it will filter through to the micro-scale context. It is through these kinds of processes that appropriate DSM strategies can be lobbied for so that they can be implemented at the micro scale. Processes such as these together with government policy-making can also be effective in influencing indirect supplier stakeholders like those of builders and mortgage lenders.

Also, in the past, funding commitments from national and local government were the main sources of dictating the structure and form of a single dwelling aimed at housing the urban poor. A single amount (say R40 000) would be made available for the construction of one dwelling. The focus therefore was on constructing a finished product worth R40 000. Other considerations like building materials and orientation which contribute to thermal comfort, were not taken into account. Attempts should be made to turn this process around by allowing the planning process to dictate the funding commitment to the construction of the dwelling unit so that it can be done properly first time round. Thorne (1995 : 50) recognises that 'mortgage lenders enter into 20 to 30 year relationships with borrowers during which borrowers are required to pay back loans. If the borrower is using less of his or her resources on keeping the house warm, this may imply that the borrower is able to afford larger loans in the first place and is in a better position to honour repayment obligations'. The relationship and potential for partnerships between policy-makers and informants of the policy-making process, should be explored more in the future.

4.3. Energy efficiency and fuels other than electricity

The literature reviewed on energy efficiency reveals that suppliers of LPG, coal and paraffin have no real interest in promoting energy efficiency in the urban poor household sector. The question arises, however, whether the onus should be on suppliers to do this or should it be on government as protector of the marginalised, promoter of energy efficiency and advocate of equitable access to energy services. The most powerful tool available to government is that of regulation. Regulations governing the processing and distribution of such fuels should therefore be examined and amended to take account of energy efficiency, health and safety measures. Some research has been initiated by the DMEA into low-smoke fuels as a solution to household air pollution problems (Dickson et al 1995).

In chapter three of this paper, it was suggested that the government's proposed housing and electrification programmes be used as an opportunity to provide new local areas with the infrastructure to accommodate a mix of fuels in order to increase household's choices and access to affordable fuels. National urban planning legislation and building regulations can facilitate this process along with promoting a mixed land use and integrated approach to mass housing development.

4.4. Energy efficiency and technology

> Analyses of the potential for energy conservation typically begin with estimates of technical opportunity. The first step is to assess energy savings which might be achieved by the adoption of economically worthwhile measures and technologies ... The trouble is that the practical application of energy efficient technologies seems to be impeded by what are routinely referred to as "non technical barriers". The conventional view is thus one in which social obstacles inhibit the realisation of proven technical potential (Shove 1995).

These words can easily be applied to the DSM tools employed by suppliers to achieve energy efficiency in the household sector. Water heating load management strategies and appliance labeling, for example, include technologies which are either absent, inaccessible or completely foreign to low-income urban households. Hence, the social obstacles of affordability to acquire these and lack of knowledge or understanding of these technologies on the part of this sector 'inhibit the realisation of proven technical potential' (Shove 1995). A further inhibiting factor is that of the usage of energy sources other than electricity which cannot fuel these technologies and therefore cannot satisfy certain end-uses with a guaranteed energy saving.

The 'social obstacle' of affordability is related to the high unemployment rate or low-earning capacity of the target group of this paper. Access to electricity is inhibited by the entry cost of preparing the household for electrification. There are two important aspects to consider here i.e. to what degree can electrification contribute to job creation and how can electricity tariffs be established within a framework of integrated energy planning?

Shove (1995) recommends a socio-technical approach as opposed to the conventional 'techno-economic' approach to energy efficiency. By this, the author implies that social criteria complement and inform technological requirements for energy efficiency. While the literature reviewed in this paper takes account of social factors, these are hardly reflected in the strategies employed to effect energy savings in the low-income household sector. More appropriate energy efficiency measures therefore need to be considered. The end-users themselves can play a significant role in identifying these measures, hence the need for participatory research at the micro scale to determine appropriate energy actions to meet the energy needs of this sector.

Education of the supplier and end-users alike (a mutual energy learning process) is required to close the gap between the conventional 'techno-economic' and the 'socio-technical' approaches. There is a place for both as long as they are complementary and not mutually exclusive.

CHAPTER FIVE

Conclusion and recommendations

5.1. Introduction

This paper has reviewed the literature on energy efficiency in the urban poor household sector of South Africa from an end-user perspective. It attempted to show what information and research is available on this topic and in what format it is presented. It also attempted to show the responses of suppliers to energy efficiency goals in the planning and provision of energy services to this sector. These responses were measured against the literature on energy demand among the urban poor household sector.

