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DOMESTIC ENERGY USE DATABASE FOR INTEGRATED ENERGY PLANNING

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1998

Domestic Energy Use Database for Integrated Energy Planning

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Submitted to the University of Cape Town

In fulfilmnet of the requirements for the degree of

Master of Science in Engineering

February 1998

Energy and Development Research Centre

University of Cape Town

Dedication

To the ever-loving memory of my Dad

who inculcated in me the essence of education.

To you, Paapa, I will forever be grateful.

Declaration

I, Yaw Afrane-Okese, submit this dissertation to the University of Cape Town in fulfilment of the requirements for the degree of the Master of Science in Engineering. I declare that, unless otherwise acknowledged, this is my original work and that it has not been submitted in this or similar form for a degree at any university.

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Y Afrane-Okese

20th day of February 1998

Abstract

One of the legacies of the apartheid policies in South Africa has been the huge gap between rich and poor households in terms of their access to basic energy services. This study explores the essence of shifting from supply-driven approach to an integrated framework in energy planning in order to evolve policies that match national goals and objectives with the energy needs of the low-income households. The principles of Integrated Energy Planning (IEP) are outlined for the household sector and the development of an energy database is identified as one of the important processes required in IEP. The design of the database is practically demonstrated by capturing existing secondary and primary data on energy use in low-income households in South Africa. The user-interface and on-line data analysis of the database are also illustrated. Furthermore, the data has been extensively analysed to show the factors that influence energy demand in the low-income households and how these factors may interact with one another. In addition, energy end-use data has been aggregated from the database as input into an energy modelling computer programme for estimating energy demand projections for low-income households. These energy demand projections are based on energy scenarios which investigate alternate energy supply options. Thus the study illustrates how energy use data can be organised into a tool for informing policy formulation.

Acknowledgement

I am most grateful to God who has been my source of strength and hope in this study. It is my sincere desire that this study could help lay a foundation for understanding the plight of millions of disadvantaged South African households in their quest for access to basic energy services. To these poor households I am deeply indebted for gaining insight into their livelihoods. I hope that the purpose of this study would have been greatly served if their lot could be improved and their access to basic energy services could receive some prominence in national energy policy-making.

My thanks are due to the South African Department of Minerals and Energy for providing the necessary funding for establishing the energy database. I am also grateful to my supervisor, Prof Anton Eberhard, for his guidance, direction and patience that steered me through this work. My sincere thanks also go to my programme leader, Ms Wendy Annecke, whose comments and moral support brought me great motivation and inspiration, especially towards the end of this study. Wendy, it seems to me that "you came that I might finish this work" and I deeply appreciate your input. I am also thankful to the Mason-Jones brothers (Craig & Neil) for all the computer assistance in the design of the database.

Finally, the patience, comfort and support of my family have been my main anchor during this study and I am very grateful to you, Nana Yaa and Akua Benewaa.

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1.
Introduction

1.1 Background

Information is crucial for development planning and it improves the decision making process. When the available information is progressively refined a reliable picture of the past and current situation can be easily presented, which provides a basis for development planners in the effective allocation of resources to achieve particular goals. This also applies to energy planning. Energy is critical here in terms of the vital role it plays in economic and social development. Despite this understanding, data for energy planning is often not available and, if available, is often qualitatively unreliable (APDC 1985:25). An extreme situation was the excessive secrecy governing the South African energy sector during the apartheid era. For example, the Petroleum Products Act (No. 120 of 1977) prohibited the

> publication, releasing, announcement, disclosure or conveyance to any person of information or the making of comment regarding the source, manufacture, transportation, destination, storage, consumption, quantity or stock-level of any petroleum product acquired or manufactured or being acquired or manufactured for or in the Republic.

The strict enforcement of the secrecy provisions and the severe penalties meted out to defaulters made rational and public debate on energy policy almost impossible. The ultimate consequence of this was an absence of government commitment to collect and publish data on the energy sector which would allow the development of sound and balanced energy policies (Eberhard & Van Horen 1995). Instead, energy policy under apartheid was governed primarily by the desire for greater energy security against the United Nations-led oil embargo placed then on South Africa.

The energy security goal was pursued mainly at the expense of social equity and access to basic energy services and infrastructure. The *social costs* of this energy policy have been enormous. The additional time spent collecting and purchasing fuels where electricity is not available is significant, and represents the loss of time for potentially more productive or enjoyable activities such as farming, education and entertainment. There is a huge social burden on women mostly in the rural areas to collect fuelwood from far distances. Low levels of access to electricity mean that millions of people are denied the convenience and improved quality of life that comes with the use of electric appliances.

Moreover, substantial *environmental and health costs* were incurred. In the absence of demand management electricity generation was expanded extensively to over-capacity levels. The power stations involved burn coal and pollute the atmosphere. In addition, the lack of access to cleaner fuels like electricity has resulted in poor households burning coal, paraffin and candles to meet their cooking, heating and lighting needs. Unfortunately, most of these households live in poorly ventilated households and this has led to many environmental and health hazards, especially in the urban areas. Similarly, the lack of affordable housing and the absence of appropriate thermal performance in many dwellings have resulted in uncomfortable living conditions for most poor households. In the rural areas most households depend heavily on fuelwood for their energy needs and this has compounded the problems of deforestation and dessertification. Best (1979) records the occurrence of households burning dung for their energy needs in some areas of South Africa where wood supplies are scanty.

Furthermore, due to the deep involvement of the South African State in the energy sub-sectors, *eçonomic efficiency and competitiveness* have been largely hampered in spite of the foreign exchange savings from the investments in the Sasol and Mossgas synthetic petroleum fuel plants. An example of this has been the disastrously fragmented electricity distribution sector previously linked to racially segregated local government which was ineffective in the provision of electricity to the majority of South Africans. A further example is the over-capacity of electricity generation plants, although there are already problems with peak demand.

Decisions in the energy sector, involving production factor allocations among energy, capital and labour, as well as investments in large projects will have long-lasting impacts not only on the energy sector but on the entire economy. The financial and opportunity costs of bad decisions in the energy sector can be high. Informed decisions need to be made but information about such aspects is often difficult to generate, not only because its collection is time consuming and expensive but also due to the fact that energy is not merely a quantity which may be expressed in physical terms such as tonnes and barrels or in heat values such as joules and BTU (British Thermal Units). Energy issues are not only physical and technological in nature but also have economic, social, cultural, political and environmental dimensions. Energy is not an end in itself but it is an input to the production of many basic human needs. For example, we do not enjoy the electricity supplied to our dwellings until it has been connected to an appliance to provide power for our cooking, heating, refrigeration or lighting needs. Information on the end-use of energy is thus a necessity for linking the socio-economic role of energy to its physical dimension. The peculiar nature of energy therefore makes it understandable that not all energy related information is quantifiable.

Eberhard (1992:13) asserts that the energy system is analogous to the financial system. All economies employ financial planning and regulation, likewise, energy planning has become a necessity for all developing countries including those which are net exporters of energy. But energy planning is also very different from financial planning which is generally short-term. Energy projects are usually large, and a short-term energy planning horizon is typically ten years. Also, unlike money that can be devalued, energy is counted in constant physical units, thus enabling more reliable long-term planning. The planning, however, will be as good as the information on which it is based. A comprehensive database enables the energy planner to identify and clarify a wide range of energy policy issues and objectives.

1.2 The shift from sub-sectoral supply-side energy planning to an Integrated Energy Planning (IEP) approach.

In the past, even though planning for secure energy supplies was recognised internationally as an important public responsibility, this was undertaken mainly at the level of separate energy supply sub-sectors. In South Africa, despite the creation of a central body like the National Energy Council, which managed to focus much needed attention on energy sub-sectors other than electricity, coal and oil, there was very little deviation from sub-sectoral approaches in terms of energy planning until the beginning of this decade when major work on energy policy research sprang up. Although Gandar (1988) and Rivett-Carnac (1990) discuss integrated energy planning in their work in South Africa toward the end of the last decade, the notion of "integrated" is applied mainly to an integrated analysis of supply options, together with some emphasis on ecologically sound exploitation of resources, rather than linking energy planning to broader development objectives.

The international energy situation changed fundamentally with the end of cheap and predictable oil supplies in the 1970s. The interconnectedness of energy and the economy became a growing consciousness and the focus began to shift from supply planning to an awareness of energy end uses and the potential of demand management. Market-induced equilibrium between supply and demand became increasingly unpredictable and incapable of guaranteeing desirable development goals in the energy system. Thus the concept of *integrated energy planning (IEP)* evolved as an important ingredient in public policy and planning environments. It has gradually become clear that an exclusive focus on sub-sectoral supply-oriented planning, as unpredictable as it is, could undermine the achievement of socio-economic objectives, such as meeting the basic needs of poor households and the provision of development opportunities.

An integrated approach to energy planning seeks to establish an understanding of the links between energy supply and demand sectors, and between energy and macro-economic factors as well as socio-econonic objectives, thus, planning for the *entire energy system*. Moss and Morgan (1981: 190) argue that effective energy planning needs factual data and especially

> an understanding of the web of inter-relationships which links together not only all aspects of the energy use system, but all other related aspects of environment and of social and economic activity.

After a voluminous analysis of a socio-economic survey of energy consumption patterns in the domestic sector of Eastern Cape, Rossouw & Van Wyk (1993: 389) conclude that

> the matter of energy supply and consumption cannot be addressed effectively if it is not viewed within the framework of other needs such as housing, job creation, health services and education.

One of the main points made by Golding & Hoets (1992) in the summary of their study of energy usage in eleven urban black townships in South Africa is that, in order to be meaningful and effective, energy planning must be both comprehensive in scope and sensitive to the socio-economic context in which policies are to be formulated. On the contrary, in the recent past, electricity dominated the scene where governmental attention was concerned and the *modus vivendi* of energy sector planners was essentially to keep increasing the levels of supply on a least cost basis to meet the (often encouraged) increases in demand. The lack of co-ordinated policies by energy sub-sectors and consumption categories resulted in the diffusion of energy conservation efforts. In addition, resource development could not be handled in a balanced manner and a vivid example is the late awareness of the contribution renewable energy resources could make to the energy equation.

For the Asian Pacific Development Centre (APDC), integrated energy planning means the analysis of all energy issues within a unified policy framework in order to arrive at a set of nationally optimal energy solutions over the long-term (APDC 1985:5). In other words, it is the process by which all physical energy needs of all sectors of the economy are planned in concert (Munasinghe 1980).

In IEP, unlike the traditional approach in energy planning, demand is no longer seen as a market-given imperative determining energy-supply planning, with prices as the sole mechanism of adjustment. Instead, planning is integrated across sectors and can include a wider range of policy measures to achieve desirable goals. Energy end-use analysis becomes central. It involves an investigation into what people are using and why, as well as an analysis of their needs. This approach leads inevitably to a consideration of energy intensity, conservation and efficiency, technical innovation and diffusion, and to fuel-switching and improved access.

Energy supply sectors have been traditionally defined according to individual energy sources such as coal or petroleum, and analysis has followed the energy chain from source, through transformation and distribution, to the services the end user demands. IEP, however, starts with the consumer. Through disaggregated end-use analysis, major consumption sectors (such as households, commerce, industry, mining, transport and agriculture) are defined. These sectors are then broken down into sub-sectors (such as rural or urban households), which are, in turn, divided into end uses (such as cooking or lighting) and end user sections disaggregated by fuel type, energy technology used, level of energy intensity and social class of users. Building up each energy end use from this level of disaggregation allows a clear analysis of policy options from fuel-switching through technology transfer and energy efficiency, to government strategies for different users. Planning for individual energy supply industries, such as electricity, is much more effective if it is undertaken with a broader IEP framework as described above.

The end-use oriented approach is directed towards sustainable development that is based on actual uses for which energy is needed and the ways the needs could be most efficiently met. In this way, a number of energy-saving opportunities are identified to formulate technological and policy alternatives for attaining higher efficiency.

1.2.1 Layers of analysis in integrated energy planning

From the above discussion, IEP can be broken down into three layers of analysis:

1. The relationship between the energy sector and other economic sectors (industry, transport, households, etc.), macro-economic variables (for example, economic growth), social welfare (for example, basic needs and equity) and the environment (for example, sustainability).
2. Inter-subsectoral links within the energy sector (interactions, competition, conflicts, fuel substitutions, and integration of resource development).
3. Intra-subsectoral analysis (for example, energy end-use analysis, demand analysis and forecasts, supply options, investment planning and pricing).

1.2.2 Process of integrated energy planning

The major tasks required in the three layers of the IEP process have been listed below. It must be understood, however, that, although the tasks may be taken sequentially, the process is often iterative and it is frequently necessary to return to previous tasks as data or analyses improve and deepen. These tasks are:

1.2.2.1 Definition of goals and scope.

The development goals need to be defined and these should be akin to the "end result" specification of the whole planning effort to meet the macro-economic targets and socio-economic needs of the people. The scope of the planning effort can be defined as national or regional or district level, all or specific energy sub-sectors required for the fulfilment of the goals, and short- or medium-term.

1.2.2.2 Database development.

The current and past energy systems should be described through data collection and appropriate presentation. The development of a database can establish the links between various energy sub-sectors in a quantitative framework as well as the links between the energy sector and the broader economy. Data collation is necessary where data is already available and, in the absence of adequate data, appropriate methodology for data collection needs to be designed and implemented. The lessons in the 1992/93 Energy Policy Research and Training (EPRET) project at the Energy and Development Research Centre (EDRC), University of Cape Town, is useful here. In the EPRET project, the search for energy related studies on low-income households done in South Africa yielded a surprising number of titles, although not all were found useful. Within a few months into the project 400 studies had been identified, of which about 200 were identified as being potentially useful for providing quantitative data (Trollip 1994:5).

For IEP, both past and present data is required on the consumption (disaggregated by end use) and production of energy within the energy sub-sectors identified in the development goals. Data must also be collected on linked macro-economic and socio-economic variables relevant to understanding determinants of energy demand and supply or the achievement of the goals.

1.2.2.3 Demand analysis and projections.

From the database, energy demand can then be estimated through disaggregation by end use. With alternative economic growth scenarios, detailed projections of energy demand by consuming sectors and end uses are then derived. The number of such projections will be determined by the extent of variation in assumptions and policy guidelines regarding prices, incomes, levels of economic activity, supply constraints, intensity of conservation efforts, and other relevant variables.

1.2.2.4 Supply analysis.

This is essentially a stock-taking exercise. It involves an inventory of resources, both non-renewable and renewable, followed by an evaluation of associated supply technologies. All possible future options are investigated, disaggregated by energy sub-sectors.

1.2.2.5 Energy policy (integrated) analysis.

This involves the balancing of energy supply and demand, construction of scenarios for future energy balances and the analysis of policy options for meeting the projected balances. Energy flows have to be traced from each end use, through conversion technologies to energy source. Policies to manage desired supply and demand are then formulated in order to achieve a desired balance, using identified policy instruments for the energy system as a whole, and for energy sub-sectors. These will include demand management and the configuration of supply options in terms of fuels and technologies.

1.3 Need for widened access to basic energy needs in South Africa

In the period leading to political transformation of South Africa into a system of universal franchise, the need for a comprehensive national energy planning could not be overemphasised. The appropriate development objectives, goals and scope were very critical in order to calm down the political temperature at the time. The overwhelming expectations of the previously disadvantaged, which were black and formed the majority of the population, required a thorough, progressive and intelligent analysis in order to give assurance of a better future for a people who had suffered suppression for centuries under the white minority rule of discrimination by race and gender. At the same time, the fears of the minority privileged whites deserved a cautious consideration in the development goals in order to avert any disastrous disruptions in the democratic transformation process.

In the period after the release of Nelson Mandela from prison in 1990, it became apparent that there would be a radical shift in policies in almost every facet of the South African society and economy. The time was therefore ripe for progressive academics and researchers to initiate energy policy research and analysis in order to develop detailed sectoral and sub-sectoral policy options, mainly along the new broad policy directions of the democratic movements, as a resource for the new government. Thus the evolution of the South African Energy Policy Research and Training (EPRET) project undertaken by the Energy and Development Research Centre (EDRC) at the University of Cape Town in 1992.

The EPRET project sought to address the huge inequalities in levels of access to adequate energy services and its main objective therefore was to identify and develop polices which would widen access to adequate and affordable energy services for the urban and rural poor households in South Africa (Eberhard & Van Horen 1995: 40). With EPRET's strong emphasis on the understanding of demand of energy services and exploration of a range of energy strategies from demand-side management to energy efficiency, the need for background information, particularly on the domestic energy sector to serve as a foundation for policy analysis became imperative. It was against this background that the then South African Department of Mineral and Energy Affairs (DMEA) funded a project to establish a *National Domestic Energy Use Database* system. The purpose was to integrate data from all available sources on household energy use into an organised form useful for integrated energy planning and to identify the existing data gaps.

Even though South Africa constitutes only 4% of Africa's population, about 20% of the continent's GDP and more than half of her electricity are generated by this country (Eberhard & Trollip 1994). It was therefore a surprising anomaly, during the EPRET project of 1992-93, that two-thirds of South Africans, predominantly the urban and rural poor households, still did not have access to electricity and had to depend on inconvenient and expensive fuels like fuelwood, coal and paraffin for basic domestic needs like cooking, heating and lighting. Despite the on-going massive rural electrification programme by Eskom, the national electric utility, the situation has not changed much for most African households and those in the rural areas are worst off. Recent estimation of households in the former homeland areas without electricity is about more than 80% (National Social Development Report 1995: 16). Research has thus been urgently needed into the available policy options that would enhance access to affordable and adequate energy services to meet household needs and development goals.

The surplus capacity of Eskom has been between 7000 and 9000 MW (Eskom 1993). Alongside the democratic transformation, Eskom has committed itself to an overall objective of *providing least cost electricity for all those who can afford it* and has been *encouraging electricity uptake* to facilitate development goals in a democratic South Africa. However, it is widely accepted that the impact of new electricity connections on Eskom's load profile could have serious repercussions if effective demand-side analysis and management are not integrated into the electrification programme.

Beute (1993) assumes that the domestic sector accounts for only about 14% of the electrical energy used in the country. Eberhard & Trollip (1994) estimate the domestic energy demand to be about 19%. However small this domestic energy demand is, the domestic load is the largest contributor to the peak of the national load. There is a very strong correlation between the time of the peak of the load for the domestic sector and the time of the peak of the national load (Beute 1993). This makes the domestic load more important than is generally realised. The load factor of the electricity grid is already uneven at present, and this is likely to be exacerbated as more and more households of both the formal and informal dwelling types are connected to the electricity grid (Thorne 1993).

Thus access to adequate and quality energy services has become a critical question in energy policy analysis. Eberhard & Theron (1992: 10) conclude their introduction to the proceedings of a conference on the International Experience in Energy Policy Research and Planning thus

> Perhaps the most significant distinction, in energy terms, between the North and the South, is that the citizens of industrialised countries universally enjoy an abundance of convenient energy sources, while in developing countries access to basic energy services is still very skewed.

Probably nowhere in the world is the above statement as true as it is in South Africa. Again Eberhard & Van Horen (1995:47) explain that a simple way of identifying the "urban and rural poor" is to define them in terms of their access to, or more correctly, their lack of access to electricity. Cecelski (1987: 53) suggests that energy can serve as a starting-point for addressing poor people's priority concerns. Clearly, the lack of electricity connection does not mean a person is "poor" in the ordinary sense of the word but, in South Africa, it can act as a useful initial indicator of energy poverty and the restricted choices which result from a lack of access to electricity services. Thus the need for critical emphasis on the domestic sector in the development of energy databases for integrated energy planning.

1.4 Research objectives and outputs:

The purpose of this study embodies the first three of the main tasks involved in the process of integrated energy planning discussed in Section 1.2.2. The main thrust of the study deals with the organisation or compilation of energy use data in the domestic sector in a comprehensive and consistent manner that is useful for integrated energy analysis and decision making. The study demonstrates how the *development of a database* on the energy use of low-income households can be used as a tool for identifying research or data gaps in the energy planning process and help redefine the *goals and scope* of integrated energy planning to include the need to widen access to basic energy services as a national responsibility. A broader objective of the study is to demonstrate the usefulness of an energy database for the *analysis and projections of energy demand* by the application of a model based on socio-economic scenarios.

The problem of lack of access to basic energy services among the urban and rural poor households has been described in the above section. Apart from the low-income households, which are predominantly black households, most of the other sectors of the economy have adequate access to quality energy services. For example, the industries, the mining sector, the commercial sector and, almost all the high- and medium-income households have adequate access to electricity. Thus the energy supply industries have reliable information on these sectors of the economy constituting their customer base.

On the other hand, however, properly organised and reliable information on low-income households has been very scanty and, in many cases non-existent, since under *apartheid* such households that formed the majority of the population were completely neglected. Under such discrimination, no incentives existed for the supply industries to collect and organise information on low-income households regularly, except for adhoc measures. Data on low-income households that were collected were for short-term goals only and no national objectives formed the underlying principle. Thus data that existed were not in the form that could support policy formulation. *This study therefore seeks to bring into the national development picture the status of the low-income households in terms of energy provision in order to focus the goals of integrated energy planning on access to basic energy services.* It thus elevates social equity issues to the political transformation agenda.

Primarily, therefore, this study seeks to create a deeper understanding of energy use in the low-income portion of the domestic sector in order to provide accurate data for policy-making that is totally linked up with the broader economy. This could inform the electrification programme, for example, since the bulk of this programme involves low-income households.

1.4.1 Research outputs

The main research outputs of the study are:

- Collation of energy use data on low-income households from all existing studies and surveys done in South Africa to date. This includes variables relevant to understanding determinants of energy demand and supply or the achievement of goals.
- Establishment of a database system which provides the means of capturing, storing and updating a wide range of data sets on energy use and related information in the low-income households.
- Provision of a user-friendly interface to make the organised information easily accessible to the ordinary user.

- Data management system that is capable of analysing and reporting on aggregated data from the database.
- Geographic display of aggregated energy use information through Geographic Information System (GIS).
- Past and current *regional (climatic) energy use profiles* developed from the database system.
- *National energy use profiles* mapped out from the regional profiles.
- National and regional *energy futures* under a "business-as-usual" scenario.
- *Alternative energy profiles* resulting from energy demand scenarios.

1.5 Research methodology.

This section summarises the research methodologies applied for the various objectives and outputs of the study. Where necessary the ensuing chapters will elaborate on methodological aspects.

At the outset of the development of the domestic energy use database system, its initial data requirement is assessed through the collation of all available reports on energy use studies and surveys undertaken in various parts of South Africa. Since all these reports represent a myriad of research objectives, data measurements and analyses, a wide range of data kinds are encountered. A database is developed in Microsoft Access software to pull together all the data in the various studies and surveys into an integrated system that could allow the organisation of all the data into a useful information tool. Data fields are then established in the database for all relevant variables found in the studies that could influence energy demand in the domestic sector. These data fields are further grouped into data categories covering household energy use information like fuel consumption, fuel expenditure, fuel prices, and a broad range of socio-economic issues like household income and education.

About 500 energy use or energy-related studies have been reviewed and the relevant datasets have been extracted into one database component. These studies comprise over 360 surveys covering over 50,000 low-income households. This component of the database has sub-components dealing with bibliographic and review information on studies and their attached surveys, and a sub-component that allows the extraction and editing of all quantitative data from the surveys. The bibliographic and review information serves as a guide to the user concerning issues like the source of the data, the coverage of information in a particular survey, the statistical usefulness of the data, the quality of information, and so on. This component of the database is designed for the continuous capturing of secondary data in cases where the primary data is not available in electronic format. It therefore requires specialised attention in the extraction of data since the data extracted in different forms from their original documents will have to be transformed into a common format established in the data capturing process of the database.

Apart from the secondary data component, a primary data component of the database has been set up to link the secondary data component. This extracts and stores data in electronic format. All the datasets are linked by geographic location to enable spatial aggregation of energy use data at the locality, magisterial, provincial or national level. A data management system designed in Microsoft Access aggregates data from both components of the database and the output can be in the form of a report (ready for the printer) or in a spreadsheet format (that can be tailored to meet the needs of the user). Another option is provided for the output of the data aggregation to be exported into *a Point Attribute Table* (PAT file) for graphic display of the data spatially using a Geographic Information Systems package like Arcview.

The design of a step-by-step user-friendly interface for both the data entry/editing and the data aggregation systems provides separate routes for the three activities in order to avoid any confusion that could arise for users with very little knowledge about computers.

For the energy demand analysis and projections, energy end-use and appliance data covering the whole of South Africa are extracted from the database in the form of dwelling type disaggregation. These are further aggregated into three primary climatic regions of South Africa. The energy requirements for the devices providing the end uses are estimated from secondary sources. Furthermore, data on projections of the number of households are estimated from secondary sources. Aggregation and disaggregation of these data sources result in a four-level hierarchical data format as the main input into the Long-range Energy Alternatives Planning (LEAP)[1] model for the energy demand analysis and projections using scenario development.

1.6 Dissertation structure

This chapter has created a theoretical background for developing a domestic energy database system as a research tool for integrated energy planning in South Africa. The chapter examined the evolution and principles of the IEP concept, outlined the processes involved, established the data needs, and discussed database development as one of the major tasks in an IEP framework. It identified lack of access to basic energy services as a critical area for policy research and focused energy database development efforts on low-income households. The chapter also sketched the broad research methodology for the thesis.

Chapter 2 focuses on low-income households and relevant issues for integrated household energy planning. The chapter discusses the characteristics of household energy as well as energy poverty in South African low-income households. For the purposes of energy demand analysis, the number of low-income households have been aggregated into dwelling types and climatic regions.

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[1] LEAP is the Stockholm Environment Institute's computer-based tool for performing integrated energy planning. The application of LEAP and its principles can be found in Chapters 5 and 6 of this study.

Chapter 3 describes the processes involved in the development of a National Domestic Energy Use Database system. The chapter details the structure of the database system, its composition, its user-interface and the data aggregation system.

Chapter 4 gives a short overview of some of the data in the domestic energy use database covering household characteristics, multiple fuel use, energy expenditure, energy end uses, electrification, wood collection and prevalence of different fuel use among households in different dwelling types. For the purpose of energy demand analysis and projections, the end-use information is disaggregated into dwelling types and primary climatic regions.

Chapter 5 details the research methodology for projecting energy demand. The chapter also gives a layout for assembling all data required for the estimations.

In Chapter 6, energy demand scenarios are developed for the energy demand analysis and projections. Graphic illustrations of some of the outputs of the energy demand profiles and projections are presented in this chapter. The chapter also analyses the output of the projections and the energy savings involved in each of the demand scenarios.

Finally, the dissertation ends with Chapter 7 demonstrating how the development of energy databases can facilitate the identification of gaps in the planning process. The chapter also makes recommendations in terms of the collection and assembling of energy use data and further draws conclusions on the benefits of exploring energy demand projections based on demand scenarios.

2.
The household sector of the energy economy

2.1 Introduction

The household unit has become an important factor in the energy economy. The democratic experience in South Africa has brought to the fore social equity issues, particularly access to basic services in the household. The emergence of Community Based Organisations (CBOs) with the democratic transformation process has brought households together more than ever before, as a force to reckon with concerning service provision. Whilst in the past, industry and commerce dominated the focus of the Electricity Supply Industry (ESI), the electrification of households has gradually become an entrenched issue in the political arena.

It is likely that the household sector will feature prominently for a long time in policy issues regarding the energy economy. As discussed in Section 1.3, the scope of this study is largely focussed on the low-income portion of the households sector since most of the previously disadvantaged people fall under this category. At the outset, however, it is necessary to accurately define the term "household" as a measuring unit in energy demand analysis.

2.2 Definition of the "household"

According to Becker (1965 and 1988), a household can be viewed as a rational economic unit maximising utility subject to a time and income constraint. The changes in household size and structure over time provide important insights into the household's changing environment. Household structure is therefore an important "economic variable" that responds to changing economic signals over time (Sperber FS 1993: 7).

In a national survey for the *Statistics on Living Standards and Development Project*, which covered many basic human needs including energy, the definition of the *household* was one of the crucial concepts in the questionnaire (SALDRU 1994). The definition was drawn up in such a manner as to avoid double-counting of individuals who may live in more than one place, and as such, two definitions of the household were used.

1. The first definition comprised all individuals who:

    - live under this "roof" or within the same compound/homestead/stand at least 15 days out of the past year; and
    - when they are together they share food from a common source (i.e. they cook and eat together); and

- contribute to or share in, a common "resource pool" (i.e. they contribute to the household through wages and salaries or other cash and in-kind income or they may be benefiting from this income but not contributing to it, e.g. children, and other non-economically active people in the household). Visitors were excluded from this definition.

2. The second definition of the household included only those members who had lived "under this roof for more than 15 days of the last 30 days". This definition was derived to eliminate double-counting of individuals.

For the purposes of this study, a household[2] is defined as a socio-economic unit of a person or persons who "eat(s) from the same pot" or who contribute to a common budget and is housed by a dwelling or group of dwellings. The common budget here refers to the combined income or resource pool from which the household expenditure or consumption comes, although not all members of the household may have equal access or contribution to the budget.

In terms of the analysis of energy usage, the service provided by an energy source is usually enjoyed not only by individuals but by a part or the whole of the household. For example, when the space heater is switched on, everyone in the house enjoys the comfort of the warmth it brings. Also when the cooking is finished energy is derived from the meal by all who eat it. In the same way, the light in the common room provides illumination for all individuals in a dwelling. Thus, it is believed that, from an energy consumption point of view, energy would largely be consumed jointly by such a grouping as the household. In this study, whilst a large volume of data is collected per capita, sufficient data is identified or redefined in terms of the household in order to establish a common basis for the database design. In the analysis of data, however, per capita basis has been used extensively in the study to provide a common basis of comparison since household sizes may differ.

2.3 Characteristics of household energy

As mentioned in Section 1.3, the low-income household sector, in particular, continues to pose major energy planning challenges in South Africa. Information on household energy use still remains relatively scarce and scattered, and the interpretations of the data vary widely. This study intends to bring together the scattered data on household energy use in one database in order to facilitate the analysis of the data in an integrated manner, and deepen the understanding of the characteristics of household energy.

Compared with industry and commerce, the household sector has energy demand and supply characteristics which make assessment and project analysis at times difficult and unique. Leach

[2] The definition of the term "household" has often been a contested issue.

and Gowen (1987: 2-3) and APDC (1985: 92) identify some of these critical differences between the household sector and other sectors:

- The household sector consists of many individual users who live in a great variety of energy "landscapes". There is enormous diversity in the availability and costs of energy supplies; in the levels of consumption and mix of fuels employed; in end uses such as cooking, water heating, space heating and lighting; and in technologies and energy-related preferences and modes of behaviour.

- Most household energy use is not recorded by supply agencies but must be ascertained through household surveys. It is in the electricity sector, and piped gas in some countries, are there centralised and disaggregated records of household consumption, because these supplies are metered and billed.

- Low-income households, especially in the rural areas, depend heavily on traditional fuels from (i) biomass and its related sources e.g. woodfuels, and (ii) animate energy sources like dung. These traditional fuels represent only one aspect of the complex, interrelated systems for producing, exchanging, and using biomass materials of all kinds, including, for example, human food, animal fodder, timber and crop residues for construction materials, as well as for fuels. There are no established market mechanisms in the rural areas to bring supply and demand for traditional fuels into balance and this situation has negative severe impacts on the livelihood of the rural and urban poor. "Energy problems" and solutions must, therefore, almost invariably be considered within this total context.

- Traditional household fuels and their usage technologies are often difficult to change, largely because alternatives are not known, or unaffordable, or inconvenient, and thus households tend to prefer to continue with age-old customs.

- Traditional fuels are collected and measured in non-standard units such as bundles, bags, headloads, backloads, baskets, buckets, etc. Since these units vary from person to person, region to region and season to season, it is very difficult to get precise measurements from adhoc surveys.

- The gross energy content of each category of traditional fuel is different and it varies from one season to another due to moisture content. Thus, in data collection, "norms" of energy content of these fuels cannot be used for obtaining estimates of energy consumption.

- Energy supply and demand patterns of households are location-specific. They normally vary considerably by region, district, village and town, and by household or dwelling type within towns and villages. National energy use studies must reflect these differences if they are to provide any valid basis for planning.

- Household energy is linked with the provision of other basic services and products like water and food. For example, the electricity connected to a household is useless for satisfying the hunger of a household unless water and food items are available for a meal to be cooked. Furthermore, energy provision is linked with many informal commercial activities in the household or the immediate neighbourhood (e.g. sewing, welding, beer brewing, and computer-based jobs like typing). Thus there is a need for consideration of other relevant basic services in household energy data collection. In this way, linkages within the household energy demand can be explored, and there can be disaggregation of demand into that for *actual domestic energy use* and that for the *associated informal commercial activities*. Methodologies incorporating end-use approach are usually helpful in analysing the energy demand for these informal activities.

These characteristics make it especially difficult to gather and assess basic energy data on the household sector, particularly among the rural and urban poor. Thus, in the collation of data on energy use in low-income households for the domestic energy use database development, special attention is paid to the methodological and analytical aspects of data collection in each source of data.

2.4 Defining the scope of the study: "low-income households"

This section briefly describes the characteristics of the "rural and urban households" in order to define the focus of this study. A classic feature of the South African household sector is its highly unequal distribution of income and wealth, with a high proportion of the population living in varying conditions of poverty. One indicator of personal income distribution is the Gini coefficient. Using this measure, an index value of 0 would signify minimum inequality, and a value of 1 maximum inequality. With a Gini coefficient of 0.68 in 1991, South Africa's income distribution was among the most unequal in the world (Whiteford 1994). Van Horen et al (1993a: 624) illustrate this inequality thus:

> In terms of income distribution, the poorest 40% of the population earned only about 9% of the total income in 1990, whereas the wealthiest 10% earned about 44% of the total income.

One measure of poverty is the Minimum Living Level (MLL), which represents the minimum financial requirement of a family for the maintenance of acceptable standards of health, hygiene, clothing and nutrition. The MLL for South Africa in 1990 was set at R709 (i.e. about US$191.43) per household per month. According to a quote of one source by Makan (1994: 22), 45% of households received incomes below this level in 1989.

> Another significant feature of poverty in South Africa is that there are enormous racial, gender (mostly in terms of household head) and geographical (in terms of rural and urban) disparities in income levels, as well as in access to land, employment, education and other social services (Eberhard & Van Horen 1995: 46).

While 53% of the households with income levels below the 1990 MLL were Africans only less than 2% were whites. In terms of income and the other indicators of poverty, women in South Africa are at a relatively disadvantaged position. In the same vein, rural areas in South Africa are more impoverished than urban areas, with about 80% of African households in rural areas having incomes below the MLL, compared to 50% in urban areas in 1990. Perhaps these disparities are more simplified in a source noted by Wilson (1991:53) and Makan (1994: 32) as:

> *poverty* is most likely to be found in a *rural* household headed by a *black woman*.

Bekker et al (1992) estimates that more than one-third of South African population may be described as the "rural poor".

This thesis uses the 1994 Nelf EDI Database for its estimation of the number of low-income households (Nelf 1994). The Nelf database was established by the Eskom-sponsored National Electrification Forum (Nelf) under broad consultations with many relevant organisations. It was established during the period leading to the 1994 democratic elections, in a pro-active and open manner, integrating all the available data on demographics into a common base as an information resource for the Electricity Supply Industry. 1993 estimations from the Nelf database result in a total of 5,847,668 low-income households as shown in Table 2-2 and Appendix I. This represents over 67% of the total 8,707,679 households[3] in South Africa in 1993 (Table 2-2 and Appendix I). From Table 2-3 it can be seen that rural households constitute over 65% of the low-income households, and this confirms the generalised assertion above that low-income households are in the rural areas more than in the urban areas. Methodology for these estimations is discussed in sections 2.6 and 2.8.

2.5 Characteristics of energy poverty in South African households

In characterising energy poverty in South African homes, Eberhard and Van Horen (1995:44) summarise the "urban and rural poor" briefly by the following themes:

- household access to electricity is highly skewed;
- multiple fuel use is the norm rather than the exception;
- geographical factors have an important influence on energy consumption;
- energy constitutes an important item in household budgets;
- energy transition theory cannot adequately account for real decision-making processes in households;

[3] This figure includes dwellings of rural and urban formal institutions as dwelling units.

- energy poverty has environmental, health and social costs which are of national significance; and
- a supply-driven household energy policy will not produce the optimal result.

Mehlwana & Qase (1996) further identify fuel and appliance sharing, household and dwelling structure, and perceptions of fuels as some of the socio-enonomic determinants of energy use in low-income households.

2.5.1 Climatic regions and dwelling types as basis for energy demand analysis

Some of the features of household energy poverty above will be explored further in Chapter 4 when an overview of the data in the domestic energy use database is presented. However, in this chapter, geographical factors (in essence, climatic influence) and dwelling structure (mainly dwelling type) will be explored further as the basis for the energy demand analysis and projections in Chapters 5 and 6.

Of all the household end-uses of energy, it appears like heating (mostly space heating and, by a smaller measure, water heating) has the most saving potential, especially with affordable housing being a high priority of the first democratic government. Simmonds & Mammon (1996: 27) asserts that the amount of fuel required for heating purposes can be tempered by using appropriate construction materials and design strategies in residential buildings. Information on the means and fluctuations in climate can be used to determine whether or when a building requires heating and/or cooling to maintain an acceptable level of comfort. In this way, climatic data, specifically the parameter of temperature, together with solar geometry, can be used to select appropriate design strategies and construction materials for building in a specific area.

In the methodology for estimating energy demand projections in Chapter 5, the energy end-use data extracted from the domestic energy use database is first aggregated at the dwelling type level and then further on to the climatic level. Subsequent sections of this chapter explain the estimation of the number of households for these two levels.

2.6 Climatic classification of South Africa

Williams (1993) mentions geographical location as one of the primary macro-determinants of a household's energy consumption in South Africa. One important dimension of this is the influences that climate has on household energy, especially space heating. In examining the role of thermal design in the future of South African housing provision, Thorne (1994:36) suggests the necessity of first considering the national climatic zones. While the climate of a region largely determines its natural thermal situation, the geographic location also determines the natural resources for energy provision, although these two determinants are often interrelated. Thus this study classifies all end-use data according to climatic regions.

In South Africa the National Building Research Institute (NBRI) has identified six climatic zones: cold interior, temperate interior, hot interior, temperate coastal, sub-tropical coastal, and arid interior. Figure 2-1 outlines South Africa's six climatic zones.

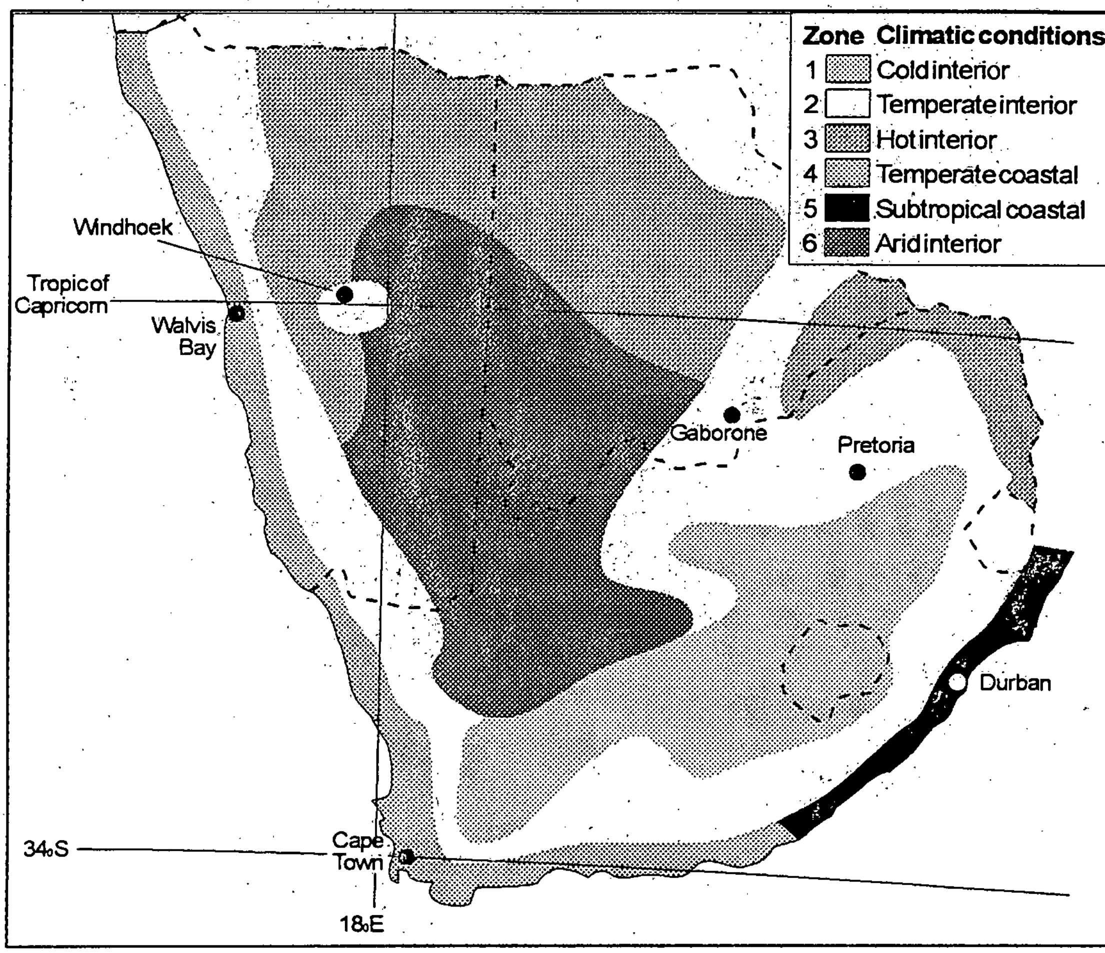

Figure 2-1: Climatic zones of South Africa
Source: adapted from Meyer (1983)

However, with respect to energy consumption, it can be assumed that three main climatic variables are important: seasonal and diurnal temperature and humidity fluctuations. Based on these variables, South Africa can be classified broadly into three main climatic zones: *hot-humid, hot-dry and temperate* (Thorne 1994). The hot-humid zone comprises the subtropical coast and small southern portions of the temperate interior and hot interior. The hot-dry comprises the rest of the hot interior, the arid interior and small middle portion of the cold interior. The temperate is largely the temperate coastal region together with most parts of the cold interior.

Thorne (1993) further groups the geographic area of South Africa into the three climatic zones as follows:

Climatic zone	*Geographic coverage*
Temperate	Western and Southern Cape, Gauteng Province
Hot-humid	Eastern Cape Province, KwaZulu/Natal Province, Mpumalanga Lowveld
Hot-dry	Free State Province, Northern Cape Province, North-West Province, Northern Province, Karoo

TABLE 2-1: Geographic coverage of climatic regions[4]
Source: Thorne (1993)

2.7 Dwelling types classification

For effective study of household energy demand and supply analysis, data has to be gathered at the point of energy end use, that is, at the household level. However, different households are housed in different dwelling types whose construction materials and design have appreciable effect on energy consumption, especially space heating. Dwelling categories of households exhibit different energy use patterns and are affected differently by various policy options (Trollip 1994: 10). A number of dwelling types were postulated for the National Electrification Forum (Nelf), together with their associated socio-economic variables. Those Nelf dwelling types that are relevant to this study (i.e. those housing low-income households) are classified below (Nelf 1994):

Urban formal

These are formally built structures (usually brick or mortar) in formally planned and administered urban areas. They usually occur in planned townships and surburbs.

Urban informal planned

These are informal structures (e.g. shack) in a formerly planned and administered areas. Informal settlements are generally defined in terms of the building materials used in the construction. The building materials may "vary considerably in origin, nature and durability, and include wattle-and-daub, mud bricks, corrugated iron, plywood sheeting and sometimes more orthodox materials such as concrete blocks and clay bricks" (Urban Foundation n.d.). Planned settlements are commonly

[4] The names of the regions in the table from the original source, which referred to those classifications used in the former apartheid South Africa, have been changed to reflect the names of the present dispensation.

described as official site-and-service schemes. They are established townships offering legal tenure and widely differing levels of service.

Urban informal unplanned.

They are informal structures in non-planned, non-formerly administered areas (e.g. squatter camp). These dwellings usually do not have access to services.

Urban backyard shacks

These are separate dwellings containing separate households on the premises of a formal or informal structure in a formally planned and administered area. They are usually erected on residential properties in formal legal townships.

Rural dwellings

These comprise all the rural dwellings classified in the Nelf database as Rural Farm Labourer Formal, Rural Farm Labourer Informal, Rural Settlements Nucleated Formal, Rural Settlements Nucleated Informal, Rural Settlements Scattered Formal, Rural Settlements Scattered Informal.

2.8 Aggregation of low-income households into dwelling types and climatic regions

In making estimates of the number of low-income households in the country for this study, two sources of data have been used. First, Nelf EDI database is used to pull together the total number of households for the urban formal, urban informal (planned and unplanned) and rural dwellings in the various magisterial districts within the regions classified under the three primary climatic zones in Table 2-1. Second, work done by Trollip (1993) is used for splitting urban formal *low-income* households from the *high and medium income* households which occur as an aggregate *urban formal* in the Nelf database. Using the percentage split worked out by Trollip (1993) approximations are made to match the present regional areas in Table 2-1 with those in that study which were classified according to the old DBSA Development Regions[5]. The results are summarised in Table 2-2. The totals of the disaggregated data in Table 2-2 can be cross-checked with the figures in Appendix I which gives the aggregated data for all the dwelling types extracted from the Nelf database.

It can be inferred from Table 2-2 and Appendix I that rural farmworker households and rural homeland households combine to form the rural dwellings in Table 2-2.

[5] The DBSA Development Regions refer to the provincial demarcations developed by the Development Bank of Southern Africa during the period leading to the 1994 democratic elections (DBSA 1990).

Climatic Zone	No of households in dwelling type					
	Formal housing	Planned Shack	Unplanned shack	Backyard shack	Rural dwelling	Total
Temperate Total	698,119	268,433	149,098	114,428	1,012,142	2,242,220
Hot-humid Total	190,471	127,555	10,913	9,640	1,650,352	1,988,931
Hot-dry Total	262,522	112,446	45,879	23,023	1,172,647	1,616,516
Total	**1,151,112**	**508,434**	**205,890**	**147,091**	**3,835,141**	**5,847,668**

TABLE 2-2: Estimated number of households in each dwelling type in each climatic zone from the projections in the Nelf EDI database (Nelf 1994).

The total number of low-income households can then be categorised into percentages of dwelling types as shown below in Table 2-3. The data in Tables 2-2 and 2-3 are used in Chapters 5 and 6 as input into the energy demand projections. The projections for the household data in Tables 2-2 and 2-3 from 1993 up to 2020 are shown in Appendices VIII and IX. These projections are based on the Nelf EDI database and they are also used as input into the energy demand projections in Chapters 5 and 6.

Climatic zone	Urban Formal	Planned shack	Unplanned shack	Backyard shack	Rural dwelling	Total
Temperate total	31.1	12.0	6.7	5.1	45.1	100.0
Hot-humid total	9.6	6.4	0.5	0.5	83.0	100.0
Hot-dry total	16.2	7.0	2.9	1.4	72.5	100.00
Total	19.7	8.7	3.5	2.5	65.6	100.00

TABLE 2-3: Percentage of low-income households in each category of dwelling type in each climatic zone

3.
Domestic energy use database development

3.1 Database development in the IEP process

Database development was discussed in Section 1.2.2 as one of the main tasks in integrated energy planning (IEP). Bouille (1992) cites database development as an essential prerequisite to the implementation of an integrated energy planning process. It involves the data aspect of energy planning. If energy planning can be considered to be a set of activities leading to the structuring of information so as to facilitate decision-making, database development would reach over the entire gamut of energy planning (APDC 1985). The ultimate goal of data base development is a complete, reliable and disaggregated energy and socio-economic information as a resource for IEP.

Database development has to be understood as very much a part of the iterative process of IEP. Although the database serves as an input to demand and supply analysis its development does not precede the analysis stage. Usually database development and analysis are carried out simultaneously, with considerable iteration between them. As the planning process becomes more sophisticated, the quality of the database, as well as that of the energy plans constructed, will improve. Even if the initial data set is incomplete and simple, it allows for a consistent and comprehensive approach to analysing national energy problems which is superior to the traditional uncoordinated planning by sub-sector (Eberhard 1992). In this way data gaps can be clearly identified and further research could incorporate the necessary data collection. A case in point is the development of energy demand data in the Energy Policy Research and Training (EPRET) project at the University of Cape Town in 1992-93. At the beginning of the project a coherent set of data describing low-income household energy usage was not available. The development of energy demand data therefore had to start from scratch at the same time as other policy work (Trollip 1994:4). In the words of the research outline:

> The analysis of existing primary and secondary data sources (of energy demand data) would *provide the starting point* for the sectoral studies dealing with energy supply options in both urban and rural areas. In turn, the energy usage information would be refined by closer investigation undertaken in these sectors (Eberhard 1993).

The most distinguishing characteristic of database development is that it provides a quantitative framework for energy planning. The amount of data required for energy planning can be enormous but it should be borne in mind that the importance of database development does not lie in its sophistication, but in the extent to which it is useful for energy planning. It must endeavour to provide answers to analytical questions concerning energy needs, and the means and resources for achieving those needs.

In IEP, it is not sufficient for an energy database to provide answers to analytical question like "how much energy from a specific source is required by a group of people or households or a sector of the economy for a period of time?". Database development requires questions more pertinent than this in order for the IEP process to be *demand oriented* and *end-use driven*. Rather, the database must go on further to provide data on the specific purposes for which energy is required, and also, the technology or devices or appliances with which those purposes can be achieved satisfactorily. In addition, it must be able to appraise how accessible and affordable the supply of energy from specific sources and their respective technologies are. The database must also disaggregate consumers into smaller groups with likely energy use patterns so that energy supply solutions can be properly channelled.

At the outset, then, data is required for energy demand analysis and energy supply analysis. This study focuses on database development for domestic energy demand analysis as discussed in Chapters 1 and 2. Most of the discussion in this chapter will focus on data for demand analysis. APDC (1985: 28-34) specifies three main sequential steps in database development, namely, *identification of data required*, *collection of data identified* and *assembling of data collected.*

3.1.1 Identification of data required

This step in database development relates to a country's energy system where activities of production, transformation and consumption of energy interact. It also pertains to variables and parameters that influence the energy system. According to the IEP Manual by APDC (1985) there is no ready made or standardised database since, as a planning concept, IEP does not prescribe any universally applicable data requirement. The kinds of data and the level of their detail required for a database depend solely on a country's energy situation and its policy objectives.

For the purposes of *energy demand analysis*, data requirement can be grouped into two categories. The first category comprises information affecting the demand for energy. This includes information on macro and sectoral economic activities, prices, demographics, climatic conditions and governmental policies and regulations. It explains the close relationship between energy consumption and socio-economic activities. The second aspect of data is on energy demand proper. This consists of data on actual energy consumption by economic sub-sectors (e.g. households) by demand categories (or end-uses like space heating and lighting) by energy source (e.g. electricity, fuelwood, and coal). Data on conversion efficiencies of end-use devices is also important at this stage.

For energy supply analysis, data is required on energy resource assessment (including total reserves and possible production rates) and technology evaluation (involving all types of technologies for transforming raw energy materials into energy forms useful to the consumer.

3.1.2 Data collection

Data collection for energy demand analysis usually involves the design of time-consuming and expensive surveys and questionnaires. It is therefore necessary to review existing data sources before beginning the actual data collection exercise. In some cases much of the required data can be generated from *secondary sources* (i.e. existing statistics, published and unpublished reports, macro and sectoral plans and programmes). However, in many cases, *primary data* is required, and this is where the design of questionnaires and surveys are very important. Primary data is usually difficult to collect and, therefore, a carefully designed method is required. This includes data on end-use energy consumption by households by fuel source and demand category such as cooking and space heating.

Often surveys are the only means to gather primary information for energy planning. There are no generalised survey methods or approaches that are universally applicable. The survey design will differ according to a country's energy resource situation and according its energy consuming sector or groupings. Practically, there is a limit to the resources available for surveys (time, skilled manpower, money). Therefore proper sampling is important in order to utilise the available resources efficiently to achieve a desirable coverage in the survey.

Special attention is required for collecting data on traditional sources of energy which supply a substantial portion of the total energy demand of low-income households. As discussed in Section 2.3, traditional energy sources data are difficult to collect and assemble due to the complexities involved in estimating their consumption. Care should therefore be taken when integrating such data with formal energy systems.

3.1.3 Assembling data collected

The last step in database development is the assembling of the data collected in a comprehensive and consistent manner for integrated analysis and decision–making. Again, there is no single database framework that is superior to others, the country situation would determine the appropriated level of detail and framework suitable. Most of the rest of this chapter deals with how both primary and secondary data on energy use in low-income households have been assembled in a *National Domestic Energy Use Database System.*

3.2 Domestic energy consumption variables

At the outset, energy planners should be cautioned about the use of the term "demand". The notion of demand typically expresses a relationship between price and quantity in a free market system. It represents the quantities that will be purchased at a given price. On the other hand, when the purchase has been made, like in most energy usage situations, we refer to "consumption" rather than demand. But actual consumption may obscure unfulfilled demand, particularly in South Africa where demand was intentionally suppressed by restricted access of black households to energy services. In compilation of historical data the equivalence of demand and consumption is often assumed.

Energy consumption and the choice of fuels consumed depend on interrelated variables. It should be obvious that many of these variables overlap and that there is often no clear distinction between variables that affect demand and supply. For example, the cost of end-use equipment is listed below as a demand variable since it concerns the final end of the energy supply-conversion chain and is linked to factors such as income, preferences for using certain fuels, and even tastes in the case of cooking equipment. However, end-use technologies are often fuel-specific, as with a kerosene lamp or stove, and so depend on supply-side issues such as the availability and price of fuels, and the price of the household equipment.

Some of these interrelated variables have been listed by Leach and Gowen (1987: 33-35):

3.2.1 Supply variables:

- Price (for marketed fuels);
- Abundance and scarcity of fuels. The measurements of these variables are not easily defined. They include the "time" and "effort" devoted to fuel gathering and fuel use; access to fuels by different household types, seasonal variation in supply; and cultural and socio-economic factors such as gender differences over decision-making;
- Fuel preferences. The reasons for choosing particular fuels and their associated appliances are usually determined by the characteristics of the energy output of the fuel. For example, in cooking, some fuels will be preferred to others because of the handling and lighting, flame quality and temperature, ability to secure fire from children, smokiness and the taste imparted to food. In a study by Cline-Cole (1981) in Sierra Leone, the cost of woodfuels relative to that of fossil fuels was the least important consideration for fuel switching by households. Although the average family in the town of Waterloo, Sierra Leone, spent 30% of its income on firewood, two-thirds of them would not switch from it because of reasons including food tastes, safety and wider range of cooking methods that are possible with open fire;
- Urban, peri-urban or rural location (i.e. settlement size and proximity to large towns or cities). These factors are closely related to supply factors such as fuel availability.;
- Substitutes for fuel and non-fuel uses of biomass (e.g. the availability of dung and the competition between the use of dung as a manure in agriculture and as fuel for cooking and heating in rural poor households).

3.2.2 Demand variables:

- Household income;

- Household size;
- Climatic factors like temperature, relative humidity and rainfall (for space heating and drying needs);
- Cultural factors (diet, cooking and lighting habits, etc.)
- Cost and performance of end-use equipment.