The general conclusions that can be drawn from this paper's analysis are set out hereunder.

5.2. IEP and DSM

The informants of integrated energy planning (IEP) and demand-side management as a component thereof need to be adapted and revised as a tool for energy project planning. IEP is a sound and useful method for informing national policy planning but is an insufficient tool for energy project planning at the household or micro scale. Furthermore, it should have as its foundation, the qualitative principles of equity, sustainability and efficiency and should attempt to incorporate all the different sectors (socio-economic, environmental, spatial and political).

Future research on end-use patterns among poor urban households therefore should attempt to develop a check list of determinants or elements at the micro scale which might influence this sector's decision making. This information, in turn, should be utilised to inform a DSMP.

Socio-economic indicators or variables (affordability, income, poverty, gender and unemployment) need to be included in DSM strategies. This is currently not the case. Also, performance standards which take account of qualitative criteria need to be formulated. The implication here is that if the intention is to build and /or electrify a certain number of dwellings per annum (quantity), there should be a simultaneous commitment to ensure that these dwellings are well insulated and therefore thermally efficient (quality of product). So the idea is to use the mass housing and electrification programmes as an opportunity to improve the living conditions of the urban poor.

The restructuring of local government provides an opportunity for integrated micro scale planning to take place. The delimitation of metropolitan areas in South Africa into larger and more manageable local sub-structures define spatial entities which can facilitate this process.

There are three important considerations here:

- the adaptation of the determinants of IEP and DSM as a component thereof so as to inform a methodology for micro scale energy planning;
- the formulation of performance standards for energy planning in South Africa; and
- addressing the question of whether current DSM policies are firstly, appropriate for the focus group of this paper and, secondly, whether they include socio-economic variables in their application.

It is therefore recommended that research be undertaken to revise and adapt the determinants upon which IEP and DSM as a component thereof, are based so as to create a methodology for micro scale energy project planning which should incorporate qualitative as well as quantitative analyses. This research should involve a primary research component for which existing local area-based studies, like those completed by Thorne and Qangule (1994) on new electrification schemes in three areas in the Western Cape and Golding and Hoets (1992) on energy usage in urban black households in selected formal and informal townships, could form the basis.

It is further recommended that the appropriate application of existing DSM policies to low-income urban households be investigated and the inclusion of socio-economic variables be ensured in future strategies.

5.3. Energy efficiency and electrification

The work completed by Afrane-Okese (1995) mentioned in chapter two of this paper clearly shows that the simultaneous introduction of energy efficiency measures and electrification will decrease the demand for electricity significantly.

For a large number of poor urban households, current inefficient end-use patterns are likely to continue even when they become electrified. The national electrification programme should therefore incorporate measures to address this issue. There also appears to be an assumption that this sector has access to appliances to utilise electricity for end-uses such as cooking. This is not necessarily the case and where appliances are accessible, electricity is not the most efficient energy carrier for cooking.

Most importantly, electrification in urban households should be considered alongside and in conjunction with the provision of other utility services (waste management, water supply, roads etc.) so that an integrated approach to the provision of services can be promoted. This requires the formulation of a prioritised area-based infrastructural investment programme incorporating all services for low-income households. One of the key elements of this programme is to determine how, from a financial point of view, such investment would be funded and how the issue of affordability is to be addressed.

Thorne (1995: 96) is cited here again as describing DSM in the context of energy planning as the 'management of electricity usage in order to reduce the life-cycle costs of supply.' It also includes the notion that the most efficient fuels should be encouraged to be used for different end-uses. The restating of Thorne's definition is to motivate for the national electrification programme not to be seen in isolation from the usage of other fuels by low-income urban households. These households use a number of fuels simultaneously (Basson 1994). It is therefore important to provide them with a choice of fuels.

The two important aspects to be considered in the planning of a national housing and electrification programme for the urban poor are therefore:

- the consideration of electricity along with other utility services for the target group of this paper; and
- encouraging this sector to use the most efficient fuels for different end-uses by providing safe and convenient access to fuels other than electricity.

It is recommended that the preparation and/or planning for the implementation of the national electrification programme be complemented by research work on the provision of other services as well. It is further recommended that research be conducted on the provision of safe and convenient access to fuels other than electricity so as to widen its choice and encourage the efficient use of energy sources.

5.4. Energy efficiency and transportation

Research determinants should include the varied considerations which reflect more accurately the energy needs of the urban poor household sector. These needs are not only about household fuels. They include energy for transportation to travel between origin (the household) and destination (mainly the work place).

In chapter four provided motivations for why household energy needs and demand should take into account transportation requirements as well. It was also argued that research on energy efficiency from an end-user perspective, needs to be conducted in a coordinated and integrated way i.e. housing, electrification, transportation etc. should be regarded as elements of the same system. The government's proposed mass housing and electrification programmes provide an opportunity to include other energy-related sectors such as transportation.

The transportation sector is also a large consumer of energy which poses other environmentally-related problems to the country. There are therefore two aspects of this sector which need to be investigated. The two are by no means separate but are concerns at different scales. Firstly, at the micro scale, the issue of access to energy efficient transportation by low-income urban households needs to be investigated. Secondly, at the macro scale, an environmental impact assessment of the transportation sector needs to be undertaken with a view to making this sector more energy efficient.

It is recommended that access to energy efficient transportation by low-income urban households and energy efficiency in the transportation sector, be investigated.

5.5. Thermal performance and integrated design

Improving the thermal performance of housing structures is not necessarily a priority among suppliers like Eskom and local authorities. National building regulations and urban planning legislation do not compel suppliers of housing products to attend to thermal comfort.

While information on passive thermal design is abundant, it has not been utilised very well in the design and implementation of low-income urban housing developments. This literature is also limited because of its focus on the dwelling only. Broader locational aspects such as the soil conditions of land, which can make a significant contribution to thermal comfort should also be considered in thermal design.

Energy end-use demand and consumption patterns are considered at a scale which is suitable for the formulation of national energy policy. Climatic zones, for example, are divided into six or three broad zones for this purpose. However, micro-climatic conditions need to be studied very carefully in order for optimal passive thermal design to take place. Natural elements (sun, wind, vegetation and so on) which should inform design at this scale, differ from local area to local area.

Future studies on the improvement of thermal performance and energy efficiency in the provision of low cost housing therefore need to focus on the following:

- the development of pilot projects where energy efficiency measures can be introduced;
- facilitative policies and legislation to entrench thermal design in the provision of housing;
- new housing developments should be targeted as models where thermal design can be introduced, monitored and evaluated;
- broader (than the dwelling's structure) planning issues like the siting of local urban areas on land which is generally suitable for urban development. These and other concerns mentioned in chapter three of this paper must be considered at the very outset of the planning process; and
- the sensitivities of low-cost housing design to the natural elements prevailing in local areas.

5.6. Appliances

This paper has not focused much on appliance efficiency because it is being investigated as a separate research paper within the Energy and Environment Programme. It is, however, necessary to reiterate that the continuation of research in this field especially on appropriate labeling, standards, retooling and financing etc., is important and should therefore be supported.

5.7. Energy efficiency funding

From chapter three it is clear that Eskom and the DMEA appear to be the only agencies in South Africa which have made some funding available for energy efficiency programmes in the low-income urban household sector. Suppliers' should be encouraged to reprioritise their budgets so that funding for research as well as energy efficiency projects for implementation in this sector become a higher priority.

It is recommended that funding be prioritised so that effective energy efficiency programmes can be considered for implementation and research into appropriate energy efficiency / DSM interventions be conducted. In addition, the idea of imposing a levy on commercial energy fuels to fund energy efficiency programmes and the establishment of an energy efficiency agency should also be investigated.

5.8. Education

Energy efficiency education is a two way process. Suppliers' need to understand the energy needs of low-income households from an end-use perspective as much as end-users need to learn about the various options available to them to conserve energy. The areas where education can play an important and immediate role include the following.

On the end-users' side:

- the meaning of energy efficiency;
- the improvement of thermal performance in self-made and/or other low- income housing;
- the safe, convenient and efficient use of energy carriers, including electricity; and
- the standards and life-cycle costs associated with dwelling structures and appliances.

On the suppliers' side:

- the true meaning of energy efficiency from an end-user perspective;
- the role of effective and appropriate DSM practices/interventions in the low-income household sector; and
- the need for socio-economic indicators or variables to be included in the planning and formulation of energy policy including the participation of marginalised groupings.

5.9. Energy efficiency in southern Africa

It is important for South Africa to understand and learn from its regional counterparts especially while the climate is right for regional cooperation in the energy sector. Zimbabwe, Tanzania and Zambia have the most active energy efficiency programmes in the region and either already have or are close to developing a national energy efficiency strategy (Stiles 1995).