3.3 Background of the National Domestic Energy Use Database System

The National Domestic Energy Use Database System was initiated as a data resource for the South African Energy Policy Research and Training Project (EPRET) in 1992/93 mentioned in Section 1.3. Thus the database has been developed alongside actual policy research, influencing and being influenced by the other tasks of IEP. The project for the development of the database is currently in its second phase, which is mainly funded by the Department of Minerals and Energy (DME), although Eskom has supported certain aspects of the project. The project attempts to provide a comprehensive collection of all research that has been done in South Africa on low-income household energy usage and related indicators in a consistent format, and to provide quick access to key quantitative data in the studies necessary for planning purposes. In this way, key national research gaps are identified

A user-friendly computerised database system has been designed and it comprises a number of data categories that are relevant to integrated energy planning for the low-income household sector. The database components hold large volumes of data on energy usage and other socio-econo-demographic and housing information. The system further aggregates data from secondary and primary sources on different levels of locality. The data aggregation facility has a Geographic Information System (GIS) output which can be viewed with a GIS package like Arcview. Attempts have been made to put the system in the public domain, by possibly making the Department of Minerals and Energy the official custodian, to enhance policy formulation that would ensure better energy provision for the poor. A framework has been designed to undertake the continuous maintenance of the system, its expansion and updating, and to rationalise energy usage and related data collection in the household sector. The main tasks involved in the project are therefore the following:

Institutionalisation of the database: Energy planning and policy work need to be situated in an institutional framework that can balance national economic and development goals, the needs of energy consumers and the capacities of energy suppliers. This function can be explicitly defined and resourced if the database could be placed in an appropriate public domain that could provide the required institutional capacity for its effective development and dissemination. It is therefore proposed that the DMEA becomes the official custodian of the database, responsible for co-ordinating and overseeing maintenance actions that are necessary. This programme would also involve the operational requirements and dissemination. Prospective users need to be identified by the department and subsequently informed of its existence, trained and supported in its use. In the project, the DMEA would co-ordinate all training needs of users, maintenance requests and user feedbacks while the Energy & Development Research Centre (EDRC) at the University of Cape Town would be responsible for taking all necessary actions on training, maintenance and feedbacks, within the constraints of the project.

Data enrichment. Even though the database system has extensive coverage of many fields and studies, there are still many data gaps that need to be filled. Much work has been achieved in gathering bibliographic and review data from the available studies into the database, but a large portion of the quantitative data is still sitting in the various reports. One clear example is the inadequate data on appliance in the database. Data gathering manually from reports of studies by different researchers with different methodologies and measurements could be quite a daunting task. The first phase of this database development was not adequately funded to provide effective data entry into the system. However, the data gathering form the reports and its capturing into the system should be obviously one of the most critical specialised function since any serious errors in this function could easily jeopardise the whole noble purpose of energy planning. It is estimated that Eskom alone has spent not less than R2.5 million on energy studies in recent years. It would therefore be reasonable if some efforts are put into extracting the necessary data from the reports on those studies into an organised format in the database in order to make such a huge investment useful. Furthermore, the programme would also ensure that all necessary data is promptly extracted from new energy study reports that come up.

Database maintenance. It is important to note that energy data is not an end in itself but is collected essentially for use in energy planning. As the database is transferred into the public domain it would certainly require some regular maintenance in order to meet the needs of different users and at the same time keep the data up-to-date. Data integrity needs to be kept intact by incorporation of the necessary validation rules so that searches will pick up all relevant records and to ensure that data is entered correctly. Sufficient user-friendliness would need to be incorporated into the system if it is to remain useful effectively in the public domain. An on-line windows help system should be helpful in this regard. A simple user manual is required to be written and this should be continuously refined. This manual should include details on creating simple queries, a simple explanation of the internal structure of the database and how to use the individual primary household records.

Database system expansion. Although the data and fields in the primary data sets comprising individual household records have been largely transformed into a form accessible to users, the data remained inadequately useful for integration with the other components of the database system since much of it are in some form of codes. The project therefore seeks to increase the level of integration of the individual household records with the other components of the database. Also, the system needs to be expanded to include primary data sets that become available. The primary data on the Project for Statistics on Living Standards and Development (SALDRU 1994) has so far been linked with the database in electronic form and the database system aggregates data from this primary data source.

Analysis and synthesis. The iterative processes of IEP are to be sieved through analysis and synthesis of data to demonstrate the power of the database in supporting policy-making. To achieve this, data queries are constructed to yield aggregate data reports on different basis and levels of data in order to provide statistical estimates from the existing data. This would have to be built up progressively and iteratively to paint more detailed quantitative pictures of energy usage patterns and how they relate to household economic and social characteristics. Some conversion facilities in terms of survey dates, currency values, energy units, etc., are also be provided at all levels of data to enhance analysis and synthesis.

Standardisation of domestic energy data collection. In the past, domestic energy data collection was undertaken in a very fragmented way in South Africa with different methodologies and measurements. Evidently, that approach not only entailed much duplication of effort and waste of resources, but also more importantly, by lacking standard definition of the common data entities collected, resulted in incompatible data sets. It is therefore proposed that, as part of this project, all questionnaires used for domestic energy data collection be pulled together and standardised, with common entities accorded standard definitions. Harmonising the definition of the common entities does not imply collecting all data in a single database (Harfoush, N & Wild, K 1994). On the contrary, the standard definitions allow the decentralised collection of data, the establishment of many application specific databases, while maintaining the possibility of aggregating or correlating such data consistently with that generated by other efforts. It is proposed that this project be informed of all national efforts in domestic energy data collection and be made part of the co-ordination of such efforts in order to ensure proper sampling coverage and standard methodology and measurements.

3.4 Review of secondary data sources for the database development

As discussed above, the development of the domestic energy use database has largely involved the collation of data from diverse kinds of studies. The extraction of data from these secondary sources required critical evaluation, since the data in the various studies were not generated primarily for energy planning and, as such, varied in terms of measurement factors, time periods, methodology, and so on (NAS 1980: 9-14). None of these studies had a national coverage, rather they covered certain selected rural, peri-urban and urban areas in different parts of South Africa.

Rural energy studies in South Africa have been extensively reviewed by Ward (1995) detailing the types of existing studies and their shortcomings, quality of data, and coverage in terms of geographic location and issues of energy use and related variables. Loon (1996: 61-69) also reviews a selected representation of rural energy studies in South Africa in terms of their methodological approach with respect to IEP. This section does not attempt to review in detail the sources of the secondary data in the database since this has been extensively done in the review and bibliographic component of the database itself (see Sections 3.3.2 and 3.3.3). However, an attempt has been made to summarise briefly below the types of studies from which data were extracted into the database, and also, a general observation of the studies, especially the constraints in capturing data from all the different sources of data into one database.

3.4.1 Types of studies

At the outset, a comprehensive search for all energy and energy-related studies on households in South Africa was initiated. This happened in a period when most institutions were struggling with the transformation of South Africa into a society of openness. In spite of the initial difficulties, the search produced overwhelming results, bringing together hard copies of reports and papers on diverse kinds of studies. Each of the reports was carefully read and the data therein critically examined.

All the studies were classified by the type of information that the particular studies purposed to gather. Another categorisation of the studies was by the kind of institution that commissioned or conducted the studies. Some of the types of studies are:

- Energy survey/studies
- Policy/analysis
- Income and expenditure survey
- socio-economic surveys
- In-depth studies
- Conference papers & journal papers
- Thesis (MSc. & PhD)
- Development studies

3.4.2 General observations of studies: constraints in data capturing

There have been many constraints to the capturing of data from the various studies. Many of these constraints are resource-related. The reading of the reports requires the services of specialised personnel with qualified experience and knowledge about household energy use especially in the low-income areas. This ensures that accurate data is captured to offer the database a good foundation. This aspect is also time consuming since the data captured from one report would often require some manipulation in order to fit into a common form for the data from all other studies. The design aspects of the database have also been a daunting task as well as the database maintenance. It must be obvious that a lot of thinking needs to go into the task of designing of a common database to suit data that has already been gathered under different circumstances, by different researchers with different objectives and methodologies.

There are other constraints too that are related to the studies themselves. Some of these constraints are:

- **Geographic coverage**. While some areas have been extensively researched, and sometimes research has been mere duplications, other areas have very scanty coverage. Although the database is useful in this regard in exposing research gaps, it does also render the aggregation of data on regional basis less meaningful. Coverage in rural areas is worse than in urban areas with some rural areas being completely neglected. Areas in the former homelands are also poorly researched. For example, the only useful study on Venda that could be identified is one undertaken as far back as 1989 on the demand and supply of firewood in the homelands (Aron, Eberhard and Gandar 1989). Although there are some few useful studies on self-governing states like Gazankulu and KwaZulu, others have scanty information. Qwa Qwa, Lebowa, KwaNdebele and KaNgwane have poor coverage of data on household energy use.

- **Units of measurement**. In some studies researchers ignore the importance of the units of measurement in their presentation of data. This is probably due to the fact such a study report was intended for the internal readership of an institution and, as such, units were usually known to be of a specific format. However, this creates problems when such data is integrated with data from other sources.

- **Study review problems.** In some of the studies no background information was reported on the study and in some others no objectives were provided for the study. An example of this problem is the frequent omission of the *sample size* and the *universe* for the sampling in the reports of some studies. With no information on the sample size and the universe it is impossible to estimate how representative the available data is. This creates review problems since accurate data can only be extracted when it is placed in the appropriate context.

- **Poor identification of study locality.** Some studies completely leave out a description of the physical location of the study area. Others that provide this do not include the necessary information like maps to clearly mark out the study area and the way it is linked with other geographic locations within South Africa. In some instances the names of certain localities and settlements have been spelt or given names differently in various reports. There are a few reports too where localities have been wrongly placed. A lot of effort is put into reconciling these differences and omissions in order to provide unique locality for each study. This is necessary for the purposes of data aggregation at different levels of locality so that no data is lost in the process.

- **Loss of survey data.** Usually, only a few tables of data are included in a report. The data that is presented therefore provides only a small fraction of the utility that the underlying data from the survey work actually holds.

- **Omission of references.** There have been times when one requires information from the author of a report (or his/her institution) in order to make any sense out of the data in the report. In some cases explanation or clarification of a methodology or measurement or a study location or objective is required, and in other cases more empirical data is needed. However, some reports leave out the institution of the author or the institution that commissioned the study. There are some instances where authors names cannot be identified. This makes it difficult to track the source of the data set and renders any data authentication process futile.

- **Limited grouping of data.** The data in reports are usually aggregated data that have been grouped into pre-defined categories. This limits the reader of such reports to the categories pre-defined in the report. To be able to re-group the data to suit the categories in the database one would sometimes require the actual data behind the pre-defined categorisation, for example, in the database data is categorised according to *dwelling types* whose definition go beyond *informal* and *formal* households. Thus studies with data categorisation according to formal and informal categorisation pose a lot of problem in data capturing. Another example is the categorisation of data into *urban*, *peri-urban* and *rural area* in the database. For reports which categorise data into only rural and urban, one would require some background information in order manipulate the data into the preferred categories. It must be mentioned that a lot of care is needed in such data manipulation, and in many cases data manipulation is virtually impossible or meaningless.

- **Omission of research dates.** Since the policy environment is rapidly changing one must be conscious of the time certain findings are made. Furthermore, for proper demand analysis and projections, time is a crucial factor. One must be able to track the changes in energy use patterns with time. Unfortunately, many of the studies have not reported the time in which survey data were collected.

- **Lack of information on statistical usefulness.** To bunch together aggregate data from different sources without any information on the statistical usefulness of the data can be very misleading. While some reports do not provide information on the sampling method used in the study, others do not even mention the sample size for the study. Some of the reports with information on the sample size too omit the size of the universe out of which the sample was selected. In such situations it is difficult to assess representativity of the data presented in the report.

- **Conflicting definition of terms.** The most confusing constraint in the reports is the conflicting nature of definition given to some of the terms in the reports. For example, energy consumption can mean a lot of things if the report refuses to define it adequately with the appropriate basis and units. Energy consumption can be in terms of physical units (e.g. weight of wood, volume of paraffin, etc..) or useful energy or delivered energy. The basis of measurement can be *all the households* in the study or only those *households using* the particular fuel. Estimation of consumption must also state clearly whether it is weekly, monthly or annual consumption. These minor omissions sometimes make the data in reports worthless. Another example is the definition of "the household" which many studies take for granted. Since most of the household energy demand variables are measured in terms of the household unit, inappropriate definition of the household can easily distort the picture of energy use patterns. In like manner, the omission of a definition of the household in a report on a study also reduces the integrity of the data it presents.

- **Conflicting research methodologies.** The research methodologies of a lot of the studies are in some cases found to be diametrically opposite to the purpose of the database. While the database is designed as a tool for integrated energy planning, a lot of the existing data were collected with supply-oriented approaches. Clear examples are the Eskom S1 reports (Eskom 1991, Eskom n.d.a, Eskom n.d.b, Eskom n.d.c) which are basically electricity marketing studies aimed at finding out people's attitudes towards electricity and their affordability. The marketing bias in the studies is clearly seen in the questionnaire design and the data presentation. All the studies have almost the same format, based on the same questionnaire in spite of the different study areas, and usually the dates of the studies are not reported.

  A second example is found in the studies by Gandar (1998) and Rivett-Carnac (1990) where even though the idea of integrated energy planning was posited, a different interpretation was employed. The word "integrated" in IEP was interpreted to mean "holistic" in the sense that *all energy supply options should be considered*, with special emphasis on an ecologically sound exploitation.

  Another example is cited by Loon (1996: 62) in a review of a study by Eberhard & Dickson (1987). In this case, even though the IEP principle was followed in the sense that energy demand was analysed before considering energy supply scenarios, the energy sub-sectors were taken as the focus for the analysis, causing overlapping of end-uses and subsequent inadequate analysis of the energy services by the sub-sectors.

- **Lack of important cross-tabulation.** Many important cross-tabulations of the demand and supply variables are very important in assessing the effect of one on the other. However, such cross-tabulations were largely left out in many of the reports. For example, even though there were substantial amount of data presented on income and demographics, these variables were not, in many cases, cross-tabulated with energy use variables like energy expenditure and consumption. Thus the relationships between these variables are not easily analysed.
- **Omission of important data categorisation.** The restrictive nature of data categorisation in the studies has led to the insufficient coverage of important social issues like gender and power relations concerning energy use in the household. Only a few studies, like that of Annecke (1992), deal with gender issues.
- **Lack of data on important energy demand variables.** A lot of the studies left out important energy demand variables. End-use information was generally lacking in most of the studies. Data on appliance acquisition is also very poor in most of the studies. Moreover, data that was not disaggregated into dwelling types could not easily fit into the design of the database.

3.5 The structure of the National Domestic Energy Use Database System

3.5.1 Introduction

The database system consists of three Microsoft Access database files, namely; NDEUD.MDB, ENGDATA.MDB and SALDRU.MDB. The NDEUD.MDB file contains the programme *objects* and various lookup *objects* required to run the whole National Domestic Energy Use Database (NDEUD) system. These objects are tables, queries, forms, reports, macros and modules which form the backbone of the system, managing the data sets in the system. The actual *secondary* energy and energy–related data that has been collated from various household energy study reports is contained in the ENGDATA.MDB file. The SALDRU.MDB file contains a separate *primary* data set that has been extracted from a national household survey co-ordinated by the South African Labour and Development Research Unit (SALDRU) for the World Bank (SALDRU 1994).

3.5.2 Collation of existing domestic energy use data

The ENGDATA.MDB file embodies the *National Domestic Energy Use* secondary data set gathered from reports and papers on household energy use studies all over South Africa. It is thus a comprehensive collection of aggregated data already analysed by the respective authors of the various reports. As one would imagine, data collection and analysis of such aggregated data covering several years and different geographic locations in the country would definitely require different research methodologies by the different authors according to the objectives set for each specific study. The extraction of data from such diverse sources into one unifying database requires a broad understanding of the issues at stake and a lot of care has been taken in grouping data items into the appropriate similar fields of information in the database.

The focus of this data set has been mainly low–income households. This is because the supply-side information on high and medium income households has been reasonably reliable whilst information on low–income households remains virtually non-existent, a situation resulting from the total neglect by the previous political dispensation. Furthermore, the development of this data set has been demand–side driven since it was purposed to identify factors for estimating the energy demand of low–income households based on the needs of the people.

The demand for a source of energy is based on the services for which it is required, the extent to which such services are spread among the population and the efficiency with which they can be delivered (Reddy et al 1995). The energy requirement so estimated is then matched with energy–supply and/or energy saving options, so as to minimise costs. Thus, the coverage in this data set extends to all issues like demographics and socio-economics that could directly or indirectly determine the energy requirement by a household in an integrated energy planning process.

There are two sub–components of this data set. For each study that has been identified as having possible relevance to low–income household energy use, there is a provision for a record in the data set consisting of basic bibliographic data and comments on the nature of the study, its objectives and usefulness. If the study was found to have quantitative data relevant to household energy consumption, the data set would then have indications on the kind of information covered by the quantitative data in that specific study. This sub–component of the data set constitutes the *bibliographic and review database.*

The second sub–component of this data set contains actual survey numerical household energy use data. It is referred to as *aggregate data* because it is invariably presented in reports as tables of averages, across a wide variety of groupings, for quantitative data from individual households. The primary groupings are locality and dwelling type. The locality can be a zone in a township, or a township, or a town or city, or a magisterial district or a province and a distinction is also made between rural and urban localities. Thus, for each study/report, provision is made for any possible number of records for dwelling type/locality combinations. This serves as a link to the groupings for energy usage profiles that also use geographic area and dwelling type as main criteria for aggregation of data. In terms of geographic locality, four levels of data aggregation are possible in the system, namely: national, provincial, magisterial district and locality levels. These four levels of aggregation of data by geographic location are stored as data fields in the *Locality* table found in the NDEUD.MDB file which can be linked up with any survey placename, provided

Fuel consumption by users: net energy (MJ/month/hh)
% households using fuels
Fuel prices (cents/unit of measurement)
Fuel expenditure by all (R/month/hh)
Fuel expenditure by users: (R/month/hh)
Fuel consumption by all: net energy (MJ/month/hh)
Fuel consumption by all: physical quantities (unit/month/hh)
Fuel consumption by users: physical quantities (units/month/hh)
Wood collection (% households)
End uses of fuels - lighting (% hh)
End uses of fuels - water heating (% hh)
End uses of fuels - space heating (% hh)
End uses of fuels - cooking (% hh)
Fuel consumption by all: useful energy (MJ/month/hh)
Appliances : planned purchases (% hh)
Appliances : purchases (% hh)
Appliances : % hh ownership
Attitudes to Electricity : priorities of advantage (% hh)
Attitudes to Electricity : perceived affordability (%hh)
Attitudes to Electricity : payment preference (%hh)
Attitudes to Electricity : priorities for appliances (% hh)
Employment : employment levels (% hh)
Employment : frequency of migration (% hh)
Employment : economic sector (% hh)
Employment : place of employment (% hh)
Services provided (% hh)
Services : community priorities (% hh)
Services : household priorities (% hh)
Socio demographics : education (% respondent)
Socio demog : education (% sampled hh)
Socio demographics : age (% hh in age group)
Housing
Household Income (R/month)
Household Expenditure (R/month)

TABLE 3-1: Categories of quantitative data in the form of tables attached to each survey number

it can be identified amongst the pre-defined enumerated areas by the Central Statistical Services. Besides the four levels, the data can also be aggregated at the level of the former homelands. The coverage of aggregated quantitative data attached to each survey is very broad. Table 3-1 lists 34 categories of data with wide range of fields for data capturing.

The ENGDATA.MDB database file contains 497 documents out of which 364 surveys have been identified. It must be pointed out clearly, however, that not all the surveys have the same details of data. Due to the varied objectives and different survey methodologies of the various studies, surveys may have different coverages of data fields and, as a result, not all surveys have data for every data field in the database. The programme file NDEUD.MDB works together with the ENGDATA.MDB data file in the analysis of the quantitative data in the various documents. Such analysis produces aggregated information in the form of reports which can be printed or outputs in the format of Geographic Information System (GIS) which can be displayed in Arcview. The synergy of both the programme and data files, respectively NDEUD.MDB and ENGDATA.MDB, is hereafter referred to as the NDEUD (National Domestic Energy Use Database) system.

3.5.3 Linking of primary energy use data with secondary data set

Like the NDEUD system, the NDEUD.MDB programme file works with the SALDRU data set (SALDRU.MDB file) in a similar fashion to produce the *Saldru system*. However, the Saldru system works with a separate data set of individual *primary* records consisting of about 9 000 households in the form of coded information. The data is stored mainly in its original form as coded information that the Saldru system decodes into meaningful formats in its analysis of the data.

The Saldru data set is an extract from the SALDRU study as mentioned in Section 3.5.1. The study was an attempt to measure a wide range of measures of living standards in South Africa, of which energy was one. Table 3-2 lists the categories of data extracted from the bulk data of the SALDRU study into the Saldru data set which forms part of this database system.

Item	*Category*
1	Household Roster - demographics, gender, relations, etc.
2	Housing - dwelling type, construction, ownership, etc.
3	Sampling frame - locality information
4	Appliance data
5	Household fuel expenditure
6	Household monthly expenditure
7	Fuel end-use - cooking, house heating, water heating, lighting
8	Wood collection
9	Employment status
10	Water and Sanitation
11	Quality of life

TABLE 3-2: Categories of data in the Saldru data set

Unlike the NDUED system where the various surveys focused on specific localities, the Saldru data set had a national basis with coverage over all the nine new provinces of South Africa. In all, 188 magisterial districts were part of the clusters used for the survey.

In the database, the Saldru data set has been grouped into three tables, namely *Saldru*, *Saldru_HH* and *Saldru_Cluster*. The Saldru table contains data collected on individual household respondents. The key fields for this table are the HHID that identifies each household and the PCODE that identifies each respondent in the household. The Saldru_HH table contains information unique to each household. The key fields for this table are the HHID, which is the unique identification number for each household, and CLUSTNUM, which is the cluster to which the particular household belongs. The Saldru_Cluster table contains information about each cluster. The key field for this table is CLUSTNUM, which is the unique cluster number. In this table there is also magisterial district code, MagCode, which links Magisterial District field to the Locality table in NDEUD.MDB file to provide locality for the cluster, and hence for each household in the Saldru system. Figure 3-1 below illustrates the data fields through which the Saldru system files and the NDEUD system are linked.

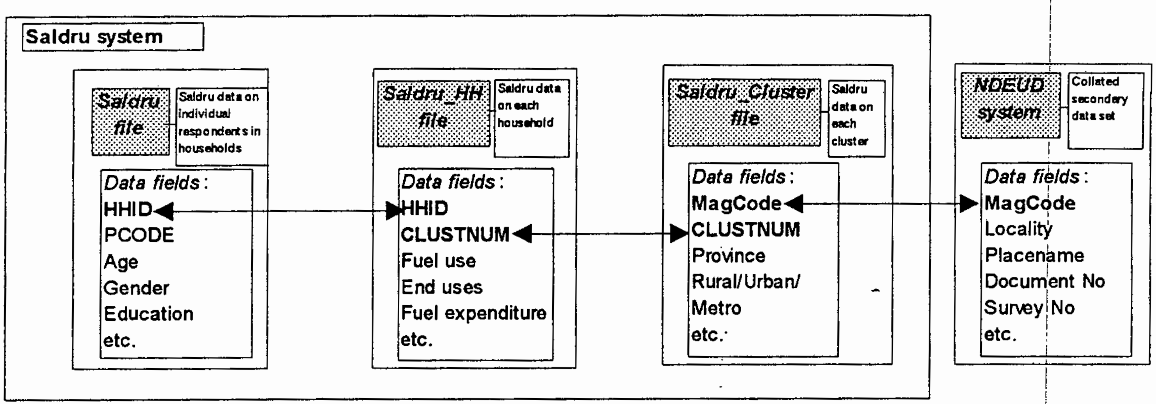

Figure 3-1: Links between the files of the Saldru system and the NDEUD system

3.6 General user-friendly interface of the database

As mentioned earlier on in Section 3.3, the current phase of the database development is aimed at transferring the system into the public domain. To facilitate the transfer of the system into the appropriate institutional set-up in the public domain, a user-friendly interface had to be provided. The system had to be improved and this improvement was extended to all the necessary requirements for expansion of the system to include the large volume of data from the Saldru studies.

As a first step, the data fields in the system were reviewed to accommodate the changes envisaged. Then the whole system was completely re-designed to enhance the linkage with the Saldru data set. To avoid scrolling through lengthy hidden pages when viewing or capturing data, a multi-paged form design is the approach largely used. Forms with lengthy pages have been broken down into many pages with each page completely visible on the screen. The pages are now easily accessed through mouse clicking on tab controls.

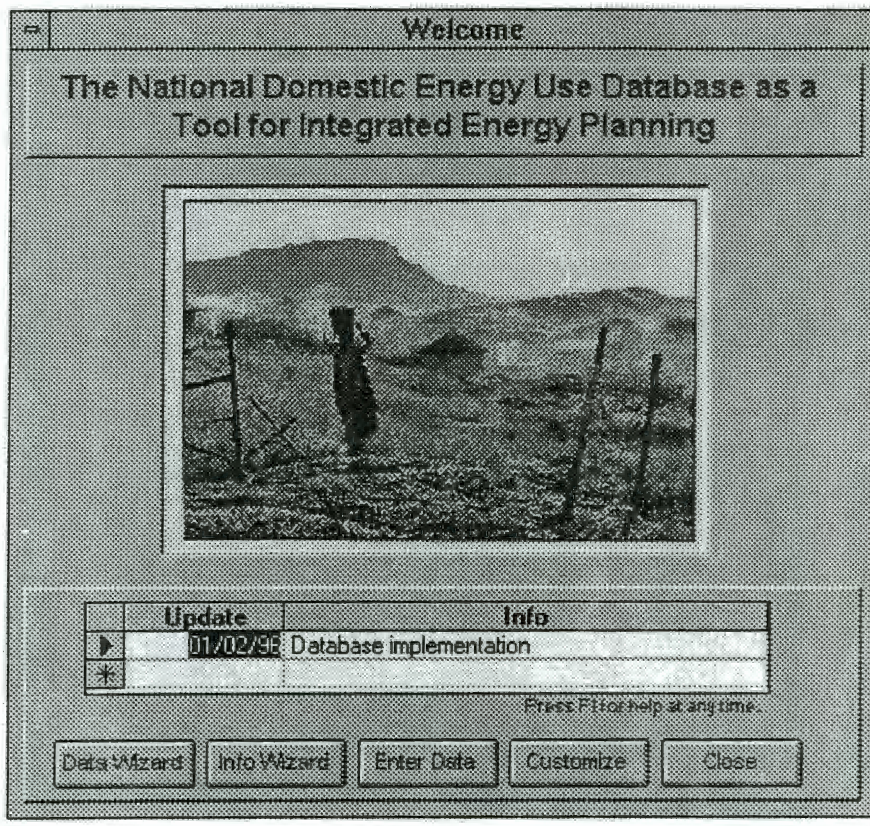

FIGURE 3-2: The first screen presenting the system[1]

When the database system is loaded up it is introduced to the user as presented in Figure 3-2 above. The clicking of the mouse on the buttons at the bottom of the figure leads the user to specific tasks. For example, the clicking of the mouse on the *Enter Data* button will lead the user to the data capturing or editing screens of the NDEUD system and also, a presentation of the raw data in that system.

3.6.1 The structure of the data capturing system

The structure of the data entry system for the NDEUD system can be seen in Figure 3-3 below. In this system, it is possible to visualise the linkage between the various documents and the attached surveys. For example, in Figure 3-3 below, 21 surveys are attached to document *Number 290* which is entitled *Energy Usage in Urban Black Households in Selected Formal and Informal Townships of South Africa,* a study which was undertaken by *Hoets, PA and Golding, AP*. It can also be seen at the bottom of the figure that this document Number 290 is the 290th record out of 497 records of reports. Whereas the horizontal arrows at the bottom of the figure allows you to

[1] The main technical aspects of the database were designed by the Lateral Alternative Consultancy cc, Cape Town.

move to any particular document, those in the middle of the figure allow you to scroll through all the surveys attached to the document in view.

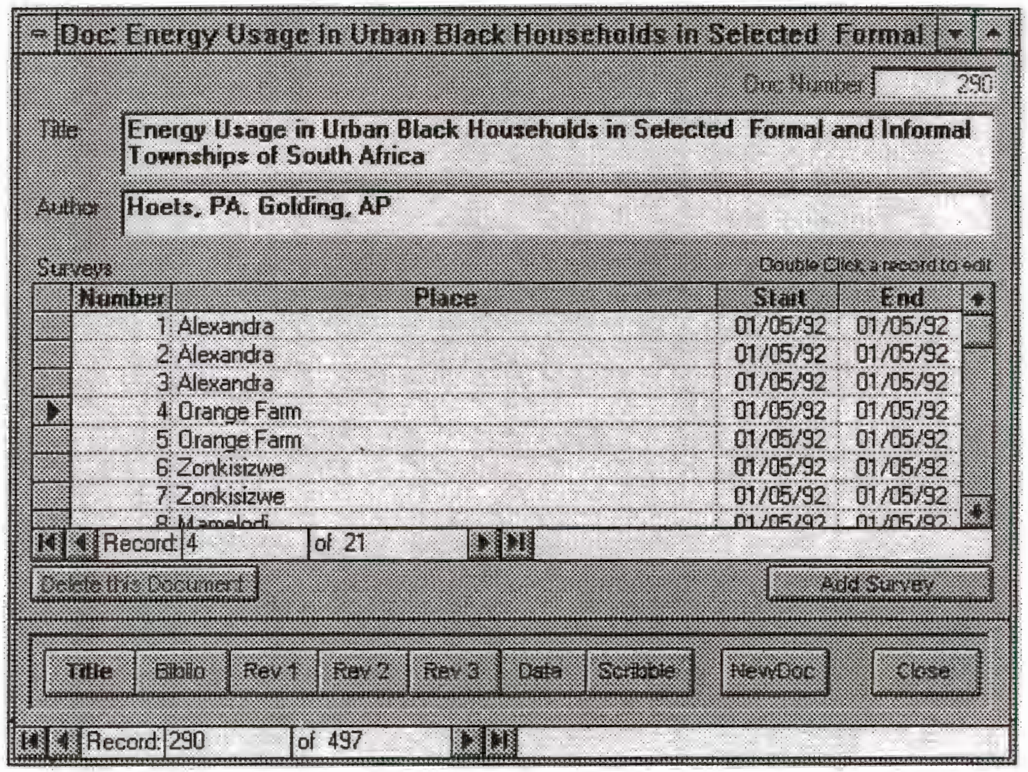

Figure 3-3: The data capturing system

Each of the buttons below the figure above takes you to a different page of information on the selected document by a mouse click. The *Title* button is the default page, which is the one in view. The *Biblio* button takes you to the bibliographic information on the selected document. The *Rev1, Rev2, Rev3* buttons are those three buttons that take you to the three pages of review of the selected documents. The *Scribble* button allows you to enter any comments on a particular document that did not fit anywhere else in the database. The *NewDoc* button creates a completely new form for a new document one intends to add to the system and, in addition, any number of surveys you wish to attach to that particular document can be created at this point. The *Close* button takes you back to the first page of the database system. This screen and all those linked to it also allow editing of data. An unwanted document can be deleted from the system and a new survey can be added to a document.

In the document shown in the above figure, within one single report, 21 surveys were identified, with the difference being the survey place or the dwelling type. A combination of a document number, a survey number, a survey place and a dwelling type uniquely identifies a survey. For example, the triple occurrence of Alexandra as surveys attached to *Document Number 290* in the above figure indicates that there were three dwelling types surveyed, namely; Formal Housing, Planned Shacks and Unplanned Shacks. The linkage between documents and their attached surveys has been illustrated in the figure below. It must be noted that not all documents have surveys attached to them. The emphasis here has been surveys with quantitative data on energy use and consumption.

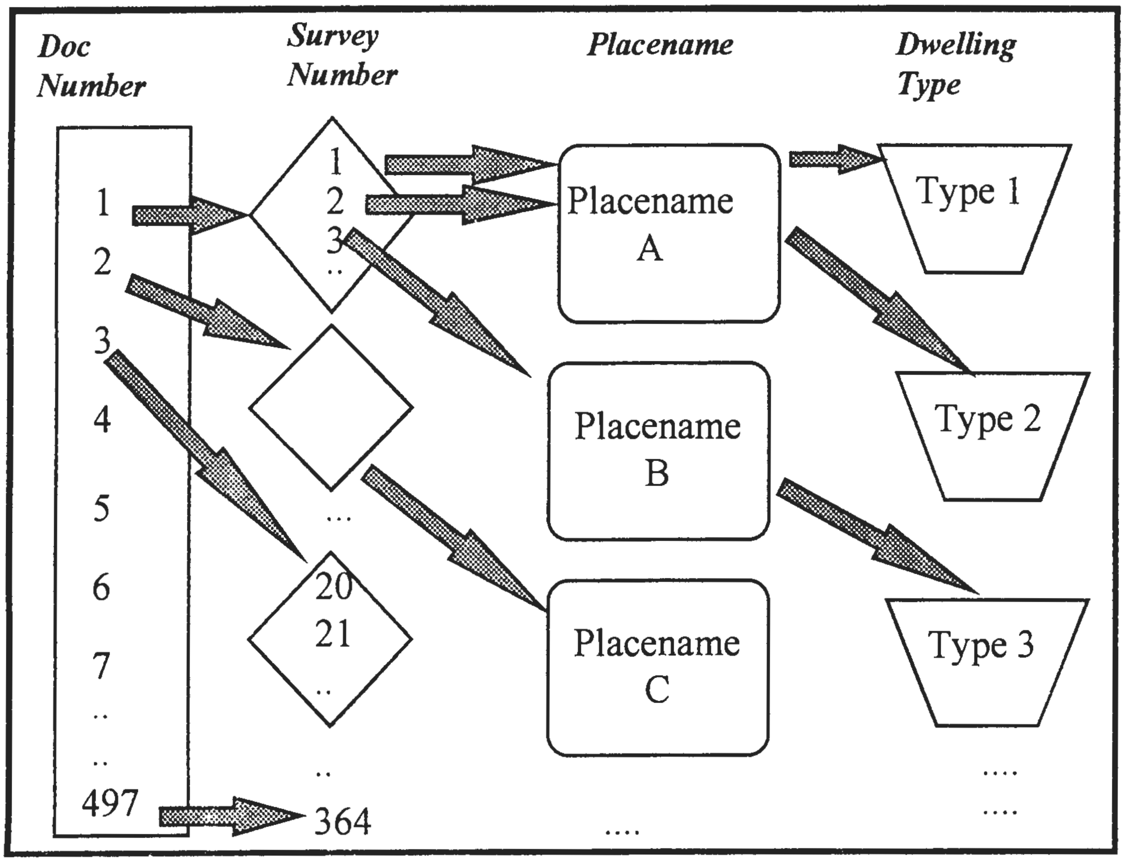

Figure 3-4: Linkage between documents and their attached surveys

3.6.2 Bibliographic and review data

As mentioned in the above section, the clicking of the *Biblio* button in Figure 3-3 opens up the first screen of the *Bibliographic and review* section of the NDEUD database system. On this screen all the bibliographic information recorded in the particular report or document is extracted and entered into the system for the benefit of the user in ascertaining the background of the data in the system. It also helps in making references to specific documents a user may be interested in checking the details of the background information. It also deals with the extent of electrification, dwelling types and urbanisation issues covered in a particular study. Figure 3-5 shows the *Biblio* screen. It can be seen on this screen that dwelling types covered by surveys attached to *Document 290* are formal housing, planned shacks and unplanned shacks.

As much as possible, each document has been reviewed and a summary of the review has been entered into the system through buttons *Rev 1, Rev 2,* and *Rev 3*. *Rev 1* stores information on the main objectives of the study, a short abstract of the study and the key recommendations made. Comments are also made on the study as well as short notes to guide the user concerning the usefulness and limitations of the particular study. Other outputs of the study that are useful information related to energy use are also captured by *Rev 2* screen. *Rev 3* also captures information on the survey methodology, statistical information and the location of the study.

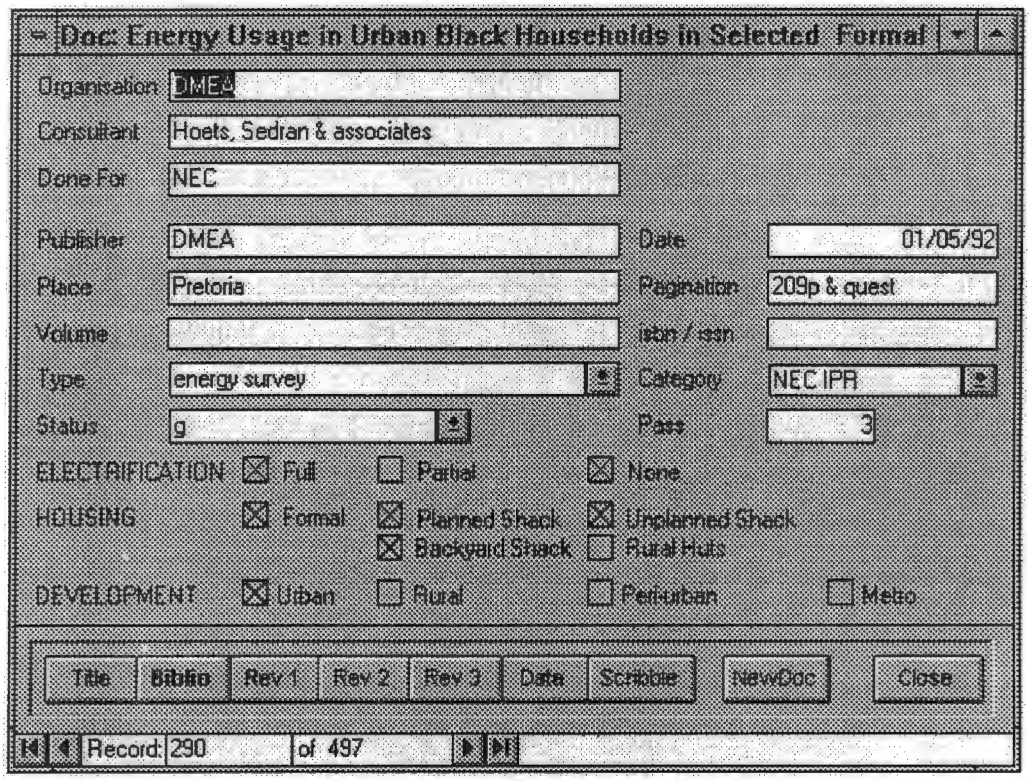

Figure 3–5: The Bibliography screen

3.6.3 Review information on surveys

Editing of the surveys have been made easy by providing immediate access to them the first time they appear with their linked document as in Figure 3-3. For example, double-clicking

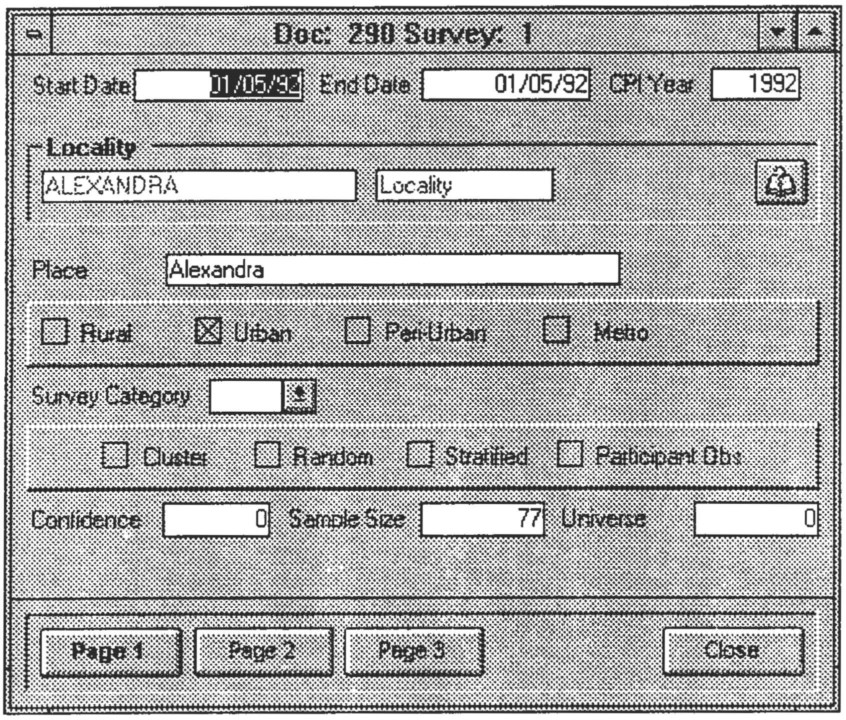

Figure 3-6: First screen of survey review information

Survey 1 of *Document 290* in Figure 3-3 opens up the first screen with review information on this particular survey as shown in Figure 3-6 above. Whilst buttons *Biblio, Rev 1, Rev 2*, and *Rev 3* cover summarised review of a whole document or report, review information captured on the above screen deals with individual surveys attached to documents. It captures methodology used for collecting data and also supporting statistical information like *Confidence Level, Sample Size* and *Universe* to show the representativeness of the data collected during the survey. It also captures the level of urbanisation of the sampled households with mutually exclusive choice between *Rural, Urban, Peri-urban* and *Metro*. For the purposes of converting energy expenditures and fuel prices into present worth values the year in which the survey was conducted is captured to indicate which Consumer Price Index (CPI) value is used for the conversion.

In Figure 3-6 above, both the survey *Place* and the *Locality* fields are Alexandra township. In some cases the survey place and the locality fields have different values showing different levels of data aggregation according to geographic location(e.g. if the survey place were say a small zone in the Alexandra township). This is because there is a pre-defined *Locality Builder* in the database system that categorises all survey places according to the enumerated areas assigned by the Central Statistical Services (CSS).

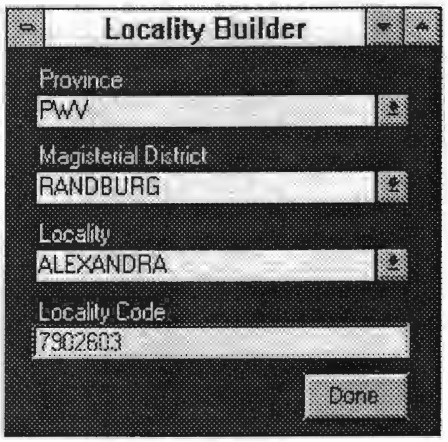

Figure 3-7: Pre-defined locality builder

The purpose of this is to link every survey in the system to identifiable geographic location so that aggregated data from the system could be displayed in a GIS output. Some survey places can be so small that they may not constitute enumerated areas, rather they are just portions of enumerated areas. For example, a survey place could be a zone in a big township or a small township or a small rural community. The database system aggregates data from such small survey places to the enumerated areas in which they occur. In such a case the *Locality* field will be the enumerated area whilst the name of the actual small survey place will be captured into the survey *Place* field.

During data capturing or editing, the survey *placename* is typed into the survey *Place* field but the associated *Locality* field would have to be selected from pre-defined values in the locality builder as shown in Figure 3-7 above. The locality builder pops up when the locality builder icon  in Figure 3-6 is double-clicked. As illustrated in Figure 3-7 above, Alexandra township was selected from the drop-down list in the *Locality* field in this figure. Consequently, Randburg Magisterial District and PWV (now Gauteng) Province in which Alexandria falls are then automatically selected. The locality builder further selects a unique *Locality Code,* 7902603, which identifies Alexandra on a GIS. Depending on the data available and the survey place in question, the locality code can be provided at any of the four levels of resolutions, namely: *Locality, Magisterial District, Provincial* and *National* levels.

On the second screen of the survey information review items like settlement type and size are indicated if the survey report covered those issues. Figure 3-8 shows the information captured on this screen. Other issues covered on this screen are household definition and size, dwelling type and the extent of electrification.

There is a third screen that captures any extra survey review information that does not fit anywhere else.

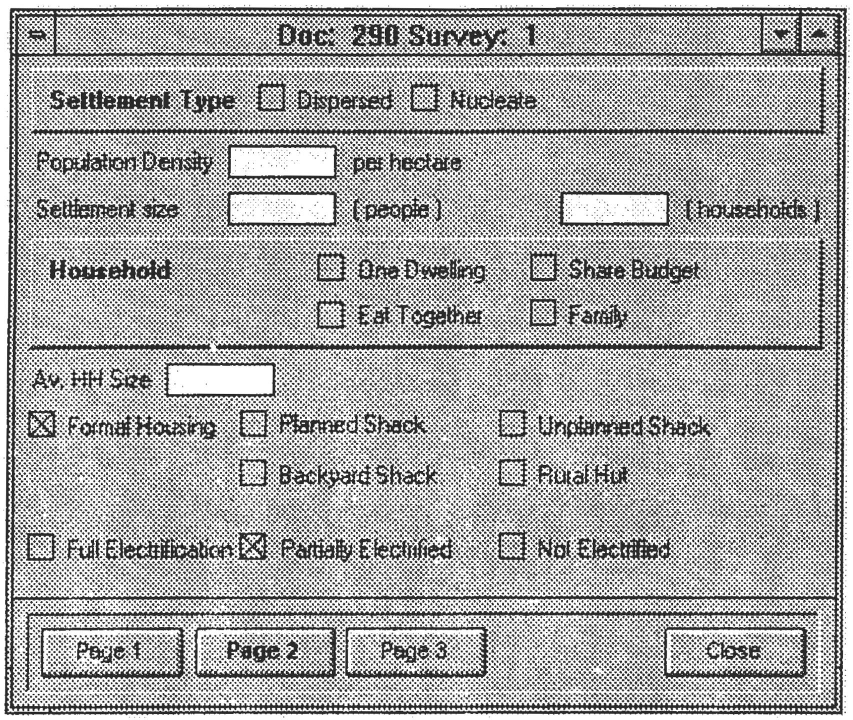

Figure 3-8: The second screen of the survey review information

3.6.4 Quantitative energy use data storage

As mentioned in Section 3.5.2, quantitative energy use data attached to the surveys of the secondary data set have been grouped into distinct categories. A screen displaying this list of categories comes up when the *Data* button on Figure 3-3 is clicked. Besides this list of quantitative data categories, one can also indicate on this same screen other general quantitative *Aggregate Data* covered in that particular report. In Figure 3-9 none of the check boxes on the left of this list of general aggregate data has been checked, which means that none of them is covered in report Number 290. In this figure *Fuel Prices* has been selected as the category of data desired. When this category of data is double-clicked a table pops up, as shown in Figure 3-10, listing the fuel prices for all the placenames of the surveys attached to document/report Number 290. The unit of each particular field can be seen in the status bar when the cursor is placed on a particular field. For example, the unit of the price of wood, cent/kg, can be seen in the status bar when the cursor is placed in the wood field.

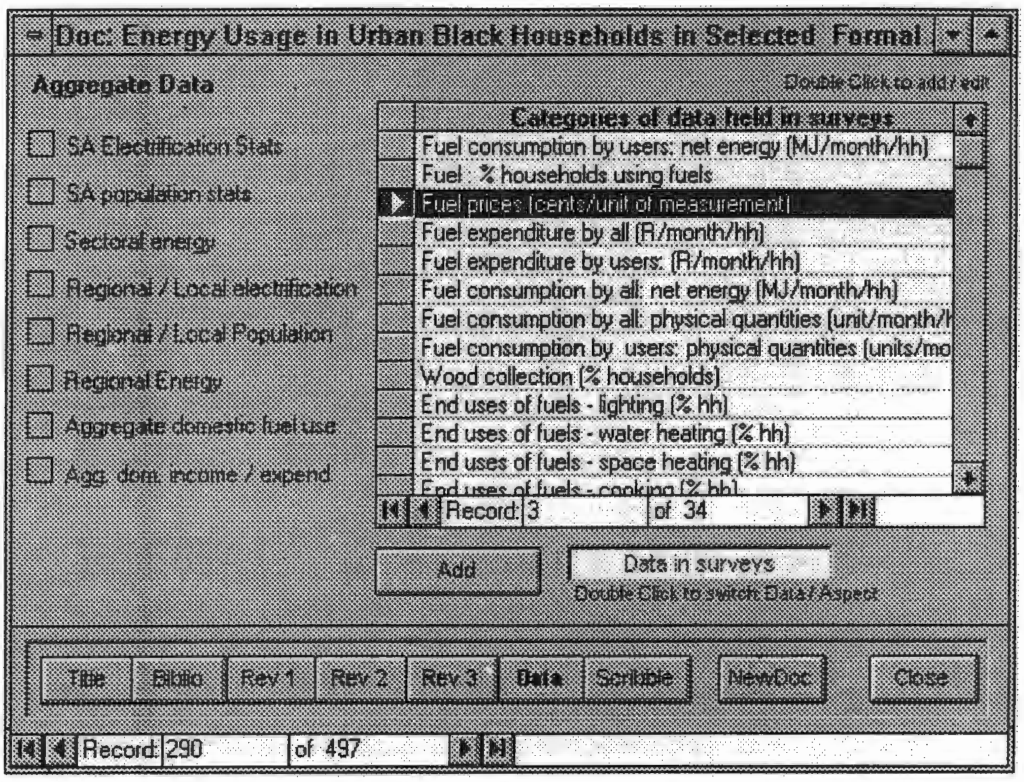

Figure 3-9: Selecting category of quantitative energy use data

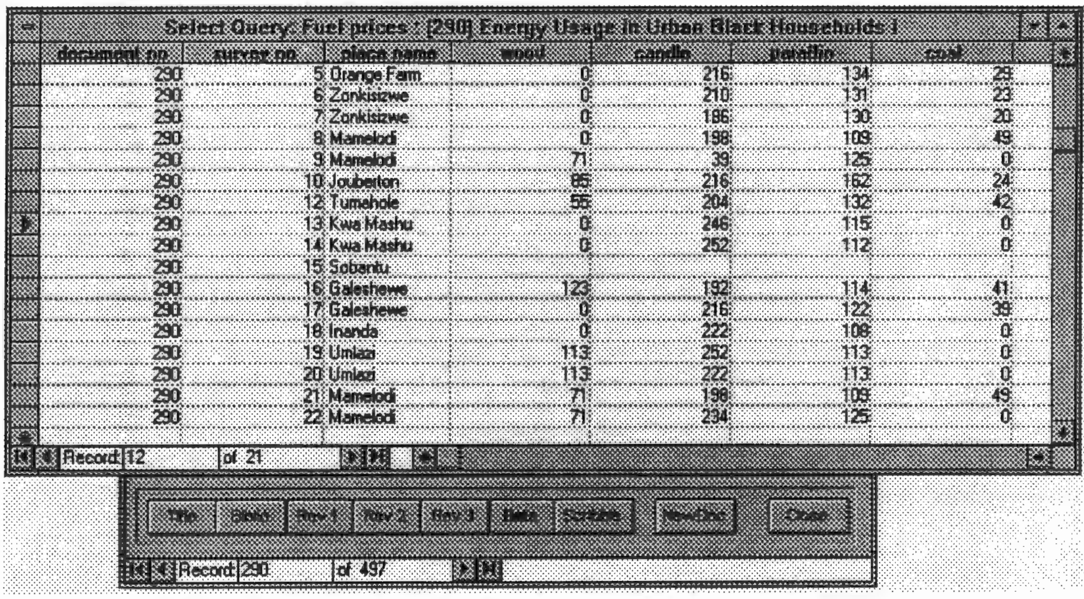

Figure 3-10: Quantitative energy use survey data linked to documents in tables

3.6.5 On-line help

There is an on-line help facility provided in the system. Wherever one is in the system, the help system is invoked when F1 is pressed. Like most Windows-based on-line help facility, help topics are linked to facilitate understanding of related issues. However, this facility does not provide deeper understanding of the system and would require further development.

3.6.6 Database documentation

In addition to the on-line help facility, a simple database documentation has been put together for the system. This manual provides a basic description of the internal structure of the database system. Part I of the documentation covers simple use of the database system and the application of query mechanisms called wizards for aggregating data on different levels of resolutions. Part II covers the more complicated aspects of the database design, for which an understanding of Microsoft Access is required. Part II also discusses the coding used for the various data stored in the tables, and explains how queries can be customised for more sophisticated requirements. The manual tries to explain how the database system has been designed to allow users to access the data easily and quickly with minimum understanding of the technical aspects of computer programming or database manipulation.

Apart from this separate manual on the documentation of the database, a table has been provided in the system itself called *DB_Structure* that lists all the important objects forming the database structure. Appendix II lists the names of the objects, the type of objects (table, query, report, etc.), their descriptions and where they are located in the system.

3.7 Data aggregation from the database system

3.7.1 Data aggregation from the secondary data component of the database system

As mentioned in Section 3.5.2, the NDEUD system is that which manages all the secondary data extracted from the various documents/reports on energy studies all over South Africa. In essence, it is the ENGDATA.MDB data file managed by the programme file NDEUD.MDB. Data aggregation from this system has been made possible through the design of a *Data Wizard* that serves as a primary query mechanism for the database. The Data Wizard is a short programme that leads the user step-by-step through the data selection process for building up queries from the database system. The wizard can organise the output of the data aggregation in four formats, namely:

- *Query output*: a spreadsheet-like output with the raw aggregated data not properly formatted. This format is useful when the output is required for further analysis in spreadsheet packages.

Thus, this output can be exported to other packages for the required analysis or graphical presentation.

- *Report output*: a well-organised output with aggregated data properly formatted. This output is a preview of a printing output and it can be included in a report when printed out.
- *GIS output*: a Point Attribute Table (PAT) file including the aggregated data from the system. In this output the wizard creates extra data fields in a GIS PAT file for the exportation of the aggregated data. With the help of GIS software package like Arcview, the PAT file can be used to create graphical displays of the aggregated data in several forms according to geographic locations.
- *SQL output*: a Structured Query Language (SQL) output of the query for more technical query design purposes.

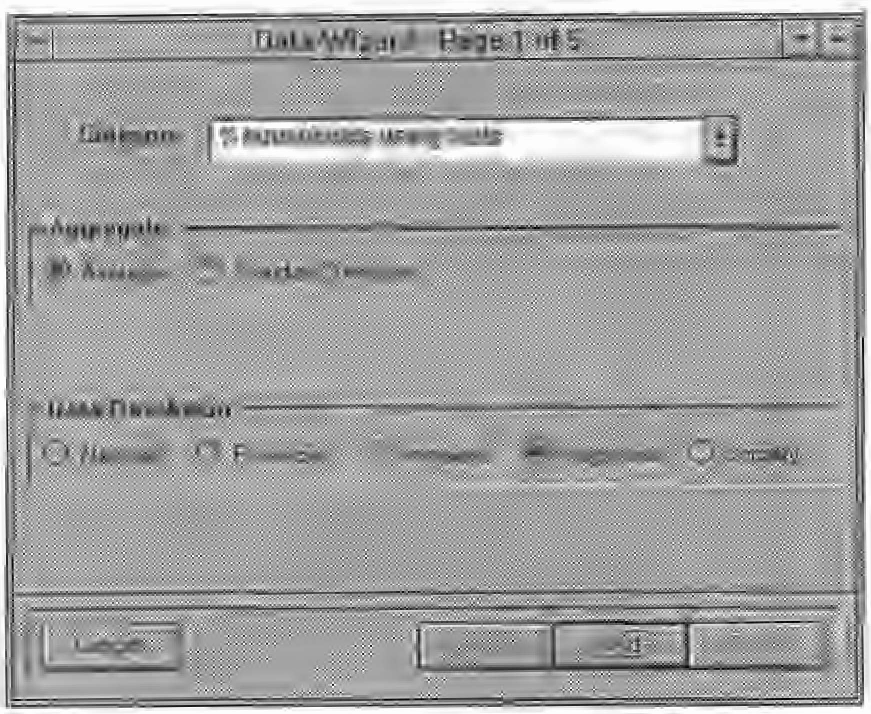

Figure 3-11: First screen of the Data Wizard

Access to the Data Wizard is gained through the clicking of the *Data Wizard* button in Figure 3-2. This brings up the first screen of the wizard that involves the selection of the data Category and the locality Data Resolution desired as shown in Figure 3-11 on the previous page. The level of data resolution to be selected can be National, Provincial, Magisterial District, former Homeland, or Locality. The lowest level of data resolution, which is the Locality level, is made up of the enumerated areas of the CSS.

On the second screen of the *Data Wizard*, a list of data fields is made available for inclusion in the query depending on the particular data category that is already selected. As shown in Figure 3-12 below, higher data resolutions are made available for possible inclusion in the query should one be interested in sub-grouping aggregated data. Even though Magisterial District was selected as the data resolution in Figure 3-11, the Provincial level has been made available for possible inclusion in the query so that the energy usage patterns for the Magisterial Districts could be grouped into their various Provinces, if so desired. The clicking of the *Zoom* button in the figure below also allows the user to edit the field names of the data as desired. This is especially useful for distinguishing data in the NDEUD system from the Saldru System. If data from the two systems are combined in the query it is necessary to give clear indications of this in the field names.

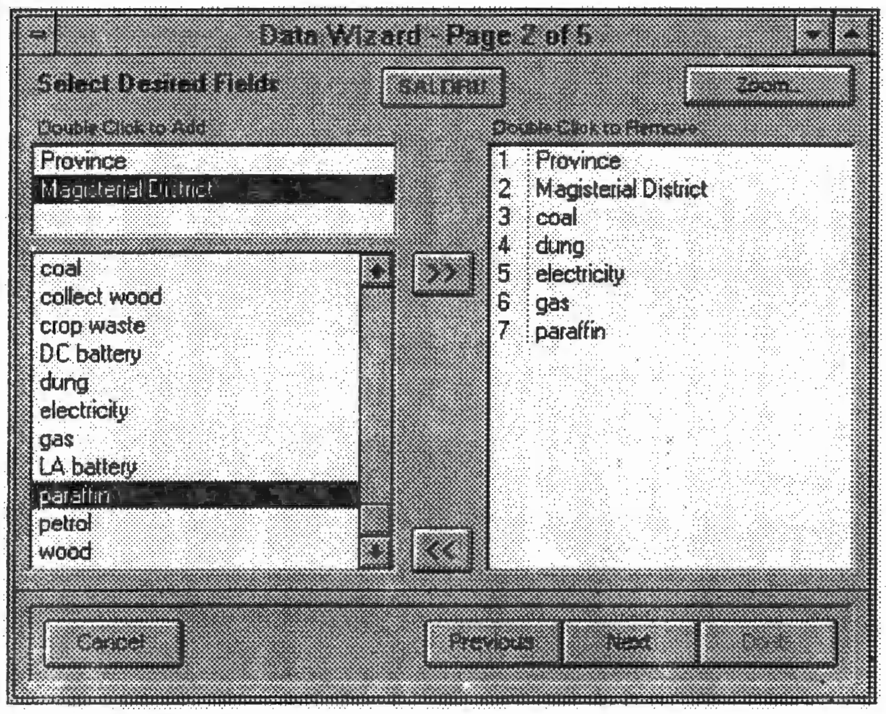

Figure 3-12: Data fields selection screen of the Data Wizard

The next screen of the Wizard lists 20 restrictions that can be specified on the data aggregation as shown in Figure 3-13. Most of the restrictions are simple logical (yes/no) fields but there are some that require specific name, number or code to be stated. For example, to restrict the data aggregation to some specific magisterial district, the user will have to use the Locality Builder icon for the selection of the specific codes interested in as explained in Section 3.6.3. The codes identified in the builder can then be copied to the Magisterial District field in Figure 3-13 using the usual Windows CTRL-C keyboard combination. For the query in Figure 3-13 only two restrictions have been specified and these are that the query should only select data on Urban, Planned Shacks as shown in the figure with Yes in those fields. Also, as indicated in the figure, double clicking of a field on the left side of the figure selects that field onto the right side for inclusion in the query.

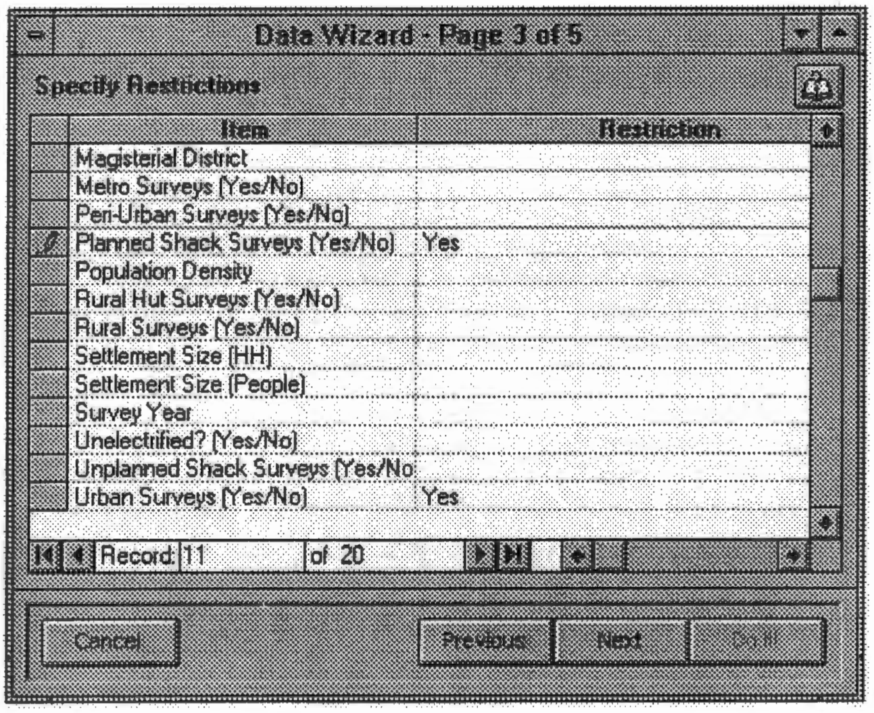

Figure 3-13: Specification of restrictions on data aggregation

The fourth screen of the Data Wizard provides three options for the format of data aggregation output desired as shown in Figure 3-14. Report, query or GIS outputs are the options available. For the report and the query outputs a portrait or landscape page set-up can be specified. In addition, an appropriate title describing the report or query may be specified, otherwise the system will provide a temporary name for it. If the output would be required for future reference it can be saved in the *InfoWizard* with an appropriate title. For cost-related data, like fuel expenditure, the required year for the consumer price index (CPI) conversion would have to be specified as shown in Figure 3-14. In this figure, all cost-related data will be converted to 1995 values using CPI for the conversion. The clicking of the *GIS* button runs the query as well as initiating the exportation of the data into a GIS PAT file. The PAT file is then accessed through Arcview for the creation of views. The query can be executed on the fourth or the fifth screen. The last screen of the Data Wizard offers the option to provide the SQL of the query for further technical design.

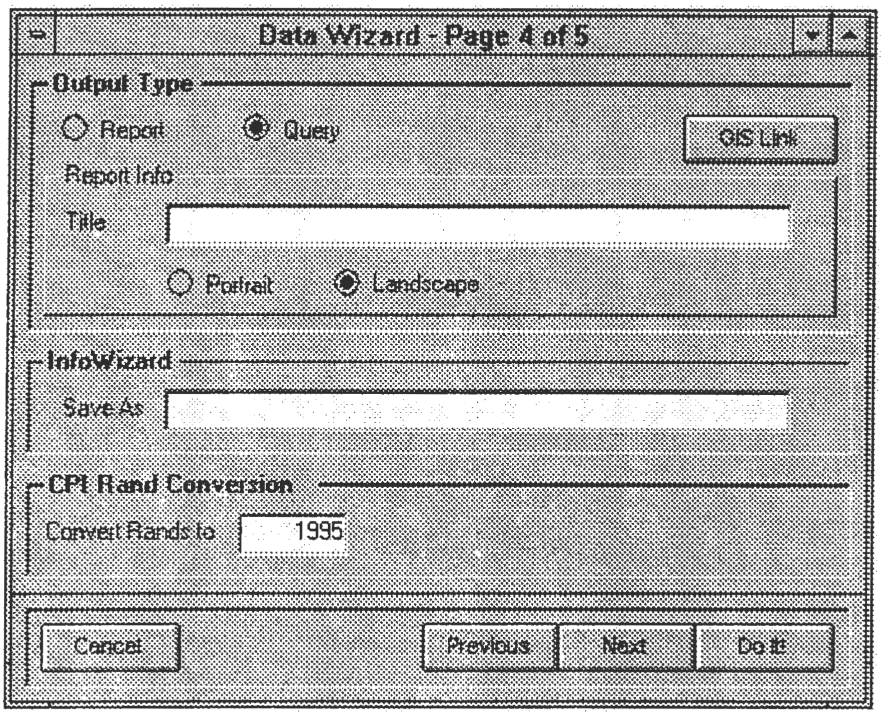

Figure 3-14: Output options for the Data Wizard

3.7.2 Data aggregation from the primary data component of the database system.

The Saldru system is that which manages the energy use and related data extracted from the Saldru/World Bank national survey in 1993 (SALDRU 1994). It functions in the database system as the SALDRU.MDB data file managed by the programme file NDEUD.MDB. Data aggregation from the Saldru system is provided through the application of a *Saldru Wizard.* The Saldru Wizard works on similar principles as the Data Wizard with few modifications. Unlike the NDEUD system, the Saldru system does not require a selection of data category for the Saldru wizard. The Saldru wizard uses the same first screen of the Data Wizard for the selection of its locality data resolution as was shown in Figure 3-11. On this screen, no data category is required for selection. Data resolution is permitted only up to the Magisterial District level since the raw data is not further disaggregated.

After the selection of the data resolution, the Saldru Wizard is initiated by the clicking of the *Saldru* button on the second screen of the Data Wizard (Figure 3-12). At this point the Data Wizard branches off to the Saldru Wizard. The first page of the Saldru Wizard lists all the data fields available in the Saldru system on the left-hand side of the screen. The main difference here is that all the data fields in the Saldru system are listed whilst in the case of the Data Wizard only the data fields of the chosen category are listed. The list of fields is a bit lengthy but it has been ordered alphabetically to make it easy for making selections. The typing of the first few letters of the field brings up the focus on that particular field for selection. Double clicking on that field selects it onto the right hand side of the screen. There is also a *Zoom* button on this screen with the same function as the one in the Data Wizard (Figure 3-12).

The second page of the Saldru wizard is similar to the third screen of the Data Wizard, the only difference being that more restrictions are available for specification in this case. In the third page of the Saldru Wizard a query or a GIS Link or an SQL output can be specified. However, for a report output, the Saldru Wizard must be closed for a default return to the Data Wizard. The Data Wizard is then proceeded to its fourth page where the option for a report output can be selected. At this point the output can also be saved with the *InfoWizard* by providing an appropriate title.

Depending on the computer hardware being used the Saldru system may run very slowly since it has very large number of records to go through in each query. The GIS transfer of the data may take much longer in this case than the case of the NDEUD system.

It is possible to combine data from both systems as separate data fields but this would have to be indicated clearly by using the Zoom button. To combine data from both the NDEUD and Saldru systems the desired data fields in the NDEUD system are selected first in the second page of the Data Wizard. Then the Saldru Wizard is clicked for the selection of additional fields from the Saldru system.

3.7.3 Sample outputs from the database system

GIS outputs display the aggregated data in the form of provincial and magisterial district maps of South Africa. The shades of the provinces or magisterial districts depict the quantitative information aggregated. An example of this has been depicted in Appendix III showing the monthly household expenditure on electricity in the sampled magisterial districts of the Saldru study. It must be noted that the Saldru system gives a better coverage of the country than the NDEUD system since the former was a national survey whilst the latter was mostly local surveys put together. It is hoped that as more data is entered into the NDEUD system the coverage could be improved. The printouts of the GIS outputs from an average printer do not have good resolution compared with the usual clear displays on the screen. For better printouts of the outputs high quality printers are required.

Appendix IV shows some of the report outputs from the energy use data aggregation of the database system. Most of the outputs in this appendix were done as a response to a request by someone in Eskom for their electrification programme in Kimberly, the Northern Cape Province. A report output can be information on magisterial districts alone or provinces alone or magisterial districts grouped into their various provinces.

One output of the NDEUD system can also be an overview of the content of the database. Appendix V shows a shorter version of a report on the list of documents/reports in the database. This list shows the title of the study, the author, the publisher, the publishing date, etc. Similar separate reports are possible for rural and urban studies.

4.
Overview of domestic energy use data

4.1 Introduction

In Chapter 2 the household sector of the energy economy is discussed as well as a brief description of the characteristics of energy poverty in South Africa. In this chapter an overview of data on domestic energy use is presented with a short analysis to illustrate, in more detail, some of the energy poverty characteristics of South African households discussed in Chapter 2. All the data presented in this chapter come from analysis of the data sets captured by the National Domestic Energy Use Database system. The data is graphically presented to facilitate an understanding of the analyses. This chapter also demonstrates some of the strengths of such a database system in handling many of the issues involved in integrated energy planning.

To simplify the data presentation in this chapter, most of the data for the analysis have been drawn from the primary data component of the database (i.e. the Saldru data set). As mentioned in Chapter 3, the Saldru data set was collected in a national survey in 1993. Thus this survey had a better coverage of the country than many of the secondary data sources put together. Secondly, since the Saldru data was collected in one national survey, the analysis of the whole data set is less complex than in the case of the secondary data set since, in this case, one would have to deal with one research methodology covering almost the same period of time with the same basis of measurements and definitions. In the case of the secondary data set, data presentation often requires extensive presentation of the background of the data sources as well. Since the secondary data set is a combination of many surveys undertaken during different periods of time with different research objectives, data gaps are a rampant phenomenon.

However, the Saldru data does not have strong categorisation according to dwelling type. The research methodology for the energy demand projections in Chapter 5 and 6 requires good categorisation of data according to dwelling type as mentioned briefly in Section 1.5 and outlined in detail in Chapters 2 and 5. Thus the Saldru data is not found to be suitable for that analysis. For the purposes of the energy demand projections, end-use and appliance data have been extracted from the secondary data component of the database (i.e. the NDEUD system mentioned in Chapter 3) for aggregation into dwelling types representing low-income households. The aggregated end-use data has been graphically presented and discussed in Section 4.12.

4.2 Basis of data analysis

4.2.1 Primary data set

Income distribution

In the case of the primary data (i.e. Saldru data) the total monthly household income and expenditure were determined for each of the 8848 households surveyed nation-wide. Thus there is a possibility of cross-tabulation of energy use variables with household income or expenditure. However, the total household income data was found to be very inconsistent, unrealistic and unreliable. The indication is that the respondents were a bit hesitant to release the truth about their incomes. The survey was conducted during the few months leading to the first democratic elections in South Africa and, in such a volatile situation, many people were apparently sceptical about the future and could hardly trust interviewers with information about their income. On the other hand, the data on the total household expenditure seems to make sense to a large extent. A plausible explanation here can be that a lot of the respondents were scared of being later on accused of, or even prosecuted for, income tax evasion if they exposed all their incomes. On the other hand, most of them were rather quite comfortable to speak about how much it costs them to provide for the needs of their households.

It must be stated clearly that this thesis accepts the fact that household income and expenditure and not always the same even when the irregular expenditures like donations, remittances, savings, health costs, vehicle and appliance repairs, etc., are taken into account. Although it looks very expedient that the more income one receives the more one can give donations to charities, or remit to relatives or probably save, the human nature can be so unpredictable that it does not necessarily happen that way. However, most of the common household expenditures may seem to have some proportional relationship with income. Hence, for the sake of reliable analysis, this study chooses total household expenditure as the basis of analysis of the Saldru data instead of total household income. An assumption is therefore made in this study that household expenditure and income have a direct relationship.

Specifically, expenditure levels are used as indicators for income levels in the analysis of the Saldru data. The income categories for cross tabulation of the data as shown in Table 4-1 are arrived at as follows:

- First, to avoid the influence of household size on household expenditure, per capita total household expenditure is used. This is achieved by dividing each total household expenditure by the particular household size.
- Second, R100 monthly per capita household expenditure in 1993 is used as the difference between different income categories.

- Third, since this study focuses on low-income households, an attempt is made to avoid a bias by extraordinary higher income households and those respondent households with over-estimated household expenditures. To achieve this, households with per capita expenditures exceeding R2000/month were assumed to belong to this group and therefore conveniently excluded in all analysis based on income distribution. About 5% of the sampled households were excluded this way from all analysis based on income distribution (Figure 4-1).

Income category	*Per capita expenditure level (R/month)*
1	Less than 100
2	Less than 200
3	Less than 300
4	Less than 400
5	Less than 500
6	Equal/Above 500

TABLE 4-1: Income categories for the Saldru data analysis

Urbanisation

As stated in Chapter 2, geographical factors have some influences on energy use in the household. In this chapter these influences are analysed only to the levels of urbanisation and not further to the level of provinces. The differences between the energy use in rural, urban and metropolitan areas are analysed and, in some cases where such differences look very grey urban and metropolitan areas are combined as non-rural. The main problem with the Saldru data here is the distinction made between what was rural and what was not. This distinction is still not very clear and this can be the main source of errors in the analysis based on urbanisation. Rural areas were largely considered as settlements with no local authority during that period of time. Metropolitan household samples were drawn from Cape Town, Johannesburg, Pretoria, East London, Port Elizabeth and Durban.

Electrification

The extent of electrification has also been examined amongst different income groups, rural and non-rural areas, and different population groups. Electrification has also been used in some cases as a basis of analysis to show the influence of electrification on other energy use variables.

Apartheid system of regions

Even though apartheid is formally gone in a democratic South Africa, the damage done to disadvantaged communities in certain geographic locations in terms of energy provision will not vanish easily unless the situation is constantly assessed and policies reviewed accordingly to avert the situation. It is for this reason that the Saldru data has also been analysed in terms of the old apartheid provinces and the homelands. The *Old Provinces* embody all the areas that used to be referred to as the Republic of South Africa under the apartheid system. The *Homelands* include the TBVC[1] states and all the so-called self-governing states[2]. The Old Provinces and the Homelands have been compared with the *overall* situation in the New Provinces of the present dispensation.

4.2.2 Secondary data set: dwelling type

In most of the studies from which the secondary data set has been extracted, there is insignificant cross-tabulation of energy demand and supply variables with income distribution. Thus it is impossible to analyse the data based on income distribution. However, one major useful basis of analysis for this data set is dwelling type categorisation, though quite a number of the studies did not provide any information on the dwelling types of the households. In cases where the dwelling type information is not extensive enough, the background information on the study in the report is used to re-organise the provided dwelling type information into the required classification. This makes the secondary data set specifically suitable for the methodology for the energy demand projections in Chapters 5 and 6. The main disadvantage in this case is that a lot of useful data had to be left out if they could not be categorised into any of the pre-determined dwelling types.

4.3 Demographics

The understanding of the population composition of a nation is very important in household energy policy analysis. It facilitates the identification of energy demand and supply factors among different population groups and provides the necessary background information as a check on how policy is shaped to avert inequities in energy provision. The specific characteristics of the traditions of different population groups may influence their energy use patterns. Appropriate policy instruments would therefore have to be put in place in order to achieve equity across the different population groups.

To begin with, it is important to assess the authenticity of the data overview in this chapter by examining the extent to which the sampled households are representative of the South African population in general. Since the secondary data set consists of many studies with different sampling methodologies, it is a little complex making such an assessment. However, for the primary Saldru data set that consists of data collected in a once-off national survey it is more straightforward assessing the data representativity of the population.

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[1] The TBVC states refer to the Transkei, Bophuthatswana, Venda and Ceskei homelands.

[2] The self-governing states were KwaZulu, KaNgwane, Qwa Qwa, Gazankulu, Lebowa and KwaNdebele

Although, as mentioned in Section 4.2.1, about 5% of the Saldru data was excluded from all the data analysis based on income distribution in order to avoid over-shadowing of the energy use patterns by upper higher income households, it is worth knowing the population distribution of the data excluded. This helps in substantiating the reason for the exclusion and also to facilitate any later inferences that may be necessary when it becomes imperative to extrapolate the analysis to include the excluded data.

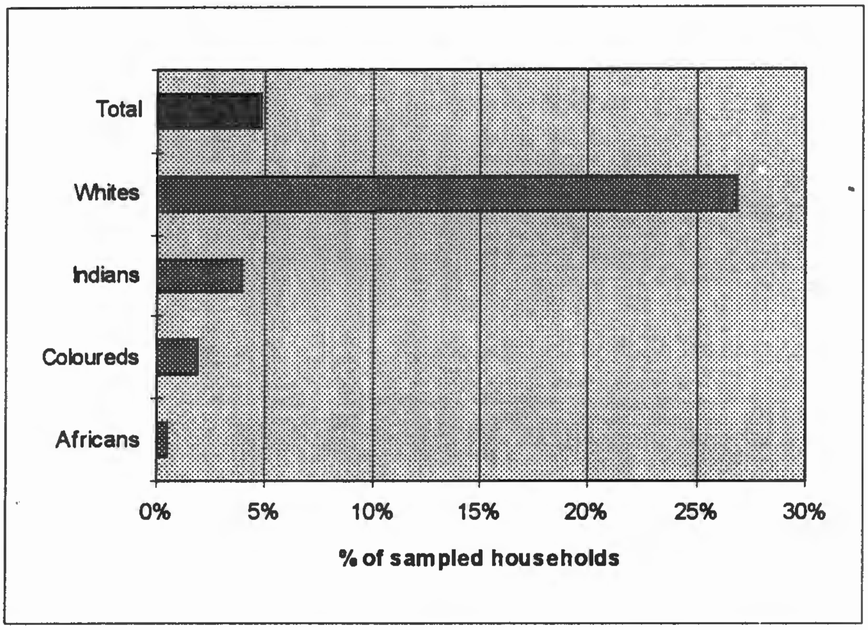
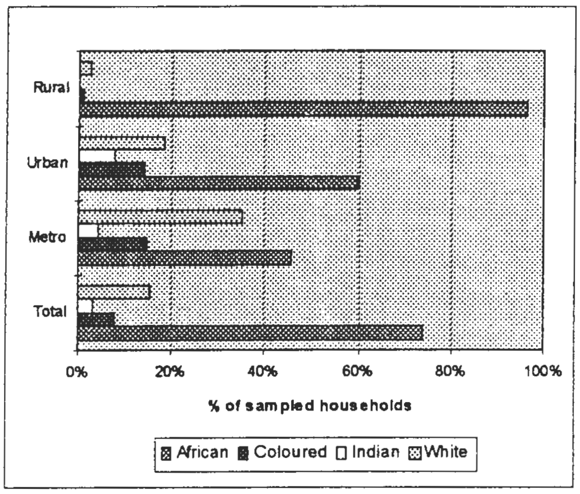


FIGURE 4-1: Percentage of sampled households excluded from the Saldru data analysis

Figure 4-1 shows the racial distribution of the data excluded from the Saldru data analysis. This figure typifies the skewness of income distribution as one main feature of the South African household economy (Section 2.5). The extent to which the income-based exclusion affects the different races is in the decreasing order for Whites, Indians, Coloureds and Africans as widely known in the South African population. While the percentages of sampled African, Coloured and Indian households excluded from the analysis are relatively very small (all under 5%), the percentage of the White households excluded is significantly high. It is therefore very important to remember that, based on income distribution, about 27% of the White population are beyond the Saldru data analysis in this chapter. This will help to focus the analysis on the low-income households and also avoid making distorted conclusions about the energy use patterns of low-income households.

4.3.1 Distribution of the different races in rural, urban and metropolitan areas

Figure 4-2 depicts the distribution of the sampled households in the Saldru data set. It must be mentioned that none of the data was excluded in this analysis and that this is a true reflection of how representative the sample is of the population in terms of racial groupings and the distribution among rural, urban and metropolitan areas.



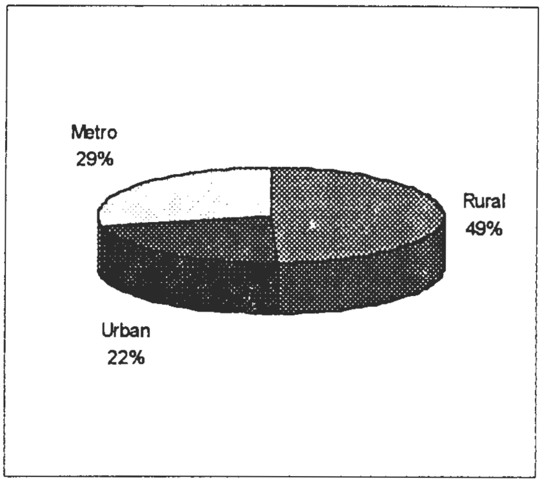


FIGURE 4-2: Distribution of the different races in rural, urban and metropolitan areas

Source: Saldru data analysis

The pie chart in this figure shows that, in 1993 (i.e. the year in which the data was collected), about 49% of South African households lived in rural areas, leaving about 51% urbanised. These percentages compare very well with data in a 1995 publication by the Central Statistical Service (CSS). While the CSS publication (Central Statistical Service 1995) puts the rural component of the population at about 51% in 1991, the urban component is stated as about 49%. However, it is widely believed that urbanisation increased dramatically from the period when Nelson Mandela was released from prison and most oppressive laws of apartheid were repealed to the period of democratic elections and governance. Thus it could be that urbanisation might have increased by 2% from 1991 to 1993 leaving the rural households at about 49%. On other hand, the indistinct divide between rural and non-rural households in the sampling methodology might have contributed to the 2% discrepancy. Furthermore, the difference might be due to the fact that the CSS rural and non-rural distinction is based on individuals rather than households. The Nelf Demand-side Database (Nelf 1994) also gives the rural households' component as about 47% leaving about 53% of the households urbanised. This data excludes dwellings for rural and urban institutions (see Table 2-5). On the whole, it could be concluded that the urbanisation distribution of the Saldru sample is fairly close to existing data.

The bar chart in Figure 4-2 illustrates how the Saldru data set reflects the racial groupings in South African in terms of rural, urban and metropolitan areas. The figure shows that, of the total sampled households, 74% are Africans, 15% are Whites, 8% are Coloureds and 3% are Indians. The existing data sets are usually based on population and therefore do not offer a common basis for comparison. For example, an African National Congress Women League publication reflects the racial breakdown of the South African population in 1990 as 75.5% African, 13.3% White, 8.5% Coloured and 2.7% Indian (ANCWL 1993:5). Similarly, computations from figures in the CSS publication (CSS 1995) results in a 1995 mid-year population distribution of 76% African, 13% Whites, 8.5% Coloured and 2.5% Indian. These population figures represent the African percentage a little bit higher and the White population a little lower than the household breakdown from the Saldru data set. The explanation for the little differences could be that majority of African households generally have household sizes higher than Whites as would become clearer in Section 4.4. Thus the racial disaggregation of the Saldru data comes very close to existing observations and this goes to prove how well the Saldru data represents the South African households in terms of racial groupings.

When the upper higher income households mentioned in Section 4.2.2 are excluded from the sample, the racial distribution of households looks like Figure 4-3. It must be noted that it is this racial distribution of the households which will be inherent in subsequent income-based analysis of household energy use variables in this chapter. Besides the distribution of the total sampled households amongst the different races, the bar chart in Figure 4-2 also depicts the extent of urbanisation of the different racial groupings. The main observation from the graph is the influence of urbanisation on the racial composition of the population.

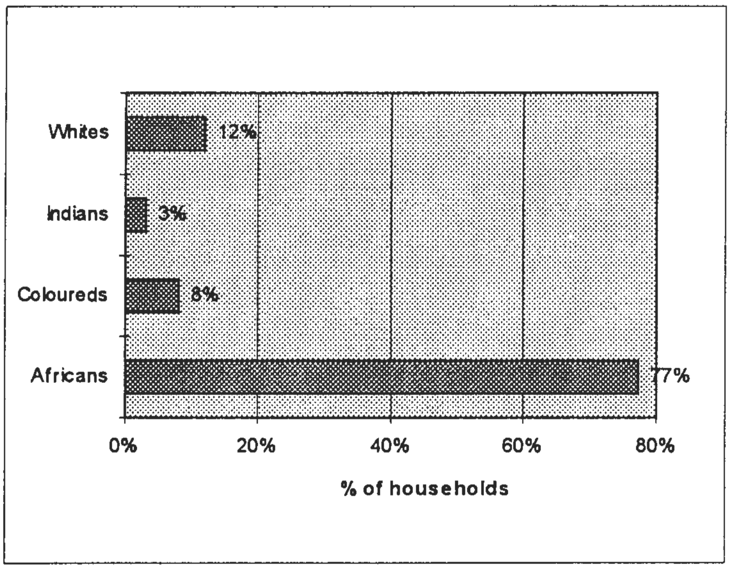


FIGURE 4-3: Racial distribution of sampled households with the upper higher income group excluded

It is interesting to note that, the higher the extent of urbanisation (i.e. from rural, urban to metropolitan areas) the less the composition of African households. It can be seen from the graph that, while about 96% of the sampled rural households are African, about 60% and 46% of the sampled urban and metropolitan households respectively are African. For the sampled White households the trend is completely opposite. While 35% of the sampled Metropolitan households are White, about 18% and 3% of the sampled urban and rural households respectively are White. Most of the White households living in rural areas are likely to be commercial farmers. For the sampled Coloured households, there is no significant difference between the compositions of both the urban and metropolitan households (i.e. about 15%). The 1% Coloured households in the rural areas could be largely farmworker households. Figure 4-2 shows that the composition of rural Indian households among the sample is virtually insignificant and that the urban households have an Indian composition (8%) a little bit higher than the metropolitan composition (4%).

The foregoing discussion shows that the racial groupings to which households belong have had great influence on where people live and the extent to which they are urbanised. This has emanated from the racial segregation policy under the erstwhile apartheid government that has obviously had an impact on the access of households from different racial backgrounds to energy resources and services.

4.4 Income distribution

4.4.1 The overall situation of racial differences

The skewness of income distribution among different racial groupings in South Africa is made vivid in Figure 4-4. This figure represents the total sampled households with no exclusion of the upper higher income.

The most interesting aspect of the graph is the split of the total sample into distinct socio-economic entities along racial lines, with each race having its own trend of income distribution. A careful examination of the trends reveals that the African households are far worse off in terms of income groupings, followed by the Coloured, and then the Indian households. For lower income groups, the percentage of African households exceeds that of the average for the total sample till the fifth income group where it equalises with the average for the population. At the sixth income group the percentage of African households falls below that of the total population.

The Coloured households seem to be a little better off than the total population for the first two income groups with lower percentage of households than the total population. For increased income levels from group three to group five the percentage of Coloured households stays above that of the overall population. At the sixth income group, even though the percentage of Coloured households is far above that of the African population, it still remains below that of the general population.

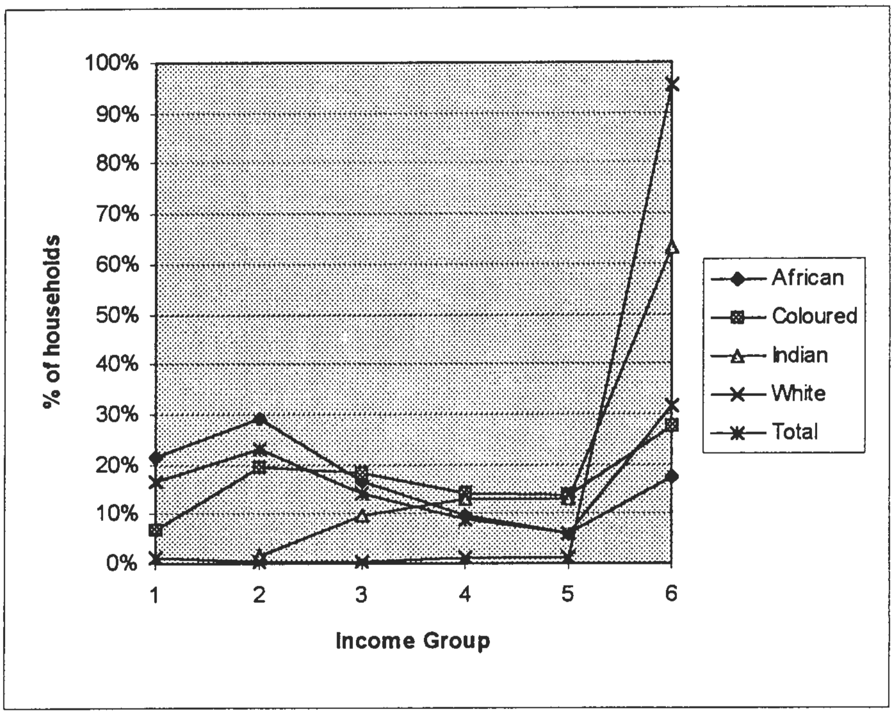


FIGURE 4-4: Income distribution of total sample along racial lines
Source: Saldru data analysis

There is no Indian household in the lowest income group. From the second income group the percentage of Indian households rises gradually past that of the overall population at the fourth income group and jumps from the fifth income group to over 60% at the sixth income group. In fact, over 75% of the Indian households seem to be in the fifth and the sixth income groups. For the White households, over 95% are in the highest income group, leaving a mere less than 5% spread evenly among the lower five income groups.

Let us assume that income groups one to three constitute *lower income* group with monthly household expenditure not exceeding R300 per capita, income groups four and five *middle income* group with monthly per capita expenditure not exceeding R500, and income group six *higher income* group with monthly per capita expenditure exceeding R500. This will mean that the African households, which are the majority of the population, are mainly lower income households with about 67% occurring in that group. The rest of the African households are distributed almost equally among the middle and the higher income groups (i.e. 16% and 17% respectively). The percentage of lower income Coloured households (44%) is also reasonably higher than those in the middle and higher income groups. The middle and higher income Coloured households are almost equally distributed (i.e. 28% and 27% respectively). The Indian households seem to have very small lower income group (12%), a slightly bigger middle income group (26%) and a substantial higher income group (63%). The White population is mostly in the higher income group (95%) with about 2.5% each in the lower and middle income groups.

It is very important to bear the above income inequalities in mind when analysing energy demand and supply factors. It is clear that the South African society has a very slim middle income group (about 15%) compared with the lower income group (about 53%), yet the high incomes of a minority of the population in the higher income group distort the income per capita picture. Energy policy formulation must address these inequalities, and energy service provision must incorporate the necessary policy instruments that deal with the inherent affordability issues.

4.4.2 Income distribution in metropolitan, urban and rural areas.

The extent to which income distribution is skewed also differs a little depending on whether a household is located in a metropolitan or urban or rural area. Figure 4-5 shows the differences in the income distributions of households in metropolitan, urban and rural areas.

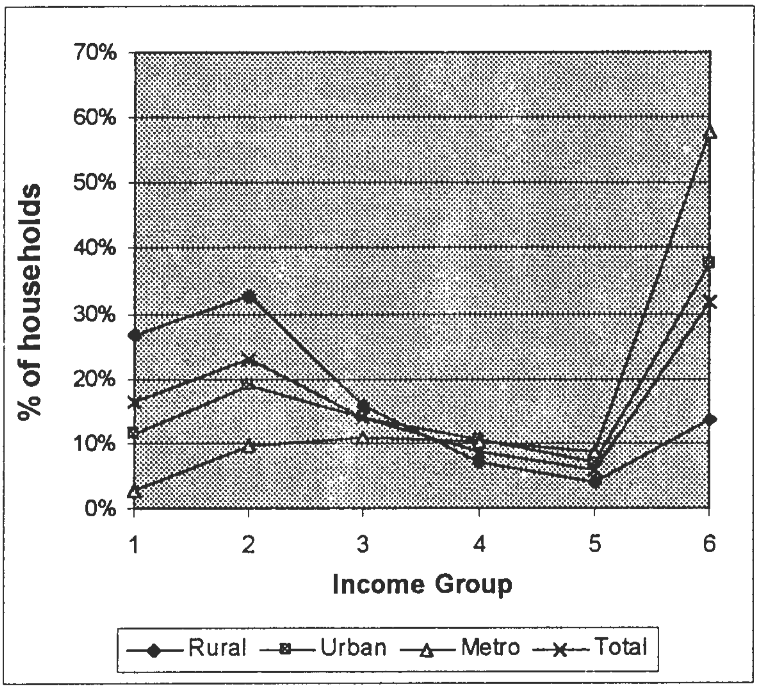


FIGURE 4-5: Income distribution of rural, urban and metropolitan households
Source: Saldru data analysis

First, comparing the total sample and the metropolitan households in Figures 4-5, it can be seen that the metropolitan area households are better off in terms of income distribution than the overall situation in the country (i.e. than the rural and urban households). While about 58% of the metropolitan households are in the top income group (i.e. Income Group 6), only about 32% of the overall sample happen to be in this group. Second, for the lower and middle income groups, while the percentage of the total sample rises from about 17% to about 23% at the second income group, and falls gradually to about 6% for at the fifth income group, the percentage of metropolitan households rises from a mere 3 % to about 10% at the second income group and stays almost constant till the fifth income group.

For the urban households, if the total sample and the urban households in Figures 4-5 are compared, it can be seen that urban households are a little better off in income distribution than the overall situation but not as much as the metropolitan households. In the lower income group, the percentage of urban households is found below that of the total sample whilst in the higher income group the reverse is the case.

For the rural households sample, the lower income group (i.e. income groups 1 - 3) constitutes about 75%, the middle income group 11% and the higher income group about 14%. This shows the extent of poverty among rural households and it is therefore obvious that affordability will be a major constraint to energy provision to the rural households.

A further investigation into the income distribution of the households in the old homelands of the former apartheid South Africa shows a situation similar to that of the rural households. This is because most of the homeland areas are located in rural areas. However, poverty in homeland areas is generally found to be more widespread than in the former provincial rural areas. Comparison of Figures 4-5 and 4-6 shows the similarity between the homelands and the rural areas as well as the widespread poverty in the homeland areas.

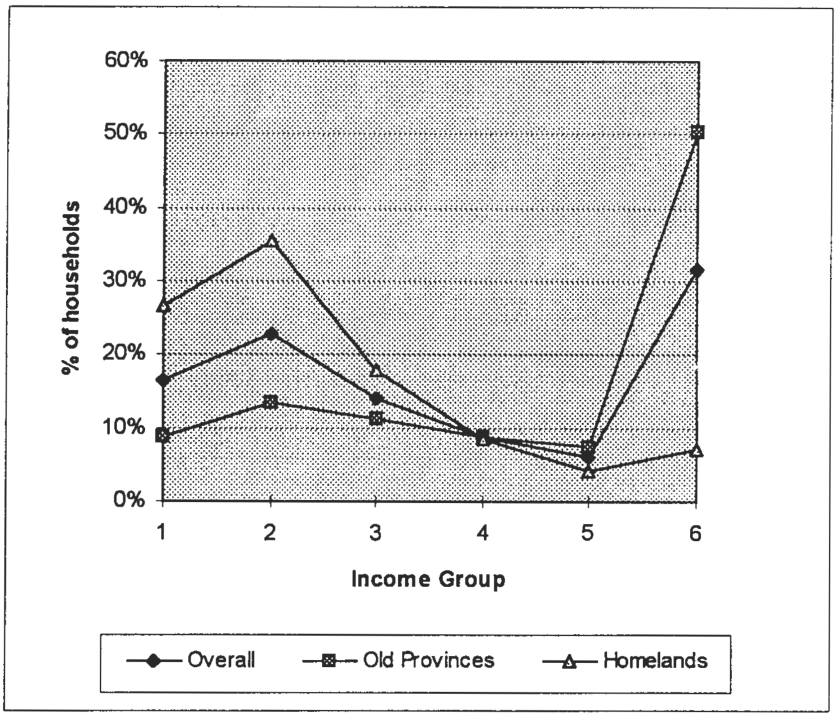


FIGURE 4-6: Income distribution of households in the former apartheid structures
Source: Saldru data analysis

A substantial proportion of about 81% of the households in the homelands is in the lower income group (i.e. income groups 1 - 3). However, a mere 7% occurs in the higher income group (i.e. income group 6). On the other hand, only 33% of the households in the former provinces are in the lower income group, leaving almost half of the households in the higher income group.

This observation shows the extent to which the lack of access to basic needs like land and energy services has led to the extreme impoverishment of the households in the homelands almost in favour of those in the former provinces. Many of the households in the homelands seem to be merely surviving on the monthly remittances from household members who are migrant labourers in areas of the former provinces. It must be noted that this extreme situation is not likely to change overnight. It is therefore imperative that subsequent household energy use analysis should continue to investigate the improvements in this gross imbalance. Even though the homelands are gone with the obnoxious apartheid system, it is only when the realities of the legacies of the racial segregation policies of the past are continually assessed in a democratic South Africa, and are adequately exposed in policy analysis, can there be tangible change in the livelihoods of the people who find themselves in this sorry situation.

4.5 Household size variation

It is important to analyse briefly the household sizes of the sampled households since household size may have a great effect on energy consumption (Baranzini & Goldemberg 1996: 33). Household energy use often shows large economies of scale associated with increasing household size. Thus, although total energy consumption usually increases with household size, per capita energy consumption may decrease. For the analysis of the average household size below, the households with upper higher incomes have not been excluded from the Saldru data set.

4.5.1 Urbanisation and average household size

Figure 4-8 illustrates the effect of urbanisation on the variation of average household size with income whilst Figure 4-7 shows the distribution of household size in terms of the extent of urbanisation. In Figure 4-7, it can be seen that the distribution of average household size seems to follow different asymptotes to the 100th percentile for households in metropolitan, urban and rural areas. This illustrates that there are differences in the sizes of households in the metropolitan, urban and rural areas. A closer look at the curves in the figure gives an impression that, in general, metropolitan households seem to have sizes slightly less than those of the urban households. The average household sizes for the overall population seem to be generally above those of the metropolitan and urban households but lower than the rural households. For example, the percentage of households with a maximum size of five people will be roughly 80%, 73%, 50%, and 63% for metropolitan, urban, rural areas and the overall population respectively.

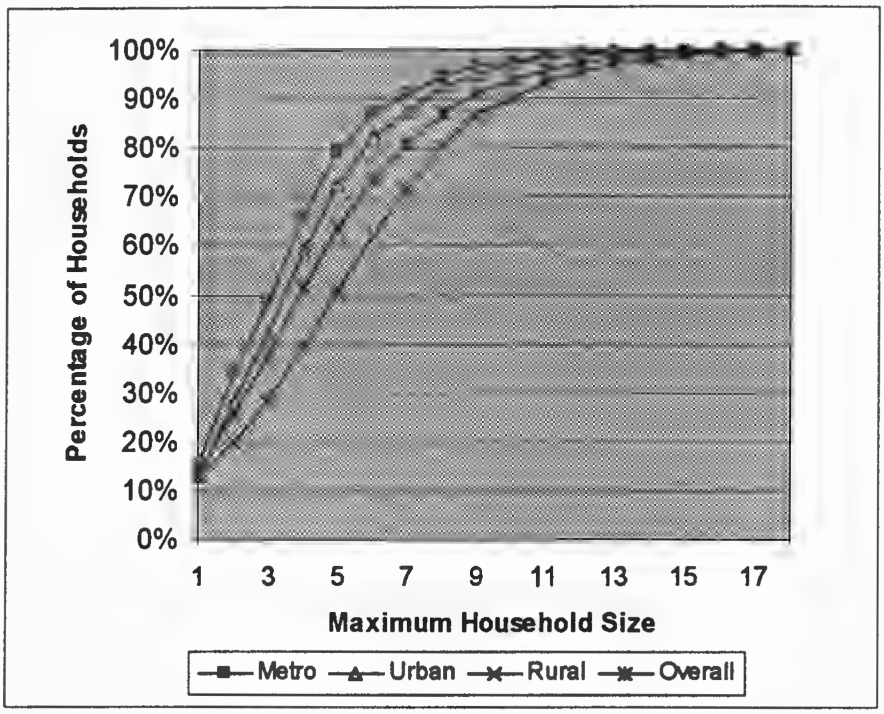


FIGURE 4-7: Distribution of average household size in metropolitan, urban and rural areas

Source: Saldru data analysis

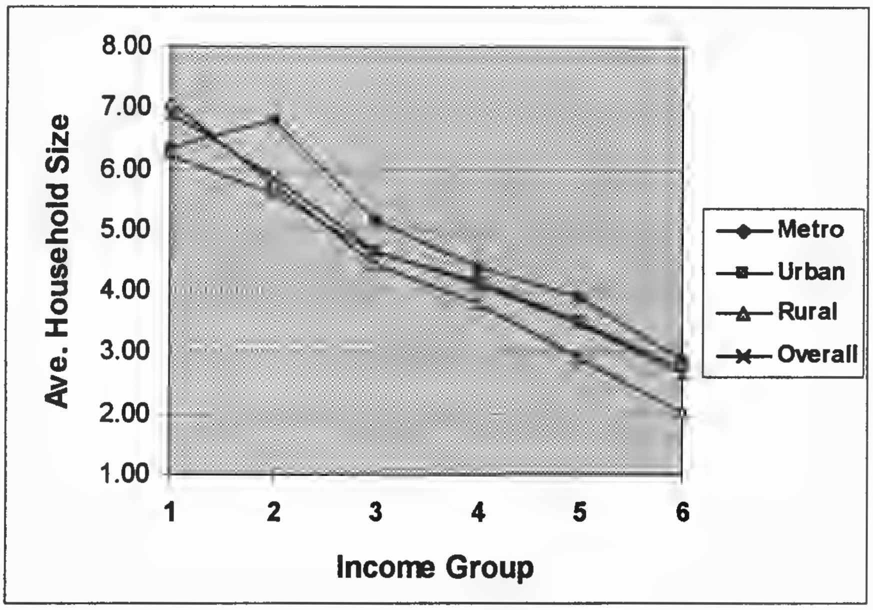


FIGURE 4-8: Effect of urbanisation on the variation of average household size with income

Source: Saldru data analysis

In Figure 4-8, apart from the first income group of the metropolitan households which is only about 3% (refer to Figure 4-5), average household size[3] seems to have approximate linear relationships with income for metropolitan, urban and rural households. However, each of these linear relationships has its own slightly different gradient, showing that average household size is influenced by income at slightly different rates in the metropolitan, urban and rural households. In general, average household size decreases with income. First, this is not surprising since, as household income increases, households are able to afford basic socio-economic services, although this could also depend on the distribution of power in the household. Households with improved incomes are naturally able to afford electrification connection fees and tariffs, better housing and better education that can lead to better employment opportunities. As people become more educated they question the essence of many traditional values like the traditionally admired large family sizes. Second, improved access to good education, efficient energy supply services, better employment opportunities, improved housing and entertainment facilities, which invariably emerge with improved income, usually places a lot of stress on the time available to households for their social activities and consequently dry up the natural desire for households to have big families.

There seems to be a general belief that rural households are usually stuck in old traditions of making large family sizes. Even though there could be some iota of truth in this belief, Figure 4-8 presents some striking revelations that tend to make such views unacceptable generalisation. The graph illustrates that rural households do not necessarily prefer to be stuck in old traditions of making large family sizes, but rather, they have not been financially empowered enough to rid themselves of such traditions. In Figure 4-8, apart from the first income group, the average sizes of metropolitan households are higher than those of urban and rural households for all other income groups. The average rural household size falls from 7 in income group 1 to about 5 in the middle of income groups 2 and 3 where it starts falling below that of urban households for the rest of the upper income groups. In fact, it can be seen that rural households have the steepest gradient for the relation between average household size and income. This seems to show that, although most rural households are trapped in lower income levels (see Section 4.4.2), the few who have been empowered to break the barrier of poverty into upper income levels seem to be dramatically trimming their household sizes. One could fairly conclude that it is not urbanisation per se that could help size down households but, more importantly, other factors that facilitate access to basic needs like improved household income and increased affordability of energy supply services. It does appear that, in the rural areas where there is greater lack of access to basic needs, more hands are needed to provide those needs in the households, hence the larger sizes of households.

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[3] The average household size in Figure 4-8 represents the average of all the sizes of the households in a particular income group.

4.5.2 Race and average household size

For the different racial groupings, Figure 4-9 shows the distribution of household size and Figure 4-10 shows the variation of average household size with income. Similar to the case of urbanisation, racial differences also exhibit asymptotic relationship for the distribution of household size and approximate linear relationship between average household size and income. A critical examination of the curves in Figure 4-9 shows that, in terms of percentages, most of the White households seem to have sizes smaller than the other racial groups. This is followed by the Indian, Coloured and African households respectively in terms of percentage of households with smaller household sizes. The average household sizes for the overall population seem to be generally larger than those of the White, Indian and Coloured households but smaller than those of the African households.

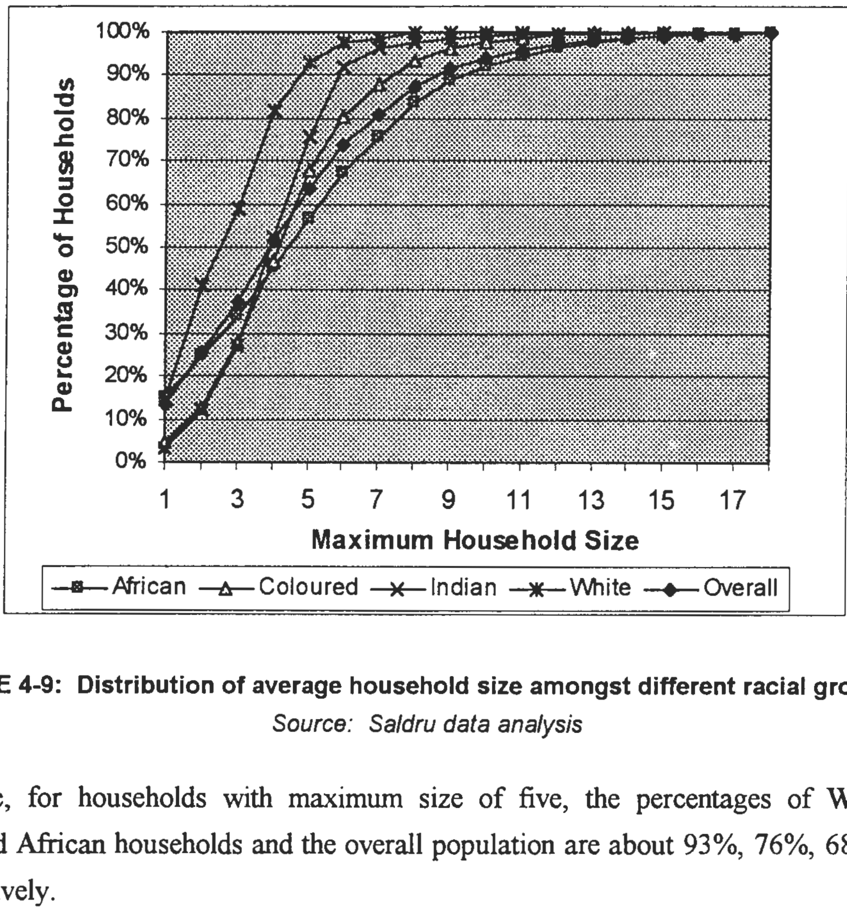

FIGURE 4-9: Distribution of average household size amongst different racial groupings
Source: Saldru data analysis

For example, for households with maximum size of five, the percentages of White, Indian, Coloured and African households and the overall population are about 93%, 76%, 68%, 57% and 63% respectively.

The discussion of Figure 4-10 requires a little bit of care in order avoid wrong impressions. In fact, the illustrated pattern for the White households for income groups 1 to 5 might be completely irrelevant since only about 5% of the White households belong to these 5 income groups (Refer to Section 4.4.1). Now, if the approximately 8% Coloured households (Refer to Section 4.4.1) showing much deviation in income group 1 are also termed irrelevant, the rest of the figure is left with approximate linear relationships if best fit lines are drawn through the points.

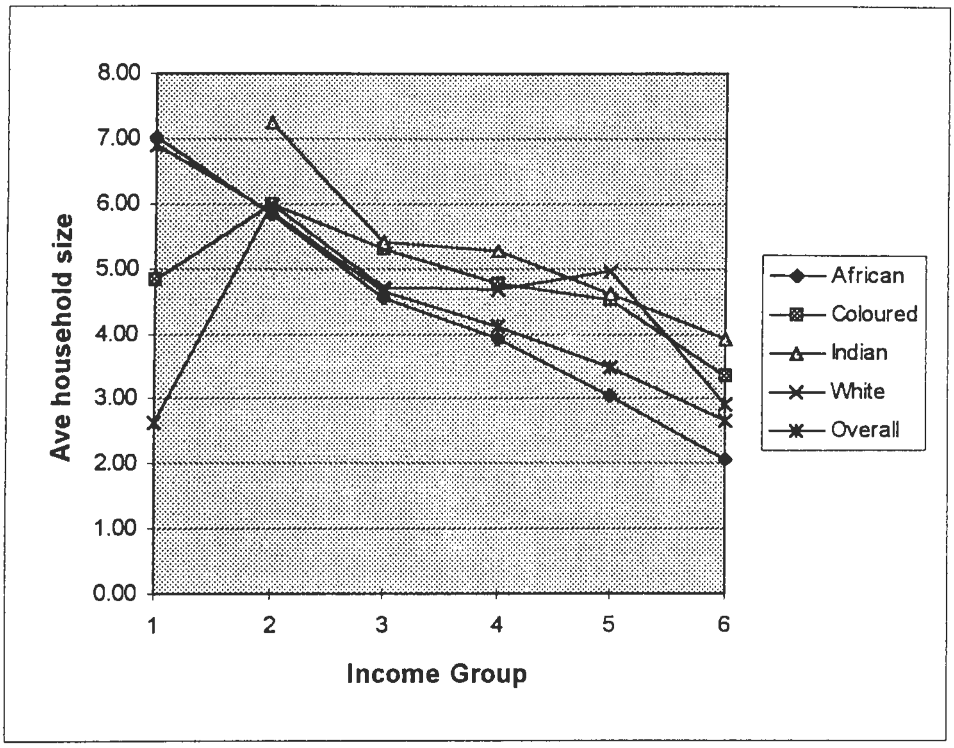

FIGURE 4-10: Variation of average household size with income along racial lines
Source: Saldru data analysis

The resultant graph leaves the African households sizes lying below all the other racial groupings in each income group. The Coloured households also lie a little below that of the Indian. This shows that, for each given income level, the African households seem to be likely to have the lowest household size followed by the Coloured and then the Indian households. Even for the approximately 95% of the White households in income group 6, the about 17% of African households in that income group (Refer to Section 4.4.1) have lower average household size than the Whites. The average White household size is however lower than the Coloured and Indian households in income group 6.

These revelations are quite striking because it is widely believed that African households generally have larger sizes. However, the figure shows that it is in terms of the large number of African households that makes it look like they have larger average household sizes. In terms of increasing income levels, African households tend to prefer smaller household size than all the other races, followed by the Coloured and then the Indian households. The relationship for the African households seem to have the steepest negative slope followed by the Coloured and then the Indian households. The White households cannot be generally compared with the others here ᵕ their incomes are mostly beyond the scope of this comparison. It may be concluded here that as more African, Coloured, and Indian households are empowered with increasing incomes they will likely trim their household sizes.

For further investigation into the household size distribution in the former apartheid regional structures, it is realised that, in general, the average household sizes for the overall population seem to be higher than those of the households in the former provinces but lower than those in the former homeland areas. For the variation of average household size with income, in lower income levels, households in the areas of the former provinces have average sizes smaller than those in the areas of the former homelands. However, as income increases, the gap between household sizes in the areas of the former provinces and the homelands decreases.

In subsequent chapters, energy use patterns are analysed largely with income levels as the basis. It should be noted that the household sizes of the various income groups are not the same but rather vary according to the patterns described in this section. The link between average household size and income should always be maintained in the analysis of energy use patterns in order to avoid misinterpretation of data.

4.6 Prevalence of fuels use

4.6.1 General household fuel use

The overall situation, areas in the former provinces and homelands

Figure 4-11 depicts the prevalence of the use of different fuels in areas of the former provinces and homelands under the apartheid structures and the overall situation. From the onset, a general observation of the overall situation (i.e. the combination of the areas of the former provinces and homelands) shows that multiple fuel use is a common phenomenon amongst many of South African households since the sum of the percentages of households using different fuels far exceeds 100%. This observation of multiple fuel use is revisited extensively in Section 4.7, but for now, it does question the simplicity of the linear model of movement up the "energy ladder" which is theorised in energy transition[4] concept (Viljoen 1990: 22, Smith 1988: 20-30). The model is less useful in explaining the occurrence of extensive multiple fuel use in many households. It is difficult accounting for a situation where electrified households continue to use coal and wood for house heating and cooking, especially when these fuels occupy different rungs at both ends of the energy ladder. Perhaps, households find themselves in a more or less permanent state of transition – a contradiction in terms, as suggested by Eberhard & Van Horen (1995:67). Furthermore, many households are probably found in *overlapping states of transition*.