Zimbabwe is in the process of developing a national energy efficiency improvement programme. Tanzania already has a national energy policy which includes energy efficiency. Its implementation is, however, stifled by a lack of finance from government. Zambia's Department of Energy has an energy efficiency policy in place which requires that stakeholders, mainly industry, provide government with information on the best ways of improving energy efficiency in the country.

It is recommended that a literature review be undertaken on energy efficiency and DSM interventions in the urban household sectors of these three countries in southern Africa.

5.10. Coordination and integration of services

For the provision and planning of energy services to be effective in the low-income urban household sector, it is necessary that direct or indirect suppliers and providers of such services, work in a coordinated fashion. At the same time, coordination can facilitate an integrated approach to the planning and development of other utility services such as street lighting in conjunction with energy services.

Furthermore, there is also a necessity for partnerships to be formed among suppliers, researchers in the energy sector and end-users. While the complexity of such an arrangement is acknowledged given the conflict of varied interests, the current paradigm of restructuring, transparency and legitimacy in South Africa provides an opportunity for this to happen.

It is recommended that this aspect of energy efficiency be expanded towards achieving coordination among various stakeholders. It is further recommended that the application of DSM by municipalities, also be expanded with a view to formulating a coordinated DSM programme for the anticipated restructured local authorities in conjunction with Eskom as the major distributor of electricity.

5.11. Conclusion

The information available on energy end-use patterns which is utilised to inform energy demand often reflects energy supplied to end-users as opposed to actual energy consumption. Surveys informed by end-user data such as the studies completed by Afrane-Okese (1995) and Trollip (1994), frequently omit qualitative factors about usage patterns. This has the effect of obscuring important factors regarding why and how consumption of energy sources takes place and may significantly distort demand analysis of the urban poor household sector. For energy efficiency measures to be successfully introduced and applied in the urban poor household sector, an in-depth understanding of the energy needs of this sector is required. It is therefore proposed that energy planning for the urban poor household sector begins to focus on the micro scale where a thorough understanding of the energy needs of this sector can be obtained.

The energy efficiency and demand-side management practices employed by distributors of electricity are appropriate for the management of their loads. However, these practices are not necessarily appropriate for the urban poor household user community. The reasons for this are: firstly, a large proportion of this sector do not have access to electricity and where electricity is available, there is still a reliance on other fuels like paraffin and secondly, this sector's energy end-use consumption patterns are largely influenced by socio-economic factors (for example, affordability) which make such patterns very different from the conventional electricity-based usage patterns of other urban households.

References

African National Congress 1994. Reconstruction and Development Programme.

Afrane-Okese, Y 1995. Domestic Energy Use Analysis to Facilitate Development Strategy, Draft report for Technology Research & Investigations (TRI), Eskom Technology Group, Energy for Development Research Centre, University of Cape Town.

Anderssen J J & F S van der Merwe, 1989. The application of demand side management by municipalities in the RSA, National Energy Council.

Basson, J A 1994. Summarised report on energy and the environment, NELF Working Group for the end-use of energy and the environment, Report no. SREU01, July.

Boerne, G and R Hatfield 1994. Energy and mass transportation, South African Energy Policy Research and Training Project, Paper No. 13, Energy for Development Research Centre, University of Cape Town.

Cape Town City Council 1993/94. Annual Report of the City Electrical Engineer.

Cape Town City Council 1994. Observations from fieldworkers working in Vrygrond, Cape Town - telephonic communication with fieldworker, Community Liason Unit, Cape Town City Council.

de Blanche, E M 1993. Latest Developments and Experiences in Making Available End-Use Finance in the Housing Market, 21st World Housing Congress, Cape Town, May 1993.

Davis, M 1995. South Africa's Electrification Programme: progress to date and key issues submitted to *Development Southern Africa*, Energy for Development Research Centre, University of Cape Town.

Development Bank of Southern Africa 1994. South Africa's Nine Provinces: A Human Development Profile, April.

Dickson, B C, C Van Horen & C Williams 1995. Low-smoke fuel as a solution to household air pollution problems - a synthesis of current research, Report completed for the DMEA, Energy for Development Research Centre, University of Cape Town.

Eberhard, A 1994. Integrated energy planning: A methodology for policy analysis and research, South African Energy Policy Research and Training Project, Paper No.2, Energy for Development Research Centre, University of Cape Town.

Eskom, 1993 *Five Year Research Programme Budget*, 18 November 1993.

Eskom, 1994. IEP Plan for Distribution : 1994-1995, Draft Version, 30 June 1994.

Eskom, 1995a. Residential Demand Side Management Programme Development Plan, 2 June 1995.