It can be seen from Figure 4-11 that, in general, the most used fuels in the households are paraffin, candles and electricity. At least half of the South African households use one or more of these fuels

[4] A common representation of the energy transition theory is the concept of an "energy ladder" which represents the different positions of society or households during their transition from "traditional" to "modern" fuels (Eberhard & Van Horen 1995: 66)

for various purposes. Wood seems to be fairly used since about 36% of the households use it for various purposes. It does appear from the graph that coal, LPG[5] (liquefied petroleum gas) and car batteries are less popular sources of energy in the domestic sector since not more than 10% of the households use them. Even though, in the overall sense, these fuels could be less popular amongst the households, it should not be assumed that they are less important since they play a critical role in the livelihoods of those households who have no access to other forms of energy or are not in the position to afford other energy services.

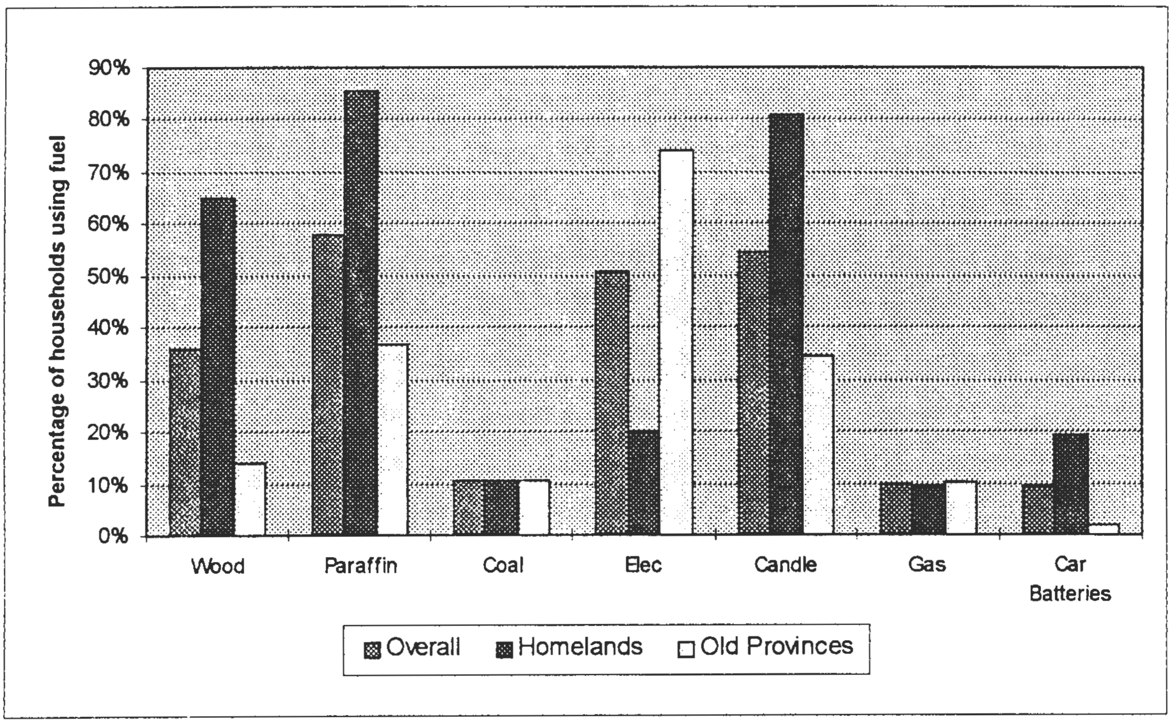

FIGURE 4-11: Percentage of households using fuels in areas of the former provinces and homelands and the overall situation

Source: Sadru data analysis

For the most used fuels (paraffin, candles, electricity and wood) there seems to be a marked difference in the extent of their usage between households of the areas in the former provinces and those in the former homeland areas. Figure 4-11 shows that whilst at least 65% of the households in the former homeland areas use paraffin, candles or wood (the less desirable fuels) or any combination of the three fuels, only less than 40% of the households in the former provinces use any of these less desirable fuels. In fact, paraffin and candles are most used amongst the households in the former homeland areas with as many as 80% of them using these for their daily

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[5] LPG (liquefied petroleum gas) is represented simply in the graphs in this chapter as Gas

needs. Amongst the households in the areas of the former provinces, wood seems to be the less preferred, or probably the least available or affordable fuel. Less than 15% of the households in these areas use it. For electricity, the opposite situation seems to be the case. Whilst more than 70% of the households in the areas of the former provinces use electricity, only about 20% of the households in the areas of the former homelands use electricity. This observation vividly illustrates the extent to which energy resources were unequally distributed in the former apartheid structures. The low level of electricity usage amongst households in the former homelands areas is not a question of choice but rather lack of access to electricity in those parts of the country. This is made clear in Section 4.8 where electrification is extensively discussed.

In the case of LPG and coal, it does appear from the figure that, in general, the extent of use of the fuel is not necessarily influenced by the former apartheid structures of homelands and provinces. About 10% of households in areas of either the former provinces or homelands use coal or LPG or a combination of the two fuels. Distribution of these two fuels is usually limited by the difficulties involved in their bulk transportation. It does appear therefore that the use of coal and LPG are largely influenced by their proximity to coalfields and oil refineries respectively.

The use of car batteries does not seem to be common amongst households in the areas of the former provinces. However, in the former homeland areas the use of car batteries is quite significant involving about 20% of the households for most of their basic electrical needs like lighting and entertainment. This may be due to the acute lack of access to electricity in the former homeland areas. It should be interesting to monitor whether the situation changes with the crumbling of the former apartheid artificial borders, especially now that a lot of households have moved from the homeland areas to settle in certain areas of the former provinces where there is still no electrification.

Rural and non-rural households

Figure 4-12 depicts the extent to which different fuels are used amongst households in rural and non-rural areas of South Africa. It is interesting to note that the differences between the fuel use in the rural and non-rural households are very similar to those observed in Figure 4-11 between households in the former homelands and those in the areas of the former provinces. This is because most of the rural households occur in the homeland areas whilst the non-rural households occur mostly in the areas of the former provinces. Thus an approximate generalisation could be made that the general fuel use pattern of urban households is similar to the fuel use pattern amongst households in the areas of the former provinces whilst the general fuel use pattern of the rural households may be likened to the fuel use pattern of households in the areas of the former homelands.

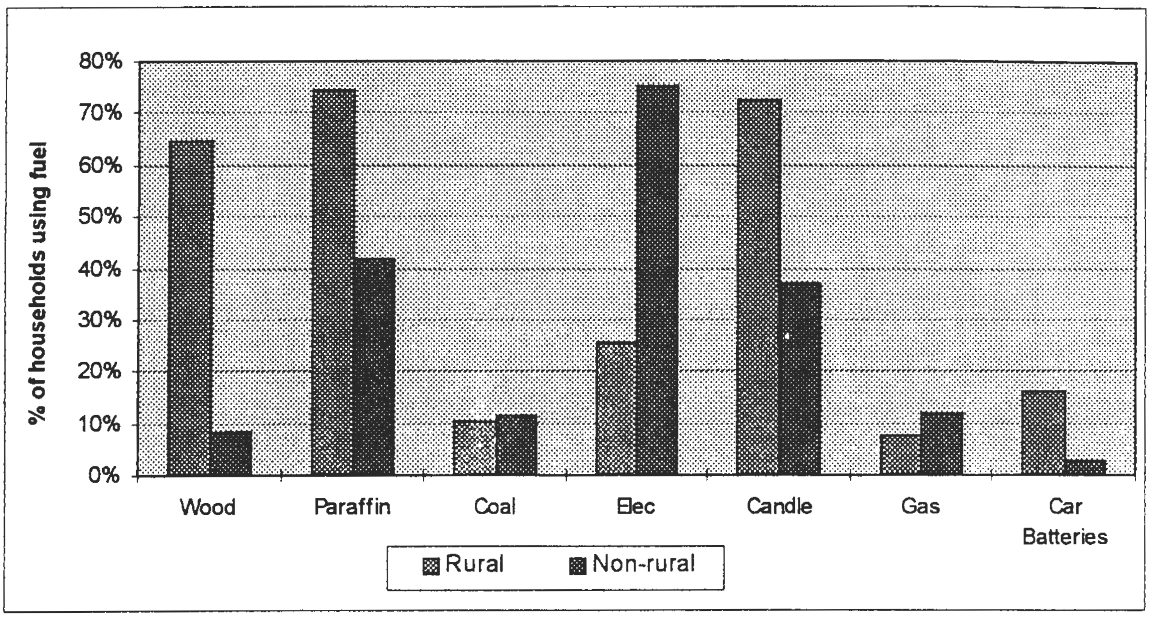

Figure 4-12: Percentage of households using different fuels in rural and non-rural South Africa
Source: Saldru data analysis

4.6.2 General effect of electrification on fuel use

There is much resemblance between the graphs comparing fuel use in the homelands and the former provinces in Figure 4-11 and that of the electrified and non-electrified households in Figure 4-13. This is due to the fact that the households in the former homelands are largely non-electrified whilst those in the former provinces are largely electrified. This shows that the type of fuel used in households is influenced by electrification, although there are other equally important factors that dictate choice of fuels used in the households. From Figure 4-13 it can be seen that at least 60% of the non-electrified households use the less desirable fuels wood, paraffin and candles. The cooking and heating needs of non-electrified households are usually met by the use of paraffin and wood whilst their lighting needs are usually met by the use of candles and paraffin. Even though the figure shows that about 96% of the electrified households use electricity, it can also be seen that the use of the less desirable fuels amongst electrified households is still significant. About 28% of the electrified households use paraffin and candles and about 12% use wood. Although the use of these less desirable fuels amongst electrified households is sometimes for special purposes like fire kindling or braaiing[6] or lighting of dining table in the case of candles, many of the low-income electrified households are unable to afford the electricity supply service. Households that find the

[6] Braaiing is a traditional South African way of making barbecue.

service unaffordable may resort to the less desirable fuels whose supplies do not require upfront large payments and these households devise survival strategies for coping with their situations.

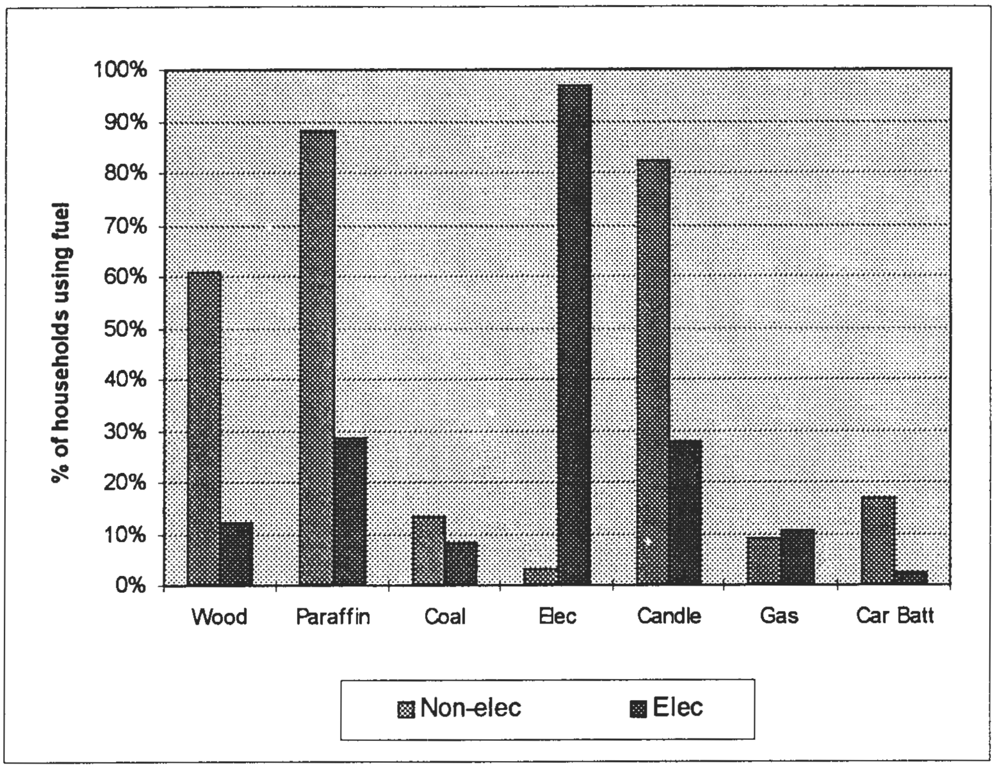

FIGURE 4-13: Percentage of households using fuels amongst electrified and non-electrified households

Source: Saldru data analysis

4.6.3 Fuel use variation with income

The overall situation in South Africa

Figure 4-14 depicts the overall picture of the extent to which different fuels are used amongst households in different income groups in South Africa. With respect to fuel use variation according to income, the six domestic fuels in Figure 4-14 fall into three main categories. Paraffin, candles and wood fall into one category that is clearly shown to be consisting of fuels predominantly used by the poor. These fuels are used extensively at lower income levels (for example, 73-80% of the households in income group 1, 60-78% of households in income group 2, etc.). However, as household income increases their usage diminishes. The degree to which the use of these *fuels of the poor* diminishes with income rise is not the same for all the fuels. Whilst paraffin and candles seem to have a gradual fall in their use as income levels rise, wood use falls steeply with income level rise. The use of paraffin and candles falls from about 78-80% at income group 1 to 23-26% at income group 6 whilst wood use falls from about 73% at income group 1 to about 5% at income group 6. Of the three fuels in this category, it appears like wood is the least preferred as household income is improved. This may be due to the dwindling availability of wood in certain parts of the country and the inconvenience involved in its use compared with paraffin and candles.

The use of paraffin and candles is surprisingly high even amongst the top income group (23-26%). There could be two reasons for this. First, candles may be used amongst higher income households mainly for the dining table and some minor celebrations like birthdays. Second, the high paraffin use in higher income households could be an indication of the extent to which the lack of access to electricity can be a barrier to even those who may be able to afford the electricity supply service.

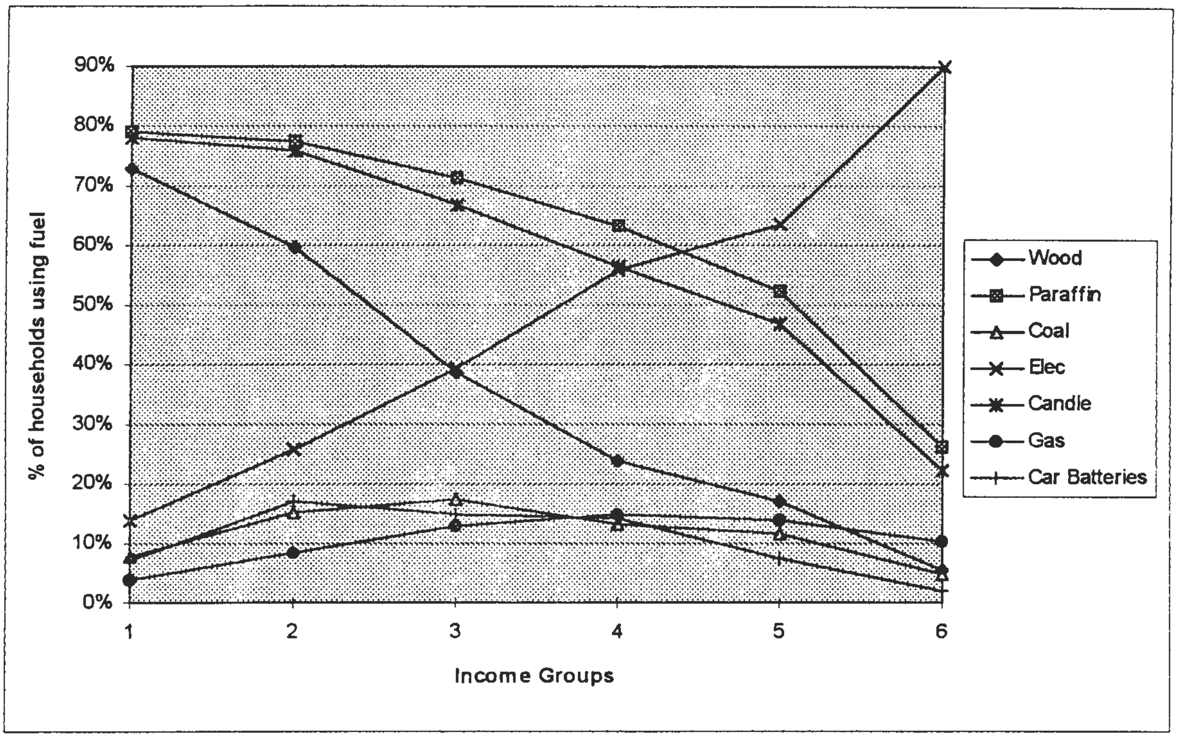

Figure 4-14: Percentage of the households in each income group in South Africa using a particular fuel

Source: Saldru data analysis

Electricity makes up the second category. In this case the extent to which electricity is used amongst the households increases almost linearly with income levels. This is obviously due to the fact that, as household incomes are improved electrification becomes affordable and households then tend to shift from the use of fuels in the first category to electricity.

The third category in Figure 4-14 is made up of the *fuels of the minority,* which are LPG, coal and car batteries. Their use in all the income groups is very low and does not exceed 18% of the households in any income group. Their curves have maximum points which means that, as income improves more households are able to afford the use of the fuels till the point where they shift to other fuels and their appliances which become affordable as well at higher income levels, especially electricity and electrical appliances. From the figure, it appears like income enhances the affordability of LPG supply service more than the other two fuels in this category since LPG's maximum point occurs at a higher income level (Group 4) than coal and car batteries. This is probably because LPG has many desirable characteristics as domestic fuel like convenience and cleanliness. Perhaps the main problems with it are reliability of supply and versatility when it is compared with the wide range of appliances that can be used with electricity. Higher income does not seem to influence the affordability of car batteries very much as the maximum point (about 17%) is reached at income group 2. From then on its use drops heavily to about 2% at income group 6, indicating shifts to other fuels more convenient, efficient and affordable. The extent to which income affects household choices for coal use seems to lie between LPG and car batteries.

Rural households

Figure 4-15 depicts fuel use variation with income for rural households in South Africa. For the rural households, the use of the six fuels can be grouped into the same three categories like in the case of the overall situation in Figure 4-14.

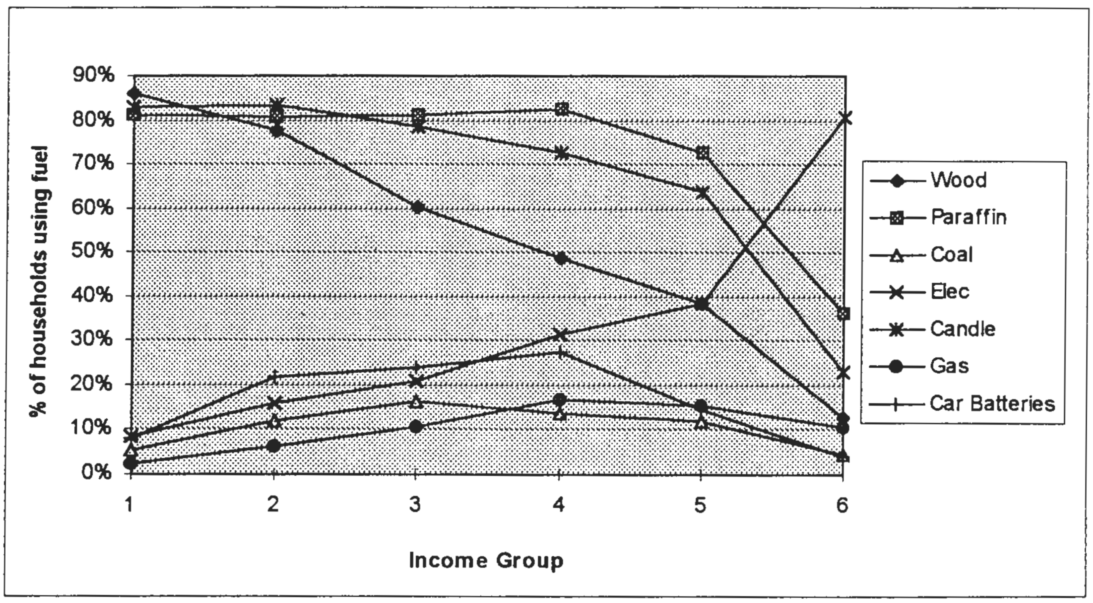

Figure 4-15: Percentage of households in each income group in rural South Africa using particular fuels

Source: Saldru data analysis

However, fuel use variation with income levels for rural households has the following specific characteristics:

- Wood stands out as the main fuel in the rural poor households since it is used extensively at lower income levels but its use drops very steeply with income level rise. Many of these rural households do not purchase fuelwood but collect it from nearby farms or woodlands. The opportunity cost involved in this wood collection could be very arduous. Paraffin and candles are also shown to be not only the fuel of the poor but also of the middle income rural households. In fact, paraffin use remains almost constant at about 80% till after the fourth income level before it drops. The drop in the use of candles with income levels is very slight till after the fourth income group when it starts falling steeply. Indeed over 70% of households use candles even at income level 4. Thus one could conveniently say that paraffin and candles are *fuels of the majority* in rural areas since over 85% of rural households are below income level 5 (see Section 4.4.2).
- For the second category, electricity can be classified as the *fuel of the rich* in the rural areas. As income improves households are able to afford the service in rural areas. Compared with the overall situation in Figure 4-14, electricity use amongst rural households exhibits a curve relationship concave towards the vertical axis. This shows that only a small minority in income levels 5 and 6 use it. The figure shows that affordability seems to an influencing factor in the choice of electricity as fuel in rural households, although lack of access is another important factor.
- The third category comprises LPG, coal and car batteries whose usage relationships with income have maximum points. Income level seems to be a positive factor in the use of these fuels at the lower income levels but a negative factor in the higher income levels. Unlike the non-rural areas, affordability of the use of car batteries seems to be enhanced by income rise till the fourth income level where households start shifting to other fuels. Coal use in rural areas also increase with income till the third income level where households start shifting to the use of other fuels. There does not seem to be any significant shift from the use of LPG to other fuels at higher income levels in the rural areas.

Non-rural households

The fuel use variation according to income levels for non-rural households (i.e. urban and metropolitan households) is depicted in Figure 4-16. The six fuels in this figure can be grouped into the same three categories for the overall situation. The nature of the curves for the fuels in the three categories are similar to the overall situation but with the following differences:

- The *fuels of the poor* in non-rural areas are mainly paraffin and candles. However, amongst the low-income households in the non-rural areas these fuels are not used as extensively as in the overall situation described above. For example, whilst about 76-80% of the households in income groups 1 an 2 use these fuels in the case of the overall situation in South Africa, only about 58-70% of the households in these income groups use these fuels in the non-rural areas.

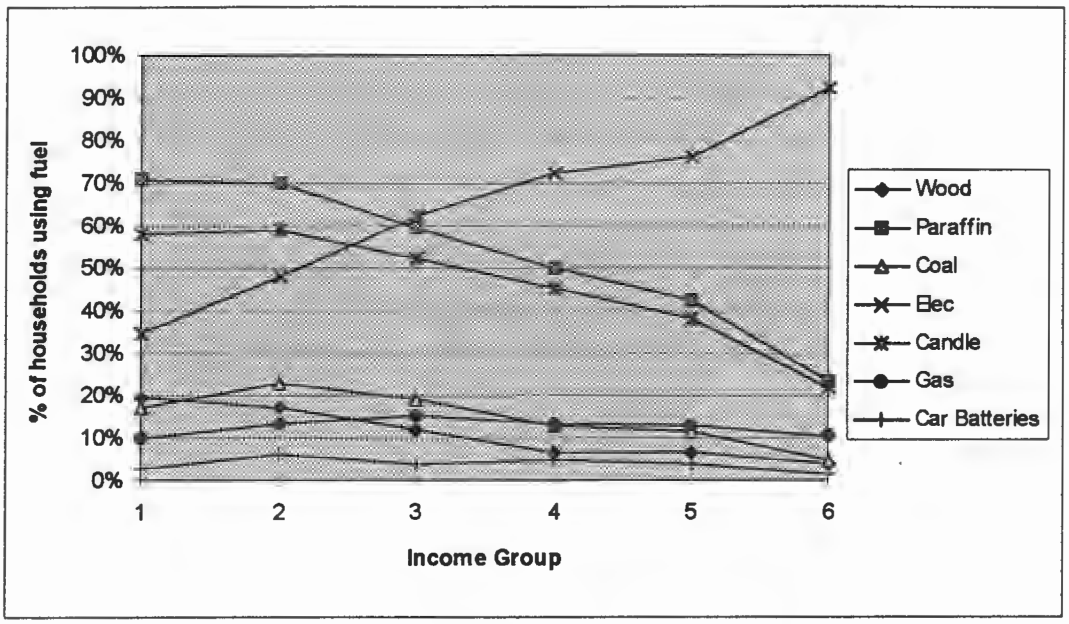

Figure 4-16: Percentage of households in each income group in non-rural South Africa using particular fuels

Source: Saldru data analysis

- The nature of the usage relationship for the electricity category is pretty much the same as the overall situation except that lower income households seem to have better access to the fuel in the non-rural areas than the overall situation in South Africa. For example, about 35% of non-rural households in income group 1 use electricity compared with the 14% in the case of the overall situation.
- There are some differences in the third category of fuels too. In the non-rural areas this category does not only consists of LPG, coal, and car batteries but also wood. The use of wood in the lower income levels in the non-rural areas is so low that wood can be counted as one of the fuels of the minority. Affordability does not seem to be a determining factor in the choice of these fuels since increase in income level does not reflect in any appreciable increment in the extent of use. For example, the extent of LPG use stays pretty constant for almost all income groups. This shows that the choice for LPG use in the areas of the former provinces is more dependent on other factors rather than affordability of the fuel supply service. Car batteries seem to be unpopular at all income levels and it appears like a few households start shifting from coal use to electricity as household income improves from income level 2 upwards.

Further investigation into the fuel use variation with income in the former homelands and provinces shows that the situation in the homelands is similar to that in the rural areas whilst that in the former provinces is similar to that in the non-rural areas. However, there are some striking differences too.

4.7 Multiple fuel use in the household

In Chapter 2 (Section 2.5) it was mentioned that multiple fuel use is the norm in most South African households rather than the exception. In the discussion of the prevalence of fuels use in Section 4.6, it was shown that the sum of the percentages of households using different fuels far exceeds 100% which gives an indication that multiple fuel use is a common phenomenon. The extent of this phenomenon amongst South African households is explored further in this section and the fuels involved are also identified. The effect of urbanisation and electrification on multiple fuel use are briefly analysed as well as the variation of the phenomenon with income levels of households.

4.7.1 Overall South Africa, areas of the former homelands and the former provinces

Figure 4-17 depicts multiple fuel use patterns for overall South Africa, areas in the former homelands and areas in the former provinces. It can be seen from this figure that only about 32% of the households in South Africa are able to depend on one fuel in meeting their daily energy needs, the rest depend on combinations of 2 or more fuels. The most common phenomenon of multiple fuel use is the combinations of 3 fuels (about 30% of all South African households) compared with the combinations of 2 fuels (about 23%) and of 4 or more fuels (15%).

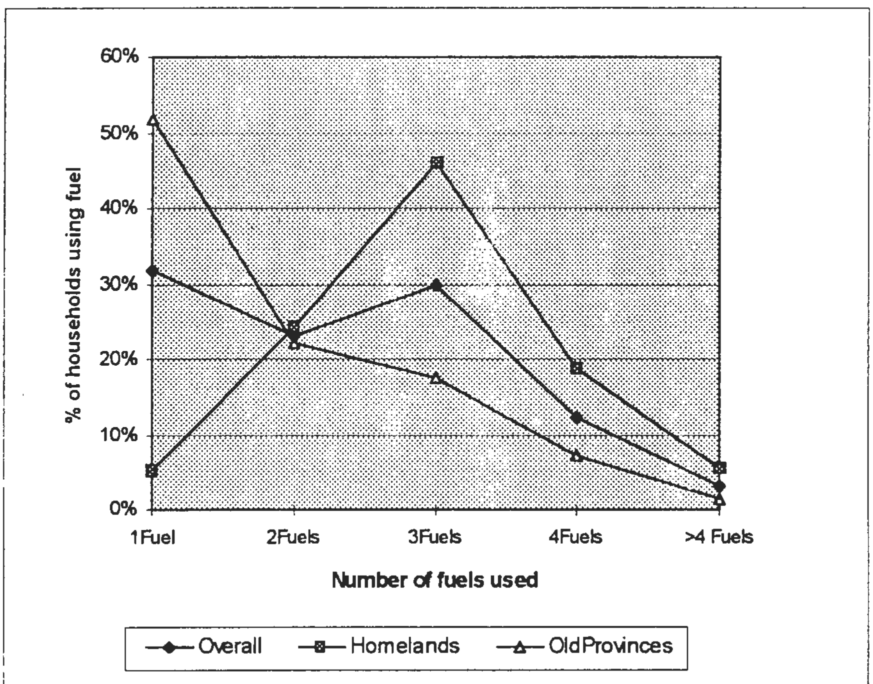

Figure 4-17: Multiple fuel use in the overall South Africa, areas of the former homelands and the old provinces

The fuels involved in the single and multiple fuel use in overall South Africa have been illustrated in Figure 4-18. It can be seen that single fuel users are largely electrified households using electricity, however, it is clearly shown here that electricity is not only used as a single fuel but also in combinations with other fuels. In fact, almost half of the electricity users use it in combination with either one or two or more fuels. Apart from electricity, paraffin is the only other fuel that is significantly used as a single fuel but that is limited to only about 3% of all households. For households using combinations of two fuels, the fuels involved are mostly paraffin and candles, and to a lesser extent wood and electricity as well as very few households using coal or LPG. For those using combinations of three fuels, the fuels involved are mainly paraffin, candles and wood. The combinations of electricity with two other fuels is also quite significant (about 9%) but only few households combine coal or LPG or car batteries with two other fuels. All the seven fuels under discussion seem to be involved in 4-fuel combinations but candles, paraffin and wood appear to dominate.

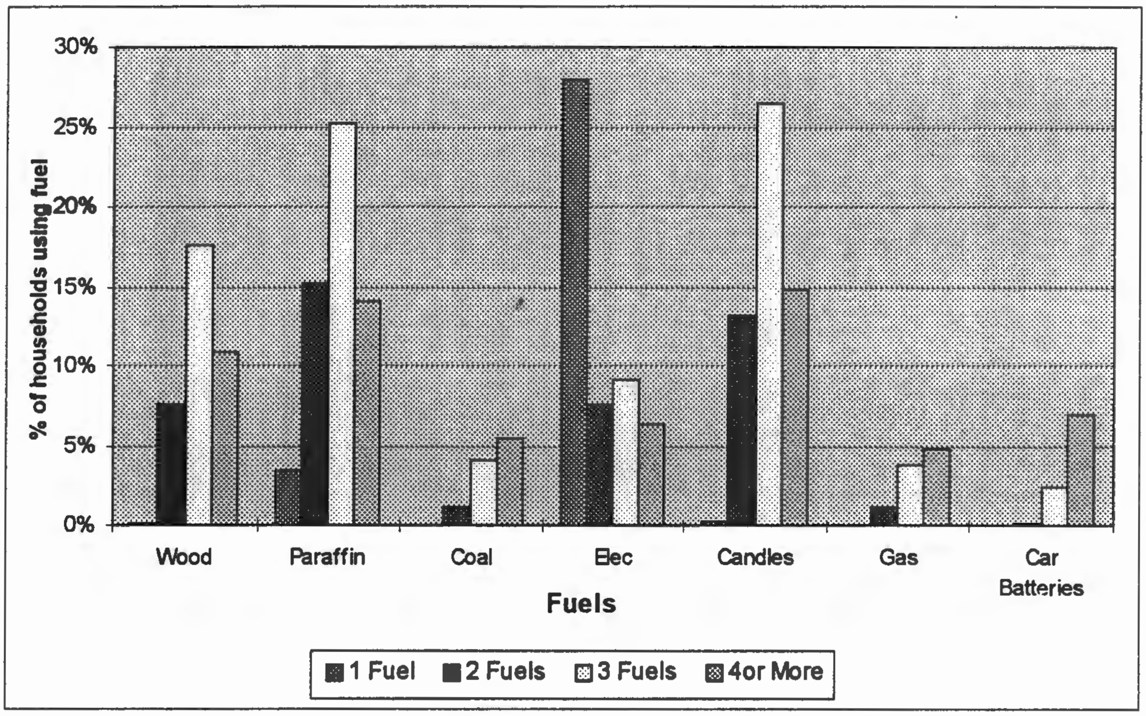

Figure 4-18: Overall fuel combinations in South Africa

It is worth noting that all the percentage combinations for each particular fuel should not be expected to sum up to 100% since only a portion of the population uses each fuel. For example, the sum of the percentage usage combinations for wood users in Figure 4-18 is approximately 36% as depicted by the overall population in Figure 4-11. Combinations for each fuel in Figure 4-18 sum up to the overall population value for that particular fuel in Figure 4-11.

Again, from Figure 4-17, multiple fuel use seems to be more pronounced in the areas of the former homelands than in the areas of the former provinces. Whilst over 50% of the households in the areas of the former provinces use a single fuel for their energy needs, about 95% of the households in the former homeland areas use 2 or more fuels for their needs. Further analysis shows that over 90% of the households who depend on a single fuel in the former provinces areas are users of electricity. It appears that extreme lack of access to affordable electricity provision in the former homeland areas has compelled the households to resort to multiple fuel use extensively as a survival strategy. Even for the 5% of the households in the former homeland areas who depend on a single fuel, only about half are electricity users; the other half entirely depend on paraffin. This shows that, to some extent, the limited electricity provision in the former homeland areas is either not affordable or appropriate or desirable by many households for all energy end uses. It is very clear that electricity use is clean and non-poisonous and one could hardly argue about the versatility of electricity in its applications and delivery to the point of use. The lighting provided by electricity is of higher quality and cheaper than that provided by other fuels like paraffin and candles. This makes electricity attractive to low-income households, however, the energy service from electricity for key domestic end uses like cooking, space and water heating is usually not affordable to poor households. For such end uses that are energy intensive, poor households often prefer to use other fuels which they find affordable regardless of the cleanliness or quality of the fuel.

In terms of the percentage of households using combinations of two fuels, Figure 4-17 shows that the difference between the former homeland areas and the areas of the former provinces is very slight. However, the fuels involved in the 2-fuel combinations are different. Whilst the fuels involved in the dual fuel use in the areas of the former provinces are mainly electricity, paraffin and candles, those involved in the former homeland areas are mainly paraffin, fuelwood and candles. The most common phenomenon of multiple fuel use in the former homeland areas is the combinations of three fuels but the use of four or more fuels in some households is also substantial.

Whilst the overall multiple fuel use situation for the former homeland areas is not uniform for all the individual homelands, the overall picture for the former provinces seems to occur in all the areas of the individual provinces. In Figure 4-19, it can be seen that many households in each of the former provinces tend to prefer single fuel use. This is a clear example of how the former apartheid policies of unequal access to basic needs have influenced differently the lifestyles of the households in the areas of the former homelands and those in the former provinces. Single fuel use is more pronounced in the areas of the former Cape, Natal and Transvaal provinces (50-60% of the households) than in the areas of the former Orange Free State (about 38% of the households).

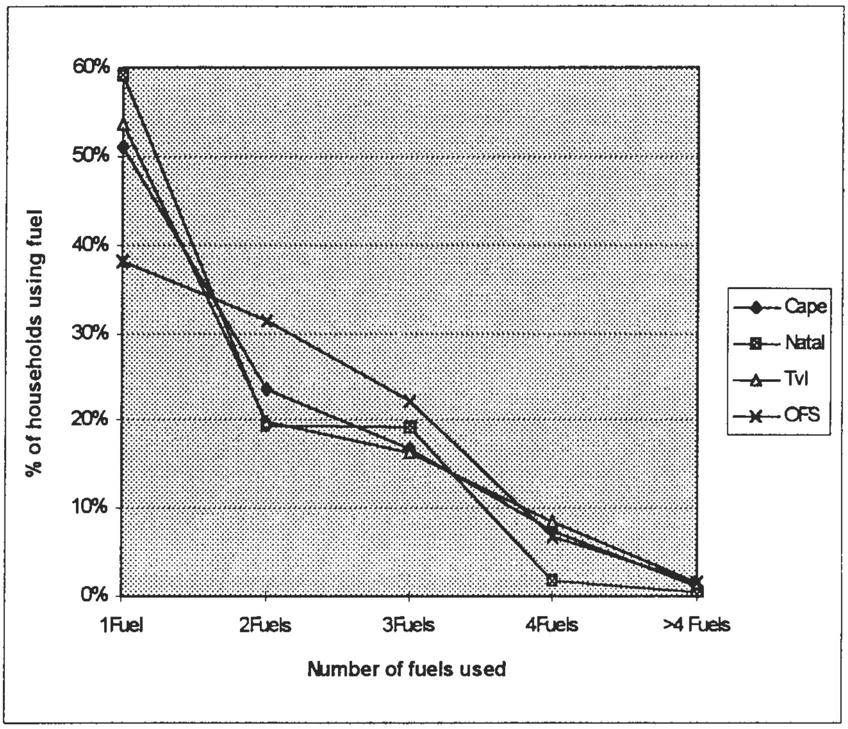

Figure 4-19: Multiple fuel use in the areas of the former provinces

4.7.2 Multiple fuel use in rural and non-rural households

Figure 4-20 depicts multiple fuel use in rural and non-rural South Africa. It can be seen that the differences between rural and non-rural households are similar to those between the areas of the former homelands and the old provinces. This is because the homeland areas are more rural than the old provinces. Whilst the most common phenomenon in the rural households is the combinations of three fuels, single fuel use is more prevalent in households in the urban households[1]. Whilst about 50% of the urban households depend solely on a single fuel for all their energy needs, over 80% of the households in the rural areas depend on more than one fuel for their energy needs. The practice of single fuel use is more widespread in rural households (12%) than the households in the former homeland areas (5%). This is due to the fact that farmers, and in some cases farmworkers, in the rural areas of the former provinces have better access to electricity than rural areas in the former homelands. In fact, electricity is the fuel used by over 80% of the households in the rural areas who are single fuel users (see Figure 4-21). This shows that affordability of electricity supply service is less a problem for some rural households in the former provinces for those in the rural homeland households.

[1] This includes metropolitan households.

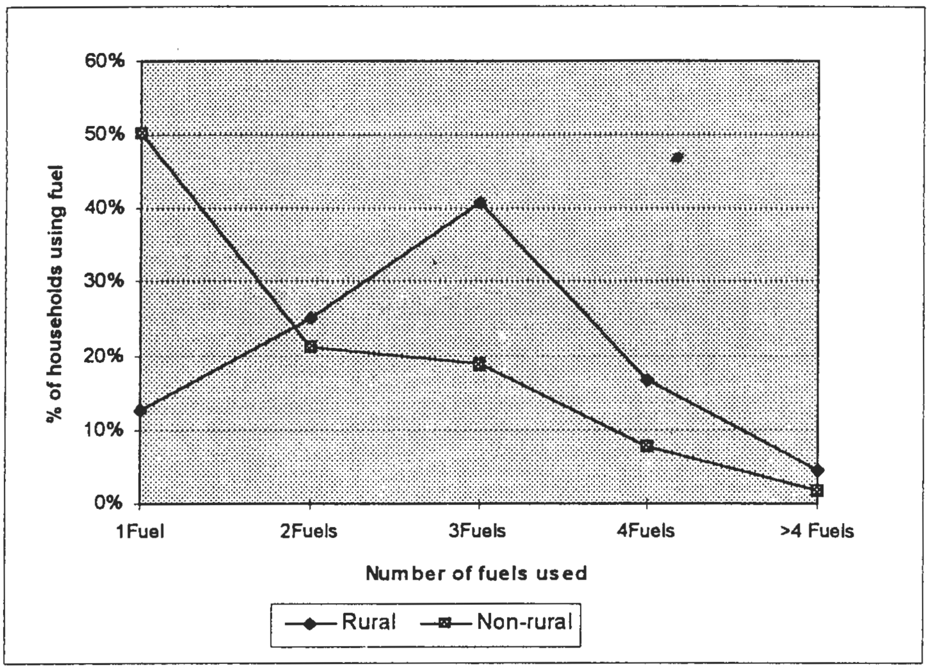

Figure 4-20: Multiple fuel use in rural and non-rural South Africa

It is interesting to note from Figures 4-21 and 4-22 that the use of fuelwood, coal, LPG, candles and car batteries as a single fuel are not practised significantly in both the rural and urban households of South Africa. These fuels are usually used in combination with one or two or more fuels since each may not be suitable for providing all the appropriate and affordable energy services required by households. In terms of percentage of households involved in dual fuel use, the difference between the rural and urban households is not much, however, the fuels involved could differ. In the rural areas, the fuels involved in the combinations of two or three fuels are mainly paraffin, fuelwood and candles whilst in the urban areas the fuels involved are mainly paraffin, candles and electricity.

In the rural areas, slightly over 20% of the households use more than 3 three fuels but in the urban areas this is slightly less than 10%. This is probably because urban households have improved access to the few fuels they use and they are more able to afford the costs of their supply than in the case of the rural dwellers. It is interesting to note that car batteries are commonly used in the rural areas where the households cannot find their energy needs met by the use of only three fuels. In fact, car batteries are used by over 70% of the rural households that use more than 3 fuels.

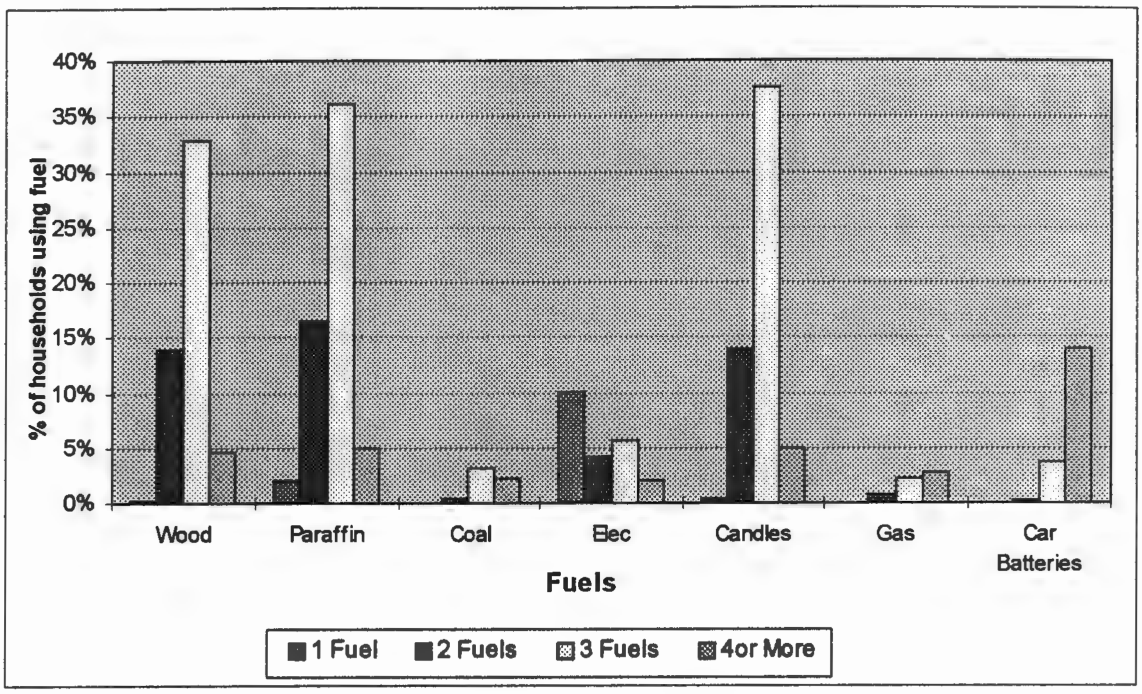

Figure 4-21: Fuel use combinations in rural South African households

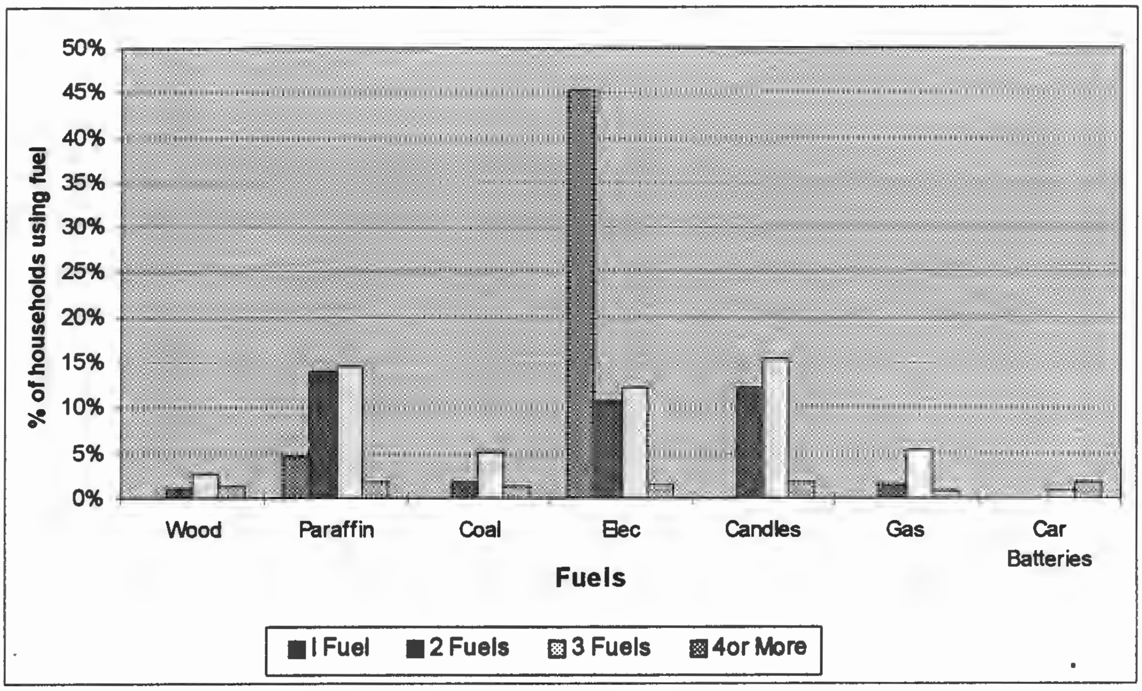

Figure 4-22: Fuel use combinations in non-rural South African households

4.7.3 Effect of electrification on multiple fuel use

Multiple fuel use in rural and urban households has been discussed in Section 4.7.2. Figure 4-23 gives an illustration of the effect of electrification on multiple fuel use in rural and urban households. The general observation from this figure is that electrification, whether in the rural or urban area, seems to reduce multiple fuel use drastically. The reason for this is that the application of electricity is very flexible and it is suitable for most of the domestic end uses of energy, provided the service and the required appliances are affordable.

Comparison between *electrified rural* households and *non-electrified rural* households shows that electrification appears to have resulted in an increase in single fuel use from about 3% to about 38%. This consequently reduces the combination of three fuels, which is the most widespread multiple fuel use phenomenon, from about 48% to about 22%. A similar comparison between electrified urban (*elec non-rural*) households and non-electrified urban (*non-elec non-rural*) shows that electrification has resulted in an increase in single fuel use from about 18% to about 60%. In the case of electrification of urban households, the combination of two fuels, which is the most common practice in non-electrified households, is consequently reduced from 38% to about 15%. If electrification is taken out of the equation too, that is, comparing *non-electrified rural* and *non-electrified urban*, multiple fuel use is more widespread amongst rural households than urban households. In this case, whilst the combination of two fuels is more popular in urban households, combination of three fuels is more common with rural households.

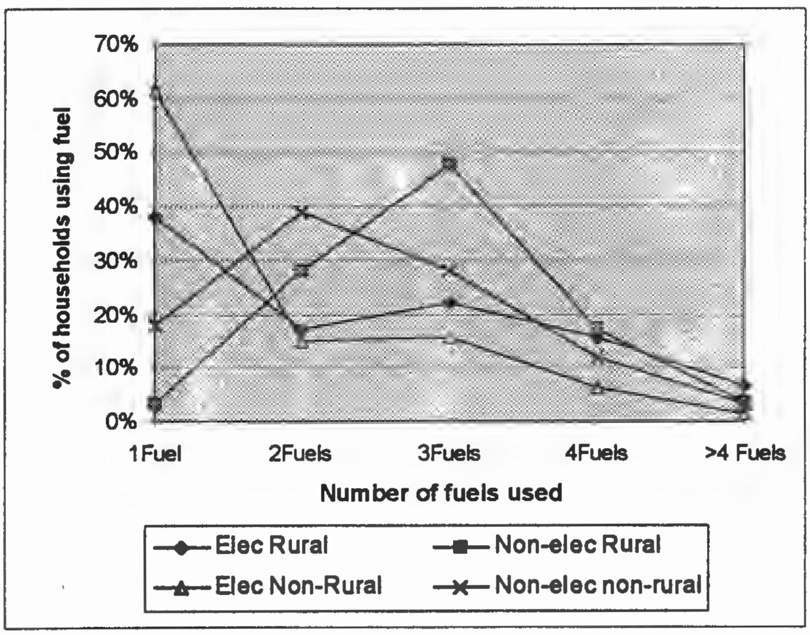

Figure 4-23: Effect of electrification on multiple fuel use in South Africa

4.7.4 Effect of household income on multiple fuel use

Overall South Africa

Figure 4-24 gives an illustration of the relationship between multiple fuel use and household income for all South African households. It is clear from the graph that, for low-income households (from income group 1 to 3), the most common practice is the combination of three fuels. On the other hand, for the higher income levels (income groups 4 to 6), the most common phenomenon tends to be single fuel use. Combinations of two fuels, four or more fuels do not appear to have any strong relationships with household income.

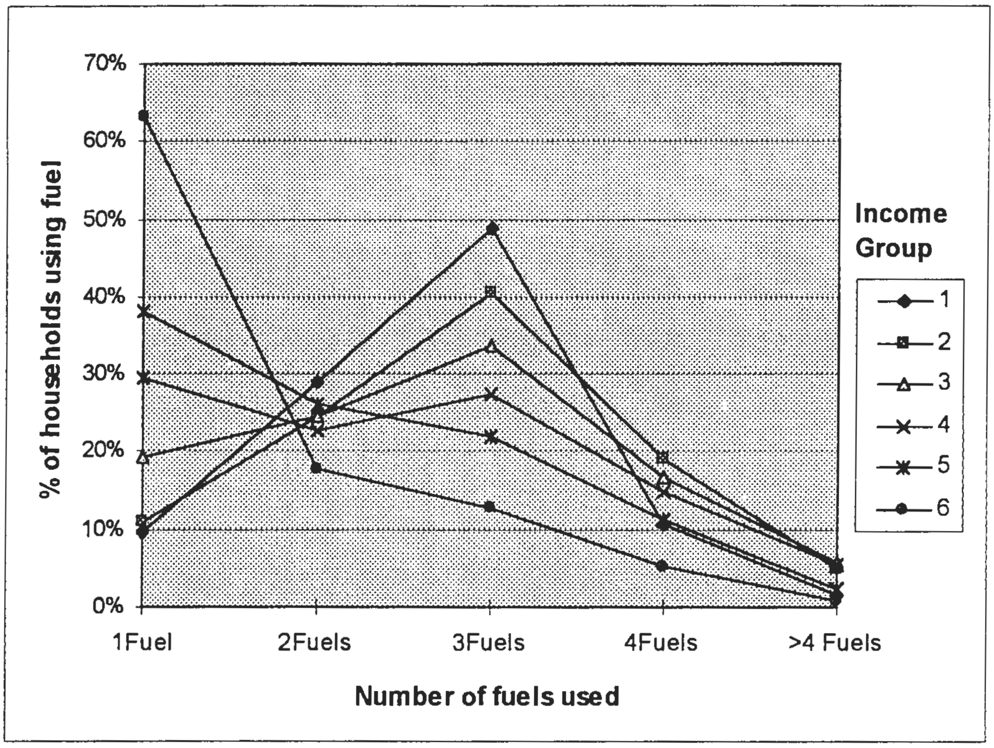

Figure 4-24: Overall multiple fuel use variation with income in South Africa

It can be seen from the graph that single fuel use becomes the preferred option for most households as income improves. On the other hand, there seems to be a negative straight-line relationship between the practice involving the combination of three fuels and household income. This means that households appear to opt out of the practice involving the combination of three fuels as their income situation improves. This is explained by the fact that, as income improves households are able to afford the cost of electrification, appliance purchases and electricity supply service or the bulk purchase of paraffin. Thus higher income households could depend solely on electricity or otherwise choose to depend solely on paraffin if they already own paraffin appliances and cannot afford the costs involved in electricity provision as well.

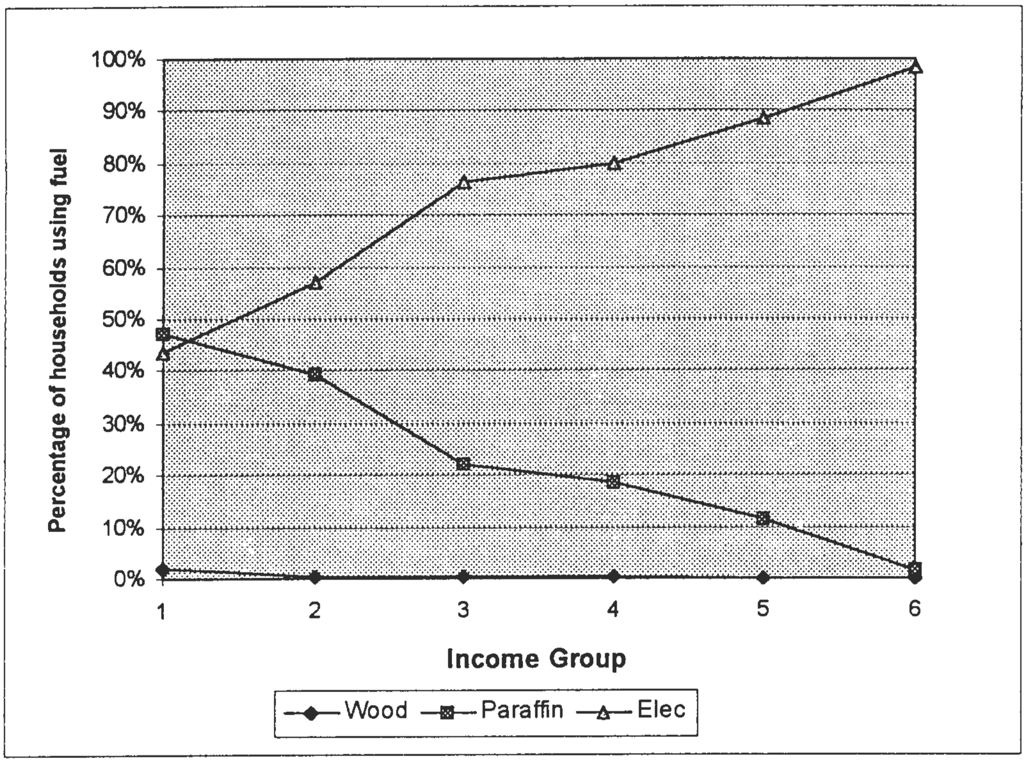

Figure 4-25: Single fuel use variation with household income in overall South Africa

From analysis in Figure 4-25 concerning single fuel use variation with income, it can be seen that single fuel users tend to shift from paraffin use to electricity use as income improves. In fact, at income level 1, about 47% of the single fuel users are paraffin users but this decreases to about 2% at income level 6 since most households (98%) at that income level use electricity, for they obviously can afford it. Although improved income influences households greatly towards the use of electricity as a single fuel in households, there are reasons why multiple fuel use persists at higher income levels. Many households might have already spent a lot of money on appliances for the less desirable fuels like paraffin, coal and wood before their dwellings were electrified. Thus, it becomes burdensome for them to purchase another set of appliances for electricity use only. Even when they can afford the purchase of these electrical appliances, they tend not to use them for end uses like cooking, water heating and space heating which are energy intensive since other fuels appear to be more affordable. Furthermore, the use of some of these fuels could be for multiple purposes, for example, cooking with fuelwood or coal stove could provide the necessary space heating.

The former homeland areas

It was discussed in Section 4.7.1 that multiple fuel use is more widely spread in the areas of the former homelands than in the areas of the old provinces. Figure 4-26 depicts how multiple fuel use varies with household income in the areas of the former homelands. It is very clear from the graph that the use of three fuels is the predominant phenomenon at every income level. In income group 1, almost 60% of the households use three fuels for their energy needs. This practice reduces as income level increases but only up to the 3rd income level. From income level 3 to 6, income does not seem to empower households to shift to single fuel use since the graph remains almost constant. It must be remembered that the lower income groups 1 and 2 constitute about 60% of the households in the former homeland areas (see Section 4.4.2). This shows that the combination of three fuels is very widespread amongst households in the areas of the former homelands. Apart from single fuel use that shows very slight increase with increase in income level, other phenomena of multiple fuel use do not appear to have any strong relationship with income. This is probably reflective how limited choices there are in the former homeland areas.

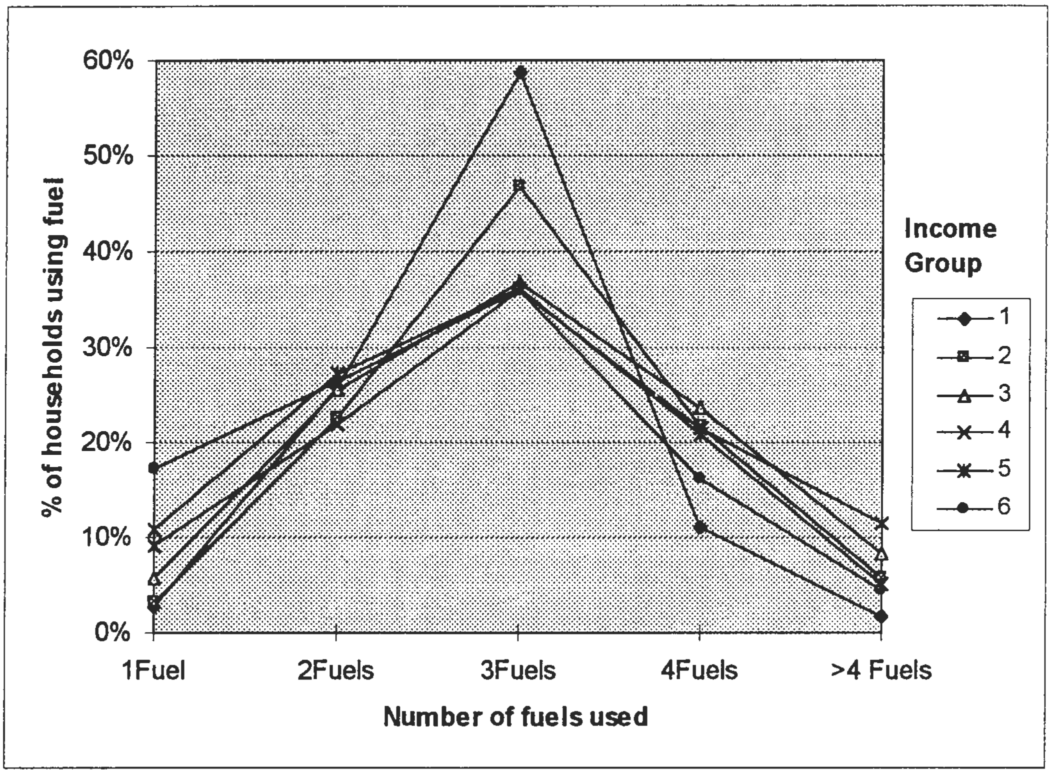

Figure 4-26: Multiple fuel use variation with income in the households of the former homeland areas

Rural and urban South African households

It has been established in Section 4.7.2 that over 80% of the households in rural South Africa depend on more than one fuel for their energy needs whilst in the urban areas about half of the households depend on only one fuel. Figure 4-27 shows that the combination of three fuels is the most common multiple fuel use phenomenon amongst all the income groups in the rural area except the highest income group whose preferred option is largely single fuel use. Those rural households in income group 6 are mostly the commercial farmers in the old provinces that are able to afford the service of electricity provision. The figure seems to portray a shift from combination of three fuels in the rural households to single fuel use as household income increases.

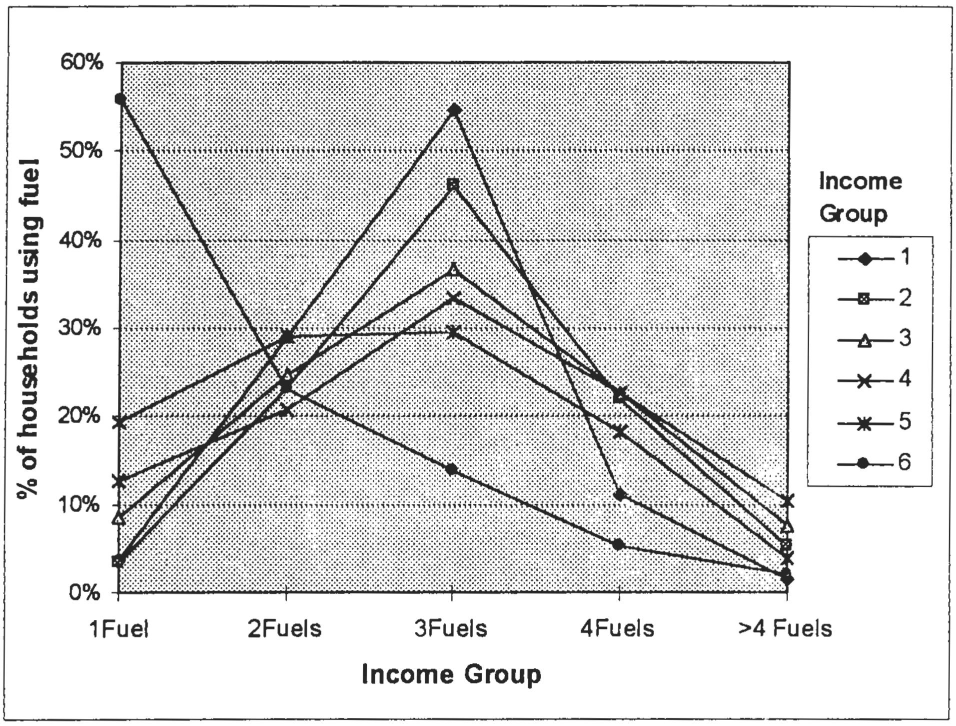

Figure 4-27: Multiple fuel use variation with income in rural South African households

Figure 4-28 depicts the variation of multiple fuel use with household income in urban areas. It is clear from this figure that higher income households in the urban areas usually opt for single fuel use. However, income does not seem to have any profound influence on whether a household would use two or three or more fuels in the urban areas. The reason could be that the availability of a particular fuel is the more determining factor in the choice of fuels in urban households.

Non-electrified households.

Although multiple fuel use persists in a number of electrified households, there is usually a tendency for such households to shift to single fuel use when electricity provision is affordable (see Figure 4-29. In the non-electrified households, however, multiple fuel use prevails at all income levels as shown in Figure 4-30. However, income seems to have some influence on the extent of multiple fuel use. In the figure, it can be seen that combination of three fuels is the predominant phenomenon in the lower income groups (i.e. income groups 1 to 3). As income level increases more households shift to the use of two fuels.

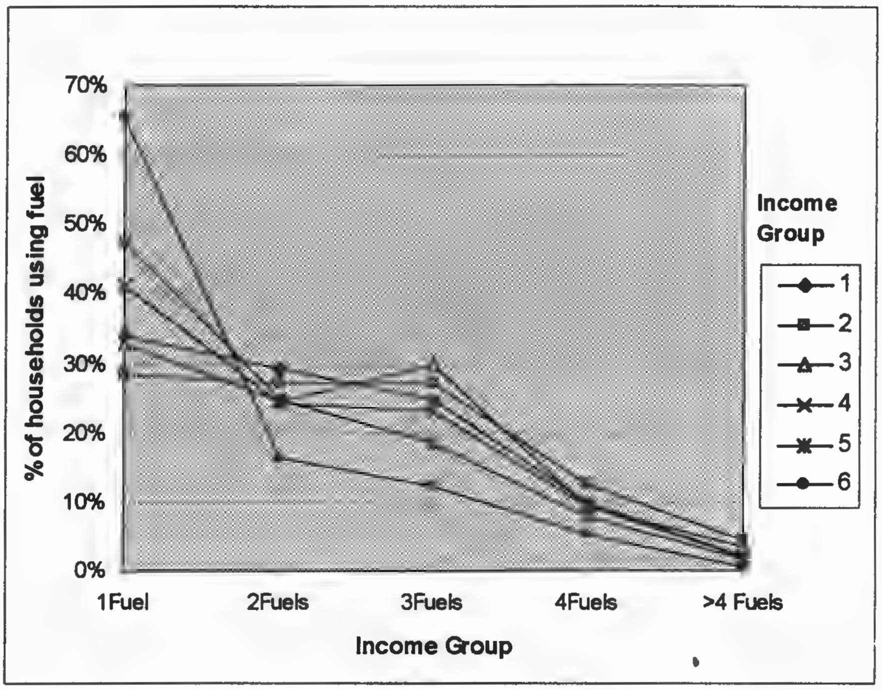

Figure 4-28: Multiple fuel use variation with income in non-rural South African households

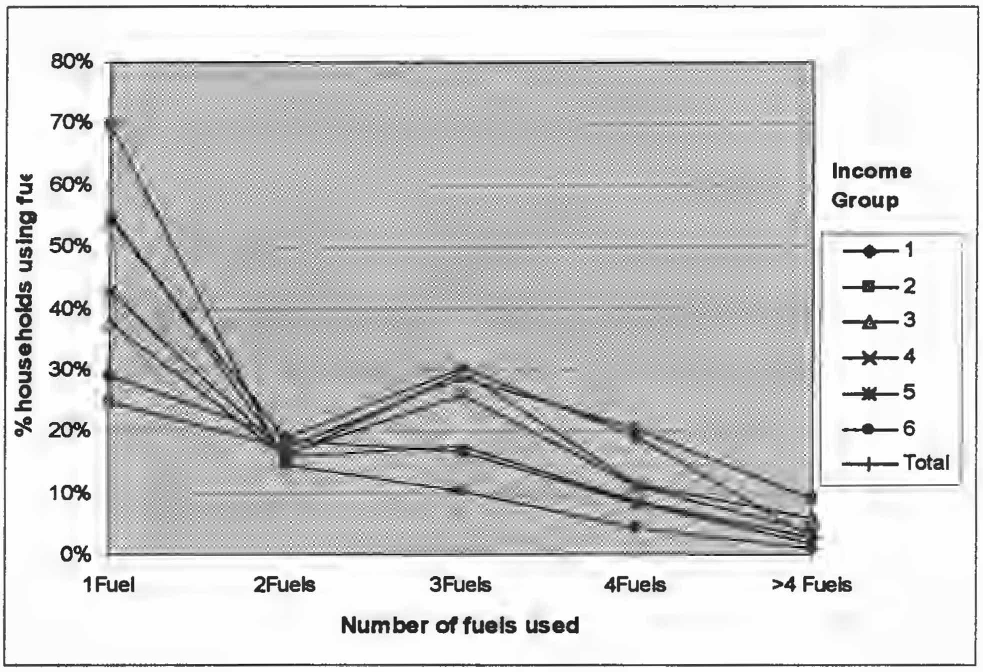

Figure 4-29: Multiple fuel use variation in electrified households in South Africa

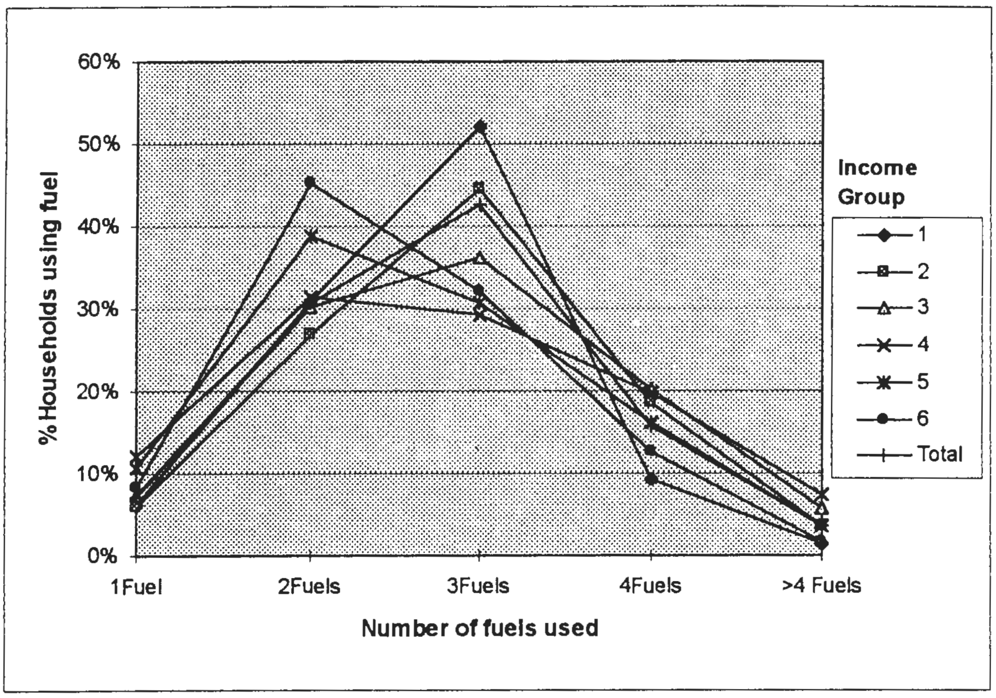

Figure 4-30: Multiple fuel use variation in non-electrified households in South Africa

4.8 Electrification

The former South African Minister for Mineral and Energy Affairs, Mr R F Botha, once said that the winning countries of the world are fully electrified (Du Plessis 1996). He argued that bringing electricity to South Africans who do not yet enjoy its benefits must be a national priority. He saw electrification in a democratic South Africa as a great opportunity that must not be delayed when he said:

> Now is our chance to bring electricity to the humblest squatter, the mother urging her children to do their homework, the tired father who seeks to enjoy some television, the baby who may otherwise shiver through the winter, the office clerk studying into the night to become a lawyer.

Mr Jay Naidoo, a former Minister in the Office of the President of South Africa, once singled out electrification as a crucial element in the Reconstruction and Development Programme (RDP) of the Government of National Unity (GNU) (Du Plessis 1996). He acknowledged that, world wide, one of the most effective ways to improve people's quality of life is to give them electricity. Although one could argue that electrification per se would not necessarily bring upliftment and empowerment of the disadvantaged communities unless it is appropriately integrated with the provision of affordable appliances as well as efficient and reliable service, the point being made here is that there is great lack of access to electricity amongst many South African households which requires an urgent attention of the government. In spite of the fact that South Africa boasts of power stations, transmission technology and infrastructure that compare with the best in the world, a large portion of her population have to depend on inconvenient and less desirable fuels like coal, fuelwood and paraffin for their basic energy needs.

In Chapter 2, it was briefly mentioned that household access to electricity is highly skewed. Eberhard and Van Horen assert that a simple way of identifying the urban and rural poor is to define them in terms of their access to, or more correctly, their lack of access to electricity (1995:47). Thus, in a way, electricity connection can serve as a useful initial indicator of energy poverty amongst households in South Africa. It is this aspect of energy poverty that is explored further in this section.

4.8.1 Overall, new provinces, areas in the old provinces and homelands

Figure 4-31 shows the extent of electrification of households in the entire South Africa, the areas of the former provinces and the old homelands. The figure shows that almost half of the households in South Africa are electrified. Comparison with other data sources shows that this could be a little bit on the high side as an estimate of electrification for 1993.

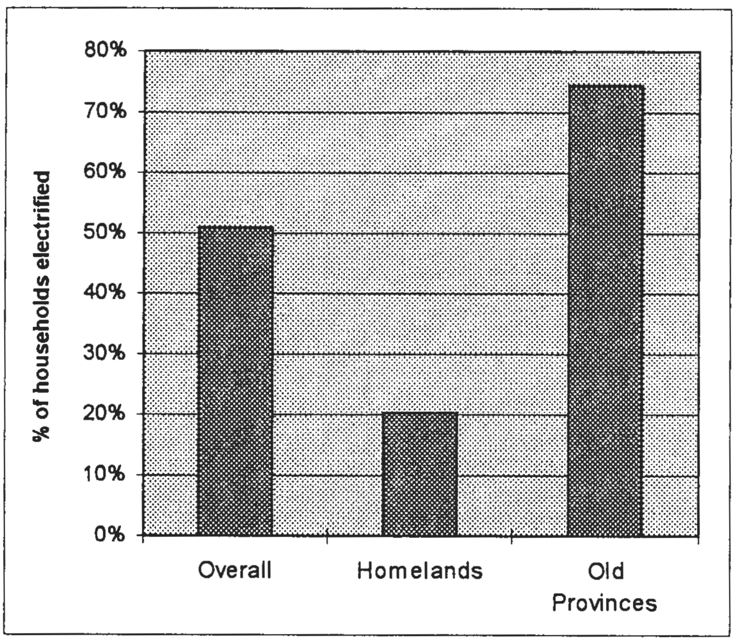

Figure 4-31: Percentage of households electrified in overall South Africa, areas in the former homelands and the old provinces
Source: Saldru data analysis

The National Electricity Regulator (NER) estimates electrification at the end of 1995 as 50.38% of all households and gives a 1992 estimate as 40% (Du Plessis 1996). Given the fact that the rate of electrification has accelerated tremendously since 1994 at the rate of over 400, 000 households annually, the Saldru data could be said to have probably over-sampled electrified households. However, if one takes into account the fact that the South African population has been growing at the rate of about 2.06%[2], and that affordable housing provision has also been enhanced since 1994, it may be that the over-sampling of electrified households in the Saldru data is not too extreme. The over-sampling of electrified households might have occurred due to over-sampling and under-sampling of households in the individual provinces of South Africa. At the time of the survey, the boundaries of the new provinces had not been fixed and some changes have occurred after the election in 1994. If the samples of the three most populous provinces are compared with some data by the NER (Du Plessis 1996:12), it can be verified that the Gauteng province which is largely electrified was over-sampled by about 2% whilst KwaZulu/Natal and the Eastern Cape provinces which have low levels of electrification were under-sampled by 2% and 1% respectively. In other words, the percentage representation of Gauteng households in the Saldru sample exceeds that presented in the NER report by 2% whilst those of KwaZulu/Natal and the Eastern Cape are less by 2% and 1% respectively.

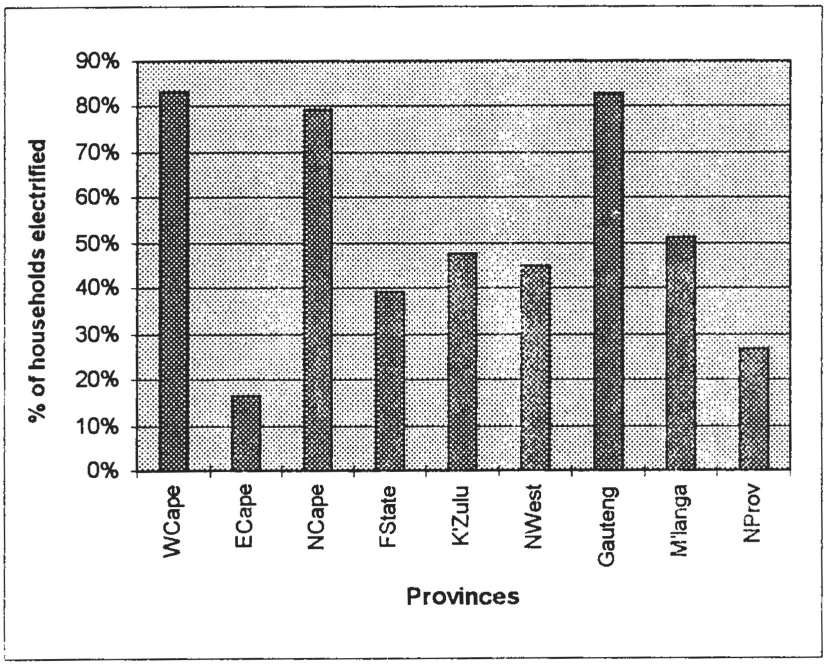

Figure 4-32: Percentage of households electrified in the provinces of the new South Africa.
Source: Saldru data analysis

The extent of electrification in the homeland areas is far below that in the areas of the old provinces. Whilst electrification in the areas of the old provinces exceeds 70%, the old homeland areas are only 20% electrified. This goes to show that the unequal distribution of access to electricity in South Africa is a product of the same political-economic forces that have shaped the

[2] 1991-1995 annual compound population growth rate (Central Statistical Service 1995).

society as a whole. The homeland areas, which are mainly inhabited by Africans, do not only have limited access to electricity but also the quality of service received has been generally poor.

The distribution of electricity in the individual new provinces also varies significantly. It can be seen from Figure 4-32 that apart from the Western Cape, Gauteng and the Northern Cape, at least half of the households in the rest of the provinces are not electrified. The situation is particularly grave in the rural areas of the Eastern Cape and the Northern Province where about 95% and 81% respectively of the dwellings do not have electricity (Figure 4-33). The Western Cape has the lowest percentage of rural households not electrified (less than 20%). The extent of electrification in Gauteng shown in Figure 4-32 could be too high due to over-sampling of electrified households especially in the rural areas.

The electrification in the Northern Cape is also a little bit too high in this figure due to the fact that insignificant number of rural households were sampled. The NER estimates the 1995 electrification figures for Gauteng and the Northern Cape as 77% and 63% respectively.

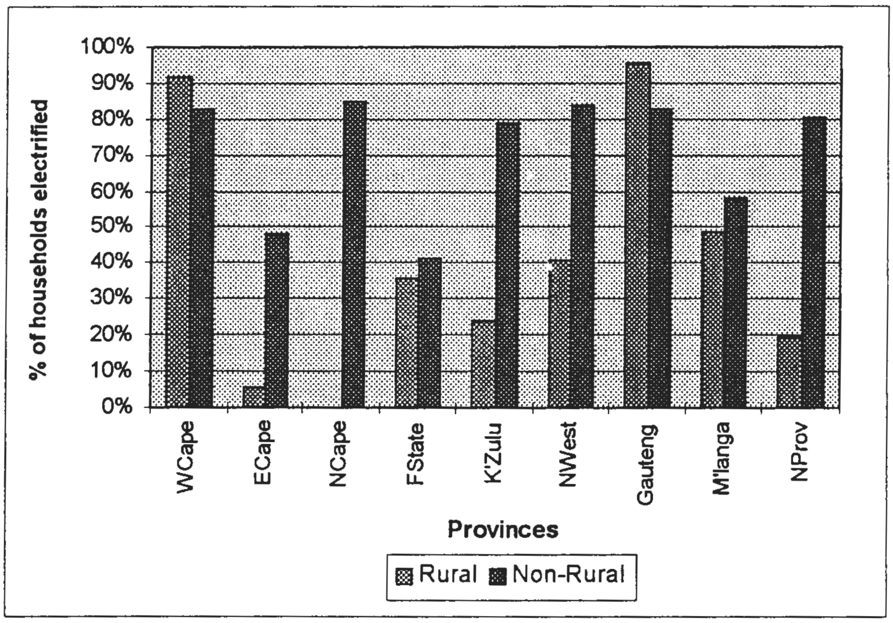

Figure 4-33: Percentage of households electrified in rural and non-rural areas of the new provinces of South Africa.
Source: Saldru data analysis

In Figure 4-34, it is shown that electrification increases with household income level for overall South Africa, the old homeland areas and the areas in the old provinces. This shows that household income is one of the main factors influencing the electrification of dwellings whether in the areas of the former provinces or the former homeland areas. It can also be seen from the figure that, at any income level, electrification in the old provinces is higher than in the former homeland areas, although it must be remembered that most of the households in the homelands are in the first and second income levels.

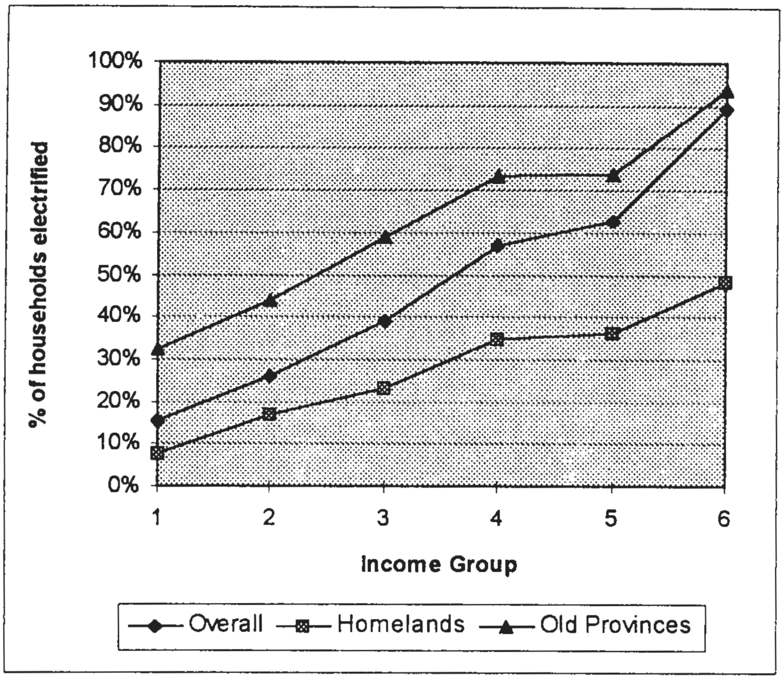

Figure 4-34: Percentage of electrified households in different income categories of overall South Africa, areas in the former homelands and the old provinces.
Source: Saldru data analysis

The gap between the electrification of the old provinces and that of the former homeland areas widens as income level increases. This indicates that the influence of household income on a household's access to electrification is less in the areas of the former homelands than in the areas of the old provinces. In the former homeland areas, the cost of electricity connection would be generally higher than the areas of the old provinces due to longer distances from the electricity grid. The quality of service in the homeland areas is also usually poor. Households in the homeland areas will thus consider these factors in their decisions concerning electrification.

4.8.2 Rural, urban and metropolitan areas

In Figure 4-35 it is shown that electrification in the rural areas of South Africa is far below that in the metropolitan or urban areas. Though 27% electrification of rural households shown in this figure is a little bit on the high side when compared with the 1995 figures by the NER (Du Plessis 1996), it is far below the over 60% and 80% electrification of urban and metropolitan households respectively. This is indicative of the levels of development in the rural and non-rural areas since electrification may lead to the establishment of other enterprises that depend on electricity.

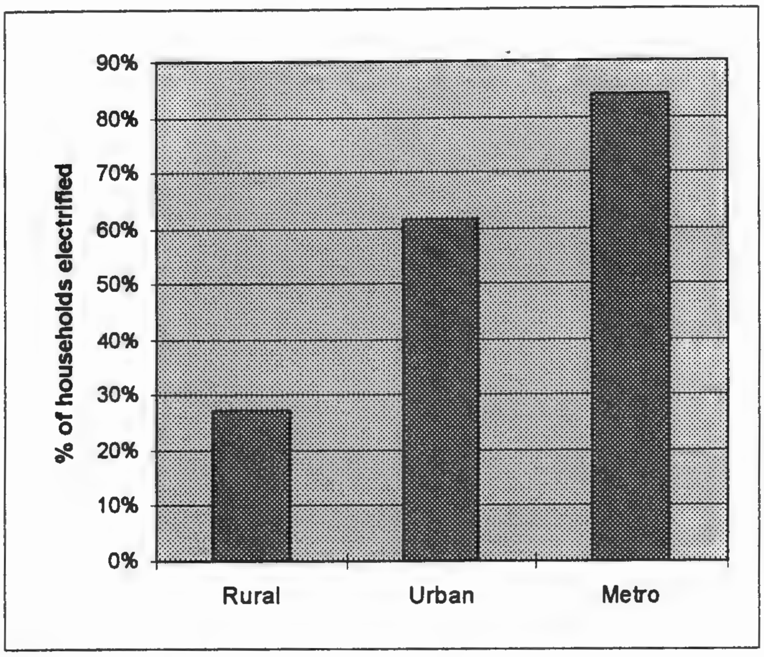

Figure 4-35: Percentage of households electrified in rural, urban and metropolitan areas of South Africa.
Source: Saldru data analysis

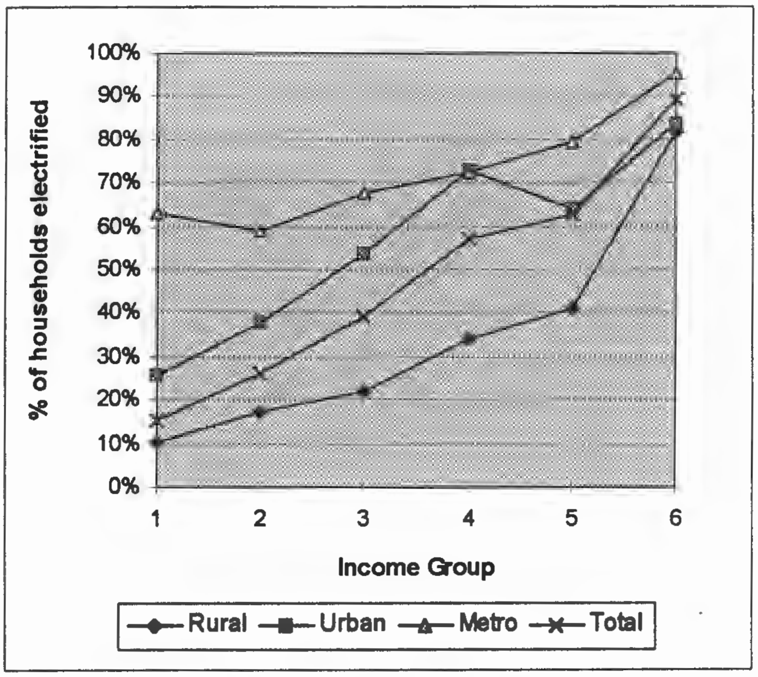

Figure 4-36: Percentage of electrified households in different income categories of rural, urban and metropolitan areas of South Africa.
Source: Saldru data analysis

Figure 4-36 shows the influence of household income on the extent of electrification in the rural, urban and metropolitan areas of South Africa. With the exception of income group 5 of the urban households, the figure seems to show that the higher the household income, the more likely households are to be electrified in the rural, urban or metropolitan areas.

For the non-rural households in the former homelands areas shown in Figure 4-37, the effect of household income on electrification seems to have a limit. It can be seen from the figure that electrification increases with household income level till the fourth income level. Beyond this income level, households who are able to afford other sources of energy like LPG may opt for such to avoid high electricity connection fees and poor level of service. Another reason why some high-income urban households in the homeland areas opt for other fuels rather than electrification of their households could be proximity to the distribution networks of these fuels. In such a situation location becomes more important. For rural households in the areas of the former homelands, however, electrification is higher only amongst high-income households since only those can probably afford the high connection costs.

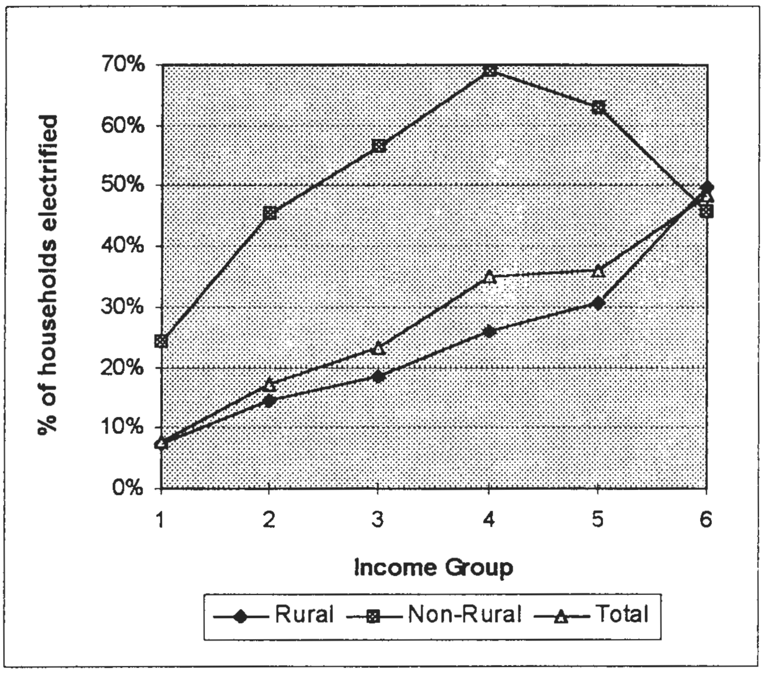

Figure 4-37: Percentage of electrified households in different income categories of rural and non-rural areas of the former homelands of South Africa.
Source: Saldru data analysis

4.8.3 Racial groupings

Figure 4-38 shows electrification of households amongst different population groups. It is amazing to notice how electrification of the households of certain population groups has been used as a form of advantage over other population groups. Whilst almost all White households are electrified, only about 35% of the African households are electrified. The electrification of Indian households is also shown here to be almost 100% but one cannot be sure about this since the sample size for the

Indian people was relatively small. Amongst the Coloured households, over 80% are electrified. It is therefore clear that, in the past, government policy was shaped in such a way that Blacks, especially African people, would be denied access to electricity as a means of undermining their progress as a people.

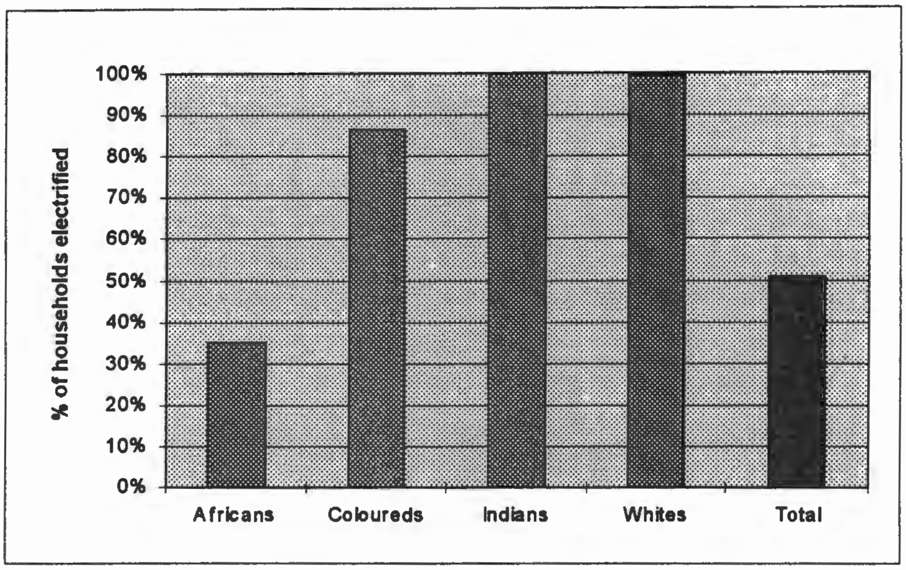

Figure 4-38: Percentage of electrified households amongst different racial groupings in South Africa
Source: Saldru data analysis

In this way, majority of Black people indirectly suffered oppression of untold measures. Due to lack of electricity for lighting, audio-visual equipment and computers, they have received poor quality education over the years. Their women in the rural areas have to spend many hours every week collecting firewood. Health services amongst the Black community have been grossly inadequate due to lack of adequate sterilisation equipment and cold storage of medicine and food. Income generating activities like welding, baking and sewing usually linked to electrification have been denied them. This observation goes to refute the paradigm of "modernisation" which underlies the "energy transition" theory. The fact that almost half of the South African households do not have access to electricity is not a natural state of underdevelopment as the theory postulates, neither is it a true reflection of the people's genuine choices. Rather, it was a calculated attempt by the prevailing political system to dehumanise a specific section of the population.

Figure 4-39 shows the effect of household income on electrification of households amongst different racial groupings. For the White households, the income groups 1 to 5 shown on the graph mean very little since about 95% of White households are in income group 6. It can therefore be said that, for the White and the Indian households, the level of household income does not seem to have any meaningful influence on electrification. For the Coloured households, the extent of electrification of households increases with household income level but only at a very slow rate. However, amongst the African population group, which constitutes three-quarters of the total population, household income seems to be one of the main criteria for determining whether a household should gain access to electricity or not.

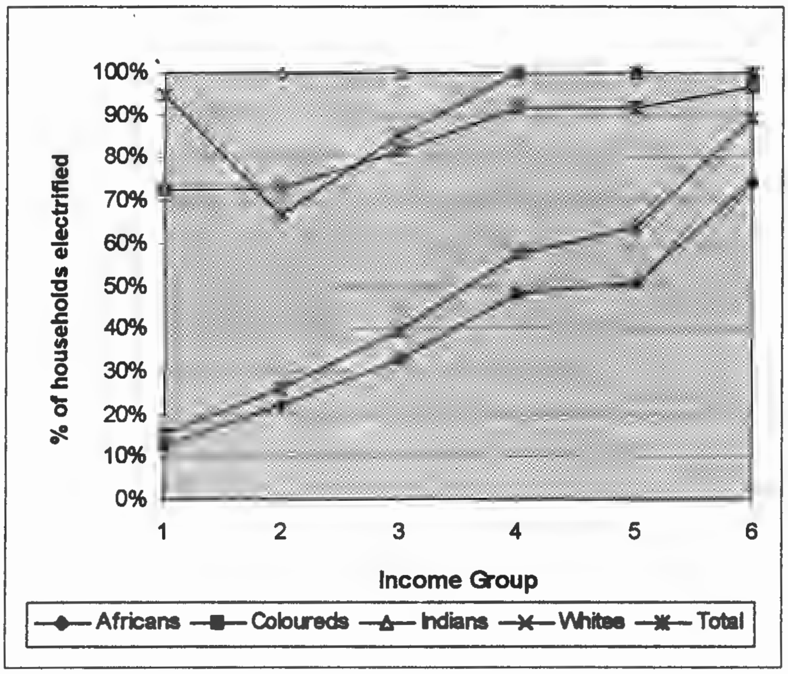

Figure 4-39: Percentage of electrified households in different income categories amongst different racial groupings in South Africa
Source: Saldru data analysis

4.9 Expenditure on individual fuels in the household

Although the prices of fuels in different parts of the country may differ slightly from one another, the average monthly household expenditure on individual fuels presented in Figure 4-40 gives some indication of how intensively the particular fuels are used in the household. In the case of wood, it must be pointed out that what is presented in the figure below may not be the complete picture since not all the fuelwood used in the households is purchased at some monetary value. In actual fact, it can be verified from Figures 4-11 and 4-49 that over 70% of the 36% of South African households who use wood for fuel do not buy the wood but collect it from the farm or natural woodlands. The actual cost of the wood collected is not included in the expenditure on wood presented in the figure below. The expenditure on wood presented below is only the average for the 10% South African households who purchase wood for fuel.

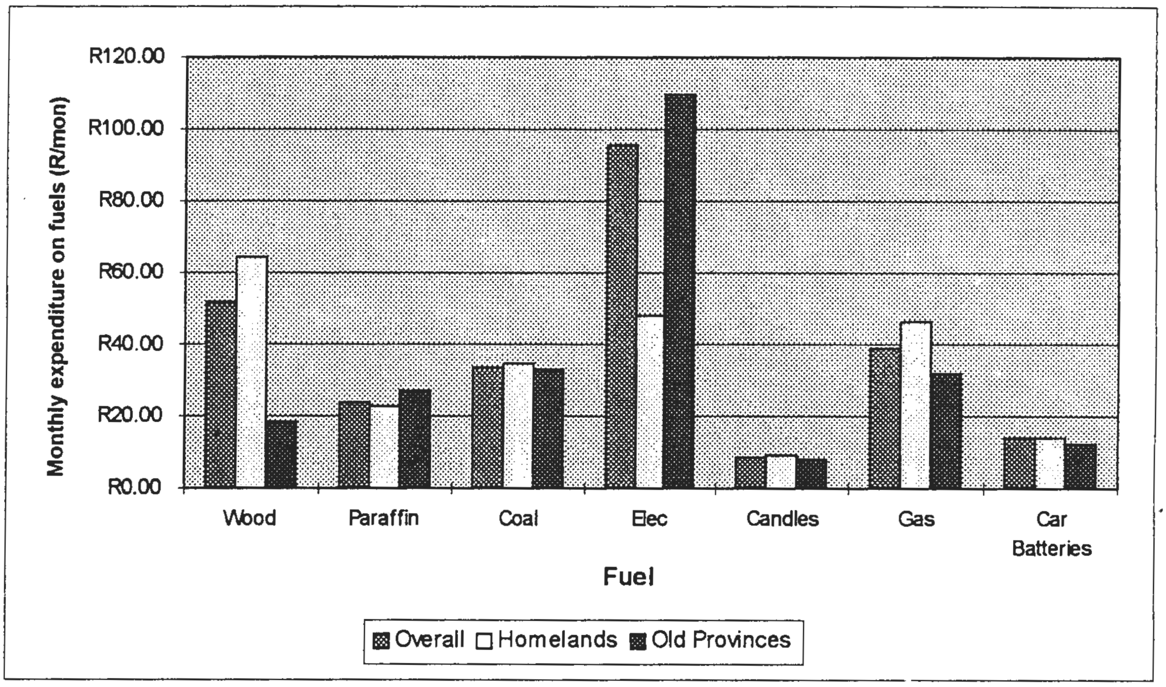

Figure 4-40: Average monthly household expenditure on individual fuels in overall South Africa, the former homeland areas and the former provinces.
Source: Saldru data analysis

On average, each household that purchases wood for fuel spends over 1993 R50 per month on wood purchase[1]. Apart from electricity, it appears like the amount spent on fuelwood by households exceeds that which households spend on any other fuel. Thus the use of fuelwood does

[1] All the expenditure values in this chapter are in 1993 South African Rand value. Consumer Price Indices (CPI) can be used to convert these expenditures to present worth values.

not only have adverse effects on the environment, it is also expensive if it has to be purchased. Even for those households who do not buy their fuelwood, the labour and other costs involved in the fuelwood collection can rob families of their meaningful social life and development, especially women and children. However, it must be accepted that wood gathering exercise is a social event in some cases and the positive social aspects of it must not be overlooked.

Comparing the monthly household expenditure on fuelwood in the areas of the old provinces and the former homeland areas, it can be seen that not only is wood used more extensively in the former homeland areas than in the areas of the old provinces (see Figure 4-11) but also it is used more intensively in the homeland areas than in the areas of the old provinces. Whilst households in the homeland areas spend over R60 monthly on fuelwood, those in the areas of the old provinces spend less than R20 monthly. The difference here may not be completely due to how intensively the fuel is used, but also due to differences in the availability of fuelwood. Wood usage in the old provinces is probably mostly on farms and given free. Wood resources are very much related to land availability but most of the homeland households have been severely marginalised in terms of land resources. Scarcity of wood resources might have been contributing to the higher fuelwood expenditure in the homeland areas.

Although paraffin, candles and car batteries are used more extensively amongst households in the former homeland areas than in the areas of the former provinces (see Figure 4-11), it appears from Figure 4-40 that there is not much difference between households in the former homeland areas and those in the areas of the old provinces concerning how intensively paraffin, coal, candles and car batteries are used. This seems to suggest that there is some limited amount of each of these fuels required for the survival of household users irrespective of their location (Williams A 1994:14). Average monthly expenditures by household users of paraffin, coal, candles and car batteries are R24, R34, R9 and R14 respectively. For users of car batteries this is primarily the amount spent on battery charging.

For liquefied petroleum gas (LPG) household users spend about R40 per month on average. Users in the areas of the old provinces spend about R10 less than that spent by those in the former homeland areas. The difference in expenditure could be largely due to the poorer distribution network in the homeland areas and the consequent higher prices.

It can be seen from the above figure that, on average, households who use electricity spend about R96 per month on electricity. It is striking that one finds expenditure on electricity to be very high when it is compared with the other fuels. One reason for this apparent high expenditure on electricity is that about half of electricity users are single fuel users (see Figure 4-18) whilst users of other fuels are often multiple fuel users. However, when the cost of multiple fuel use is taken into consideration, expenditure on electricity is still very high. Electricity is not only more extensively used amongst the households in the areas of the old provinces than in the former homeland areas, but it is also intensively used in the areas of the old provinces than the former homeland areas. Whilst households in the areas of the old provinces spend about R110 per month on electricity on the average, those in the former homeland areas spend less than half of that amount on electricity. The poor quality of service, the affordability of the service and of the purchase of appliances could be some of the main reasons for low electricity consumption in the homeland areas.

4.9.1 Effect of household income on expenditure on individual fuels

Figure 4-41 shows the effect of household income on the household expenditure on the various fuels in South Africa. In general, it can be seen from the figure that, apart from electricity and fuelwood, household income does not seem to have appreciable influence on the expenditure on the individual fuels. In other words, expenditure on fuels other than electricity is income inelastic, although fuelwood shows some minor elasticity towards income up to income level 4.

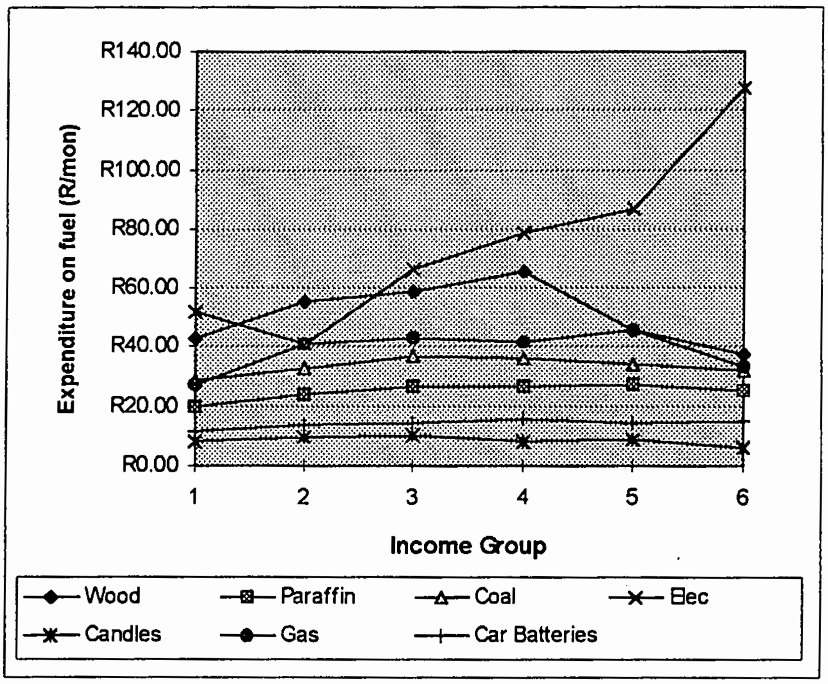

Figure 4-41: Average monthly expenditure on individual fuels by households in different income groups in South Africa.
Source: Saldru data analysis

For households up to the fourth income level, fuelwood users are able to afford to spend a little bit more on wood purchase as their income increases, even though the number of households using wood generally decreases with household income (see Figure 4-14). Beyond the fourth income group, households seem to prefer to either shift completely or partially to other fuels, or spend less on fuelwood and more on other fuels like electricity.

Households do not only tend to shift from other fuels to electricity (see Figure 4-14) as their incomes improve but also they tend to spend more on electricity. Average monthly electricity consumption increases from about R40 in income group 2 to about R130 in income group 6. The drop in electricity expenditure from income group 1 to 2 is a bit odd. In general, it appears that the more income the households receive, the more they are able to afford the service and the purchase of more appliances. It is, however, not known whether increase in household income does not eventually lead to extravagant use of electricity that could create unnecessary load on electricity generation plants.

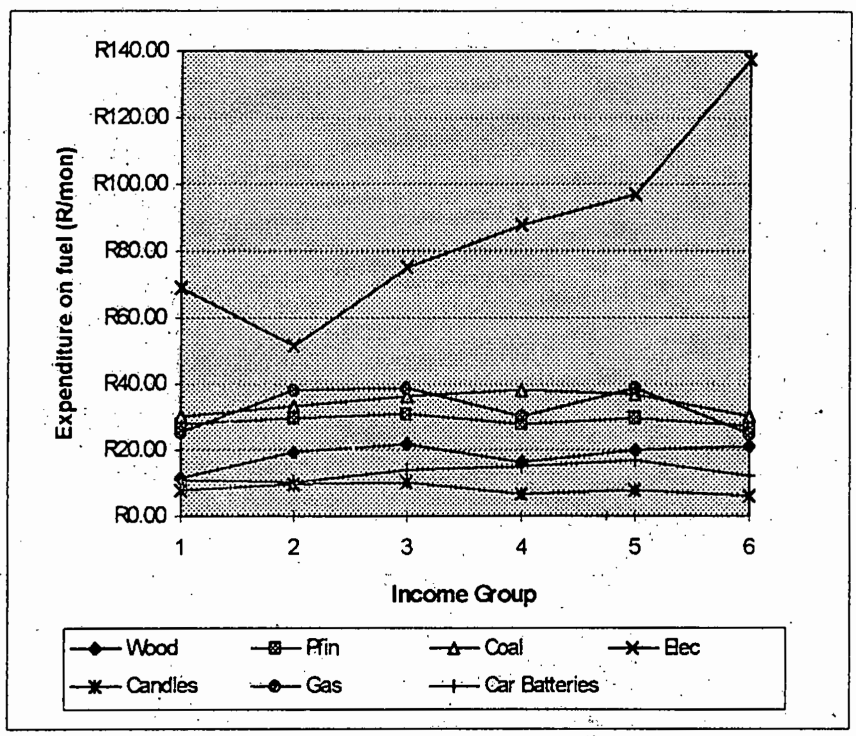

Figure 4-42: Average monthly expenditure on individual fuels by non-rural households in different income groups in South Africa.
Source: Saldru data analysis

Figure 4-42 shows that, in the non-rural areas of South Africa (including metropolitan areas), household income does not appear to have any influence on the amount of money spent by households on any of the fuels, the only exception being electricity. This seems to suggest that households, irrespective of their income, would always find strategies of acquiring the required amount of fuels for their survival, except for electricity. In the case of electricity the consumption by households is heavily limited by their income.

On the other hand, Figure 4-43 shows that, in the rural areas of South Africa, expenditure on (or in other words, consumption of) electricity, LPG and fuelwood are all influenced by household income.

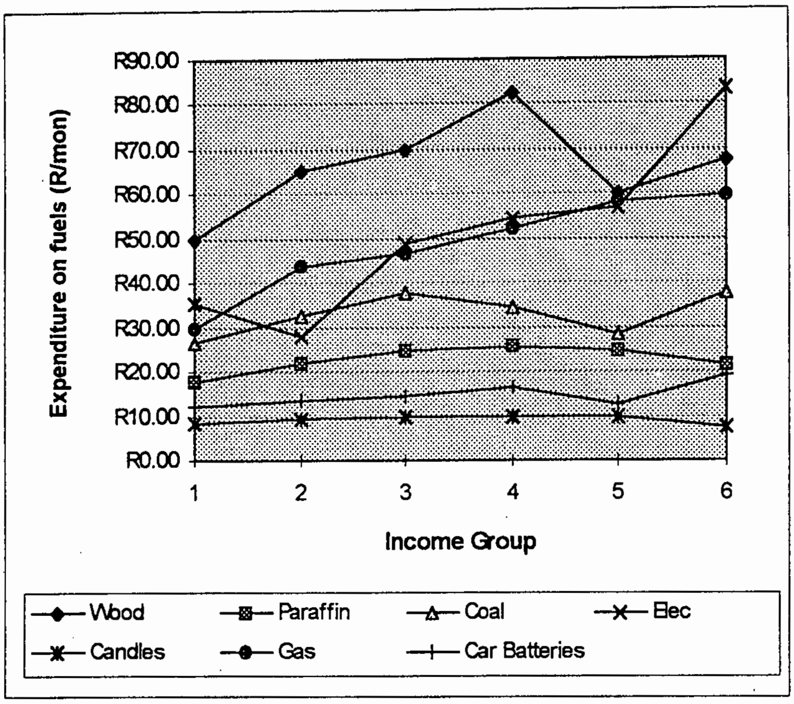

Figure 4-43: Average monthly expenditure on individual fuels by rural households in different income groups in South Africa.
Source: Saldru data analysis

In general, as household income improves, households are able to afford to spend more on electricity or LPG. Wood consumption also increases with household income but beyond the fourth income group households tend to either lower their consumption or shift to other fuels (see Figure 4-15).

4.10 Total household expenditure on fuels

4.10.1 Overall South Africa

Section 4-7 details the widespread multiple fuel use phenomenon in South Africa. In such an extensive multiple fuel use situation, expenditure on individual fuels which is discussed in the preceding section does not give a clear picture of the total household expenditure on fuels. Figure 4-44 presents a total picture of the variation of average total monthly household expenditure on fuels with household income for overall South Africa.

The figure shows a general increase in average household total expenditure on fuels as household income improves. At the same time, it also depicts that as household income improves, the lower the percentage of the total household expenditure spent on fuels. This paints an impression that lower income households might be feeling the pinch of their expenditure on fuels more than the higher income households might.

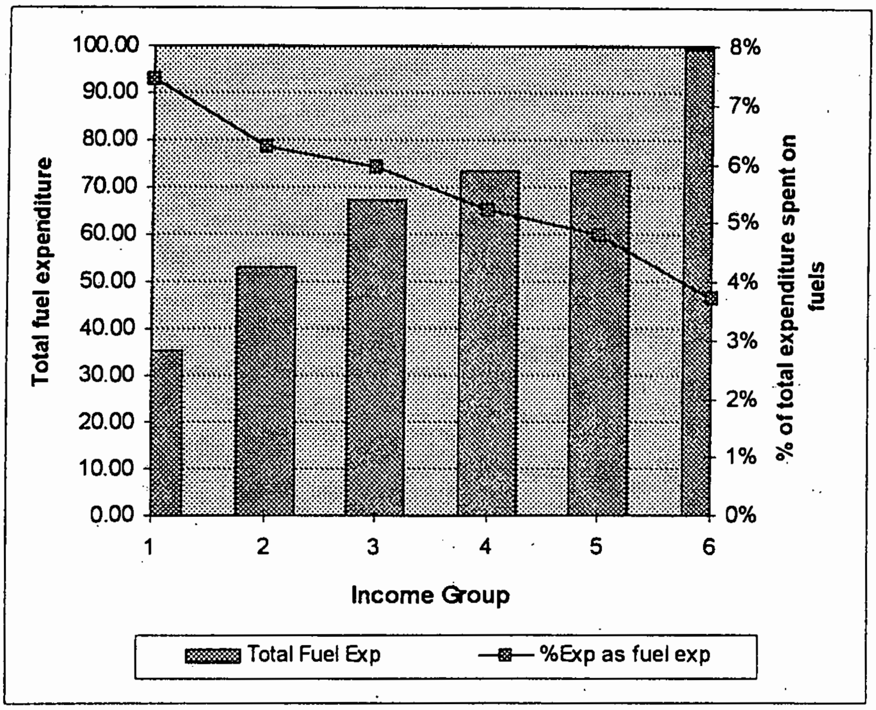

Figure 4-44: Average total monthly fuel expenditure by households in different income groups in South Africa compared with total monthly expenditure
Source: Saldru data analysis

4.10.2 Racial groupings

Energy use in South Africa is not only skewed amongst the different racial groups in terms of access to energy resources but also in terms of how intensively the energy is used in the households. Figure 4-45 shows a vivid illustration of the skewness of energy consumption amongst different racial groups in South Africa. The figure shows that White households spend more on energy in their homes than all the other races.