Eskom, 1995b. Overview of Projects per Portfolio : Energy Management Systems, 2 August 1995.

Holm, D et al 1994. Towards a policy for passive thermal design in low cost housing, Report prepared for the Department of Mineral and Energy Affairs, August.

Johannesburg City Council 1994 Annual Report of the City Electrical Engineer, 1 July 1993 to 30 June 1994.

Lewis, L 1993. State of the Building Industry, BMI Building Research Strategy Consulting Unit, Information Transfer Group, Johannesburg.

Ligoff, D 1993. Small Customer Demand-side management ten-year plan, Eskom Pricing Policy, Eskom.

Makan, A 1994. A gendered perspective of the development context for energy planning in South Africa, Energy Policy Research and Training Project, Paper No.3, Energy for Development Research Centre, University of Cape Town, 1994.

Nel, H H 1992. Synthesis of National Energy Efficiency research, excluding Transportation Energy, Final Report to the National Energy Council.

Republic of South Africa 1995. Budget Review, Department of Finance, 15 March 1995.

Shove, E 1995. *Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings,* Paper presented at the Energy Efficiency Challenge for Europe 1995 Summer Study, European Council for an Energy-Efficient Economy.

Styles, G 1995. Personal Communication, Zimbabwe.

Theron, D 1994. Eskom proposals for a national strategy on electrification to advance rural development, Report of the Eskom National Electrification Planning Department Sandton, Eskom.

Thorne, S J and Qangule, V 1994. Analysis of new electrification schemes in the Western Cape - Phase III, Report prepared for the Department of Mineral and Energy Affairs, August 1994.

Thorne, S J 1995. Energy efficiency and Conservation : Policy options for low-income households in South Africa, A Masters dissertation submitted to the Faculty of Engineering at the University of Cape Town.

Trollip, H 1994. Energy demand information for integrated energy planning, South African Energy Policy Research and Training Project, Paper No.5, Energy for Development Research Centre, University of Cape Town.

Williams, A 1994. Energy supply options for low-income urban households, Energy Policy Research and Training Project, Paper No.11, Energy for Development Research Centre, University of Cape Town.

Van Gass 1994. Presentation of some observations related to domestic energy requirements based on fieldwork done in informal settlements in the Cape Town Metropolitan area based on incomplete Masters thesis entitled *User requirements for domestic energy appliances - households in informal urban settlements,* Energy for Development Research Centre, University of Cape Town.

Van Horen, C *1994.* Financing and economic implications of household energy policies, South African Energy Policy Research and Training Project Paper No.18, Energy for Development Research Centre, University of Cape Town.

Van Wyk, S L & Rousseau, P G 1992. An investigation into energy-efficient low-cost housing design, TEMM International (Pty) Ltd, October.

Bibliography

Ameu 1993. Elektrisiteit vir al hoe meer mense... *AMEU news*, (21), June 1993.

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

Basson, J 1993. *Summary of domestic electric appliance standards in South Africa*, October 1993, 2pp.

Bauman, T 1993. *Executive summary: The household electrical durable industry in South Africa*, May 1993, 14pp.

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

Berrisford, AJ & Surtees, RM 1992. Electrical demand characteristics of low income and developing urban communities. Eskom report N0. TRI/EA?92/LR005.

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

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

Comparisons of investment Programmes: Energy Demand vs. Supply, Association for the Conservation of Energy, 1985.

Paraffin (kerosene) poisoning in childhood: is prevention affordable in South Africa? To be published in *South African medial journal.*

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

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

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

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

Eberhard, AA 1984. Energy and poverty in urban and peri-urban areas around Cape Town. Carnage Conference Paper N0.155. University of Cape Town.

Eberhard, AA & Dickson, BJ 1987. Energy consumption patterns and alternative energy supply strategies for underdeveloped areas in Bophutatswana. Energy Research Institute Report N0 IN073, University of Cape Town.

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

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

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

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

Eskom 1993. *Electro Wise programme, Folder with brochures*, October 1993.

Extract of appropriate papers from conference", *"Domestic use of Electric Energy"*, October 1993.

Fitzgerald, KB, Barnes, D & McGranahan, G 1990. Interfuel substitution and changes in the way households use energy: the case of cooking an lighting behaviour in urban Java. Energy Series Paper N0 29, World Bank, Washington.

Fowles P; *The marketing and provision of electrical appliances and education of consumers on the effective and safe by electricity distributors*, Final Report WGEU01, September 1993, 6pp and appendices.

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

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

Helm, J L (ed) 1990. Energy production, consumption and consequence.

Holm,D 1993. *The State of Knowledge of Passive and Thermal Design of Dwellings*, Final Report WGEU03, November 1993, 26pp and appendices.

Holm, D, et al 1994. *Passive/thermal design and space heating of dwellings*, Subgroup report SGEU03, July 1994, 28pp.

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

Kessel, A 1988. Black squatter market: technical report. Markinor (Pty) Ltd. Job N0 88/286/AK.

Kidgell, U, et al 1993. *Space heating in developing communities in South Africa: A Synthesis*, Department of Mineral and Energy Affairs, November 1993, 9pp.

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

Lawrence, V A et al 1994. *Domestic Water Heating: Requirements for Dwellings in the developing Sector*, Final report WGEU09, March 1994, 38pp and appendices.

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

Lennon, S J, et al 1994. *Environmental impacts of electrification*, Final Report WGEU05, March 1994, 54pp.

Lennon, S J, et al 1994. *Environmental strategies for electrification*, Subgroup report SGEU05, July 1994, 19pp.

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

LHA Associates; *Electrification and the electrical appliance manufacturing and distribution industry*, Final report WGEU06, March 1994, 48pp.

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

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

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

McGregor, GAG 1993. South African Energy Policy Research and Training Project Paper No. 14b. Hydrocarbon fuels. Cape Town: Energy for Development Research Centre, University of Cape Town.

Minerals Bureau 1990. South Africa's mineral Industry 1990. Johannesburg: Mineral Bureau, Department of Mineral and Energy Affairs.

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

Olivier, Anton-Louis 1995. *A framework for the implementation of Energy Efficient Building Design in the low income domestic sector*, Paper presented to the Southern African Institute of Energy (SAIE) conference on household energy for developing communities, 18-21 July 1995.

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

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

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

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

Sawhill,JC & Cotton,R 1986. Energy conservation ,successes and failures.

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

Rossouw, A M M & van Wyk, M J 1993. A socio-economic survey of energy consumption patterns in the Eastern Cape: a database. Institute for Planning Research, Report N0.48. Port Elizabeth.

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

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

Simon, E A & Norval, R D1987. Ondersoek na verbruik van en besteding aan water en energiesbehoeftes in Botshabelo and Mangaung. READ Consultants, Bloemfontein.

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

Snow, A, and Pather, K 1994. *International literature review: energy in developing countries*, Final report WGEU08, June 1994, 30pp and appendices.

Stassen, D, et al 1994. *Manufacturing and distribution of and consumer requirements for appliances*, Subgroup report SGEU01, July 1994, 13pp.

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

Steyn, G 1993. The electricity distribution sector, South African Energy Policy Research and Training Project Paper Paper No. 14 Energy for Development Research Centre, University of Cape Town.

Surtees, R et al 1994. *Demand profiles and their influence on electric demand profile,* Final Report WGEU02, June 1994, 23 pp.

Surtees, R, et al 1994. *Demand profiles and their influence on electrification strategy,* Subgroup report SGEU04, June 1994, 23pp.

Surtees, R 1993 *The Implications of electrification on the South African electric demand profile,* Final Report WGEU02, October 1993, 42pp and appendices.

Thorne, S 1994. Discussion notes entitled *"Household loads", "Loads again"* and *"Energy efficiency and conservation",* April to July 1994.

Du Plessis, J 1991. The socio economic impact of electrification in S.A., keynote address delivered at the SAIEE Workshop on Electrification of Developing Communities, November 1991.

Topp, C 1995. Improving the thermal performance of low cost housing in South Africa, Paper presented to the Southern African Institute of Energy (SAIE) conference on household energy for developing communities, 18-21 July 1995

Van Gass, J 1994. *The South African situation: Nature and determinants of energy and appliance requirements,* Final Report WGEU04, February 1994, 28 pp and appendices.

Van Rensburg, BDJ 1994. *Consumer requirements pertaining to the acquisition of electrical appliances,* Final report WGEU07, March 1994, 38 pp and appendices.

Van Wyk D 1994. *Influence of market segment and technology choice,* 4 pp and appendices, letter to Chairman of Technology Working Group, July 1994.

Viljoen, R and Van Wyk, D 1994. *The establishment of appropriate domestic electricity tariff subsidies with an integrated energy planning framework,* June 1994, 8pp.

Viljoen, R, et al 1994. *The use of equipment and energy,* Subgroup report SGEU02, July 1994, 23pp.