This is followed by the Indian and Coloured households respectivefully with African households spending the least amount on energy. Whilst White households spend an average of about R164 per month on energy in the home, the Indian, Coloured and African households spend about R148, R106 and R55 per month respectively in the home. This is in spite of the fact that African, Coloured and the Indian households are generally larger in numbers than White households (see Section 4.5.2). The differences in energy expenditure amongst the different races are not likely to be due to mere differences in prices at which the different racial groupings purchase their fuels. This is because it can be argued that the most remote areas in the country where prices are likely to be higher due to lack of access to the fuels, are inhabited by Africans more than any other racial group.

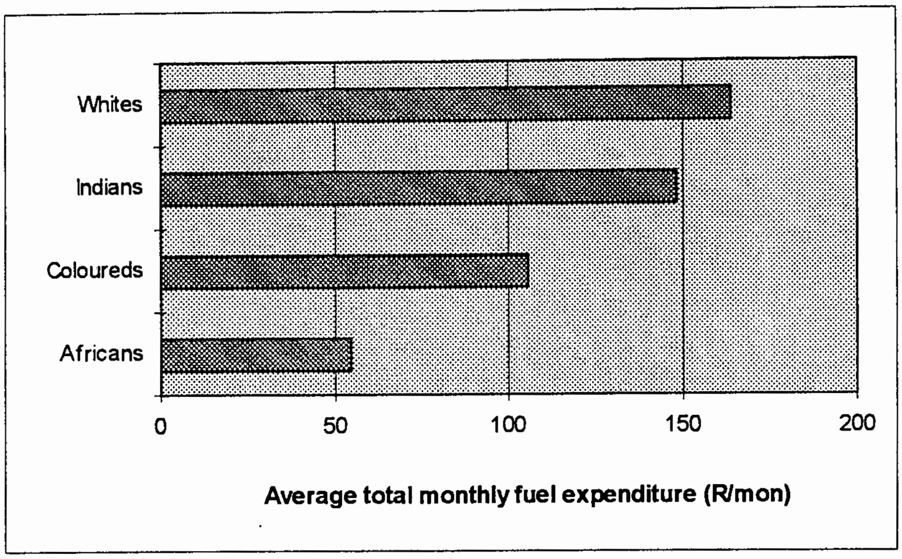

Figure 4-45: Average total monthly household fuel expenditure by different population groups in South Africa
Source: Saldru data analysis

One probable explanation for the different expenditures by the different racial groups could be that the different fuels are not used by the different racial groups to the same extent. Figure 4-38 shows that almost all White and Indian households are electrified whilst about 85% and 35% of Coloured and African households respectively are electrified. It follows that whilst the White and Indian households are largely dependent on electricity, African households are mostly dependent on other fuels like paraffin, coal and wood. But in Figure 4-41, household expenditure on electricity in the high-income groups is shown to be very high compared with the other fuels. Since White households, and to some extent Indian households, are mostly in the higher income groups, it is not very surprising that their total expenditure on energy in the home is that much higher.

Figure 4-46 depicts the variation of total energy expenditure with household income amongst the different racial groupings. The Indian and White households do not have relevant data for the first 2 and 3 income groups respectively since data on those income groups.is scanty.

For the White households no clear relation is seen between the two variables (household income and energy expenditure) and, perhaps, the appropriate relationship lies beyond the analysis here since most of the households are in the income group 6. For the Indian and Coloured households, the average total expenditure on fuels generally increases as household income improves. The households tend to spend more on energy as they become empowered with more income. In the case of the African households, they tend to spend more on energy as their income improves but only up to the fourth income group. Beyond the fourth income group African households tend to spend a little less on energy. This might be due to the fact that, beyond income group 4, expenditure on (or rather consumption of) wood by households usually falls (Figure 4-41) and shifts to other fuels. In the case of African households, this energy consumption shift is not largely towards electricity due to the lack of access to electricity.

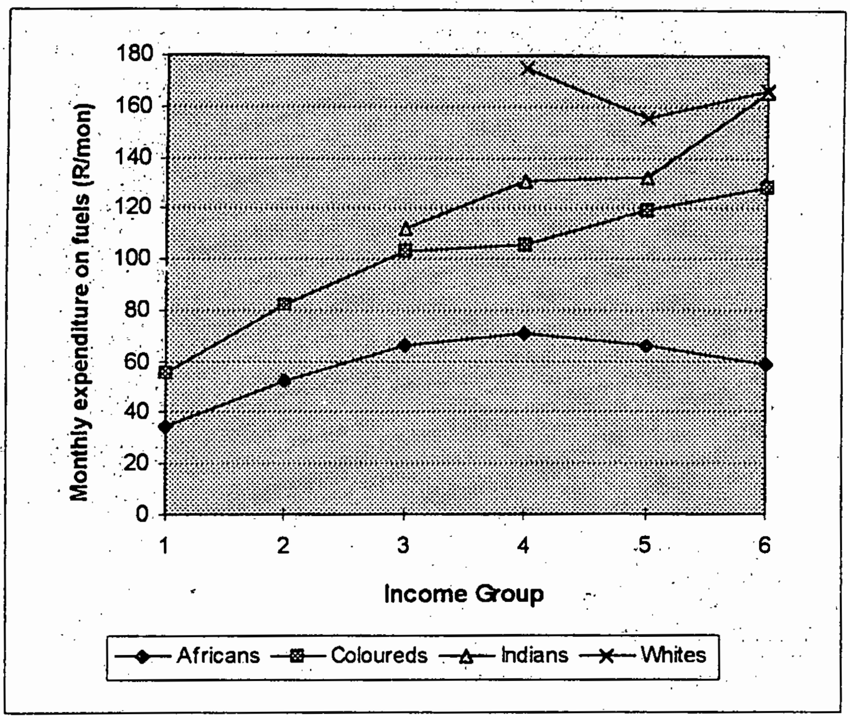

Figure 4-46: Average monthly fuel expenditure by households in different income groups of different racial groups in South Africa
Source: Saldru data analysis.

4.10.3 Rural and non-rural areas

There is also a big gap between the consumption of energy by rural households and that of the non-rural or urban areas. Figure 4-47 shows that the average energy expenditure by households in rural areas is just a little over half of the amount of money that households in urban areas spend on energy. There may be two main reasons for this. First, rural households generally have incomes lower than those of urban households. Second, the cost of wood collected from the farm and natural woodlands for fuelwood is usually not accounted for in the household expenditure.

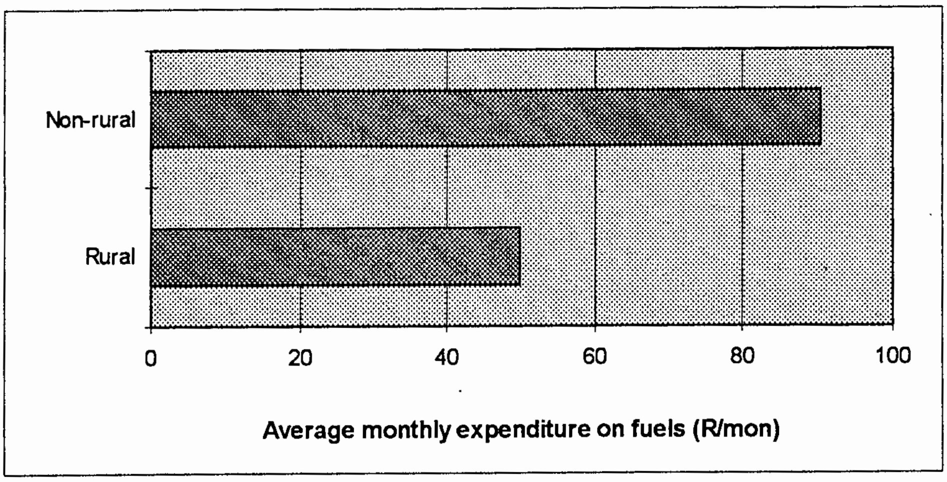

Figure 4-47: Average total monthly fuel expenditure by rural and non-rural households of South Africa
Source: Saldru data analysis

4.10.4 Electrified and non-electrified households

It is widely believed that electrification of households will bring a much awaited relief to many households in terms of lower expenditure on energy in the home. The promise of electrification has therefore become politically expedient means of providing hope for the previously marginalised communities. There is obviously little doubt about the many advantages of electricity over the other household fuels in terms of convenience of use, versatility, safety, and so on. However, the cheapness of electricity compared with the other household fuels is debatable. The analysis of the Saldru data reveals a totally different picture as depicted in Figure 4-48.

First, as can be seen from the figure, in every income group, electrified households spend more on energy than non-electrified households do. Second, whilst energy expenditure by electrified households generally increases with household income, that by non-electrified households increases with income only up to the fourth income group and then stays almost constant. This explains why it has not been prudent for many low-income households to use electricity intensively after they have been connected. Besides the expensive nature of the service, households have to pay for high connection fees as well as purchase different costly appliances for almost every end use. For some other fuels, a cheaper appliance may be sufficient for multiple end uses for a poor household. For example, paraffin stove, which is invariably cheaper than electric stove in general could be used for cooking as well as for space heating and ironing[2]. The affordability of the electricity supply service should be looked at more carefully otherwise the cost involved in extending the grid to many households may be wasted if households cannot afford to use the service. It is worth mentioning

[2] Paraffin ironing is done by heating the solid ironing appliance on paraffin stove.

that Eskom, the main utility, has found a way around this by incorporating the electricity connection fee into the tarrif structure in order to avoid high upfront costs by consumers.

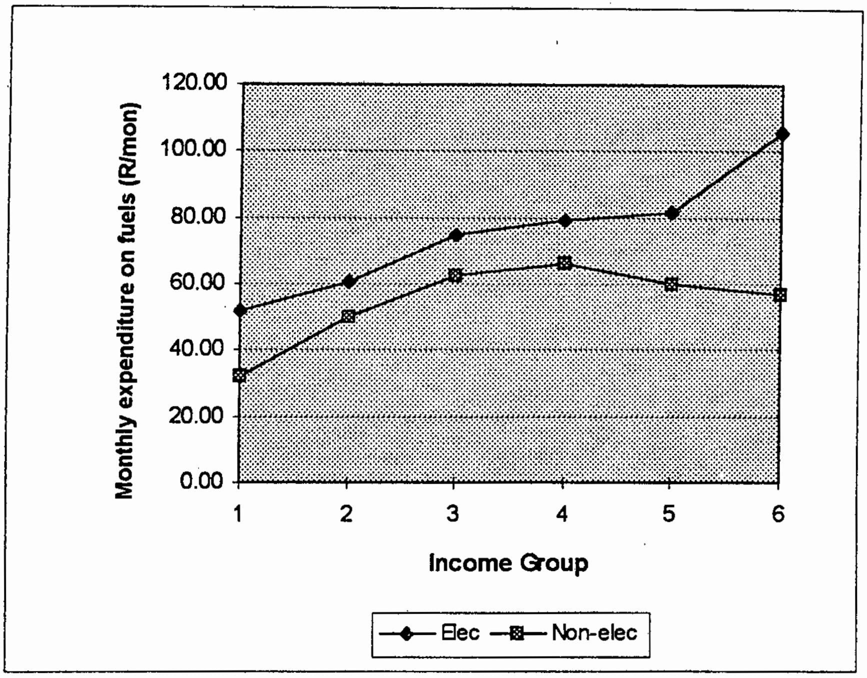

Figure 4-48: Average household expenditure spent on fuels in different income groups of electrified and non-electrified households in South Africa
Source: Saldru data analysis

4.11 Wood collection

As mentioned in Section 4.9, most of the households in South Africa who use wood for fuel usually collect them from farms or natural woodlands. Therefore, the actual value of fuelwood used does not reflect in the household expenditure on energy. In Figure 4-49 it is shown that over 25% of South African households collect all or part of their wood from available sources without buying it. Wood collection is more prevalent in the former homeland areas than in the areas of the former provinces. Whilst about 50% of the households in the former homeland areas are involved in wood collection, only about 8% in the areas of the old provinces collect their wood.

Although no monetary value is usually attributed to fuelwood that is collected from the bush, the social cost involved can be enormous. Wood collection is usually a chore performed by women and children, which means that other essential activities of those women and children are severely hampered since wood collection often consumes a lot of time. According to Best (1979: 71) women in African villages spend a long time collecting wood, averaging up to 15 hours a week, a chore that hardly exists for an urban housewife. There is physical hardship of collecting and carrying the bundle of wood, which causes pain in the heads, necks and shoulders.

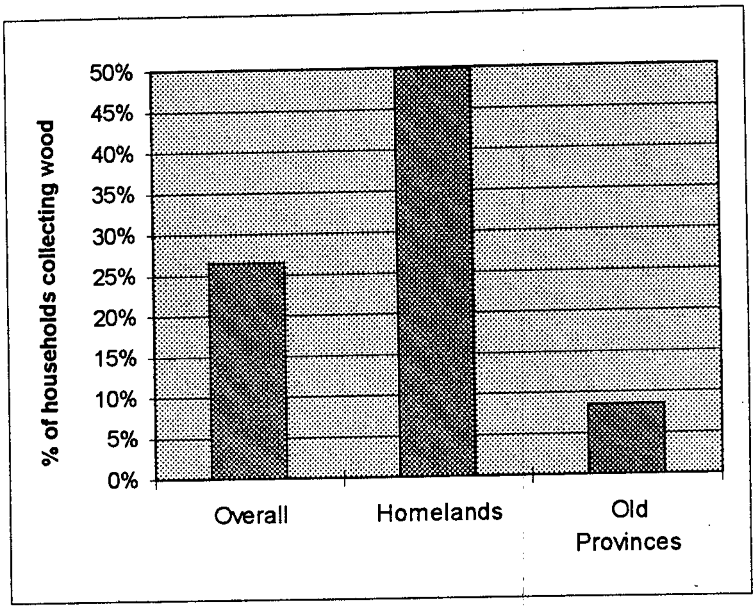

Figure 4-49: Percentage of households collecting wood in South Africa
Source: Saldru data analysis

Figure 4-50 illustrates that fuelwood collection is mainly a low-income household affair. Households tend to stop collecting wood as their income improves. For the households in the areas of the former homelands, the percentage of households collecting wood drops from over 75% at the lowest income level to about 10% in the highest income level. This shows how people's dependence on wood as a fuel could probably be reduced enormously as they are provided with income generation opportunities. In this way, environmental degradation resulting from wood denudation is also reduced.

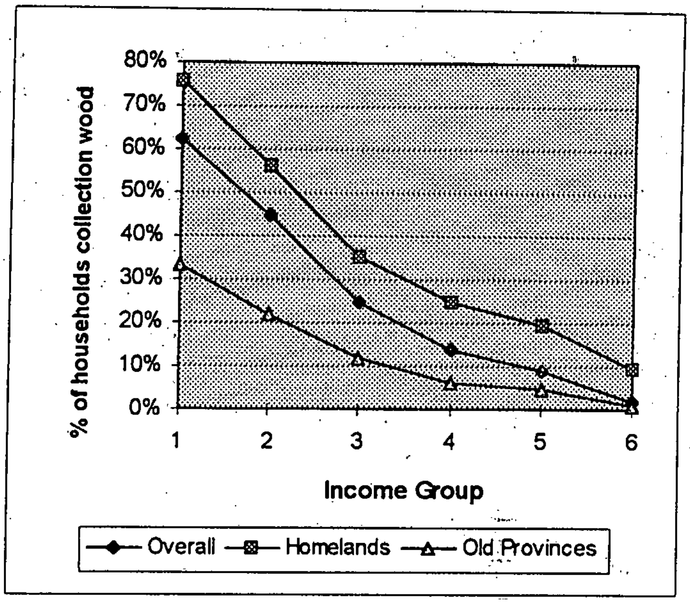

Figure 4-50: Percentage of households collecting wood in different income groups of South Africa
Source: Saldru data analysis

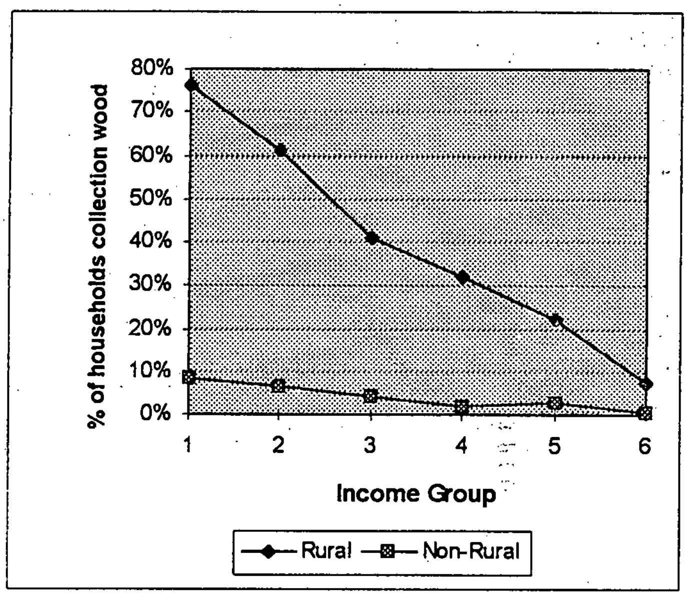

Figure 4-51: Percentage of rural and non-rural households collecting wood in different income groups of South Africa
Source: Saldru data analysis

Figure 4-51 also depicts that wood collection is not only mainly low-income household affair but also largely a rural activity. Whilst wood collection is below 10% even in the lowest income households in the urban areas, the activity is common amongst over 70% in the lowest income households of the rural areas and drops below 10% in the highest income group in the rural areas.

4.12 Energy end uses in different climatic zones

The energy required for specific purposes could differ from place to place depending on the climatic conditions. The dwelling type inhabited by a household can also influence the energy required for a specific end use. However, as mentioned in the introduction of this chapter, the primary data set (i.e. the Saldru data set) does not have useful representation of dwelling types. Thus, for the purposes of the energy demand projections in Chapters 5 and 6, end-use and appliance usage data have been extracted from the secondary data component of the database (i.e. the NDEUD[1] system) instead of the primary data. The extracted data at the provincial level has been aggregated into the 5 dwelling types classified in Section 2.7. It is then further aggregated into the three basic climatic zones classified in Section 2.6 as *temperate, hot-humid* and *hot-dry* zones. It must be noted though that the resultant end-use data is a reflection of only the low-income households since the studies in the NDEUD cover only low-income households at this stage. The energy demand projections from this source of data is therefore only for the low-income households. The low-income households in the NDEUD are roughly equivalent to the first three income groups in the Saldru data set.

4.12.1 Status of energy end-use and appliance data in the secondary data set

In the NDEUD, there are quite a number of fields covering domestic energy end uses and appliance ownership or usage. However, for the purposes of the energy demand projections, the discussion in this section is limited to only 5 basic end uses in the low-income households, namely: *cooking, lighting, space heating, water heating* and *refrigeration*. The fuels whose end uses are discussed are electricity, wood, paraffin, liquefied petroleum gas (LPG) and coal. In cases where data has not been categorised into end uses, it is sometimes possible to organise appliance usage or ownership data into end uses depending on the type of appliances used. For example, a refrigerator is matched with *refrigeration* services and an electric stove with *cooking* services.

[1] *NDEUD* stands for the secondary data set in the National Domestic Energy Use Database whilst Saldru data set constitutes the primary data set. These data sets have been described in Chapter 3.

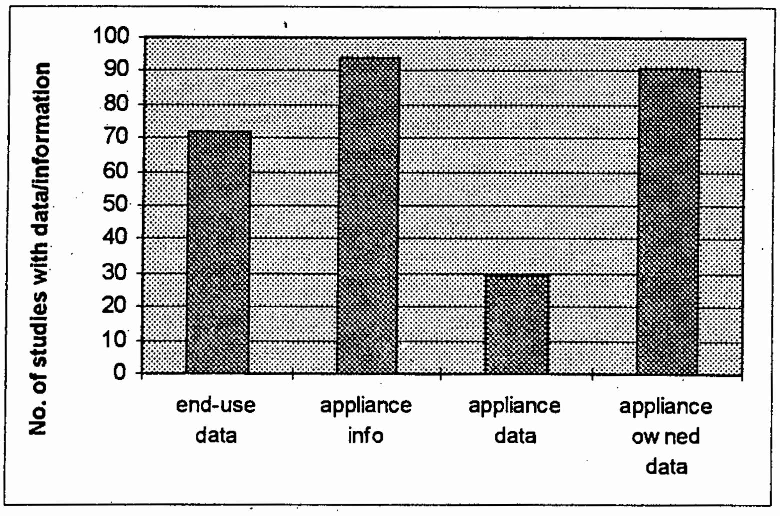

Figure 4-52: Status of end-use and appliance data in the secondary data set component of the energy database

Figure 4-52 shows the number of studies that have energy end-use or appliance usage data in the secondary data set component of the NDEUD system. The data types in the above figure are explained as follows:

end-use data: quantitative data on the percentage of households staying in a particular dwelling type in a specific geographic location using a specific type of fuel for a specific end use;

appliance info: qualitative general information on appliance usage or ownership;

appliance data: quantitative data on appliance usage - percentage of households using a particular appliance;

appliance owned data: quantitative data on appliance ownership.

The figure shows that end-use data in the NDEUD system is scanty compared with the other categories of data in the system. Out of the about 500 studies captured into the system, just only 72 of them have end-use data. The data on appliance usage is used to improve the end-use data as explained earlier on. The aggregated end-use data for the three broad climatic zones gives an indication of who is using which fuels for specific purposes and under what conditions. The aggregated end-use data for the three climatic zones, the five household dwelling types, the five end-uses, and the five fuels have been graphically depicted in Figures 4-53 to 4-57.

4.12.2 Cooking

It can be seen from Figure 4-53 that most of the low-income households do not cook with electricity. This seems to be the general situation in all the three climatic zones and this could be due to the question of affordability and/or the lack of access to electricity and adequate quality of services. It could be said further from Figure 4-53 that the more formalised the dwelling type in each climatic region, the more households tend to use electricity for cooking. The reason could be that the more formalised dwelling types have better access to electricity. However, it is important to bear in mind the complexity of making fuel choices for various end uses in the household.

Extensive wood usage for cooking in all the zones is very striking. Wood appears to be used widely for cooking in all three climatic zones. This shows the important role which fuelwood, and therefore its collection, plays in the socio-economic life of low-income households, if the time spent by mostly women and children in the collection of fuelwood is taken into consideration. Wood usage for cooking is extremely high in the hot-dry climatic zone among all dwelling types although the over 80% usage indicated seems to be on the high side. Across the climatic zones, backyard shacks seem to be involved in wood use more than the other housing types. Rural households also use wood extensively for cooking in the temperate and hot-dry zones but surprisingly, less wood use is indicated in the hot-humid zone.

Paraffin is also an important fuel for cooking among low-income households. In the temperate and hot-humid zones, paraffin usage for cooking is very prominent among the planned and unplanned shacks, with over 70% of households using it. In the hot-dry climate, paraffin usage for cooking is lower, at around 40% of all housing types except for planned shacks, where its use is higher at about 75%.

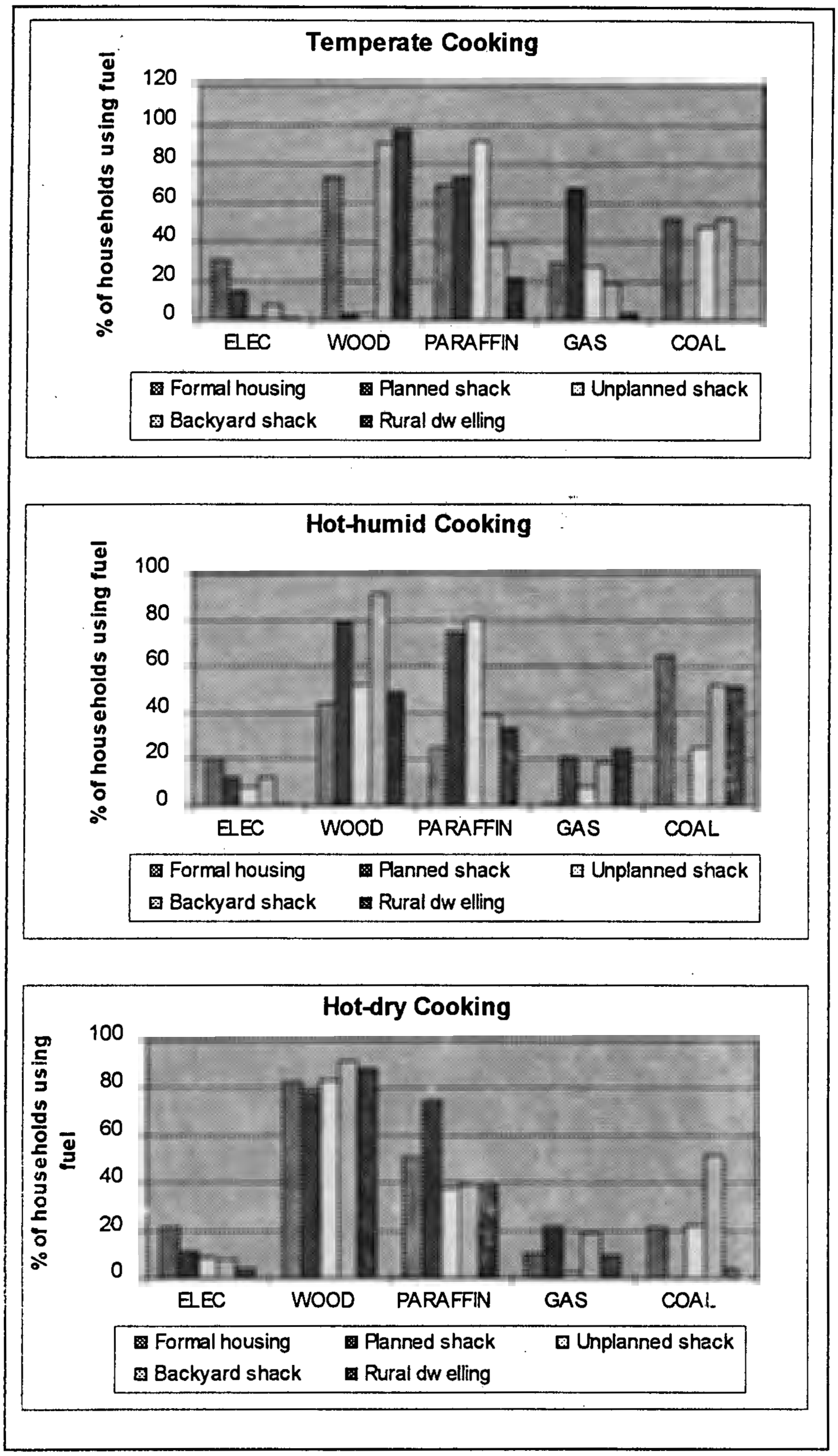

Figure 4-53: Percentage of households using fuels for cooking in the 3 broad climatic zones
Source: NDEUD data set

Liquid petroleum gas (LPG) does not seem to be an important fuel for cooking except for planned shacks in the temperate climate where over 60% of households are reported to use it. This might even be too high taken into consideration the low LPG use amongst the lower income groups of the Saldru data set

Coal usage for cooking in the temperate and the hot-humid zones seems very similar. In the two zones, about 50% of households in formal and unplanned shacks use coal for cooking. The decrease in coal use for cooking in the hot-dry zone might be due to relative inaccessibility of the resource and its resultant high price.

4.12.3 Space heating

From Figure 4-54 it can be seen that electricity usage for space heating is very similar to cooking in all the climatic zones and among the different dwelling. Among rural households, wood is the fuel most commonly used for space heating, with a range of 70% to 90% of households using it. In the hot-dry zone, wood seems to be important for space heating in the urban dwelling types but it is very low in other climatic zones. Paraffin usage for space heating is prominent only in the urban planned and unplanned shacks in the temperate and hot-humid zones. The percentage of households using LPG is below 10% in all cases.

Surprisingly, the data shows that coal is used by a relatively low percentage of households in all three zones, with the exceptions only of formal houses and rural dwellingss in the hot-humid zone. In general, coal use in the household is not so high as shown by the Saldru data set (see Figure 4-11). However, the low percentage usage for cooking shown here does not seem consistent with the known situation where coal is widely used in many households in the Gauteng province, which falls into the temperate zone.

Three reasons may exist for the low coal use for space heating shown here. First, while coal use is reported to be low for space heating, it is more widely used for *cooking* purposes (refer to Figure 4-53) with about 50% of low-income households in some dwelling types using coal. The low coal usage for space heating may therefore be attributable to a classification problem: surveys often fail to account for the *multiple services* provided by coal stoves, namely that they are often used simultaneously for cooking as well as space and water heating. This is an important point that underlies the need for household surveys to consider the *energy services* which different energy sources fulfil. The second reason for the surprisingly low levels of coal use in the temperate zone, is that there are very different conditions within the zone regarding the availability and cost of coal resources. In other words, there is a divergence between climatic conditions and resource availability. In the Western Cape, which largely falls within the temperate zone, for instance, coal is relatively expensive compared to other sources of fuel because of the high costs of transporting it from the coalfields and so few households use it for heating. Consequently the average percentage for the temperate zone is lower. Another reason could be that some of the data might have come from summer surveys, thus introducing a seasonal bias to the results.

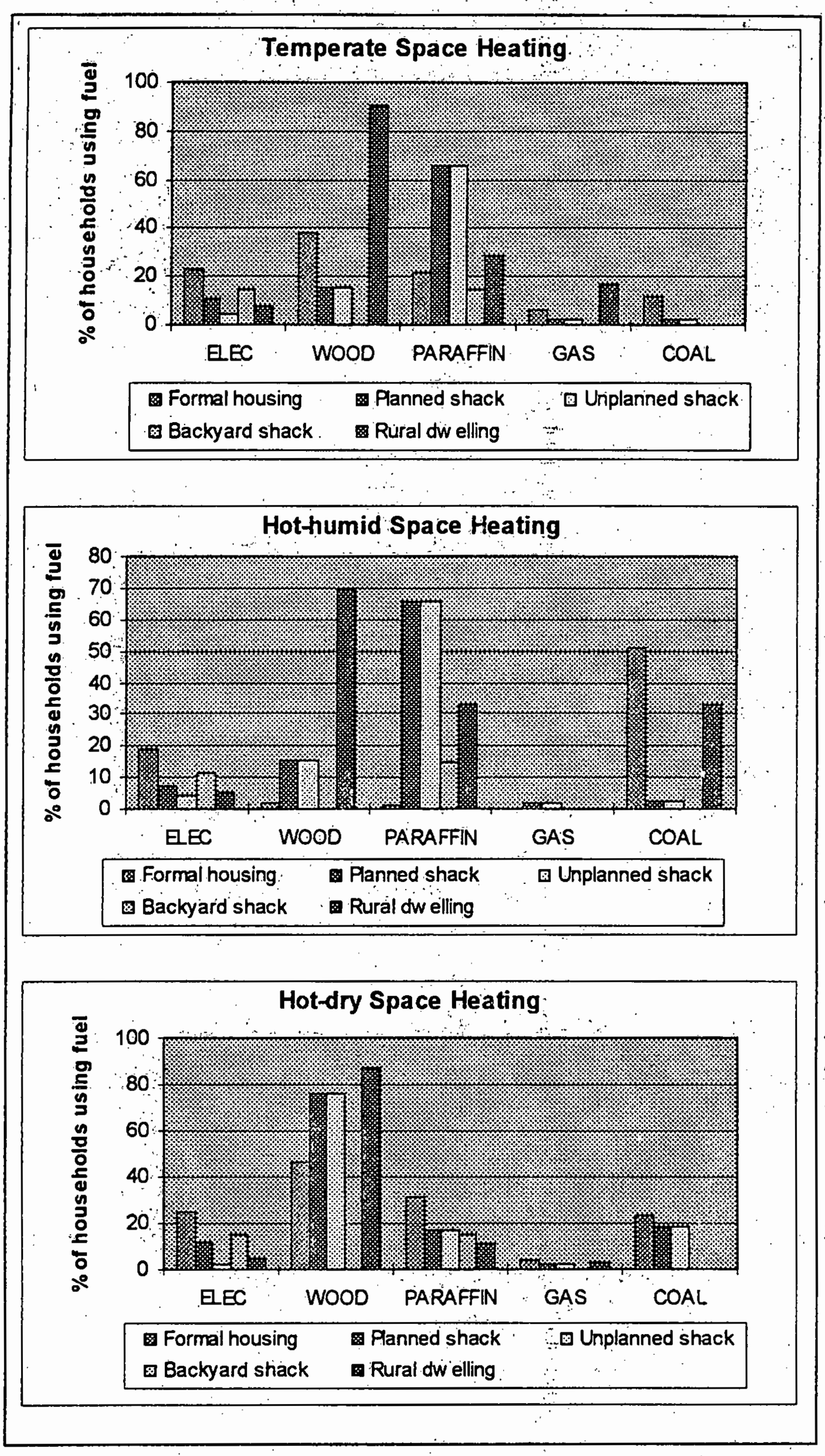

Figure 4-54: Percentage of households using fuels for space heating in the three climatic zones.
Source: NDEUD data set

4.12.4 Water heating

Wood and paraffin are the most common sources of energy among low-income households in the case of water heating. Figure 4-55 shows the percentage of households using the five fuels for space heating in the three broad climatic zones. On average, about 50% of households in all dwelling types and at least 80% of rural dwellers use wood for water heating. In all climatic zones, wood usage for water heating drops in the formal housing category, while electricity usage increases, probably as many formal houses have electric water geysers installed. Coal use for water heating does not exceed 20% except for the rural dwellings in the hot-dry climatic zone. Again, this coal use figure may be low, especially for the temperate zone where many households are known to use coal for cooking. The same explanations as were given in Section 4.12.3 above for space heating probably apply to water heating.

In general, the mix of energy sources used for water heating does not differ widely between climatic zones; importantly, however, this does not suggest that the *quantity* of energy consumed is the same in each zone. Chapter Five addresses the absolute amounts of energy consumed.

4.12.5 Lighting

The basic fuels used for lighting in the low-income households are paraffin, candles, electricity and, to a small extent, LPG. Paraffin and candles are the most common fuels for lighting. At least 70% of rural households use paraffin for lighting except in the hot-dry zone where only about 40% is indicated. The zero candle usage indicated on Figure 4-56 for some dwelling types is not really the case. Rather, it is an indication of data gaps in the case of candle use, since most surveys ignore candles as one of the basic fuels for low-income households. Where data is available there is a high indication of candle usage (at least 60% of households in the temperate and hot-humid zones). It could even be that the lower paraffin usage in the rural areas of the hot-dry zone might be due to high candle usage that has not been recorded. It must, however, be said that candles are quite often used as back-up light in some homes. Electricity use for lighting is much higher than for the other end uses. The pattern of electricity usage for lighting amongst the different dwelling types is very similar in all the zones: the more formal the housing, the more electricity is used. However, more households use electricity for lighting in the temperate zone than in the other zones. This is probably because the areas occurring in temperate zone (Gauteng and Western Cape) are more urbanised, and thus more electrified, than those occurring in the other zones. Comparatively, LPG is very rarely used for lighting.

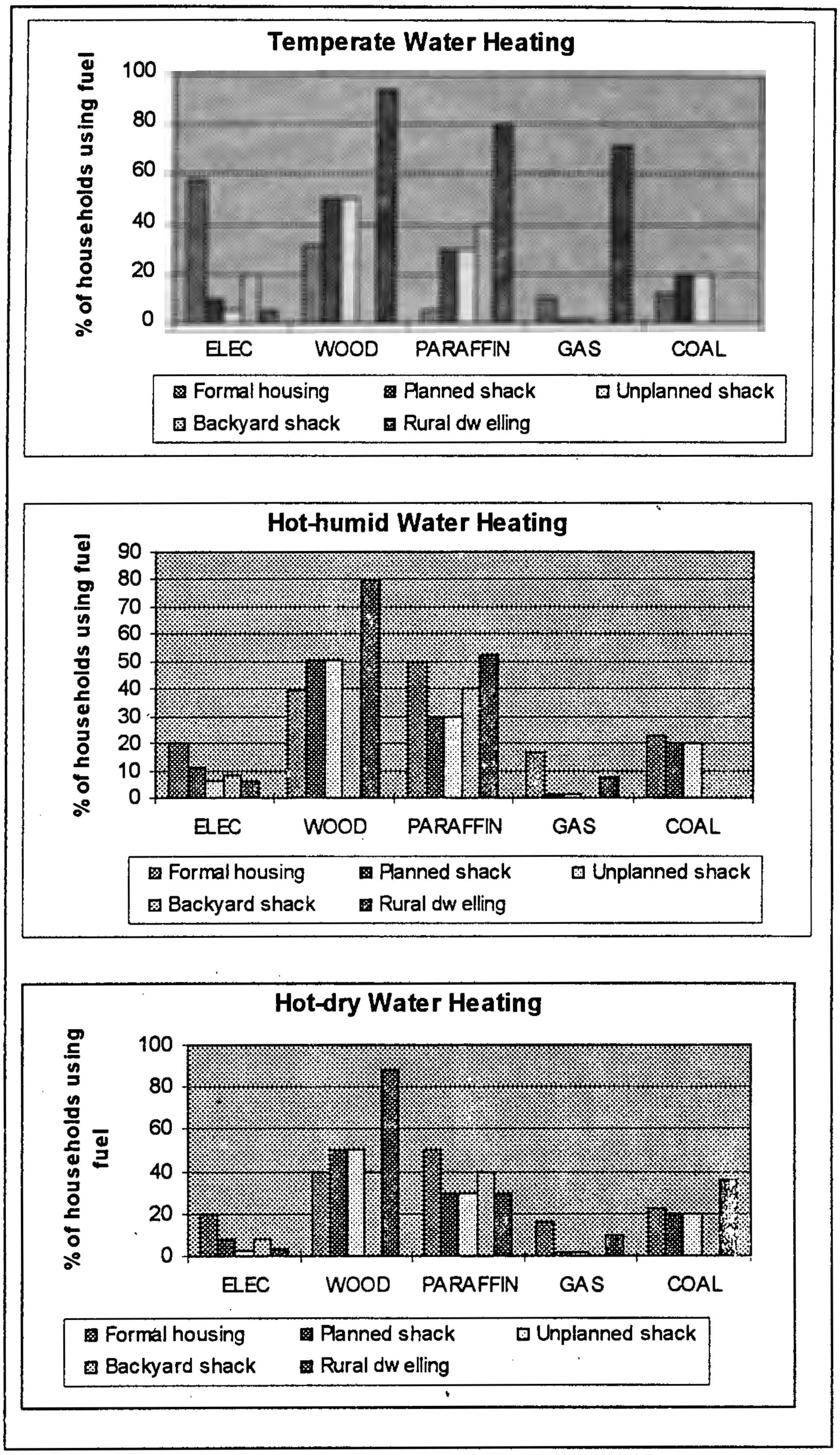

Figure 4-55: Percentage of households using fuels for water heating in the three climatic zones.
Source: NDEUD data set

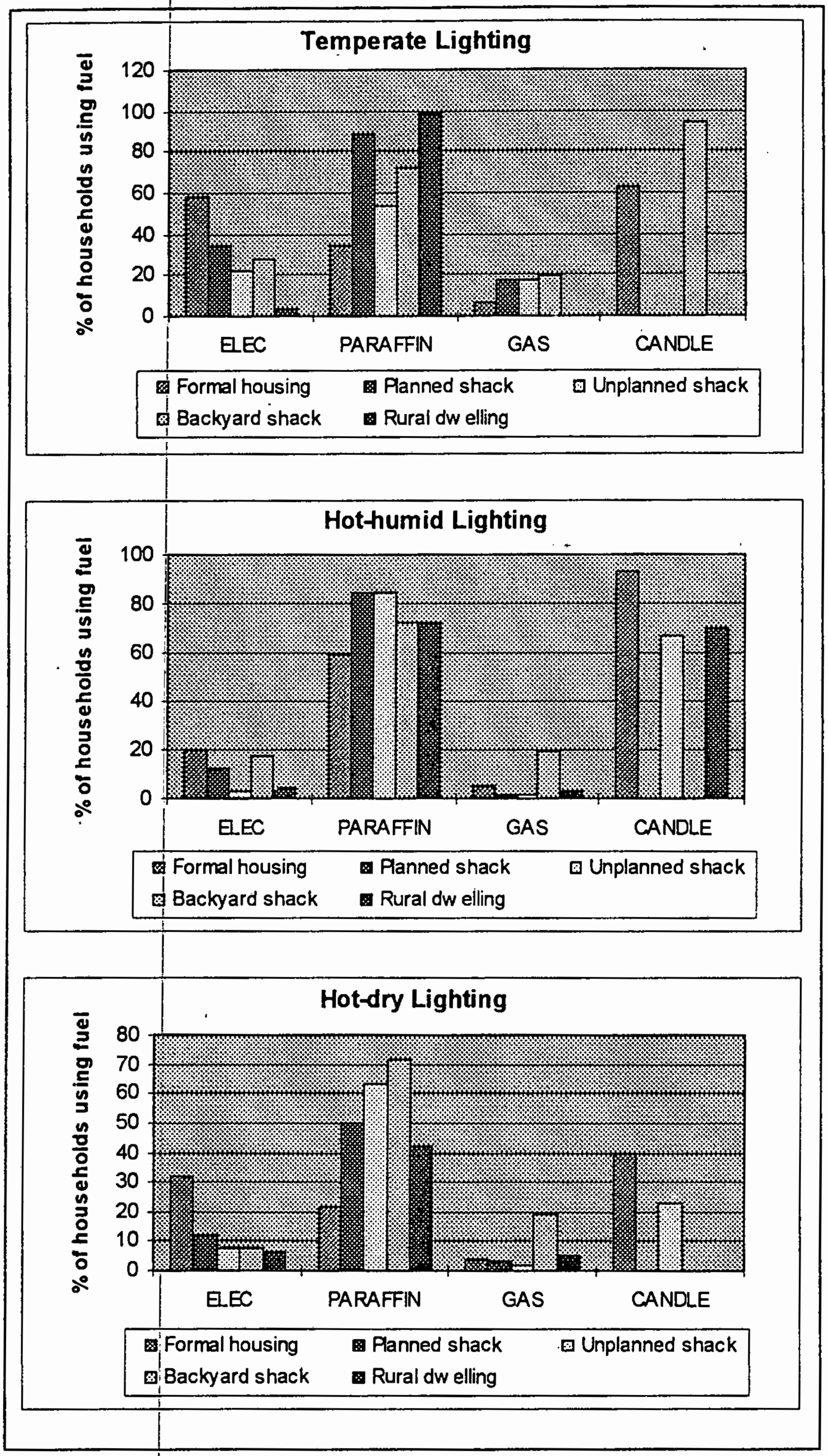

Figure 4-56: Percentage of households using fuels for lighting in the three climatic zones.
Source: NDEUD data set

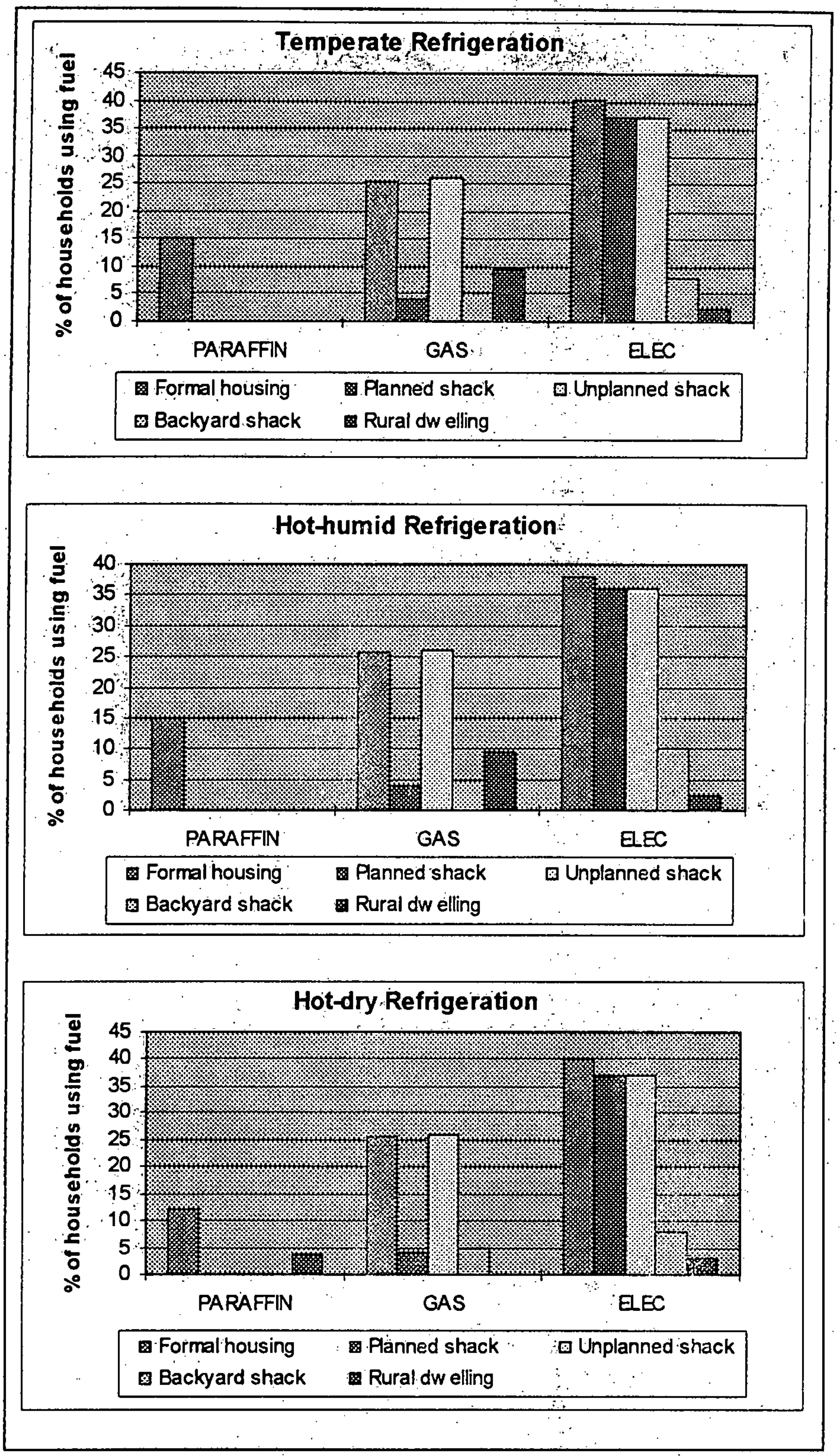

Figure 4-57: Percentage of households using fuels for refrigeration in the three climatic zones.
Source: NDEUD data set

4.12.6 Refrigeration

Electricity is the main fuel for refrigeration in all the climatic zones. In the formal houses, planned and unplanned shacks, at least 35% of households use electricity for refrigeration. In general, refrigeration in rural households is insignificant. Paraffin is used only in formal houses for refrigeration and even then it is used only to a small extent. LPG is also used for refrigeration in 25% of formal houses and unplanned shacks.

4.12.7 General remarks

There is a need to caution that the above discussion has mainly dwelt on the data available in the energy database and as such some misrepresentation of facts could result from data gaps in the system. For example, the high percentage of formal households using wood for cooking reported in Figure 4-53 needs to be questioned. However, this in practice, only shows how *extensively* that energy carrier is used and not how *intensively* it is used. Other data sources show that low-income formal houses use less quantity of wood compared with other low-income household types. Another explanation for that could also be that wood is often used as *kindling* for coal-fires, which is a frequent practice in low-income households, but might have been reported as *cooking with wood.*

5. Methodology for the estimation of energy demand projections for low-income households

5.1 Introduction

The general research methodology for this study has been briefly outlined in Section 1.5. This chapter deals with the detailed methodology for estimating energy demand projections for the various dwelling types in different climatic regions. In Section 2.4 the scope of this study has been limited to low-income households and therefore only dwelling types of the low-income households are included in this energy demand estimation. These dwelling types have been defined and classified in Section 2.7 as *formal housing, planned shack, unplanned shack, backyard shack* and *rural shack*. In Section 2.6, South Africa has been classified into three basic climatic regions *namely temperate, hot-humid and hot-dry* for the purposes of regional energy demand projections. It is into these three climatic regions that the number of households in each of the 5 dwelling types has been aggregated in Section 2.8.

Household energy end use data drawn from the energy use database is aggregated (see Section 4.12) and used as an input for the energy demand model. The energy requirement for each end use by each dwelling type in each climatic zone is estimated. The data on the number of households for each dwelling type, together with the aggregated end-use data (i.e. the percentage of households involved in a particular end use) and the related energy requirements are used in the energy model to estimate the energy demand for each dwelling type in each climatic zone. With the application of the energy model, the "scenario approach" is then used for computing the energy demand projections for alternative policy options.

5.2 Energy demand analysis by the "end-use approach"

Energy consumption is not a goal in itself. The real goal of using energy is to provide end-use services like cooking, space heating, water heating, lighting and refrigeration. Additional end-use service can be met either by increased supply or by more efficient use on the demand-side. It is the latter method for providing additional end-use service which forms the purpose of the energy demand analysis in this study.

The study uses the Long-range Energy Alternatives Planning (LEAP) system for the energy demand analysis. LEAP is the Stockholm Environment Institute's computer-based tool for performing integrated energy planning (IEP). It is an accounting and simulation tool designed by Stockholm Environment Institute-Boston to assist policy makers in evaluating energy policies and developing sound, sustainable energy plans (Raskin et al 1993). LEAP is used in this study to estimate and project the energy demand situation of the low-income households of South Africa in order to glimpse future patterns, identify potential savings and shortages, and assess the likely impacts of energy policies in the medium- to long-term.

LEAP is based on a disaggregated, end-use, demand-driven approach. The first task in an analysis is to determine the specific end uses or "energy services" required by different socio-economic groups or sectors. In the household sector, end uses are mainly cooking, space heating, water heating, lighting and refrigeration. Then, the energy requirements associated with those end uses are estimated. Finally, the analyst seeks the optimal mix of energy resources and efficiency improvements for meeting those energy end-use requirements. The end-use approach reflects the understanding that energy is not a final commodity in itself, but rather a means for meeting some human amenity or economic purpose.

In the household energy demand analysis, LEAP achieves the goal of IEP by allowing the developing plans of different socio-economic groups-households in different dwelling types. For example, with a given improved living standard objectives in a development plan, the analyst can determine required energy, and then evaluate various strategies for meeting those needs at the lowest cost. Thus in demand analysis, LEAP permits the blending of demand-side initiatives in designing a low-cost integrated system. Its *scenario approach* allows the testing of the consequences of alternative assumptions about the future.

In addition, the LEAP model permits the treatment of all fuels and end-uses in one comprehensive framework. Therefore, opportunities of fuel switching can be assessed and included in strategic plans that encompass efficiency and supply enhancement.

In this study, energy end-use data on the various dwelling type is gathered from the energy database (NDEUD) and used as the main input to the LEAP **Demand** programme. LEAP allows for co-ordinated planning at more than one *spatial* level due to its **Aggregation** programme. For example, energy scenarios can be built at the national level or climatic regional level or the dwelling type level. Consequently, the household sector has been disaggregated according to the different climatic zones of South Africa, and the different household types typified by the different dwelling types.

5.2.1 Disaggregation of energy demand by the "end-use" approach

Levels of disaggregation of data

Energy demand data is assembled in a hierarchical format based on four levels, denoted by the names *Sector, Subsector, End Use, and Device*. At level 1 in the LEAP programme, the low-income household sector split into the climatic regions which form the Sectors. At level 2, each climatic region is disaggregated into subsectors of dwelling types. At level 3, each subsector is divided into end uses. Finally, at level 4, each end use is further divided into the Devices or appliances used. The analysis takes place at each of the four levels.

Aggregation of end-use data into climatic sectors and dwelling type subsectors

In order to obtain a better representation of information in the analysis, all available data is grouped into the respective geographic locations to reflect the appropriate climatic conditions and energy resource availability. End-use data on low-income households extracted from the energy database is categorised into the former nine Development Bank of South Africa (DBSA) development regions[1]. The end-use data at the development regions level is further aggregated into the three main climatic regions.

To summarise then, the main components of the demand analysis are the following:

A. The demand for each domestic fuel is projected from the point of consumption (i.e. "end-use" demand) and thus domestic energy use data is assembled within the following four-level hierarchical structure:

1. Firstly, South Africa is categorised into three *climatic sectors*.
2. Households in each climatic sector are disaggregated into five *dwelling type* subsectors: formal, planned shacks, unplanned shacks, backyard shacks and rural shacks.
3. For each sub-sector, different *end uses* to which each fuel is utilised are analysed. These end-uses are *cooking, water heating, space heating, lighting, refrigeration, and others* (others referring to all other end uses).
4. For each end use, *devices* which provide that end use are identified. For example, devices for electric lighting include fluorescent tube and incandescent bulb. A lot of generalisations are incorporated in assigning devices to end uses and fuels due to lack of data. For example, all *electric cooking* in low-income households is generalised as *electric stove/hot plate*. For each device, the fuel(s) used is/are specified and how much energy the unit of that device consumes per month of normal usage by a particular household type is estimated. This is referred to as the energy requirement of that device for that particular dwelling type. Work done by Thorne (1994) on the estimation of life-cycle costs of appliances is particularly useful in this estimation of the energy requirements.

   The domestic fuels considered in this study are electricity, coal, paraffin, liquid petroleum gas (LPG) and wood. This is due to a combination of two factors: firstly, the realities of basic household energy needs and, secondly, data availability. The construction of a fully developed energy use profile for each climatic region is like the one depicted in Table 5-1.

B. The climatic regional level profiles are further aggregated into a national profile.

C. The *scenario analysis approach* is used to paint a picture of alternative energy/appliance mixes for the current situation and the future under defined assumptions. The impacts on future energy balances,

[1] The data was captured into development regions in the database since the new provinces were not yet in place.

social costs and benefits, deforestation, and the environment for each scenario could be further evaluated from scenario outputs. In this way, the most desirable scenarios can be identified for informed recommendations to be made on possible courses of action.

Sector	Sub-sector	End-use	Device
Temperate Urban Households (Number of household)	Formal Housing (% of households)	Cooking (% of households)	elec stove/hot plate (% hh)[2] wood stove (% hh) primus/ wick stove (% hh) gas stove (% hh) coal stove (% hh)
		Water heating (% of households)	electric geyser (% hh) gas geyser (% hh) paraffin stove (% hh)
		Space heating (% of households)	elec heater (% hh) gas heater (% hh) paraffin (% hh) wood stove (% hh)
		Lighting (% of households)	incandescent bulb (% hh) fluorescent tube (% hh)
		Refrigeration (% of households)	elec (% hh) gas (% hh) paraffin (% hh)
	Planned shacks (% of households)	ditto	ditto
	Unplanned shacks (% of households)	ditto	ditto
	Backyard shacks (% of households)	ditto	ditto
Temperate Rural Households (Number of households)	Rural shacks (% of households)	ditto	ditto

Table 5-1: Structure of energy use profile for the temperate climatic region

5.3 Energy requirements for domestic end uses

In addition to the percentage of households using a particular fuel for specific end uses, one other important variable required for the LEAP energy demand analysis is the *energy requirement* for

[2] % of households

each device. Energy requirement for the analysis in this is defined as the *annual energy required* by a household for a specific end use with a specific device. It can also be expressed in terms of *daily* or *monthly energy requirement*. Ideally, its estimation is best accomplished by directly measuring end uses in a representative sample of households. However, in the absence of good end-use data, a less direct approach known as conditional demand analysis can be used in which a regression technique relates total energy use to the saturation of different end-use devices (obtained from survey data), and establishes unit consumption figures (de Villa 1993). This section outlines the method used to estimate this variable for the LEAP energy demand analysis.

Appendix VI details the practical ranges of energy efficiencies for a range of appliances that are used for cooking, space heating and water heating. Using both extremes of the efficiency ranges and a number of assumptions, the maximum and minimum daily energy required by each appliance have been estimated - these are evident from the last two columns of the table. The various assumptions made for these estimations have been detailed in Thorne (1994), which reviews data sources and analysis of many works on household energy efficiency and appliances, such as Leach & Gowen (1987), Uken & Beute (1991), and others.

For refrigeration and lighting, whose energy requirements presented in the work by Thorne (1994) are not in the format suitable for this study, an indication of the energy requirements of various appliances is given in Tables 5-2 and 5-3. In Table 5-2, it is assumed that each household which has access to a refrigeration service uses a 200-litre refrigerator on the average. Maximum and minimum daily energy requirements have been estimated for refrigerators powered by electricity, paraffin and LPG in Table 5-2. The energy requirements assumed for this study are the middle points of the maximum and minimum energy requirements in the table.

In Table 5-3, the average number of incandescent bulbs required for the different dwelling types has been assumed. For all dwelling types, an average of 5 hours of lighting daily has been assumed for the estimation of the annual and monthly energy requirements. For paraffin lighting, an average requirement assumed is roughly 25 litres/household/year (Leach & Gowen 1987) which is 0.025 cubic metres/household/year.

All devices of each fuel for any of the end-uses under discussion have been simplified as one. For example, all electric devices for cooking are simplified as "Elec Cook", and paraffin devices for space heating are simplified as "Paraffin Space Heat", etc. Since electricity has many other uses in the home, all other end uses besides the ones considered in this study are classified together as "Elec Other" and this includes the use of appliances like irons, televisions, radios, fans, etc.

Summary of characteristics of a 200-litre refrigerator				
Fuel source: electricity (grid or off-grid)				
	Electricity consumption/unit volume		Total electricity consumption/day	
	kWh/litre/day*	kWh/litre/day*	kWh/day	kWh/day
	min	max	min	max
Freezers	0.006	0.036	1.2	7.2
Refrigerators	0.0045	0.01	0.9	2
Fuel source: LPG				
	LPG consumption /unit volume		Total LPG cons/day	
	kg/litre/day	kg/litre/day	kg/day	kg/day
	min	max	min	max
Freezers	0.006	0.03	1.2	6
Refrigerators	0.002	0.005	0.4	1
Fuel source: paraffin				
	Paraffin consumption/unit volume		Total paraffin cons/day	
	litre/litre-vol/day	litre/litre-vol/day	litre/day	litre/day
	min	max	min	max
Freezers	0.004	0.024	0.8	4.8
Refrigerators	0.012	0.038	2.4	7.6

Table 5-2: Refrigeration energy requirements
**Source: RAPS Design Manual (Cowan 1992: 38)*

Dwelling type	incandescent bulb usage		Hours/day used	Energy requirement	
	No of 60W bulbs	No of 100W bulbs		kWh/month	GWh/year/1000
Formal	3	1	5	42	0.511
Planned shack Unplanned shack Backyard shack	2	1	5	33	0.401
Rural shack	3	0	5	27.38	0.328

Table 5-3: Average energy requirement for electric lighting

Figures 4-59 to 4-63 in Chapter 4 disaggregate end-use percentages into different fuel types for each dwelling type. The next step in the analysis is to disaggregate the monthly household energy consumption into the five basic end uses discussed in Section 4.12. Appendix VII shows the average monthly household energy consumption by dwelling type and fuel type aggregated from the secondary data set component of the database (NDEUD).

For the purpose of energy requirements estimation, these consumption values have been iteratively disaggregated into energy requirements for the five basic end uses. This has been done on the basis of the daily energy requirements for the different end uses in Appendix VI, Table 5-2, Table 5-3 and the discussion above. These proportions have been varied iteratively within the range of the maxima and minima until the monthly energy requirement calculated for the end uses for a specific fuel sums up to the consumption values in Appendix VII.

Table 5-4 presents an illustration of the output of such an iterative calculation for the energy requirements of electric appliances in formal low-income households. It can be verified that the totals of the monthly electrical energy requirements approximately match the monthly energy consumption data in Appendix VII. An assumption made in this calculation is that all other end uses besides the five basic ones in Table 5-4 (i.e. 'Elec Other') consume at least 20% of the total electricity of an electrified dwelling.

Finally, it is possible to get a rough idea of the efficiencies of appliances used in low-income households, by converting the energy requirements in Table 5-4 *to daily energy requirements*, and comparing the results with the ranges given in Appendix VI, Tables 5-2 and 5-3. For example, from Table 5-4, the daily energy requirements for 'Elec Cook' (assumed to be a hot plate on the average for low-income households) in the temperate, hot-humid and hot-dry climatic zones become 7.61, 7.15 and 8.38 MJ/day respectively. These values are on the high side of the range for an electric hot plate (2.7 - 7.92 MJ/day) as shown in Appendix VI. This suggests that the efficiency of electric cooking is poor in low-income formal households.

End use	Temperate Climate		Hot-humid Climate		Hot-dry Climate	
	kWh/month	GJ/yr[3]	kWh/month	GJ/yr	kWh/month	GJ/yr
Elec Cook	64.3	2.8	60.4	2.6	70.8	3.1
Elec Space Heat	164.2	7.1	154.7	6.7	181.1	7.8
Elec Water Heat	85.5	3.7	80.6	3.5	94.4	4.1
Elec Refrigeration	59.4	2.6	55.4	2.4	64.9	2.8
Elec Lighting	42	1.8	39.6	1.7	46.4	2
Elec Other	120	5.2	113.2	4.9	132.6	5.7
Total	**535.4**		**504.9**		**590.2**	

Table 5-4: Energy intensities for end-uses of electricity in low-income formal houses

[3] 1GJ/yr is approximately equal to 2.74 MJ/day.

5.4 Energy demand scenarios

In this section, energy demand projections for low-income households are estimated for the period 1993 to 2010. These projections are produced by the LEAP model and are based on a *scenario approach*. They are specifically aimed at examining possibilities and they are *not meant to predict the future*. Initially, a picture of the current energy situation and estimated future changes is created. This 'business-as-usual' scenario is referred to as the *Base Case* in LEAP and the estimated future changes in this case are based on expected or likely plans and growth trajectories. With the Base Case in place, one or more policy scenarios can be developed with alternative assumptions about future developments. Scenario features can be used to ask an unlimited number of "what if" questions like "*what if the number of households in a climatic region changes over a period of time at a certain growth rate*?"

Four scenarios have been used in this section to examine some development strategies. To build fuel use into the scenarios, energy use profiles are entered into the LEAP Demand programme for each household type in each climatic zone. Each fully developed energy use profile describes the percentage of households using each appliance-fuel combination (as described in Section 5.2), as well as the average amount of energy used by each appliance per household per annum (refer to Section 5.3). With the inclusion of the number of households for each dwelling type, LEAP then calculates the total demand for that specific household type in each climatic zone.

5.4.1 Base Case (BA) Scenario

The Base Case for this study assumes that there are no direct major development interventions in energy supply options for low-income households. The household projections entered into the scenario have been estimated from the NELF EDI demand-side database (Nelf 1994) which represents a collective effort by many institutions to incorporate growth trajectories into demographics (this data is discussed in Chapters 2). These demographic projections have been compiled from the NELF database in terms of dwelling types and aggregated into climatic zones in Chapter 2 (Table 2-2). These dwelling type aggregates in Tables 2-2 and 2-3 are used together with the energy requirements of the devices for the end uses as LEAP inputs for the Base Case energy demand projections.

5.4.2 Energy efficiency (EF) scenario

This scenario introduces energy efficiency policy interventions into the Base Case. One main intervention is a major drive to encourage the use of compact fluorescent light bulbs instead of incandescent bulbs. It is widely accepted that compact fluorescent lights can achieve electric energy savings up to about 75% of the demand required by incandescent bulbs. However, as people begin to experience lower expenditure on lighting by the use of such efficient system, they tend to leave their lights on for longer times in the night. Thus, actual savings on consumption is about two-thirds of the theoretical demand. In this scenario, it is assumed that the use of compact fluorescent lighting will be progressively promoted and implemented in such a manner that about two-thirds electric energy savings on lighting will be achieved by the year 2010.

Another major policy intervention assumed in this scenario is the installation of an insulating ceiling in every dwelling type. The use of this type of insulation in the design of houses can save up to 91% of the energy consumption during winter (Matthews & van Wyk n.d.). It is assumed in this scenario that about 70% energy savings from space heating is achievable by all households by the year 2010.

5.4.3 Electrification (EL) scenario

The current ESKOM Electrification Programme will impact heavily on fuel/appliance usage among low-income households. This scenario examines possible fuel and appliance switches resulting from this major electrification programme. It must be emphasised that electrification of a dwelling does not necessarily mean that the household will switch over immediately or completely to electricity usage. Electricity is not used in a vacuum in the household but it requires appliances to be purchased first. For low-income households, this is a very difficult step since they might have already invested heavily in appliances for wood, coal, paraffin and gas and they may not have enough resources to fully utilise electricity in the dwelling. Appliance penetration in the low-income households is usually lower than the rate of electrification due to affordability problems. In this scenario, a number of assumptions have been made for fuel-switching for each end use that could result from electrification. One general assumption is that backyard shacks will have end-use characteristics similar to planned shacks by the year 2010, in the hope that backyard shacks will have been upgraded to the status of planned shacks. The rest of the assumptions are detailed below.

Cooking:

By 2010 the percentage of formal low-income houses, urban planned shacks, urban unplanned shacks and rural dwellings using electricity for cooking will be 75%, 50%, 30%, 20% respectively. These end-use percentage switches to electricity are assumed to have resulted from paraffin, coal, wood, LPG in the ratio 5:4:2:1 respectively; in other words, five-twelfths of the increase in dwellings using electricity will come from those previously using paraffin, four-twelfths from coal, and so on.

Space heating & water heating:

It is assumed that by 2010 fuel-switching to electricity for space heating will be the same as that for water heating. All formal houses are assumed to have completely switched over to electricity by 2010. By 2010, percentage of planned shacks, unplanned shacks and rural dwellings using electricity for space and water heating are assumed to be 60%, 40% and 40% respectively. Just like in the case of cooking, these end-use percentage switches to electricity are assumed to have resulted from paraffin, coal, wood, LPG in the ratio 5:4:2:1 respectively.

Lighting:

All formal houses and planned shacks are assumed to have switched completely to electricity for lighting by 2010. For unplanned shacks and rural dwellings, electricity for lighting is assumed to be 80% and 50% respectively by 2010, otherwise paraffin is used for lighting. For simplicity's sake, candles are not assumed to be used at all by 2010.

Refrigeration:

It is assumed that no paraffin is used for refrigeration in all dwelling types by 2010 and that all formal households will have switched over to electricity. For planned shacks, unplanned shacks and rural dwellings, households using electricity for refrigeration by 2010 are assumed to be 60%, 40% and 40% respectively; LPG usage for refrigeration in these household types will have reduced to half the 1993 percentages by 2010.

5.4.4 Combined (CO) scenario

This scenario is a combination of the electrification and energy efficiency interventions. Thus efforts are made to introduce energy saving lighting systems and housing with efficient thermal performance at the same time electrification is proceeding. The combined effects of the two strategies are examined under this scenario.

6.
Energy demand projections for low-income households

The outputs of the energy demand projections with the LEAP model discussed in Chapter 5 constitute an enormous amount of data on low-income households. This data set has been organised into several categories of profiles, in the form of energy demand projections from 1993 to 2010 for the three climatic zones (sectors), five household types (sub-sectors), five end uses and their fuel devices. A detailed discussion of *all* the outputs of the LEAP analysis is beyond the scope of this study. Nonetheless, important sample outputs are presented in the form of graphs at the end of the chapter. It must be noted that not all levels of disaggregation of the outputs form part of each group of graphical presentation in this study, and that some graphs have been included primarily to illustrate the capabilities of energy demand modelling as a computerised planning tool. For a discussion of some of the important outputs under the scenarios mentioned in Chapter 5, some of the profiles have been graphically presented in Figures 6-1 to 6-11d. In all the graphs demand is expressed in *annual net energy delivered* by each fuel type or by all fuels combined.

6.1 National and regional total energy demand projections of all low-income households

Figure 6-1 depicts the national energy demand projections for all low-income households under the four scenarios. It also shows the energy demand projections for the *temperate*, *hot-dry* and *hot-humid* climatic regions under each scenario. Each graph shows both the national energy demand (i.e. 'total demand' in Figure 6.1) and demand in each climatic region.

Under the *Base Case* scenario, it can be seen that the national energy demand would increase progressively from about 225 million GJ in 1993 to about 289 million GJ in 2010. The implications of this massive rise in demand in the low-income sector of the national economy alone can be tremendous. It could require the expansion of electricity generation capacity that could consequently involve serious environmental costs and a huge burden on national resources.

However, the graphs illustrate 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, such that the increase in demand would only be about 6 million GJ by 2010. Moreover, energy efficiency policies seem to offer a more effective energy savings option. Under the *Efficiency Scenario*, the national energy demand decreases progressively from 1993, until it starts rising at the end of the period under review, due to probably an increase in urbanisation in the temperate zone (which includes Gauteng and the Western Cape Provinces). The Efficiency Scenario offers an overall *decrease* in the national energy demand of about 2.8 million GJ over the period to 2010. The wisdom of undertaking the national electrification programme concurrently with energy efficiency policy interventions is clearly seen by the projections from the *Combined*

Scenario. This suggests that a combination of energy efficiency measures with the electrification of the low-income households would result in a general decrease of the national energy demand over the period and an overall decrease of about 43.5 million GJ by the end of the period under review.

For the energy demand projections of the climatic regions, it can be seen that the demand projections of the temperate region lie between those of the hot-humid and hot-dry regions under all the scenarios. This level of disaggregation in the LEAP analysis therefore allows for development strategies to be targeted at specific climatic regions since one can identify which option will be the most appropriate for a particular region. For example, the energy demand for the hot-humid region should be of great concern since its projections lie way above the others in all the scenarios. Another striking result is the rise of energy demand in the temperate region even under the Efficiency and Electrification Scenarios. It appears that there would be a great need for integrating energy planning with interventions to accommodate the rise of urbanisation in the temperate region. For the hot-dry region, Figure 6-1 seems to suggest that both energy efficiency and the electrification drive could cause a decrease in energy demand growth. Again for the Combined Scenario, there is an apparent downward trend of the energy demand for all the three climatic zones.

6.2 Electricity demand projections of low-income household

Figure 6-2 depicts the national electricity demand projections for low-income households in the three climatic regions from 1993 to 2010 under the four scenarios. The figure clearly depicts a positive growth in electricity demand for all the four scenarios since electricity supply is considered an important service for development. In the `business-as-usual' scenario, the low-income household demand for electricity increases from about 28.8 million GJ in 1993 to about 39.4 million GJ in 2010, an increase of over 10 million GJ for a period of 17 years. It is apparent from Figure 6-2 that energy efficiency measures in the low-income households could lower the electricity demand growth in such a way that the increase in demand over the period would only be about 6.7 million GJ. On the other hand, if the national electrification programme proceeds without any serious energy efficiency interventions, it is clear from the figure that the rise in electricity demand could be phenomenal, which obviously has serious implications for policy-making, not least of all, for generation planning. Under this electrification programme there is an overall increase of over 45 million GJ in electricity demand by 2010, at an annual growth rate of over 9%. However, an introduction of energy efficiency measures at the same time as the electrification programme would reduce this overall increase to about 28.5 million GJ (i.e. a 35% reduction compared to the Electrification Scenario) and the annual demand growth rate to about 6%. The economic gains in the development paths under the four scenarios could therefore be estimated in terms of power generation costs, environmental costs, natural and human resources.

In terms of the demand projections for electricity in the climatic regions, similar growth trends result from all the scenarios but at different rates. The major point here is that, unlike the national energy demand projections for the climatic zones described in the preceding section, the electricity profile of the hot-dry climatic zone lies in between the temperate and the hot-humid zones with the temperate zone lying on top of all the demand curves. This demonstrates again how integrated energy planning approach allows the planner to identify different development strategies both for the energy sector as a whole and for the individual fuel sub-sectors such as electricity.

6.3 Energy demand projections for different fuels

Figure 6-3 compares the national energy demand projections for the individual fuels, as well as for all fuels combined under the different scenarios. This facilitates planning for the individual fuel sectors at the national level in an integrated manner. Apart from liquefied petroleum gas (LPG) and paraffin which appear to have similar profiles under the four scenarios, the rest of the energy carriers have different trajectories.

For LPG and paraffin, the energy efficiency measures introduced do not seem adequate to effect any visible drop in the demand over the period. On the other hand, electrification appears to result in a dramatic drop in demand for both fuels. However, the gains in combining electrification with efficiency interventions are not as significant as in the other fuel sub-sectors. Energy planners and policy-makers would have to identify the appropriate incentives for the petroleum sector to support improvements in these directions.

For wood, it appears as both energy efficiency interventions and electrification drive would result in immediate negative growth in demand. However, it can be seen that the energy savings from the energy efficiency policy option alone would be far greater than the savings from the electrification programme. To save the environment from continual fuelwood depletion, policy-makers and planners would need to consider the combined effect of electrification and energy efficiency programmes since this approach results in greater energy savings.

For coal, efficiency measures alone do not seem to result in negative growth in demand over the period under review but the measures are apparently significant enough to stabilise demand during the period. On the other hand, electrification alone seems to result in immediate negative growth in demand and much greater energy savings over the years. The combination of electrification with energy efficiency measures would decrease the demand even further. These projections on the energy savings could provide a background information for estimating the socio-economic benefits from the electrification and energy efficiency programmes in terms of pollution and health costs.

6.4 Other energy demand projections

The LEAP model produces several other outputs for the energy demand projection analysis in the form of different categories and levels of aggregation. Some of these results have been presented graphically in Figures 6-4 to 6-11d.

Figure 6-4 makes comparisons of the national energy demand projections for the different *energy carriers* under each scenario. Figure 6-5 illustrates that similar comparisons can be made according to the different *climatic zones*, in this case, for the temperate zone.

Figure 6-6 gives an overview of the overall *savings* in the national and the climatic regional energy demand for the four scenarios over the period under review. The savings for each energy carrier have been depicted for the year 2010 and the 1993 demand projections have been summarised for comparison and estimation of energy savings.

Figures 6-7 to 6-10 depict the energy demand projections for various *end uses* of a typical *dwelling type* in the *temperate region* under each scenario. Clearly, many more permutations exist than have been illustrated here, but the figures demonstrate the levels of disaggregation of outputs that are possible in the LEAP model. The figures illustrate the situation only for formal housing and urban planned shacks and they cover electricity, paraffin and all fuels combined.

Figures 6-11a to 6-11d illustrate a further lower level of disaggregation of demand of an end use into different fuel devices. Formal housing, urban planned shacks and rural dwellings in the temperate zone have been used for this illustration. S*pace heating* has been used to illustrate the energy savings that can be achieved in fuel- and device-switching for a particular end use.

6.5 Conclusion

It is readily apparent from the preceding section, and from close examination of the graphs at the end of this chapter, that the LEAP model has a formidable range of outputs. An attempt to analyse *all* its potential outputs would be overwhelming and would require enormous resources. Nonetheless, one of the strengths of the model is its ability to produce a wide range of detail in the outputs which result from any given policy question. Thus, if any one scenario is being considered as a policy option, it is possible to model the effects of such an option in a comprehensive manner, at a number of levels of detail in the economy. Ultimately, this can assist in energy planning by improving the information base underlying policy decisions.

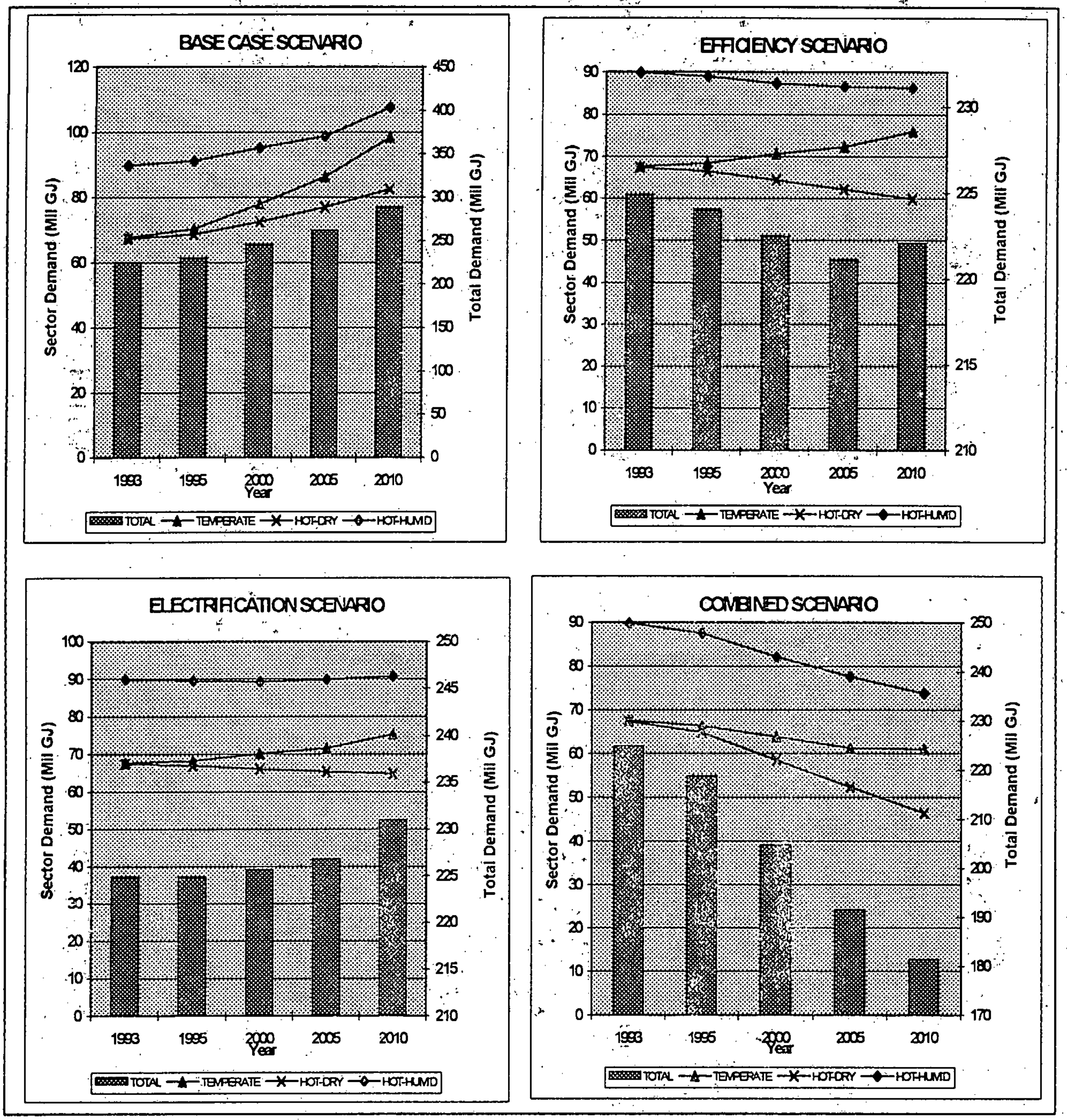

Figure 6-1: Energy demand projections - total (national) and sector(climatic zone) by year, all fuels

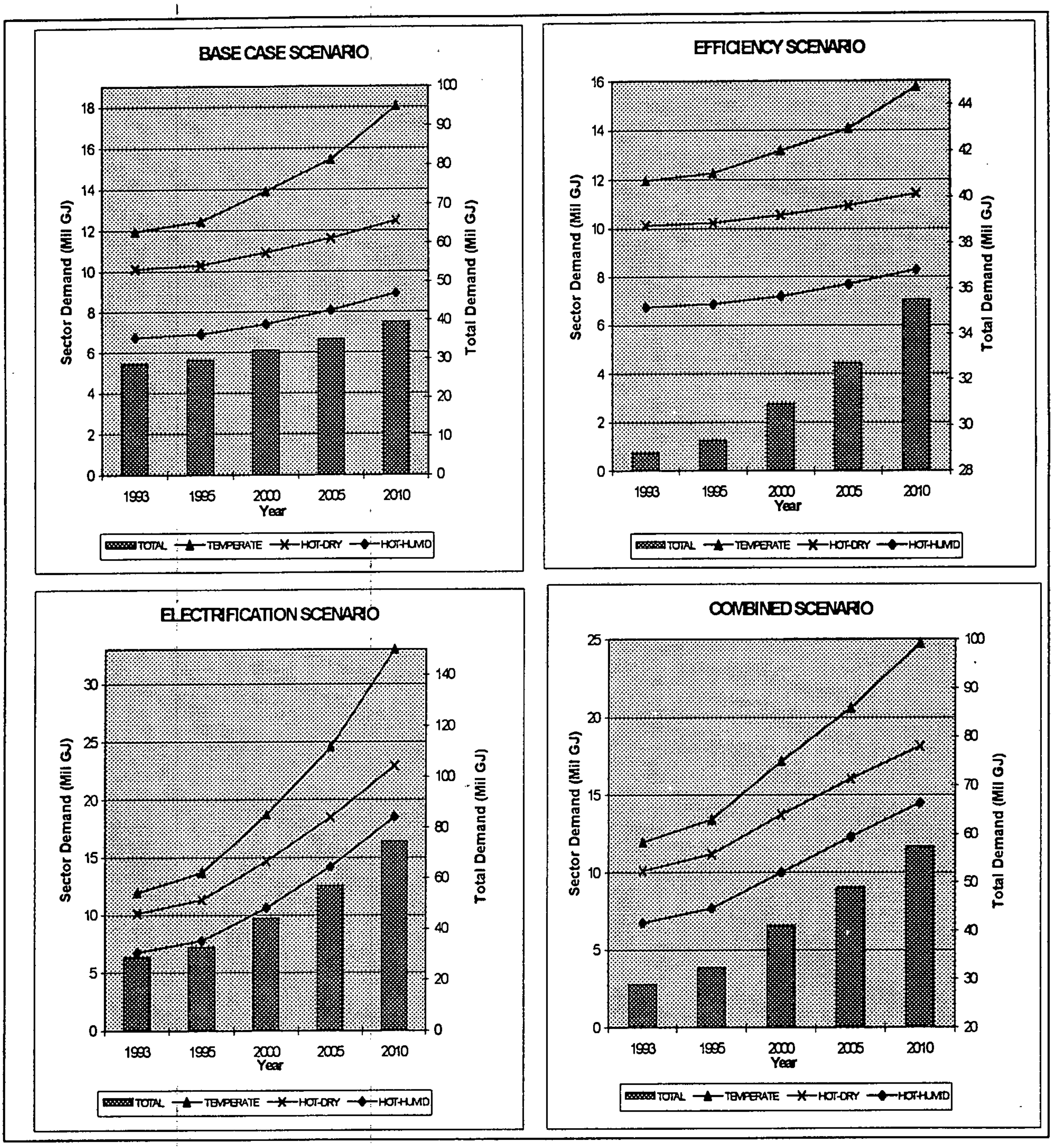

Figure 6-2: Energy demand projections for electricity, total (national) and sector (climatic zone) by year

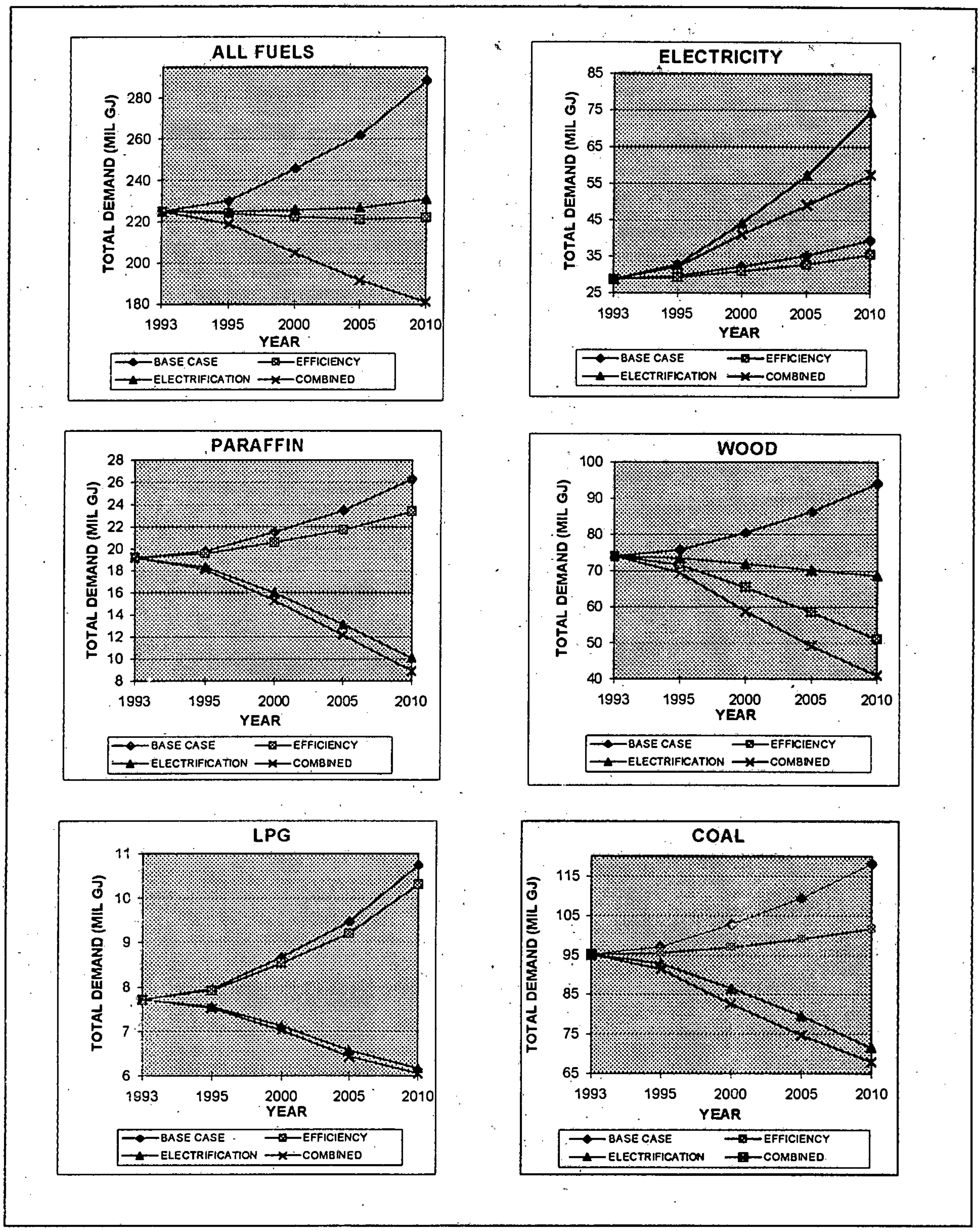

Figure 6-3: Total demand projections for different fuels, all sectors by year

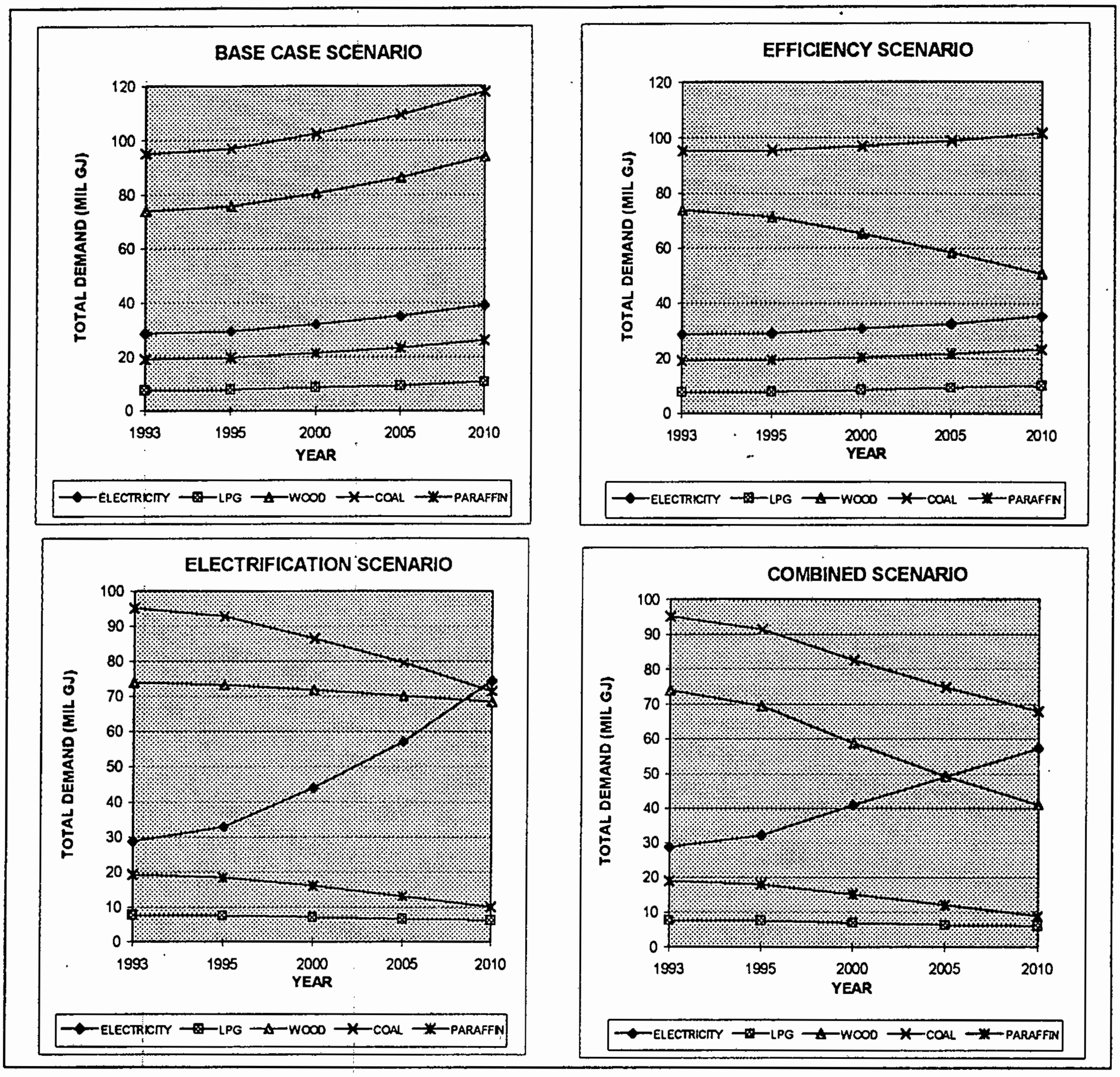

Figure 6-4: Energy demand projections for all sectors combined, fuel by year

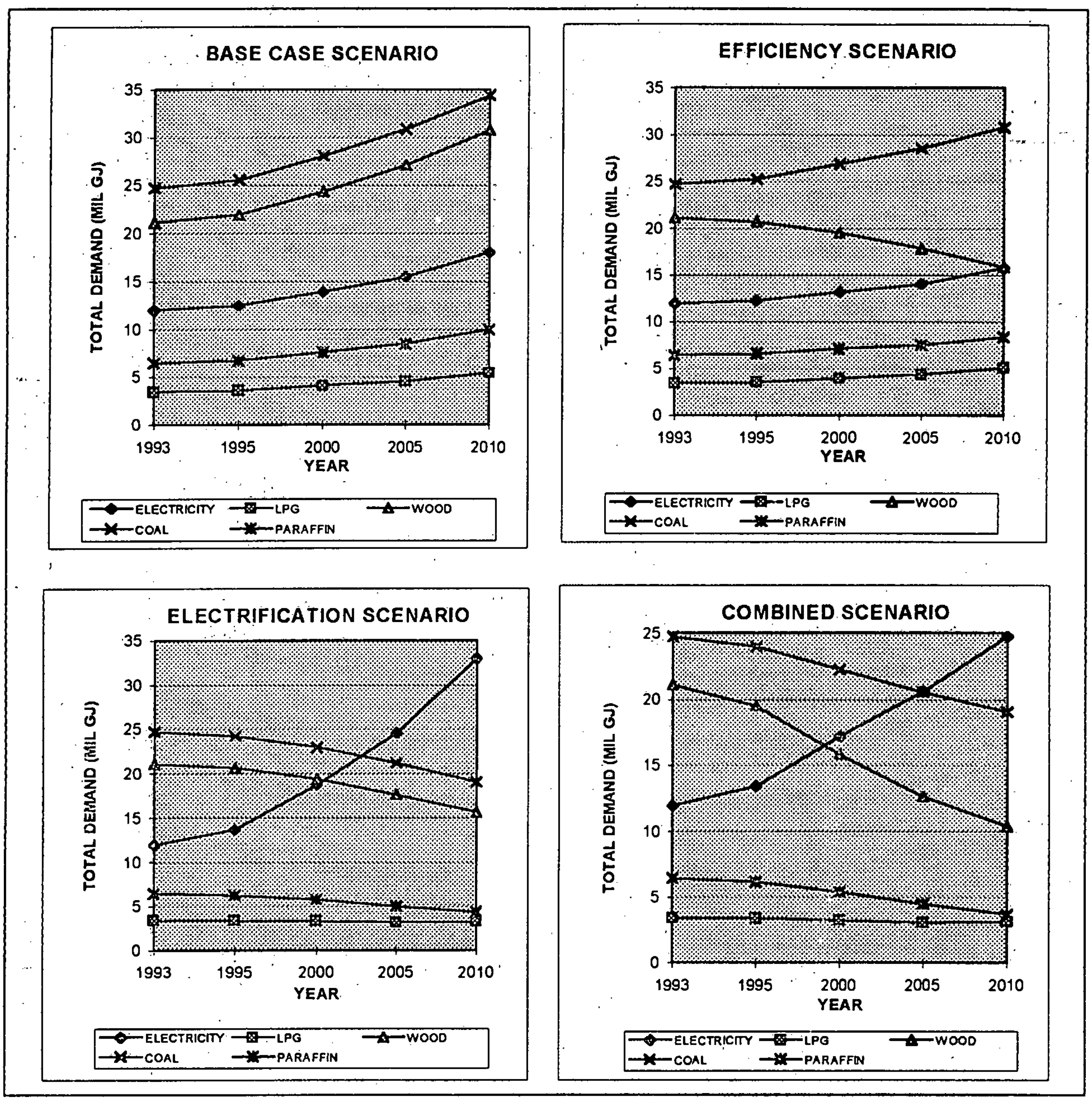

Figure 6.5: Energy demand projections for the temperate zone, fuel by year

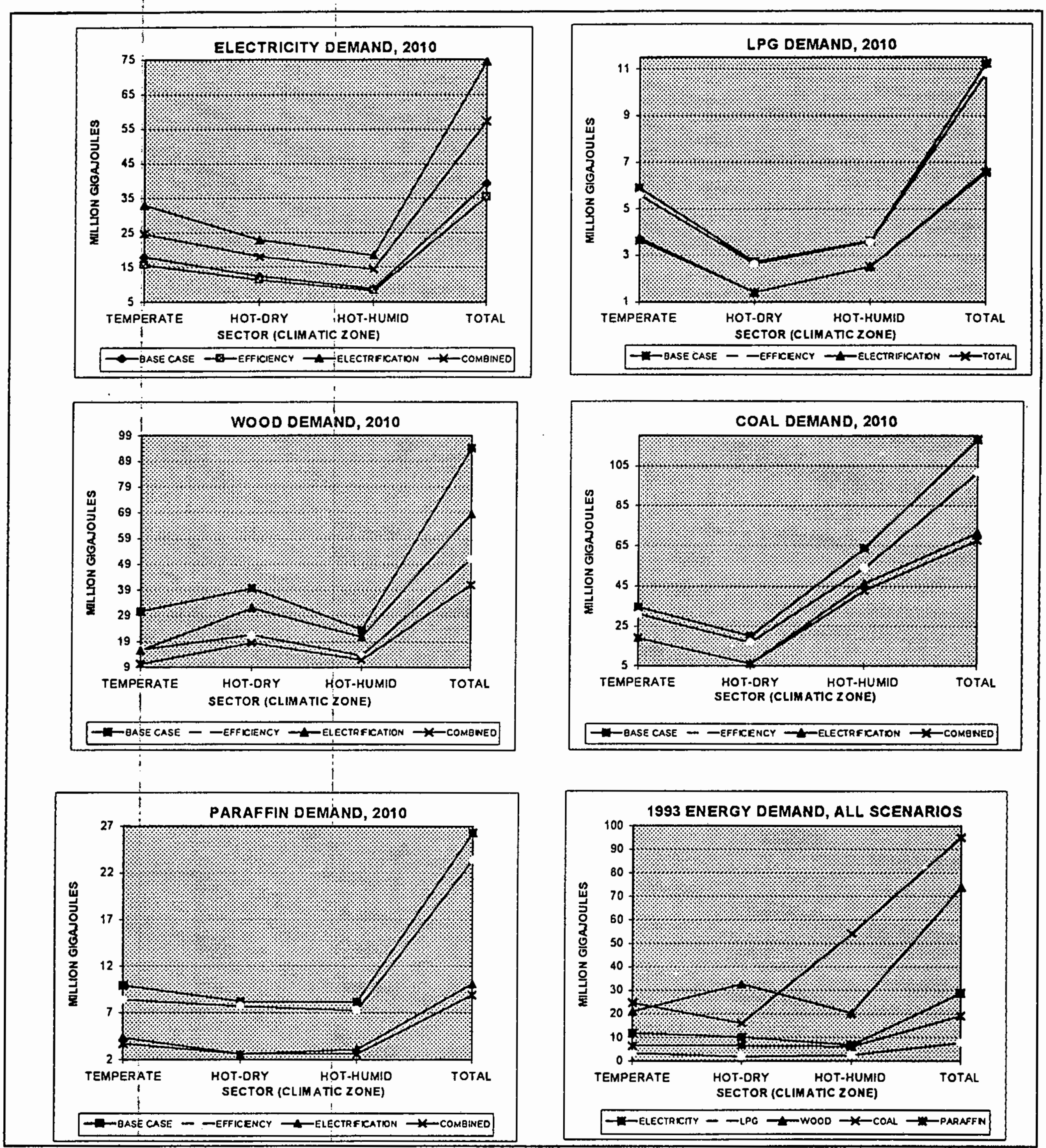

Figure 6-6: Energy demand projections for the years 2010 and 1993, fuel by sector

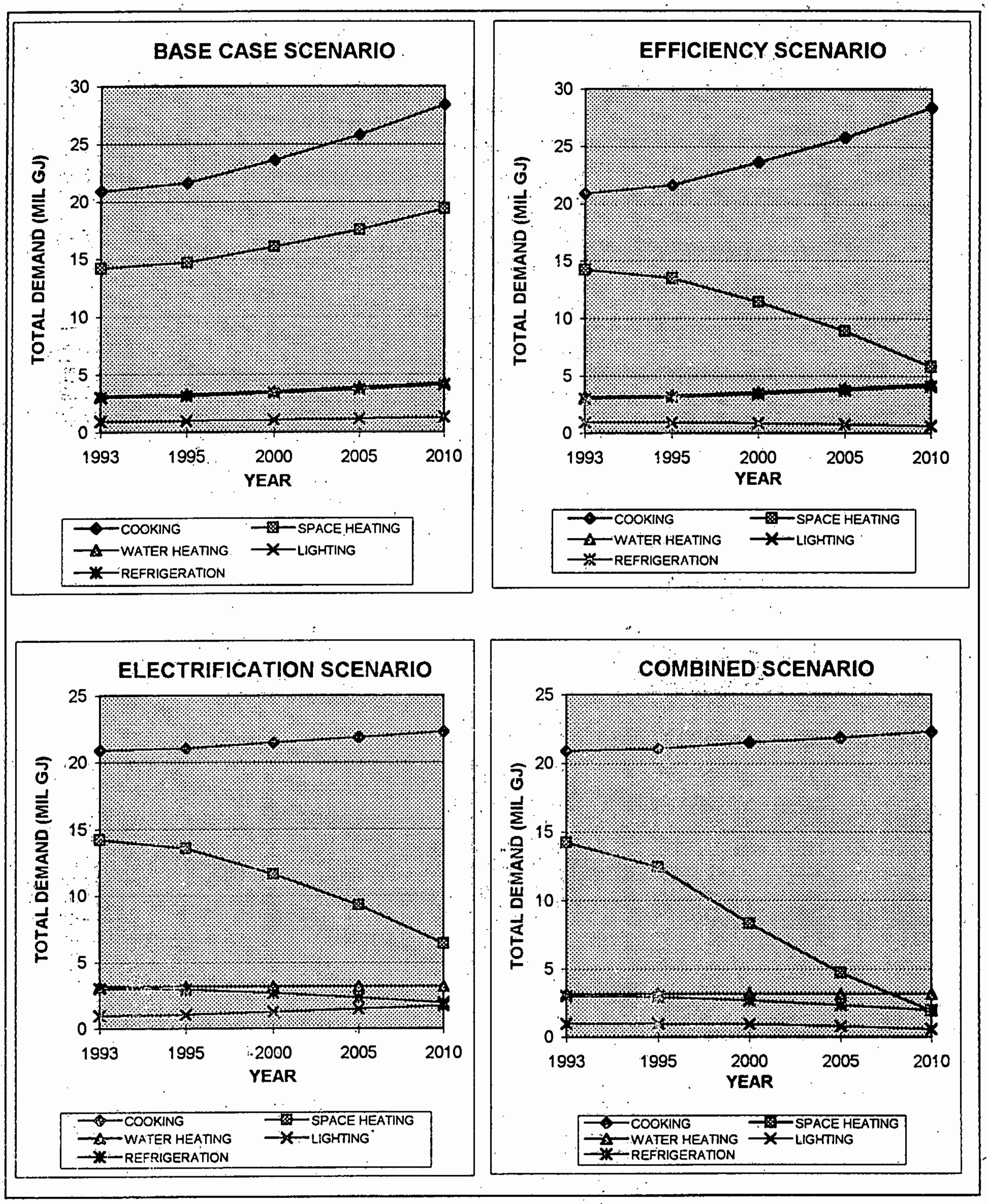

Figure 6-7: Total energy demand projections for temperate formal housing, end use by year for all fuels

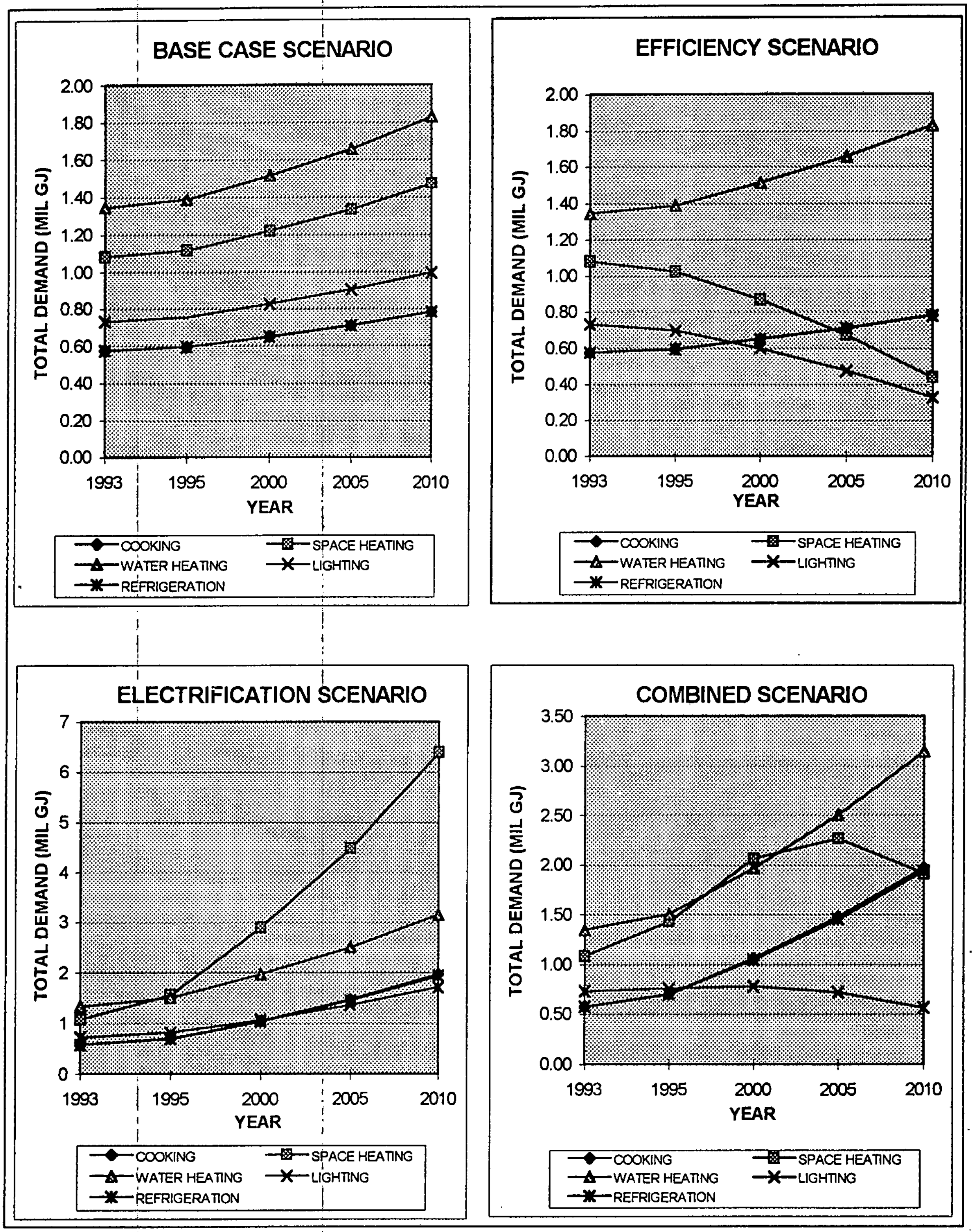

Figure 6-8: Electricity demand projections for temperate formal housing, end use by year

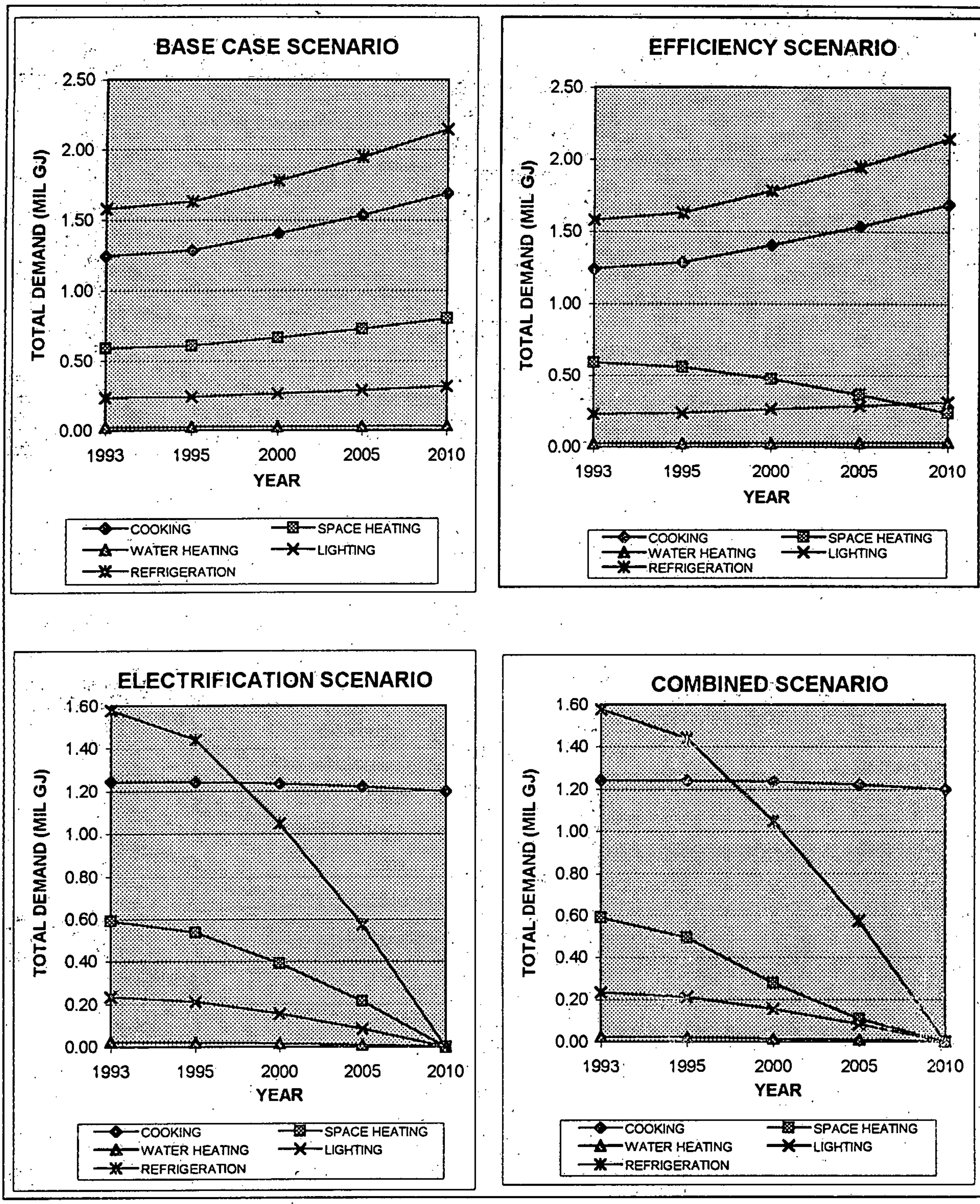

Figure 6-9: Paraffin demand projections for temperate formal housing, end use by year

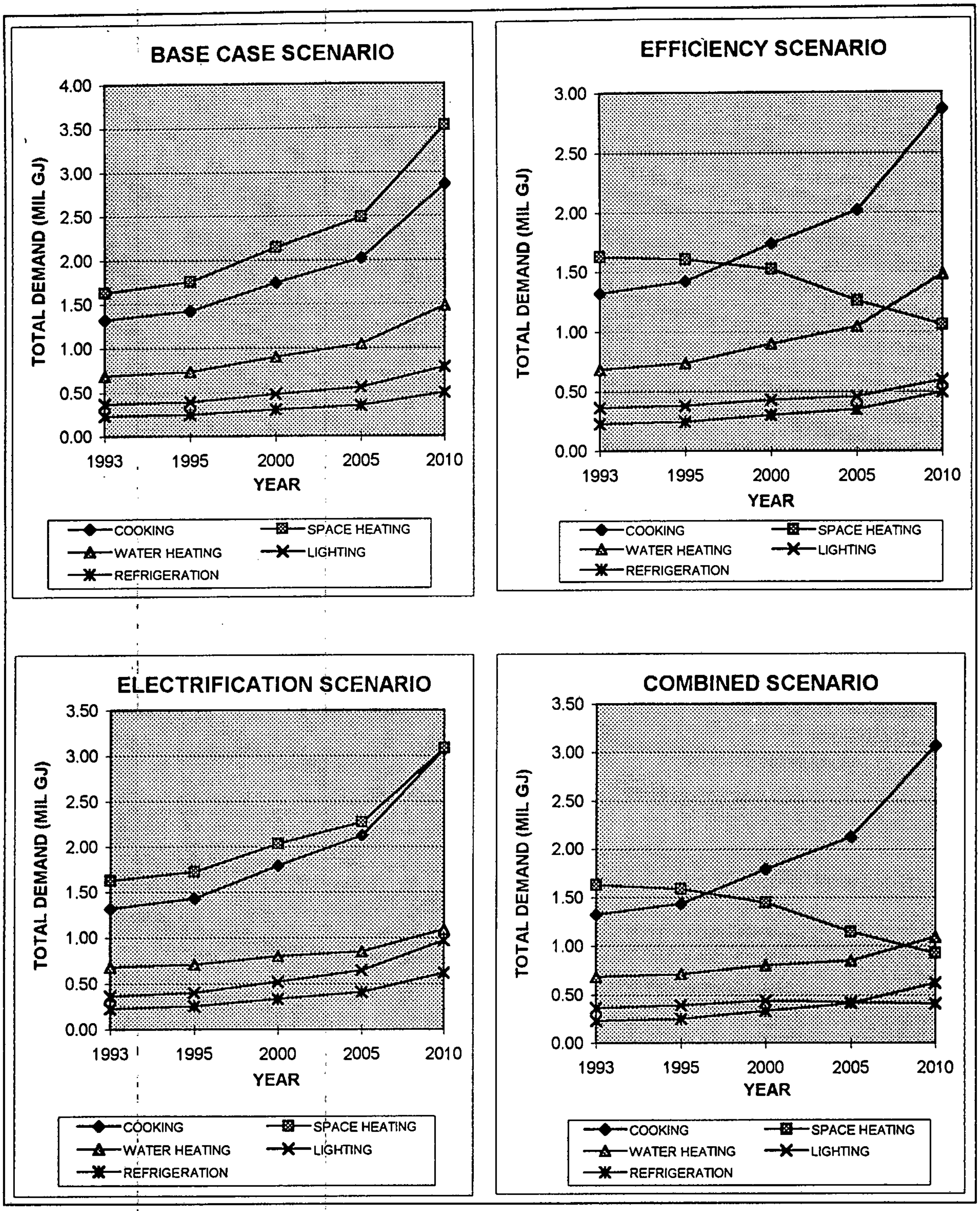

Figure 6-10: Energy demand projections for temperate planned shacks, end use by year for all fuels

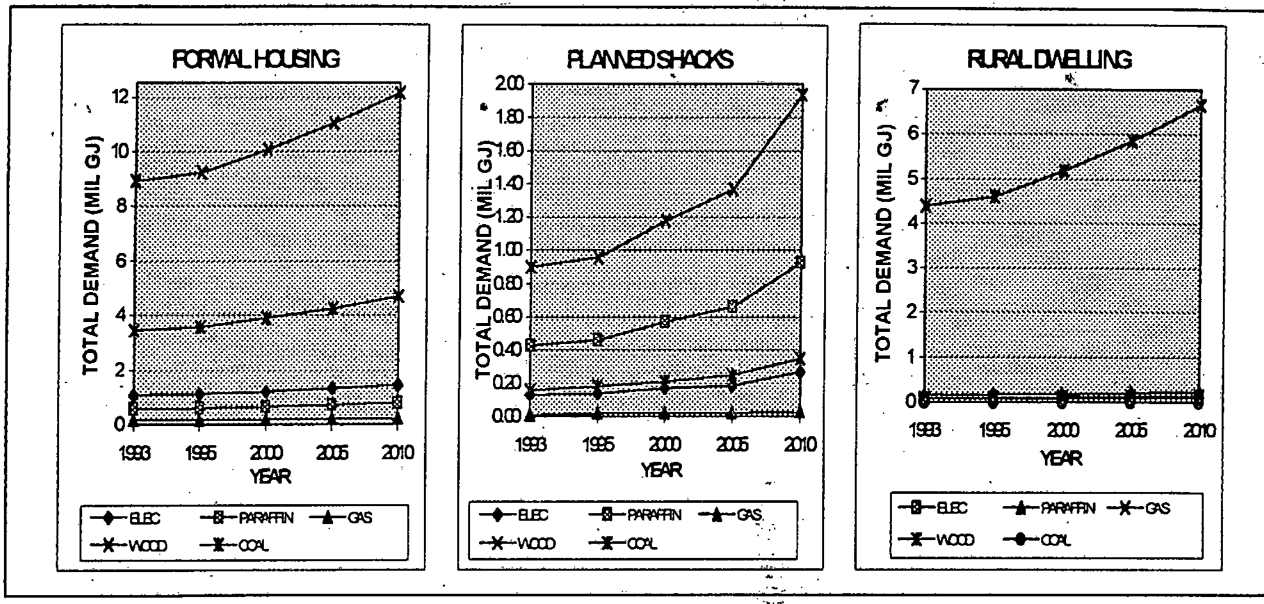

Figure 6-11a: Energy demand projections for space heating in the temperate zone - Base Case Scenario

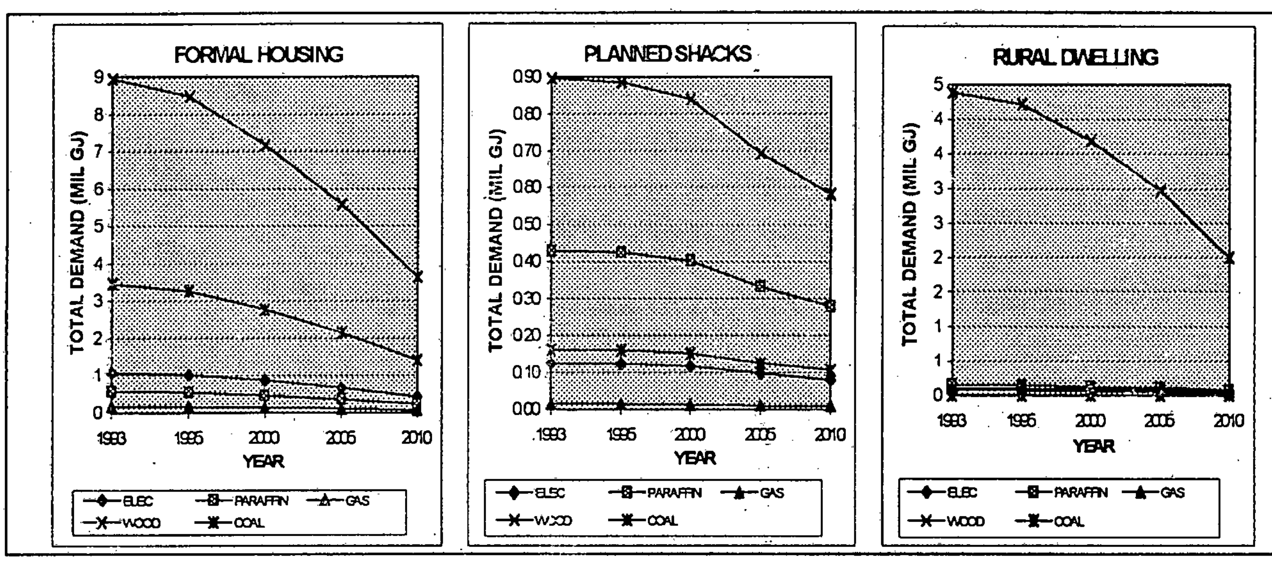

Figure 6-11b: Energy demand projections for space heating in the temperate zone - Efficiency Scenario

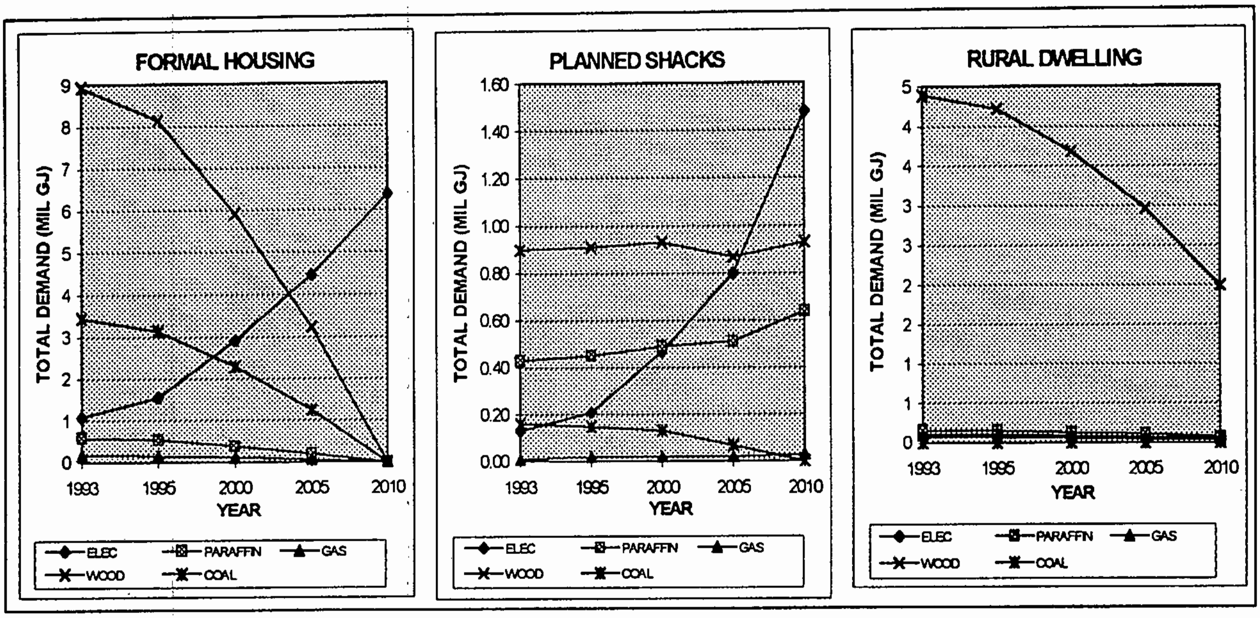

Figure 6-11c: Energy demand projections for space heating in the temperate zone - Electrification Scenario

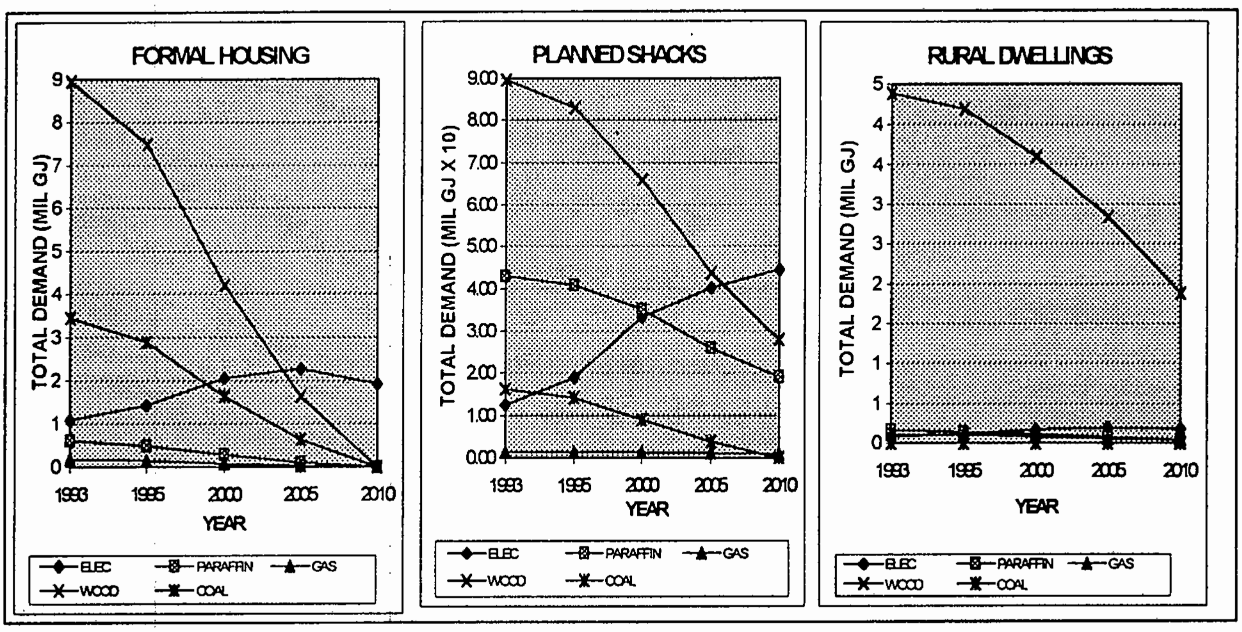

Figure 6-11d: Energy demand projections for space heating in the temperate zone - Combined Scenario

7.
Conclusions

The study has demonstrated the importance of integrated approach to energy planning over sub-sectoral supply-oriented planning. The household sector has been used to illustrate how integrated energy planning (IEP) facilitates the understanding of the links between the energy supply and demand sectors, and between energy services and socio-economic objectives. It has been shown that the IEP concept allows the coverage of a wider range of policy issues in the household sector and it establishes the existing inter-relationships linking the household sector with the entire energy use system. The various layers of analysis in IEP have also been explored. Besides establishing various relationships between the energy supply sectors and the household sector, inter-subsectoral links within the household energy sector have also been established including fuel interactions, competition, conflicts and fuel substitution. The IEP concept also enabled intra-subsectoral analysis in the household sector, for example, end-use analysis for a particular fuel, appliance use analysis, and total demand analysis and projections.

The study has shown the role database development can play in an IEP process to enhance decision making in policy formulation. It has shown that data, however quantitative and/or qualitative it may be, may not be classified as information until it has been properly organised into a structured and comprehensive manner to provide adequate response to relevant issues in decision making process. This has been done through the collation of scattered energy use data on low-income households from all existing studies and surveys done in South Africa. Data variables relevant to understanding determinants of energy demand and supply in the domestic sector have been included in this. A database system has been established for capturing, storing and updating a wide range of data sets on energy use in the low-income households and related information. The system captures not only quantitative data but also qualitative information, providing background information to enable the user to place the available data in the right context. Apart from capturing and storing secondary data sets, the system also allows the storage of primary data so that data available in electronic format could be directly linked to the system.

For the information available in the system to be useful, the ordinary user would require easy access. This has been achieved by the provision of a user-friendly interface that has been illustrated in the study. The dissemination of the system has, however, remained an obstacle due to the lack of adequate institutional support and it is recommended that the system be published on the Internet providing all the necessary query functions. In addition to the ordinary user-interface, the database has a data management system that is capable of analysing and reporting on aggregated data from the database so that users may not require any technical knowledge of the software. The availability of this aggregated energy use information has been enhanced by the provision of graphic display through a linkage to Geographic Information System (GIS).

The overview of the analysis of domestic energy use data drawn from the database system illustrates how a database developed with the IEP concept can help bring the status of the low-income households into the national development picture in terms of energy provision. It has been demonstrated in this thesis that the *National Domestic Energy Use Database* system contains useful organised data that can be periodically updated in a structured manner to provide a wealth of valuable information for energy researchers, planners and policy-makers in South Africa. The outputs of the extensive data analysis in the thesis clearly illustrate how such a resource can facilitate the identification of the basic energy needs in the various geographic locations. Some of the factors influencing these energy needs of the poor are also analysed and the outputs could provide some direction in policy-making and implementation. For example, it is interesting to note how energy demand variables are correlated with household income. The analysis also helps to quantify who constitute the poor in South Africa and what the types and levels of fuels used in those households are. In the delivery of energy services to low-income households, this information could help in drawing up policies for subsidy provision and the setting up of selection criteria, especially in the case of electrification.

Some of the conclusions of the energy use data analysis are summarised here as follows:

- *Multiple fuel use.* It is striking to notice the extent of multiple fuel use phenomenon in the whole country and the analysis points out the communities, the geographic locations and the income group brackets in which it is more of a norm than an exception. About 45% of all households depend on a combination of at least three fuels for their daily household needs and the fuels involved are mostly paraffin, fuelwood and candles. Whilst over 50% of the households in the areas of the former provinces of South Africa use a single fuel for their energy needs, about 95% of the households in the former homeland areas use 2 or more fuels for their needs. Similar observations are also distinguished between rural, urban and metropolitan areas and it is made clear that the provision of a single fuel like electricity to poor households may not meet their basic needs. In fact, almost half of the electricity users use it in combination with either one or two or more fuels. Apart from electricity, paraffin is the only other fuel that is significantly used as a single fuel but that is limited to only about 3% of all households. For the end uses that are energy intensive, poor households often prefer to use other fuels which they find affordable regardless of the cleanliness or quality of the fuel.
- *Electrification.* First, the general observation about electrification of households is that, whether in the rural or urban area, it seems to facilitate the reduction of multiple fuel use drastically. The reason for this is that the application of electricity is flexible and it is suitable for most of the domestic end uses of energy, provided the service and the required appliances

are affordable. However, appliance requirement in the household use of electricity is usually found to be too high since the electric appliances are not suitable for multiple purposes. Second, the high paraffin use in higher income households could be an indication of the extent to which the lack of access to electricity has been a barrier to even those who may be able to afford the electricity supply service.

- *Affordability of electricity*. First, it appears from the study that the more income the households receive, the more they are able to afford the electricity supply service and the purchase of more appliances. However, the study suspects that increase in household income eventually leads to extravagant use of electricity which could create unnecessary load. This is because it was found in the study that, whilst energy expenditure by electrified households generally increases with household income, that by non-electrified households increases with income only up to the fourth income group and then stays almost constant for the fifth and sixth income groups. Second, in every income group, electrified households spend more on energy than non-electrified households do. This picture might not be entirely correct since over 25% of South African households collect their fuelwood from the bush and woodlands and thus the cost of the "free wood" is not included in this analysis. However, this explains the reason why it has not been prudent for many low-income households to use electricity intensively after they have been connected to electricity. Besides the expensive nature of the service compared with other fuel sources, households have to pay for the purchase of different costly appliances for almost every end use. For some other fuels, a cheaper appliance may be sufficient for multiple end uses for a poor household. For example, paraffin stove, which is invariably cheaper than electric stove in general, could be used for cooking as well as for space heating and ironing. The affordability of electricity supply service should be looked at more carefully otherwise the cost involved in extending the grid to many households would become a waste if households cannot afford to use the service.

- *Total fuel expenditure*. The study illustrates that, as household income improves the lower the percentage of the total household expenditure spent on fuels. This paints an impression that lower income households might be feeling the pinch of their expenditure on fuels more than the higher income households might.

- *Wood collection*. The study shows that fuelwood collection is mainly a low-income household affair. Households tend to stop collecting wood as their income improves. For example, for the households in the areas of the former homelands, the percentage of households collecting wood drops from over 75% at the lowest income level to about 10% in the highest income level. This shows how people's dependence on wood as a fuel could probably be reduced enormously as they are provided with income generation opportunities. In this way, environmental degradation resulting from wood denudation is also reduced.

- *End-use analysis.* In the energy end-use analysis the study shows that certain anomalies may arise in the energy use data due to poor classification of end uses that occur in surveys. Surveys often fail to account for the multiple services provided by the traditional and transitional fuel cookstoves, namely that they are often used simultaneously for cooking as well as space and water heating. This is an important point that underlies the need for household surveys to consider the broad energy services which different energy sources fulfil.
- *Demographics.* The understanding of the population make-up of a nation is very important in household energy policy analysis. It facilitates the identification of energy demand and supply factors among different population groups and provides the necessary background information as a check on how policy is shaped to avert inequities in energy provision. The specific characteristics of the traditions of different population groups may influence their energy use patterns. Appropriate policy instruments can therefore be put in place in order to achieve equity across the different population groups.
- *Household income.* The study exposes the extent of income inequalities that characterise the South African society in terms of different population groups and geographic locations. It shows how important it is to bear the income inequalities in mind when analysing energy demand and supply factors. It is clear that the South African society has a very slim middle income group (about 15%) compared with the lower income group (about 53%), yet the high incomes of a minority of the population in the higher income group distort the income per capita picture. Energy policy formulation must address these inequalities, and energy service provision must incorporate the necessary policy instruments that deal with the inherent affordability issues.
- *Household size variation.* First, the study shows that household sizes of the various income groups are not the same and, where possible, this must be taken into consideration when quantifying energy consumption on the basis of households. In general, it was established that households tend to trim their sizes as household income improves. There is therefore the need to maintain the link between average household size and income in the analysis of energy use patterns in order to avoid misinterpretation of data. Second, the study dismisses the generalised misconception that most rural and African households have larger household sizes due to their own choices and preferences according to their traditions. The study suggests that, although most rural and African households are trapped in poverty due to past policies, a few that have been empowered to break the barrier of poverty into upper income levels seem to be dramatically trimming their household sizes more than other population groups. One could fairly conclude that it is not urbanisation or a particular culture per se that could help size down households but, more importantly, other socio-economic factors that facilitate access to basic needs like improved household income.

- *Data gaps*. An important data gap identified in the study was in the area of appliance information. Much of the error in this study is attributed to the scanty information in this area. Data on energy required for specific end uses were also very scanty and a lot of approximations were made. It is recommended that these areas be given special attention in the gathering of domestic energy use data.

Finally, the study has shown that the IEP analysis starts with the consumer. It allows the investigation into what people are using and why they are using certain fuels for certain purposes. In the analysis of the needs of different groups of people, IEP permits demand sectors to be disaggregated into subsectors and energy end uses, fuel types, energy technology or appliances, levels of energy requirements – all these lead to clear analysis of policy options. The study has demonstrated the usefulness of domestic energy use database for analysis and projections of domestic energy demand based on socio-economic scenarios. The projections were based on data drawn from the database to practically illustrate how fuel switching, energy efficiency measures, electrification and combinations of these measures could result in different energy demand trajectories. The consequencies of potential policies and strategies become apparent and hence, better and more informed decisions can be made.

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Appendix I:
Aggregated dwelling type data from the Nelf Demand-side Management Database

HOUSING TYPE	POPULATION	H/HOLD SIZE	HOUSES	AVG H/HOLD INCOME	PER CAPITA INCOME	TOTAL INCOME
Rural Farm Labourer Formal	864,650	4.49	192,637	12,127.07	2,701.81	2,336,122,196
Rural Farm Labourer Informal	1,455,162	5.13	283,433	6,174.34	1,202.62	1,750,010,716
Rural Farms	287,861	4.04	71,246	90,359.05	22,363.99	6,437,721,126
Rural Institutions	1,011,137	5.92	170,801	45,691.33	7,718.17	7,804,125,325
Rural Settlements Nucleated Formal	157,389	4.81	32,736	26,317.52	5,473.89	861,530,300
Rural Settlements Nucleated Informal	3,377,588	5.40	625,384	10,614.54	1,965.36	6,638,163,042
Rural Settlements Scattered Formal	3,672,496	5.19	707,717	13,197.08	2,543.17	9,339,799,972
Rural Settlements Scattered Informal	10,202,573	5.12	1,993,233	5,385.93	1,052.23	10,735,416,071
Urban Formal Houses	15,031,239	4.31	3,483,776	45,777.59	10,609.83	159,478,872,055
Urban Formal Institutions	1,103,917	3.87	285,301	33,225.60	8,586.97	9,479,296,766
Urban Informal Backyard	539,496	3.67	147,091	12,298.36	3,353.09	1,808,977,946
Urban Informal Planned	1,897,085	3.73	508,434	11,173.82	2,994.67	5,681,149,948
Urban Informal Unplanned	721,772	3.51	205,890	10,175.31	2,902.57	2,094,994,644
TOTAL	40,322,365	4.55	8,707,679	24,809.04	5,651.41	224,446,180,107

Database : Version : 1.2 Date: 26-Aug-94

Appendix II: List of objects forming the database

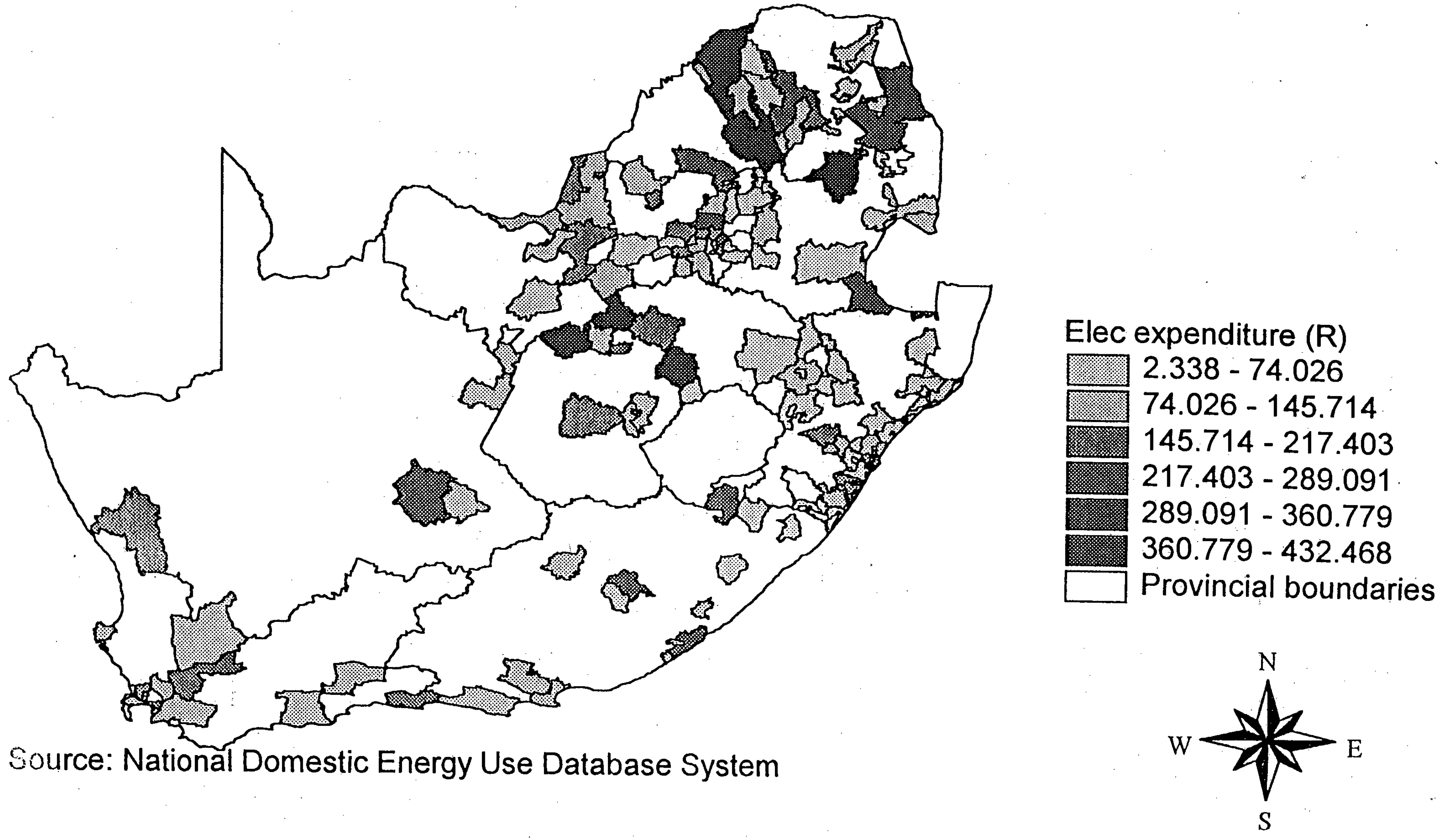
Item	Type	Location	Description
Add data category to survey	Form	NDEUD	Allows the addition of data categories to a document
appliances	Table	ENGDATA	Table contains appliance data for surveys
Aspect covered by surveys	Table	ENGDATA	Aspect data for each survey
Aspect covered in survey subform	Form	NDEUD	Displays the aspects covered by a document's surveys - subform in Edit_Document
AutoExec	Macro	NDEUD	Macro that hides the database and activates the NDEUD - executed when NDEUD database is opened
CPI	Module	NDEUD	CPI Conversion functions
CPIIndex	Table	NDEUD	CPI Index values for various years
Customize	Form	NDEUD	Form allowing cusomization of the data in Customize Table
Customize	Table	NDEUD	This table contains customizable information for the NDEUD database
Customize_Embed	Form	NDEUD	Form listing all customizable options embedded into form CUSTOMIZE
Data held in survey subform	Form	NDEUD	Displays the info covered by a document's surveys - subform in Edit_Document
DataWiz_ClearIncludeFields	Query	NDEUD	Clears all included fields in the Data Wizard
DataWiz_ClearRestrictions	Query	NDEUD	Clears all restrictions in the Data Wizard
DataWiz_EmbedRestriction	Form	NDEUD	Allows the entry of restrictions in the DataWizard - subform in DataWizard
DataWiz_Fields	Table	NDEUD	DataWizard table of available fields
DataWiz_IncludeFields	Form	NDEUD	Lists included fields in the DataWizard - subform in DataWizard
DataWiz_IncludeFields	Table	NDEUD	DataWizard table of fields included in a DataWizard session.
DataWiz_ResLookup	Table	NDEUD	DataWizard table of resolution fields available at a particular resolution
DataWiz_Restrictions	Table	NDEUD	DataWizard table of restrictions available for the DataWizard
DataWizard	Form	NDEUD	DataWizard main form
DB_Structure	Table	NDEUD	This table - info on every database object, also used for table reattachment
DB_Update	Table	NDEUD	Table of updates made to the database- just for administration
Debug	Module	NDEUD	Debugging functions
doc and summary	Query	NDEUD	Basic query for entering document data - summarizes surveys for the document
document	Table	ENGDATA	List of the documents in the database
document_status	Table	ENGDATA	Lookup table of possible status codes for documents.
Edit_Document	Form	NDEUD	Main form for editing documents
Edit_Documents_Select_Survey	Form	NDEUD	List of a document's surveys - subform in Edit_Document
Edit_Keywords	Form	NDEUD	Form to allow editing of available keywords
Edit_Localities	Form	NDEUD	Used to edit available localities
Edit_Survey	Form	NDEUD	Main form for the editing of surveys
elec_attitude	Table	ENGDATA	Survey data for attitudes to electricity
employment	Table	ENGDATA	Employment data for surveys
fuel	Table	ENGDATA	Fuel data for surveys
GIS	Module	NDEUD	GIS related functions
GIS_MakeNewPat	Query	NDEUD	Creates new GIS Point Attribute Table (PAT) file for export

Item	Type	Location	Description
GIS_MakeNewPat_exSaldru	Query	NDEUD	Creates new GIS PATfile for export from the Saldru Wizard
GIS_Temp	Query	NDEUD	Temporary file created as an intermediary for GIS export
Globals	Module	NDEUD	Globals available to all modules
hh_expend	Table	ENGDATA	HH Expenditure data for surveys
hh_income	Table	ENGDATA	HH Income data for surveys
Homelands	Table	NDEUD	List of possible homelands
housing	Table	ENGDATA	Housing data for surveys
Info covered in surveys	Table	ENGDATA	Info data for each survey
InfoWizard	Form	NDEUD	Main form of the Info Wizard
InfoWizard	Module	NDEUD	InfoWizard functions
InfoWizard	Table	NDEUD	All reports and queries registered with the Info Wizard
Interpret	Module	NDEUD	Functions for interpreting restrictions
IWI_*	Report	NDEUD	Reports registered with the Info Wizard
IWI_*	Query	NDEUD	Info Wizard queries - both standalone and as the data set for reports
KeyWords	Module	NDEUD	Functions for breaking and checking keywords
KeyWords	Table	NDEUD	List of possible keywords
List of survey information categories	Table	NDEUD	All available survey information categories in ENGDATA
Localities	Table	NDEUD	REDUNDANT - held previous localities data, now replaced by LOCALITY table
LOCALITY	Module	NDEUD	Locality related functions
LOCALITY	Table	NDEUD	Main locality data: all possible localities.
LocalityBuilder	Form	NDEUD	Locality Builder form
Magisterial Districts	Table	NDEUD	List of Mag Districts in LOCALITY, stored here for use by some sophisticated fns requiring speed.
Misc	Module	NDEUD	Miscellaneous functions
Normal	Form	NDEUD	Used to provide default form controls in form design
PAT	Table	NDEUD	Output file for the GIS - exported to the GIS Point Attribute Table (PAT) file
PAT_Template	Table	NDEUD	Template for the output file for the GIS
PLACENAME	Table	NDEUD	Saldru-related place data - REDUNDANT
Prov_Pat_Template	Table	NDEUD	Template for the Provincial output file for the GIS
ReportBuilder	Module	NDEUD	Functions that generate reports for the DataWizard
ReportBuilderTemplate_Landscape	Report	NDEUD	Template report for DataWizard generation of Landscaped reports
ReportBuilderTemplate_Portrait	Report	NDEUD	Template report for DataWizard generation of Portrait reports
Saldru	Table	Saldru	Saldru data per respondent
Saldru_Cluster	Table	Saldru	Saldru data per cluster
Saldru_HH	Table	Saldru	Saldru data per household
Saldru_MagNames	Table	NDEUD	List of original Saldru magisterial district names, and closest matches from LOCALITY db
SaldruWiz	Module	NDEUD	SaldruWizard functions
SaldruWiz_ClearIncludeFields	Query	NDEUD	Clears all included fields in the Saldru Wizard
SaldruWiz_EmbedRestriction	Form	NDEUD	Restrictions in Saldru Wizard - subform in SaldruWizard

Item	Type	Location	Description
SaldruWiz_Fields	Table	NDEUD	All available Saldru Wizard fields
SaldruWiz_IncludeFields	Form	NDEUD	Included fields in Saldru Wizard - subform in SaldruWizard
SaldruWiz_IncludeFields	Table	NDEUD	All included fields in latest Saldru Wizard query
SaldruWiz_Restrictions	Table	NDEUD	All possible Saldru Wizard restrictions
SaldruWiz_Temp	Query	NDEUD	Temporary query used by the Saldru Wizard to interface with the Data Wizard
SaldruWizard	Form	NDEUD	Main Saldru Wizard form
SaldurWiz_ClearRestrictions	Query	NDEUD	Clears all restrictions in the Saldru Wizard
services	Table	ENGDATA	Services data for surveys
Set SaldruWiz_Restrictions from SaldruWiz_Fields	Query	NDEUD	Updates SaldruWiz_Restrictions to include all non-stat'd SaldruWiz_Fields fields
socio_demog	Table	ENGDATA	Socio-demographic data for surveys
surv_summary	Table	ENGDATA	Summary data for surveys
survey	Table	ENGDATA	Data on each survey
SurveyCategory	Table	NDEUD	List of all possible survey categories
Tech	Module	NDEUD	Technical table-manipulation fns used in development
Tech_QueryDesign	Form	NDEUD	Technical form used for the modification of data specifications with survey information categories
Temp	Query	NDEUD	A query used as a temporary query for adding surveys and elsewhere. Do not delete, but if you do, create a new query and save it as Temp. It doesn't matter what this query does: the code will overwrite it.
Title_Page	Form	NDEUD	Title page of the NDED database
Title_Page_Embed	Form	NDEUD	Displays NDED Updates - subform in Title_Page
WoodCollect	Table	NDEUD	Wood Collection data for surveys.

Appendix III:

Monthly household expenditure on electricity (R)
(in sampled magisterial districts in all provinces)



Source: National Domestic Energy Use Database System

Appliance Ownership (%) in all Provinces - Saldru

Province	Magisterial District	Elec Kettle	Elec Stove	Fridge	Gas Stove	Paraffin stove	Elec Geyser	TV
01 W-KAAP/W CAPE								
	BELLVILLE	86.90	88.50	87.54	39.30	5.75	79.55	92.01
	CALEDON	33.87	51.61	54.03	37.90	48.39	40.32	64.52
	CERES	73.91	95.65	89.86	28.99	10.14	78.26	66.67
	GOODWOOD	82.35	81.18	69.41	41.76	10.59	0.00	83.53
	KAAP/CAPE	96.15	92.31	92.31	0.00	0.00	96.15	92.31
	KNYSNA	100.00	89.47	100.00	7.89	5.26	100.00	92.11
	KUILSRIVIER/RIVER	100.00	100.00	100.00	17.60	0.00	100.00	97.60
	OUDTSHOORN	5.13	33.33	11.97	36.75	73.50	0.00	43.59
	PAARL	91.67	96.88	100.00	34.38	4.17	14.58	100.00
	PRINCE ALBERT	4.08	18.37	12.24	4.08	2.04	12.24	14.29
	RIVERSDAL/RIVERSDALE	67.74	66.13	47.58	70.16	16.94	9.68	66.94
	SOMERSET-WES/WEST	94.95	95.96	98.99	20.20	6.57	93.43	93.94
	VANRHYNSDORP	100.00	76.36	100.00	23.64	0.00	100.00	100.00
	VREDENBURG	64.89	64.36	65.96	59.04	0.00	50.53	82.45
	WORCESTER	93.55	93.55	100.00	19.35	0.00	100.00	100.00
	WYNBERG	63.82	65.18	68.13	30.44	27.93	55.13	77.82
02 O-KAAP/E CAPE								
	ADELAIDE	0.00	0.00	0.00	6.09	100.00	0.00	37.39
	BIZANA	0.00	0.00	0.00	13.77	83.28	0.00	11.80
	BUTTERWORTH	13.16	20.18	13.16	15.79	89.47	0.00	50.00
	COFIMVABA	0.00	0.00	8.70	10.87	100.00	0.00	7.97
	ELLIOTDALE	0.00	0.00	0.00	0.00	100.00	0.00	0.00

Province	Magisterial District	Elec Kettle	Elec Stove	Fridge	Gas Stove	Paraffin stove	Elec Geyser	TV
	ENGCOBO	0.00	0.00	0.00	0.00	97.22	0.00	0.00
	FLAGSTAFF	0.00	0.00	6.36	15.55	75.27	0.00	6.71
	HEWU	0.00	0.00	8.89	3.33	72.22	0.00	17.78
	HOFMEYR	0.00	3.61	0.00	0.00	60.24	0.00	0.00
	HUMANSDORP	6.33	6.33	12.66	67.09	53.16	6.33	73.42
	IDUTYWA	0.00	0.00	0.00	5.15	80.15	0.00	0.00
	KEISKAMMAHOEK	0.00	0.00	0.00	5.17	98.28	0.00	15.52
	KENTANI	0.00	0.00	0.00	7.50	98.33	0.00	15.00
	KIRKWOOD	0.00	0.00	0.00	0.00	100.00	0.00	32.14
	LADY FRERE	0.00	0.00	19.82	18.02	79.28	0.00	0.00
	LIBODE	0.00	3.11	5.59	34.16	83.23	0.00	11.18
	LUSIKISIKI	0.00	0.00	0.00	12.12	70.71	0.00	4.55
	MACLEAR	0.00	10.53	0.00	7.02	82.46	0.00	10.53
	MALUTI	0.00	5.56	1.98	7.14	89.68	0.00	10.71
	MDANTSANE	29.69	31.47	41.52	27.68	81.03	7.37	53.79
	MPOFU	0.00	0.00	7.07	5.05	85.86	0.00	5.05
	MQANDULI	0.00	0.00	0.00	5.07	85.51	0.00	0.00
	MT FLETCHER	0.00	0.00	8.12	2.99	93.59	0.00	2.99
	MT FRERE	0.00	0.00	0.00	19.57	69.57	0.00	6.52
	NGQELENI	0.00	0.00	11.76	37.82	87.39	0.00	31.93
	NQAMAKWE	0.00	0.00	4.58	7.84	100.00	0.00	38.56
	OOS-LONDEN/EAST LONDON	66.86	60.47	56.98	34.88	34.30	61.63	67.44
	PEDDIE	0.00	1.64	4.10	29.51	86.07	0.00	50.82
	PORT ELIZABETH	35.15	42.74	47.03	17.33	55.45	25.58	68.48
	PORT ST JOHNS	0.00	0.00	0.00	0.00	62.50	0.00	23.61
	QUEENSTOWN	97.33	93.33	100.00	38.67	5.33	100.00	100.00
	QUMBU	0.00	0.00	0.00	0.00	94.27	0.00	3.18

Province	Magisterial District	Elec Kettle	Elec Stove	Fridge	Gas Stove	Paraffin stove	Elec Geyser	TV
	STERKSPRUIT	0.00	3.33	11.67	25.56	100.00	0.00	20.00
	TABANKULU	0.00	0.00	4.55	1.30	85.06	0.00	0.00
	TSOLO	0.00	0.00	0.00	9.63	89.63	0.00	14.07
	TSOMO	0.00	0.00	0.00	0.00	97.69	0.00	0.00
	UITENHAGE	56.98	73.18	62.01	28.49	54.19	25.14	91.06
	UMTATA	0.00	1.61	4.82	15.26	97.19	0.00	4.02
	UMZIMKULU	0.00	0.00	4.69	2.17	97.11	0.00	10.47
	WILLOWVALE	0.00	0.00	15.38	28.85	90.38	0.00	25.96
03 N-KAAP/N CAPE								
	BRITSTOWN	27.78	22.22	30.56	2.78	52.78	22.22	33.33
	DE AAR	31.63	25.51	31.63	52.04	67.35	0.00	67.35
	GORDONIA	0.00	0.00	78.13	100.00	0.00	34.38	34.38
	KIMBERLEY	70.37	94.07	78.52	10.37	16.30	45.93	83.70
	NAMAKWALAND	37.50	0.00	0.00	25.00	0.00	25.00	12.50
	POSTMASBURG	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	WARRENTON	49.55	66.52	61.16	20.98	43.75	3.57	56.70
04 OVS/OFS								
	BETHULIE	0.00	0.00	14.37	17.96	100.00	0.00	13.77
	BLOEMFONTEIN	44.30	46.33	57.47	16.96	74.43	17.47	70.38
	BOTHAVILLE	3.70	3.70	17.28	4.94	51.85	3.70	27.16
	BOTSHABELO	0.00	1.84	10.60	11.06	99.08	0.00	26.27
	EXCELSIOR	16.76	20.00	10.81	2.70	59.46	6.49	25.41
	FICKSBURG	8.84	10.20	19.05	13.61	90.14	2.72	18.37
	HARRISMITH	11.83	11.83	7.53	5.38	59.14	11.83	34.41
	HOOPSTAD	9.68	38.71	9.68	3.23	45.16	9.68	30.65

Province	Magisterial District	Elec Kettle	Elec Stove	Fridge	Gas Stove	Paraffin stove	Elec Geyser	TV
	KROONSTAD	69.27	68.78	79.02	27.32	41.46	62.93	73.17
	ODENDAALSRUS	0.00	0.00	15.38	15.38	100.00	0.00	61.54
	SASOLBURG	0.00	0.00	11.76	11.76	61.76	0.00	67.65
	SENEKAL	14.10	14.10	14.10	6.41	56.41	14.10	28.21
	THABA`NCHU	10.38	10.38	9.84	6.56	93.44	0.00	54.10
	WELKOM	59.71	66.30	59.34	7.33	32.60	62.64	57.51
	WESSELSBRON	0.00	0.00	4.26	0.71	100.00	0.00	26.60
	WITSIESHOEK	3.67	0.00	1.83	3.21	88.53	0.00	26.15
05 KWAZULU/NATAL								
	ALFRED	9.71	11.65	19.74	36.25	60.84	0.00	31.07
	CAMPERDOWN	16.99	41.92	47.67	10.41	83.56	2.47	46.03
	CHATSWORTH	40.95	100.00	100.00	9.52	25.71	80.00	100.00
	DUNDEE	6.40	11.63	9.88	12.79	50.58	0.00	22.67
	DURBAN	94.69	94.69	98.23	43.36	11.50	97.79	98.23
	ESTCOURT	4.64	9.65	7.05	7.98	81.26	0.00	11.87
	INANDA	62.04	86.03	77.48	21.79	35.97	53.60	83.00
	KLIPRIVIER	34.42	43.12	42.57	11.78	65.58	19.02	52.36
	LIONS RIVER	90.63	89.06	100.00	10.94	4.69	92.19	100.00
	LOWER TUGELA	7.02	23.68	6.14	4.39	63.16	1.75	14.04
	LOWER UMFOLOZI	13.56	13.31	36.12	32.57	76.30	10.52	40.81
	MAHLABATINI	0.00	0.00	12.43	14.59	91.89	0.00	25.95
	MAPUMULU	0.00	6.25	13.84	13.39	88.84	0.00	16.52
	MSINGA	0.00	0.00	11.88	13.79	79.31	0.00	4.98
	MTUNZINI	9.73	9.73	21.68	17.26	80.53	2.65	28.32
	NDWEDWE	7.30	16.31	23.61	28.76	71.67	0.00	41.20
	NEW HANOVER	0.00	0.00	6.35	6.35	20.63	0.00	4.76

Appendix V: List of documents in the bibliography database (4 pages out of 46)

19-Feb-98

author	title	publisher	date	place	organization
Ackermann, R.H.	Appropriate technology for electrical reticulation	CIGRE			
Annecke W	Fuel for thought	Journal of Energy in South Africa	93/05/01	Cape Town	
Aron, J. Eberhard, A. A. Gandar, M. V.	Fuelwood deficits in rural South Africa		91/01/01		
Aron, J., Eberhard, A. and Gandar, M.	Demand and supply of firewood in the homelands of South Africa.	University of Cape Town. Energy Research	89/07/01	Cape Town	
Auditore, F.A.	Economical feasibility for the application of bare-overhead-conductor versus aerial-bundled-conductor distribution for varying population in developing areas	CIGRE			
Auerbach, R. Gandar, M.V.	Energy and small scale agriculture				
Back, D. University of Cape Town. Energy Research Institute	Review of available micro-computer design packages for passive solar design of low cost dwellings. Chapter 2. Low income housing and energy consumption	University of Cape Town. Energy Research	89/01/01	Rondebosch	
Barnard, H.B.	Customer opinions on aspects of electricity supply; a research report presented to School of Business Leadership, University of South Africa	Unisa	91/01/14	Pretoria	
Barnard, HB	Electrification of workers houses		91/10/01		Eskom

author	title	publisher	date	place	organization
Barnard, HB	Electrification Project evaluation (policies and models)				
Basson, J.A.	Energy implications of accelerated urbanization		87/05/01		
BEC	Project energy, BEC, Research proposal	Research Surveys	89/03/08		
Bembridge, T. J. Tarlton, J.E.	Ciskei woodlot survey and woodfuel strategy	Foundatn for Research & Dev. CSIR	88/04/01		Foundation for Research and Dev, CSIR
Bembridge, T.J. Coleman,M. Lategan, F.S.	Rural household energy in developing areas with special reference to te use of dung.	DMEA	92/11/01	Pretoria	Fort Hare University, Dept of Agric Ext
BENBO	Black development in South Africa	BENBO	76/01/01	Pretoria	
Bennett, K.F. University of Cape Town. Energy Utilization Unit	Energy requirements of the domestic sector	University of Cape town. Energy Utilizat	77/01/01	Rondebosch	
Bennewith D	Fredville Area		89/10/01		
Bennewith D	Hlabisa		89/11/01		Eskom
Bennewith, D	Agricultural Survey (Eastern Natal Region)				
Bennewith, D	Kyamayakazi area (Eshowe district)				
Berrisford, A.J. & Surtees, R.M.	Electrical demand characteristics of low income and developing urban communities	Eskom	92/09/01		
Best, M.G.	Consumption of energy for domestic use in three African villages	Saldru	79/01/01	UCT	
Beute, N	Domestic utilisation of electrical grid energy in South Africa		93/11/01		

author	title	publisher	date	place	organization
Blomkamp, Y.	South African renewable energy bibliography : 1975 - 1991	DMEA	92/11/01		Engineering Research
BMR	Income and expenditure patterns of non-white urban households, Johannesburg survey (multiple Asian households) 1970	UNISA. Bureau of Market Research	71/01/01	Pretoria	
Booyens Konsultante	Urban Housing (No of dwellings, elect, water supply... 1990)		90/01/01		
Booyzen, A.G.	Note on the electrification of housing premises				
Borchers M L; Archer F M; Ravenscroft P	Household energy use in Namaqualand urban areas	EDRC	91/04/01	Cape Town	
Borchers, M.L.; Archer, F.M.; Eberhard, A.A.	Namaqualand household energy survey; A study of energy consumption patterns and supply alternatives in six reserves.	Energy Research Institute	90/10/01	Cape Town	Univ Cape Town. Energy Research Institut
Borchers, ML. Eberhard, AA	Household energy supply and price trends	EDRC	91/05/01	Cape Town	NEC
Bos, H.A.	Appropriate use of prepayment meters	CIGRE			
Botha, E.C.	To develop an affordable electricity tariff model for a developing city like Soweto	Eskom. North Eastern Transvaal Region	89/01/01		
Bureau of Market Research	Eskom-Soweto study 1989				
Buro vir Ekonomiese Politiek en Analise	Invloed van die elektrifisering van swart stedelike woonbuurtes op die Suid-Afrikaanse ekonomie	Buro vir Ekonomiese Politiek en Analise	88/10/01		
Buys, J.; Wolhuter, J.	Behoefte aan elektriese krag: Bongani Woonbuurt Douglas		90/10/01		

author	title	publisher	date	place	organization
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Campbell, K.J., Ferrando, L.J. and Krumm, D.A.	Pricing of electricity for developing communities	CIGRE			
Clark J	Lowcost small scale charcoal production in the Western Cape		90/05/01		
Cloete, S.A. and Du Toit, J.	Structural change in the economy and energy needs: a South African perspective	Development Bank of Southern Africa	88/01/01	Halfway House	
Co-ordinated Marketing & Management (Pty) Ltd	Attitude survey on energy usage in Soweto	Econolec	90/09/01	Southdale South Africa	Eskom
CONSULTOR	Market research into the need for electricity in Driefontein		90/10/01		
Consultor	Orange Farm - Marketing for electricity supply				
Cooper, CJ	National commercial energy consumption summary excluding liquid fuels, 1991 Final Report	DMEA	93/03/01	Pretoria	
Crawford, C.J.	Preliminary Market Research on Ezakheni Township	Eskom	90/02/03		Eskom
Crawford, C.J.	Preliminary Market Research On Nqutu Township		90/02/01		
Crawford, G.J.	Preliminary Market Research on Mondlo Township		90/02/01		
Crawford, GJ	Preliminary Market Research om Madadeni	Eskom	90/02/12		Eskom
CSIR?	Energy problems of developing areas	CSIR. South African Energy Information S	87/01/01	Pretoria	

Appendix VI
Energy efficiencies and intensities of cooking, space heating and water heating

fuel	appliance	MJ/unit	efficiency worst	best	accept	hrs/day max	hrs/day min	Units per hour vol.or mass	ave power assumption	Energy MJ/day minima	energy MJ/day maxima
	cooking										
elec	hot plate	3.6	55	75	65	4	1	1	1.00	2.70	7.92
	oven	3.6	55	75	65	4	1	2	2.00	5.40	15.84
	micro-wave	3.6	55	65		2	0.5	1	1.3	1.52	5.15
paraffin	wick	37	20	35	30	8	1	0.13	0.13	1.68	7.70
	primus	37	30	55	40	8	1	0.13	0.13	2.65	11.54
gas	ring	49	40	60	45	4	1	0.19	0.19	5.59	14.90
	stove	49	40	60		4	1	0.19	0.19	5.59	14.90
wood	3-stone	17	13	15	15	4	1	2.6	2.6	6.63	22.98
	stove	17	20	30	25	4	1	2.6	2.6	13.26	35.36
dung	stove	12	11	11	11	4	1	2.6	2.6	3.43	13.73
coal	stove	27	20	30		8	2	4	4	64.80	172.80
	brazier	27	6	10	8	4	2	4	4	21.60	25.92
low-smoke coal	stove	27	20	46		8	2	3.2	3.20	79.49	138.24
	space heating									0.00	0.00
elec	radiant heater	3.6	100	100		4	1	1.4	1.4	5.04	20.16
	heat pump	3.6	250	340		24	24	12	3	881.28	648.00
	blower	3.6	100	100		4	1	2	2	7.20	28.80
	panel	3.6	100	100		6	2	0.65	0.65	4.68	14.04
paraffin	heater	37	45	100		4	1	0.13	0.13	4.81	8.66
	primus	37	45	100		8	1	0.13	0.13	4.81	17.32
gas	heater	49	40	100		4	1	0.19	0.19	9.31	14.90
	ring/stove	49	40	100		4	1	0.19	0.19	9.31	14.90
wood	open fire	17	85	100	inside	4	1	2.6	2.6	44.20	150.28
	stove	17	20	60		4	1	2.6	2.6	26.52	35.36
	fireplace	17	27	27		4	1	2.6	2.6	11.93	47.74
dung	wood stove	12	20	60		4	1	2.6	2.6	18.72	24.96
coal	stove	27	20	60		8	1	4	4	64.80	172.80
	brazier	27	17	17	17	4	1	4	4	18.36	73.44
low-smoke coal	stove	27	20	60		8	1	3.2	3.2	51.84	138.24
	water heating									0.00	0.00
elec	heat pump	3.6	250	340	320	15	2	1	1	24.48	135.00
	geyser	3.6	48	92	58	2	0.5	3	3	4.97	10.37
	on line	3.6	96	96	96	0.5	0.5	9	9	15.55	15.55
paraffin	wick/pot	37	20	35	30	2	0.5	0.13	0.13	0.84	1.92
	primus/pot	37	30	55	40	2	0.5	0.13	0.13	1.32	2.89
gas	ring/pot	49	40	60	45	1	0.5	0.19	0.19	2.79	3.72
	geyser	49	75	92		1	0.25	0.19	0.19	2.14	6.98
wood	pot/fire	17	13	15		1	1	2.6	2.6	6.63	5.75
	pot/stove	17	20	30		1	1	2.6	2.6	13.26	8.84
dung	pot	12	11	11		1	1	2.6	2.6	3.43	3.43
solar	SWH	1	1000	1000		8	6	0	1		
mix	Solar/electric	3.6	160	307		2	6		1		
coal	stove(jacket/pot)	27	20	46		2	1	4	4	49.68	43.20
low-smoke	stove(jacket/pot)	27	20	46		2	1	3.2	5.00	62.10	54.00

Source: Thorne, S 1994

Appendix VII:

Summary of Monthly Energy Consumption in Low-income Households in South Africa

		kWh	kg	litres	kg	packets	kg
Climatic Region	**Dwelling Type**	**Consumption by All in relevant units/household**					
		ELEC	WOOD	PARAFFIN	GAS	CANDLE	COAL
Temperate	Formal housing	534	17	7	4	1	19
	Planned Shacks	65	16	25	9	3	55
	Unplanned Shacks	4	9	25	7	4	49
	Backyard shacks	149	13	20	15	2	8
	Rural shacks	5	158	7	7	1	1
Hot-humid	Formal housing	504	3	2	0	1	35
	Planned Shacks	53	32	24	4	5	88
	Unplanned Shacks	2	78	15	0	6	67
	Backyard shacks	172	7	22	2	5	16
	Rural shacks	2	219	7	1	2	10
Hot-dry	Formal housing	590	2	9	0	0	34
	Planned Shacks	45	19	21	2	7	116
	Unplanned Shacks	4	16	22	2	5	81
	Backyard shacks	139	7	22	7	2	5
	Rural shacks	3	71	10	1	3	66

Source: National Domestic Energy Use Database *(NDEUD)*, EDRC

Appendix VIII: Total number of households in different climatic zones (1993-2020)

Year	Temperate total	Hot-humid total	Hot-dry total
1993	1,589,192	1,988,931	1,999,786
1995	1,661,009	2,017,905	2,033,148
2000	1,869,552	2,110,991	2,131,978
2005	2,093,816	2,238,049	2,254,632
2010	2,464,482	2,409,152	2,406,905
2015	2,913,418	2,641,114	2,597,633
2020	3,552,166	2,963,651	2,841,093

Appendix IX: Percentage of households in each category of dwelling type in each climatic zone

Year	Climatic zone	Formal housing	Planned shacks	Unplanned shacks	Backyard shacks	Rural shacks
1993	Temperate total	43.9	16.9	9.4	1.3	28.5
	Hot-humid total	9.6	6.4	0.5	0.5	83.0
	Hot-dry total	13.1	5.6	2.9	1.2	77.8
1995	Temperate total	43.4	17.4	9.3	1.3	28.6
	Hot-humid total	9.9	6.9	0.6	0.5	82.2
	Hot-dry total	13.2	5.8	3.0	1.2	77.5
2000	Temperate total	42.1	18.9	9.2	1.2	28.6
	Hot-humid total	10.6	8.2	0.6	0.6	80.0
	Hot-dry total	13.5	6.4	3.0	1.2	76.7
2005	Temperate total	41.1	19.6	9.2	1.1	28.9
	Hot-humid total	11.3	9.8	0.7	0.7	77.6
	Hot-dry total	13.6	7.1	3.1	1.2	75.8
2010	Temperate total	38.5	23.6	8.9	1.0	27.9
	Hot-humid total	11.8	11.7	0.9	0.8	74.8
	Hot-dry total	13.7	8.0	3.1	1.2	74.8
2015	Temperate total	36.1	27.3	8.7	1.0	27.0
	Hot-humid total	12.2	14.2	1.1	0.9	71.6
	Hot-dry total	13.7	9.1	3.2	1.3	73.6
2020	Temperate total	33.0	32.4	8.4	0.9	25.4
	Hot-humid total	12.4	17.5	1.4	1.1	67.6
	Hot-dry total	13.6	10.7	3.3	1.3	72.0